Doppler Ultrasonic Flow Meter

DOF6000-P Series Manual

(Partially Filled & Open Channel)

Version 1.10

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules in the U.S.A. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

This equipment has been tested for compliance with European regulations as follows:

Application of Council Directive:
2004/108/EC

Standards to which Conformity is declared:
EN-61000-6-1:2001
EN-61000-4-2:1995
EN-61000-4-3:1995
EN-61000-4-4:1995
EN-61000-4-6:1996
ENV-50204:1995

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1.0 INTRODUCTION

The DOF6000 series flowmeter consists of flow calculator and the Ultraflow QSD 6537 sensor.

The Ultraflow QSD 6537 sensor is used to measure water velocity, depth, and conductivity of water flowing in rivers, streams, open channels and pipes.

When used with a companion Lanry DOF6000 calculator, flow rate and total flow can also be calculated.

The flow calculator can calculate the cross-sectional area of partially filled pipe, open channel stream or river, for stream or river, it can input up to 20 coordinate points describing the river's shape of cross section. It is suitable for various applications.

Ultrasonic Doppler Principle *in Quadrature Sampling Mode is utilised to* ***measure water velocity****. The 6537 Instrument transmits ultrasonic energy through its epoxy casing into the water. Suspended sediment particles, or small gas bubbles in the water reflect some of the transmitted ultrasonic energy back to the 6537 Instrument's ultrasonic receiver instrument that processes this received signal and calculates the water velocity.*

Water depth is measured with two methods*. An ultrasonic depth sensor measures water depth using the ultrasonic principle from a top mounted sensor on the instrument. Depth is also measured using the pressure principle from a bottom mounted sensor in the instrument. These two sensors provide flexibility in depth measurement. Some applications, for example measuring from the side of a pipe, better suits a pressure principle, while other applications in clear open channels better suit an ultrasonic principle.*

The QSD6537 Sensor has a ***4 electrode electro conductivity instrument*** *(EC) included to measure the quality of the water, with four electrodes exposed to the water at the top of the instrument. Water quality is measured on an ongoing basis and this parameter can be recorded along with velocity and depth to better analyse the nature of the water in open channels and pipes.*

Features：

- Rechargeable battery can work up to 50 hours.
- 20 coordinate points to describe the river's shape of cross section.
- One instrument can measure the velocity, depth and conductivity at same time.
- Velocity Range : 0.02mm/s to 12m/s bi-directional, accuracy is 1%.
- Depth Range: 0 to 10m.
- Measure velocity in both forward flow and back flow.
- Depth is measured by both the pressure sensor and ultrasonic level sensor principles.
- With coordinate correction and pressure compensation function.
- IP68 Epoxy-sealed body design, long time under water.
- RS485/MODBUS output, can contact computer directly.

2.0 SPECIFICATIONS

Sensor:

Velocity:	Velocity range:	20mm/sec to 12 m/sec Bidirectional velocity capability, set using configuration tools
	Velocity accuracy:	±1% Typical
	Velocity resolution:	1mm/s
Depth (Ultrasonic):	Range:	20mm to 5000mm (5m)
	Accuracy:	± 1%
	Resolution:	1 mm
Depth (Pressure)：	Range:	0mm to 10000mm (10m)
	Accuracy:	± 1%
	Resolution:	1 mm
Temperature：	Range:	0°C to 60°C
	Accuracy:	±0.5°C
	Resolution:	0.1°C
Electrical Conductivity (EC):	Range:	0 to 200,000 µS/cm, Typically ± 1% of measurement
	Resolution:	±1 µS/cm
	May be recorded as a 16-bit value (0 to 65,535 µS/cm) or a 32-bit value (0 to 262,143 µS/cm)	
Tilt (accelerometer):	Range:	±70° in roll and pitch axes.
	Accuracy:	±1° for angles less than 45°
Output:	SDI-12:	SDI-12 v1.3, Max. cable 50m
	Modbus:	Modbus RTU, Max. cable 500m
Environmental：	Operating temperature:	0℃ ~+60℃ water temperature
	Storage temperature:	-20℃ ~+60℃
	IP class:	IP68
Others：	Cable:	The standard cable is 15m, the maximum option is 500m.
	Sensor material:	Epoxy-sealed body, Marine Grade 316 Stainless Steel Mounting Bracket
	Sensor size:	135mm x 50mm x 20mm (L x W x H)
	Sensor weight:	1kg with 15m of cable, it can extend o 100m

Calculator:

Type:	Portable
Power supply:	Calculator:85-265VAC (Charging battery)
IP class:	Calculator: IP66
Operating temperature:	0℃ ~+60℃
Case material:	ABS
Display:	4.5” color LCD
Output:	Pulse,4-20mA（Velocity & Depth）,RS485/Modbus, Datalogger, GPRS
Size:	270L×215W×175H (mm)
Weight:	3 kg
Data storage:	16GB
Application:	Partially Filled Pipe: 150-6000mm; Channel: width >200mm

3.0 OPERATING PRINCIPLES & MEASURED PARAMETERS

Ultraflow QSD 6537 measures:

- Flow velocity
- Depth (Ultrasonic)
- Temperature
- Depth (Pressure)
- Electrical Conductivity (EC)
- Tilt (the angular orientation of the instrument)

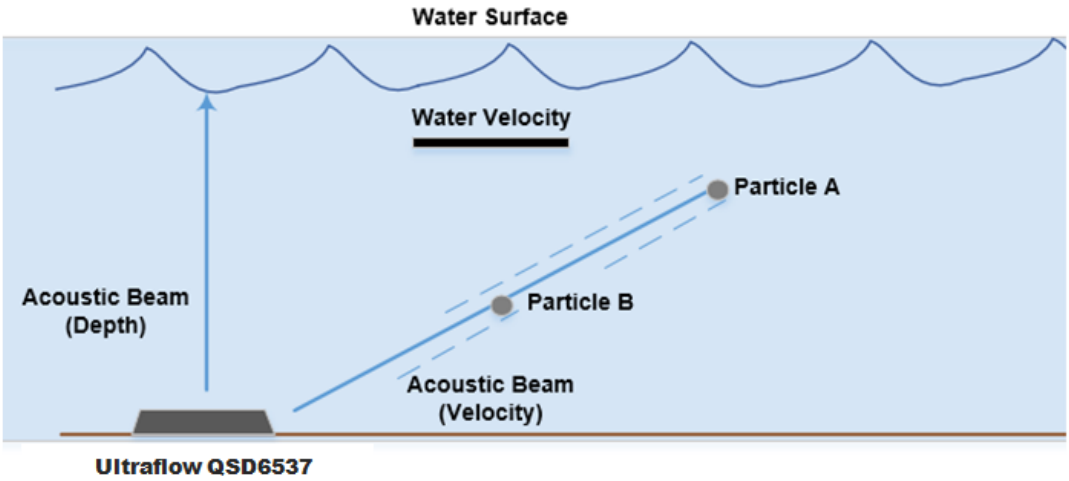
The Ultraflow QSD 6537 performs data processing and analysis each time a measurement is made. This can include rolling averaging and outlier/filter functions for Depth (ultrasonic), Velocity, Conductivity and Depth (Pressure).

3.1 Flow Velocity Measurement

For Velocity Ultraflow QSD 6537 uses Continuous Mode Doppler. To detect water velocity, an ultrasonic signal is transmitted into the water flow and echoes (reflections) returned from particles suspended in the water flow are received and analysed to extract the Doppler shift (velocity). The transmission is continuous and simultaneous with the returned signal reception.

During a measurement cycle Ultraflow QSD 6537 emits a continuous signal and measures signals returning from scatterers anywhere and everywhere along the beam. These are resolved to a mean velocity that can be related to a channel flow velocity at suitable sites.

The receiver in the instrument detects reflected signals and those signals are analysed using digital signal processing techniques.



3.2 Water Depth Measurement - Ultrasonic

For Depth measurement Ultraflow QSD 6537 uses Time-of-Flight (ToF) Ranging. This involves transmitting a burst of ultrasonic signal upwards to the surface of the water and measuring the time taken for the echo from the surface to be received by the instrument. The distance (water depth) is proportional to the transit time and the speed of sound in water (corrected for temperature and density)

The maximum ultrasonic depth measurement is limited to 5m.

3.3 Water Depth Measurement - Pressure

Sites where the water contains large amounts of debris or air bubbles may be unsuited for ultrasonic depth measurement. These sites are better suited to using pressure to determine the water depth.

Pressure based depth measurement may also be applicable to sites where the instrument cannot be located on the floor of the flow channel or it cannot be mounted horizontally.

Ultraflow QSD 6537 is fitted with a 2 bars absolute pressure sensor. The sensor is located on the bottom face of the instrument and utilises a temperature compensated digital pressure sensing element.

Where depth pressure sensors are used the atmospheric pressure variation will cause errors in the indicated depth. This is corrected by subtracting the atmospheric pressure from the measured depth pressure. A barometric pressure sensor is required to do this. A pressure compensation module has been built into the calculator DOF6000 which will then automatically compensate for the atmospheric pressure variations ensuring an accurate depth measurement is achieved. This enables Ultraflow QSD 6537 to report actual water depth (pressure) instead of barometric pressure plus water head.

3.4 Temperature

A solid state temperature sensor is used to measure the water temperature. The speed of sound in water and its conductivity is affected by temperature. The instrument uses the measured temperature to automatically compensate for this variation.

3.5 Electrical Conductivity (EC)

Ultraflow QSD 6537 is equipped with the capacity to measure the conductivity of the water. A linear four electrode configuration is used to make the measurement. A small current is passed through the water and the voltage developed by this current is measured. The instrument uses these values to calculate the raw uncorrected conductivity.

Conductivity is dependent on the temperature of the water. The instrument uses the measured temperature to compensate the returned conductivity value. Both raw or temperature compensated conductivity values are available.

3.6 Accelerometer

Ultraflow QSD 6537 has an integral accelerometer sensor to measure the inclination of the instrument. The sensor returns the roll and pitch angle of the sensor (in degrees). This information can be useful in ensuring the installation position of the sensor is correct and for determining if the instrument has moved (bumped or washed away) during post installation inspection.

3.7 Signal Spread

This can be used to determine the amount of “turbulence” affecting the signal quality and used to reject the measurement if the spread (turbulence) is too great.

A good flow would return a spread value of around 50, anything above 100 would be considered poor.

10	Excellent SPREAD
20	Very good SPREAD
30	Good SPREAD in dirty river water
40	Good SPREAD in clean river water (Typical)
60	Average SPREAD
80	Poor SPREAD
90	Bad SPREAD (Poor site selection)
100	Above 100 gives unreliable velocity data.

3.8 Received Signal Strength Indicator (RSSI)

The RSSI channel is the measurement of the received signal power.

RSSI values may change significantly each measurement because of the number of reflectors in the water at that time.

RSSI Channel	Interpretation
0	Threshold signal at Analog. Gain=5 (default)
1	Useable Signals
5	Good signal
10	} Typical signal in clean river water
20	
40	
1000	Saturated signal

Therefore in very laminar flow situations (perfect conditions) the RSSI value should be very low between 1-10. In typical river situations RSSI will be between the 1 and 30.

4.0 CALCULATOR INSTALLATION AND CABLE CONNECTION

4.1 Calculator Installation

Mount flow calculator in a location that is:

- Where little vibration exists.
- Protected from falling corrosive fluids.
- Within ambient temperature limits -20 to +60°C)
- Out of direct sunlight. Direct sunlight may increase transmitter temperature to above the maximum limit.

4.2 Calculator Size

Length*Width*Height: 270L×215W×175H (mm)

4.3 Calculator Wirings

Figure 4.3. Portable Calculator Wiring Diagram

- In the right of above picture is POWER which is connected to power supply 85-265VAC for charging.
- Output is for Pulse, 4-20mA output.
- *Pulse: Pulse communication interface, output is flow rate.*
- *Dep: Output depth with 4-20mA.*
- *Vel: Output velocity with 4-20mA.*

Function/Signal Name	***Wire Color***
4-20mA Dep +	*Red*
4-20mA Dep -	*Brown*
4-20mA Vel +	*Black*
4-20mA Vel -	*White*
Pulse +	*Blue*
Pulse -	*Green*

- Modbus: To connect with Modbus communication interface.

Function/Signal Name	***Wire Color***
Modbus A	*Green*
Modbus B	*Blue*
Modbus GND	*Black*

- Sensor: To connect with sensor.

5.0 SENSOR INSTALLATION

5.1 Site Considerations

The Doppler signal received, and the accuracy of the computed velocity, is related to the flow and cross-section characteristics of the site. A suitable site has the following features:

Feature	Description
Flows are laminar and the velocity measured by the transducer can be related to the mean velocity of the channel.	Velocity is measured from a limited path in front of and above the acoustic sensors. This area varies with the amount of suspended material in the water and the channel characteristics. The user has to determine the relationship between the measured and mean velocity.
The channel cross section is stable.	The relationship between water level and the cross-sectional area is used as part of the flow computation.
Velocities are greater than 20 mm / second.	The transducer does not process velocities slower than this. The maximum velocity is 5 metres / second. The transducer will measure velocities in both directions.
Reflectors are present in the water.	Generally the more material in the water the better. Ultraflow QSD 6537 generally works well in clean natural streams but problems may be encountered in extremely clean water.
No excessive aeration.	Bubbles are good scatterers and occasional small bubbles will enhance the signal. However the speed of sound can be affected if there are excessive amounts of air entrapped in the flow.
The bed is stable and Ultraflow QSD 6537 will not be buried by deposits.	Some coating and partial burying has little effect on the measured velocity but it should be avoided. Any burying or sediment covering the depth transducer will affect the depth reading results.
Ultraflow QSD 6537 Pointing Upstream or Downstream?	Pointing the sensor end downstream will stop it accumulating debris; however in some channels the sensor body may disturb the velocity distribution unacceptably. The velocity reading will be positive when pointing upstream and negative when pointing downstream. The Ultraflow QSD 6537 may be configured to only read positive velocities regardless of water flow direction.
Ultraflow QSD 6537 Depth sensor not situated parallel to the surface?	If Depth sensor is not parallel to the surface (~ ±10 °) the readings could be compromised
Corrugated Pipes	In general the Ultraflow QSD 6537 is not suited to installation in corrugated pipes.

5.2 How to choose a suitable location of partially filled pipe

A typical installation is in a pipe or culvert with diameters between 150mm and 2000 mm. The Ultraflow QSD 6537 should be located near the downstream end of a straight and clean culvert, where non-turbulent flow conditions are maximised. The mounting should ensure the unit sits right on the bottom to avoid debris catching beneath it.

It is recommended that in open pipe situations that the instrument is situated 5 times the diameter from the opening or discharge. This will allow instrument to measure the best possible laminar flow. Keep the instrument away from pipe joints. Corrugated culverts are not suitable for Ultraflow QSD 6537 instruments.

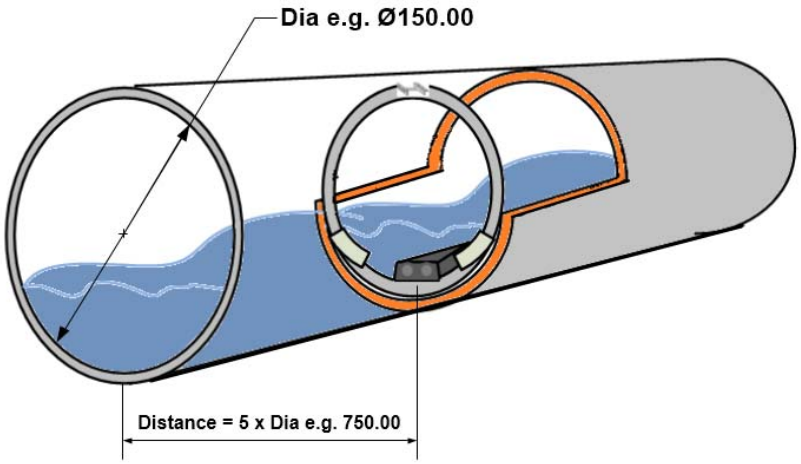


Figure 5.2 Require 5 diameters from pipe opening

In culverts the sensor can be mounted on a stainless steel band that is slipped inside the pipe and expanded to lock it in position. In open channels special mounting brackets may be required.

5.3 Sensor Installation

Velocity level sensor is shown in the following figure.

When installing the sensor, the mounting bracket is usually used to fix the sensor in an appropriate position.

Figure 5.3 Velocity Level Sensor

Remarks:

The sensor should be installed in a position that avoids the covering of sediment and alluvium and fluids.

Ensure that the cable is long enough to be connected the calculator.

5.4 Open Channel Flowmeter Installation

When installing in riverbed, underwater or other channels, the installation bracket can be directly welded to the bottom of the channel, or can be fixed with cement or other base as needed, as shown in the following figure:

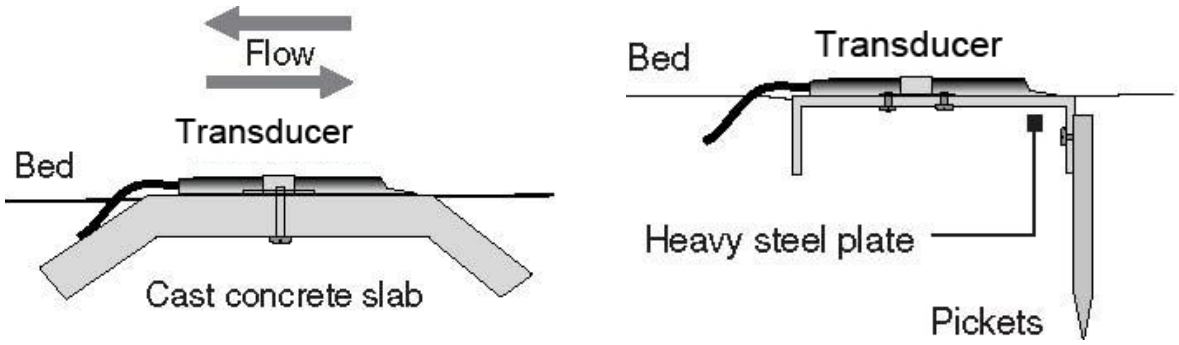


Figure 5.4. Velocity level sensor's installation for open channel flowmeter

5.5 Installation In A Pipe

A typical installation is in a pipe or culvert with diameters between 150 and 1800 mm. Ultraflow QSD 6537 sensor should be located near the downstream end of a straight and clean culvert, where non-turbulent flow conditions are maximized. The mounting should ensure the unit sits right on the bottom to avoid debris catching beneath it.

In culverts the sensor can be mounted on a stainless steel band that is slipped inside the pipe and expanded to lock it in position. In open channels special mounting brackets may be required.

The Model 6705 Expanding Band Kit allows you to install a Ultraflow QSD 6537 instrument into a pipe.

Kit design is modular, allowing it to fit into any size pipe. The band is flexible enough to fit irregular shapes, such as ovoid (egg shaped) sections.

All components are made from stainless steel and the band fittings are 100mm wide to fit the standard Ultraflow QSD 6537 mount.

Although pipes come in standard diameters, their dimensions are not always accurate. This means that an expanding band kit must allow the installer to make adjustments on site. To achieve this, the Model 6705 kit is made so that general assembly can be done in the workshop, whilst adjustments can be made in the field with hand tools. An expanding turn-buckle locks the band into the pipe.

To determine what installation hardware is needed for a pipe installation the pipe diameter needs to be known.

Pipe Diameter	Clamp	Bands	Joiners
Up to 600mm	6705A	6705D	-
600 - 1200mm	6705B	2 x 6705D	1x6705F
1200 - 1800mm	6705B	3 x 6705D	2x6705F

Note: *Pipes less than 150mm diameter are NOT RECOMMENDED for Ultraflow QSD 6537 installation due to the instrument's size.*

Do the following:

1. If the inside circumference of the pipe is ACCURATELY known, then cut the band assembly to this length LESS 25mm for fitting clearance. Circumference (length) = Diameter x 3.14.

2. Arrange the clamp, band(s) and joiner(s) so that Ultraflow QSD 6537 sensor will be positioned at the bottom (invert) of the pipe and an Expanding Clamp at the top (obvert) of pipe (see diagram).

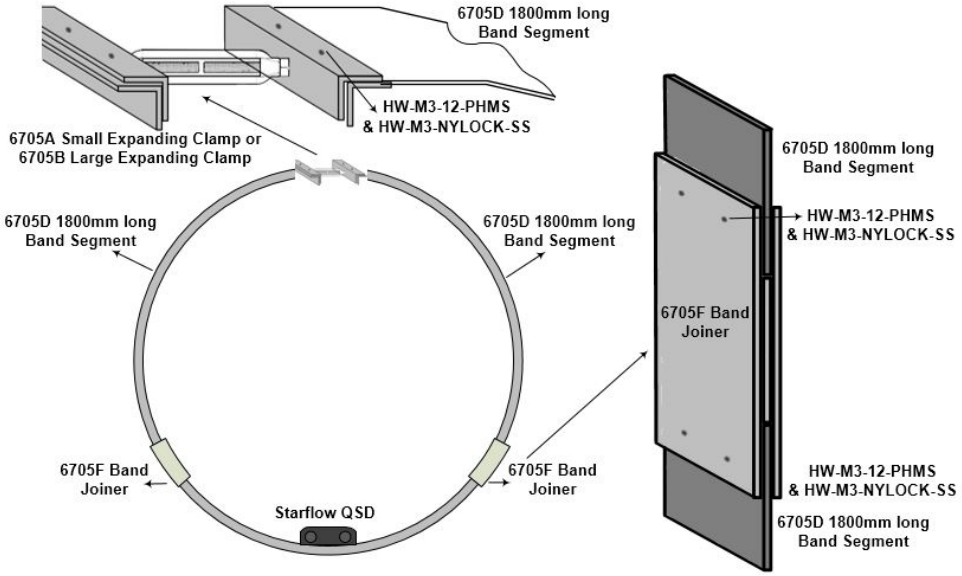


Figure 5.5. Model 6705 Expanding Band Kit

3. Drill 4 x 5mm holes, 85mm spaced in the centre of the band to locate the instrument. Use the Ultraflow QSD 6537 mounting bracket as a guide.

Use a small pilot drill bit (about 2mm) then finish with the 5mm bit. When drilling stainless steel use a slow speed and high pressure. Avoid stopping as the material will work harden making it more difficult to drill.

4. Use M3 x 12mm stainless steel machine screws and M3 nylock nuts (supplied) to connect all parts. (If pop rivets and the pop rivet gun are available they can be used as the replacement for the screws and nuts sets)

***Note**: the band length must be measured to include the Expanding Clamp (fully closed), bands and joiners all together as shown.*

5. Position and tighten Ultraflow QSD 6537 sensor and band, mounted the bolt of Ultraflow QSD 6537 sensor to the band.

6. Fold the band into a circle to easily fit inside the pipe and position into place inside the pipe.

7. Slip the loose end of the band into the expanding clamp.

8. Adjust clamp until band is tight inside pipe (use spanner if necessary).

6.0 FLOW CALCULATOR OPERATION

6.1 Keys Instruction

DOF6000-P flow calculator contains a eight-key tactile feedback keypad interface that allows user to view and change configuration parameters used by the flow meter operating system.

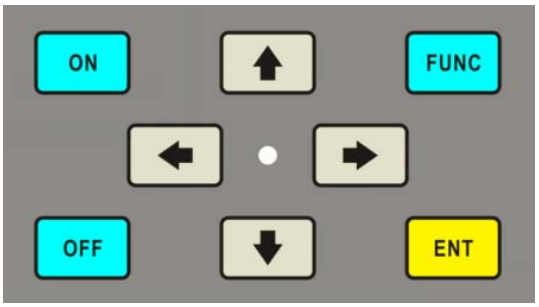


Figure 6.1 DOF6000– P Calculator keypad

ON Key

Turn on the calculator.

OFF Key

Turn off the calculator.

FUNC Key

When choose menu, press it to return superior menu;

When set parameters, press it to cancel the setting, the setting parameter is invalid, and return the last parameter.

ENT Key

When choose menu, press it to select menu users need;

When set parameters, press it to save the setting.

Key

When choose menu, press it to see the superior menu;

When set parameters, press it to shift the focus position to left.

Key

When choose menu, press it to see the follow menu;

When set parameters, press it to shift the focus position to right.

Key

When choose menu, press it to shift the focus position up to select menu users need;

When set parameters, press it to change the value or move to the up option.

Key

When choose menu, press it to shift the focus position down to select menu users need;

When set parameters, press it to change the value or move to the up option.

6.2 Menu Structure and Functions

6.2.1 Menu Structure

The calculator menu adopts hierarchical structure, which looks simple and clear. The figure of menu structure as below:

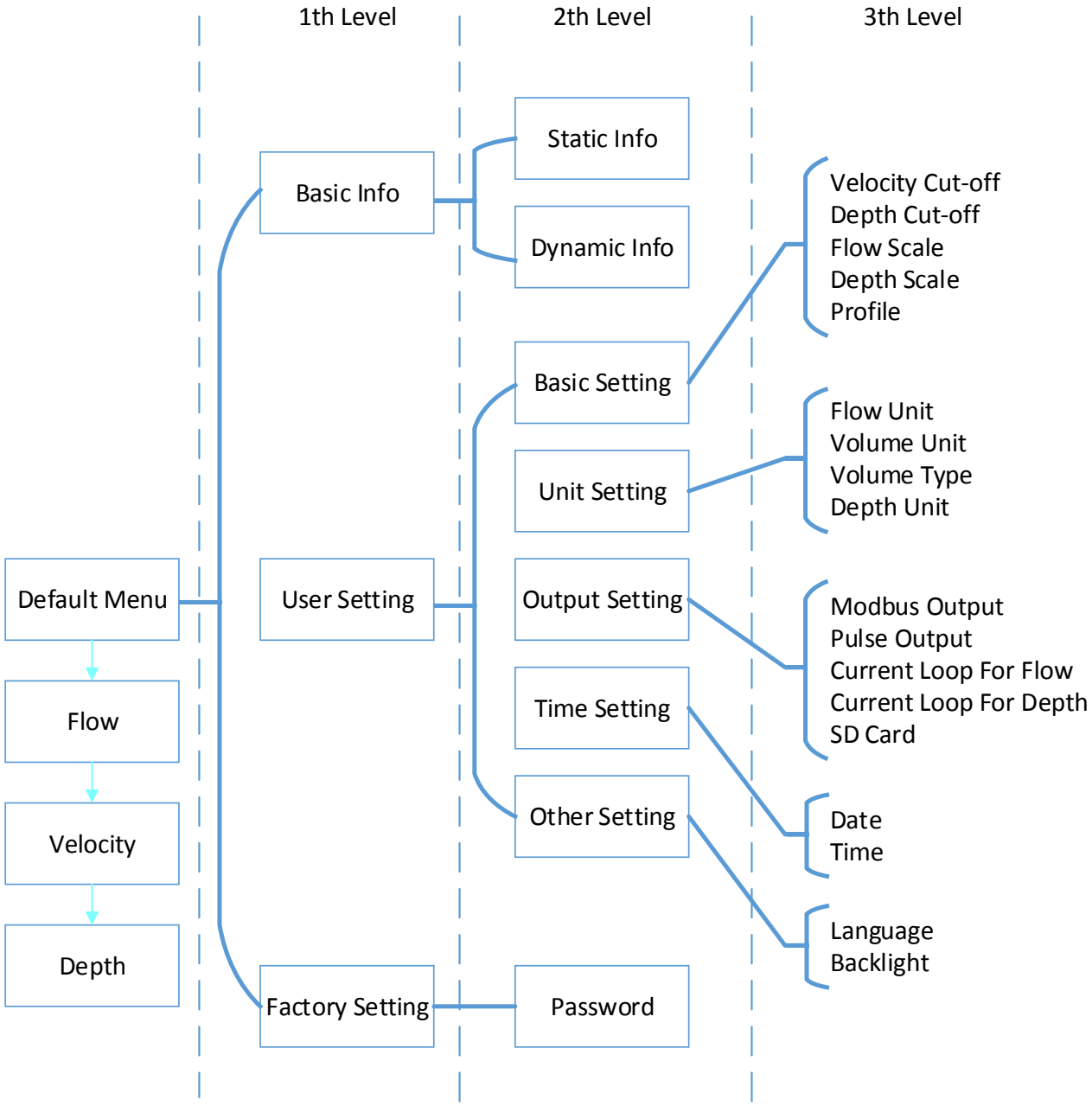


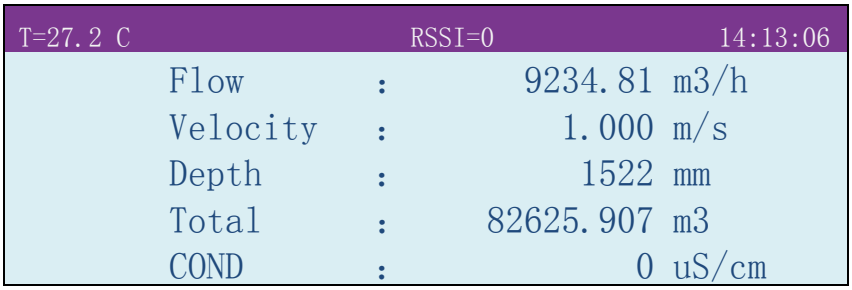
Figure 6.2 Menu Structure

Note: *Some items in the three-level menu will also have corresponding sub-menus, details of which are introduced in the corresponding chapter 6.2.4 and 6.2.6.*

Entering the factory setting menu requires a password, which is used by the manufacturer.

6.2.2 Default menu

When the calculator is powered on, it will display the default menu automatically as below:



The top row is information row, it display at the top of all menus.

T： Sensor ambient temperature, accuracy is 0.1 ° C , read - only.

RSSI：Ultrasonic signal strength received after reflection, Integers without units, read only.

14:13:06：The current system time, can be modified in the time menu.

The default menu data are all read-only items, which are described as follows:

Flow: Instantaneous flow value. The default unit is m3/h. and unit is optional. Pls check the menu details of flow unit.

Velocity: Instantaneous velocity, unit is fixed as m/s.

Depth: Instantaneous liquid level value, unit is fixed as mm.

Total: Flow volume. Type is optional, default is positive flow volume. Unit is optional, default is m3. Pls check the menu details of volume type and unit.

COND: Conductivity of liquid, unit is fixed as uS/cm.

Buttons Introduction under this menu:

Up button, Down button, left button: no use.

Func button, right button: go to the first level menu page.

ENT button: Enter a circular display menu. As below figure:

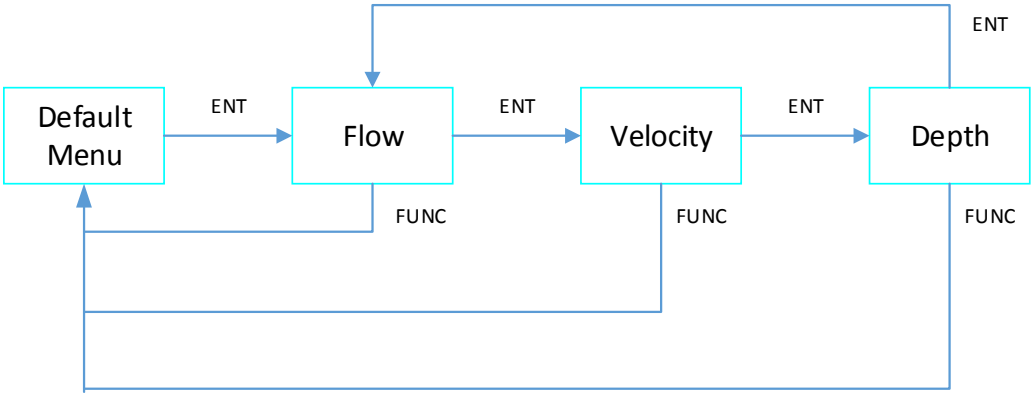
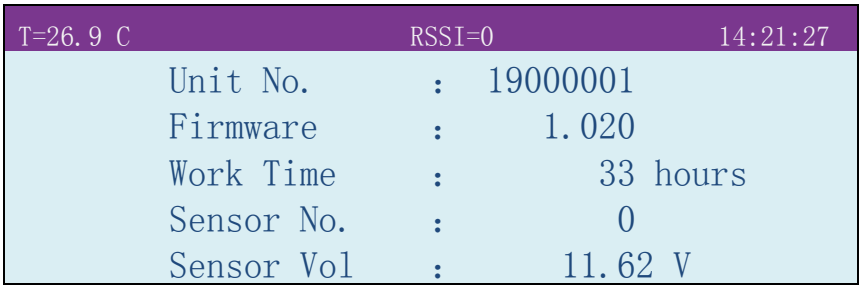


Figure 6.2.1 Circular Display Menu Structure

This menu is a circular menu, it can be returned to the default menu with the FUNC key. It is display with large font, which is convenient for user installation and debugging.

6.2.3 Basic Information Menu

The first item in the first-level menu is basic information, which is divided into two parts. One is static information, which is constant or slowly changing information; the other is dynamic information, which is sensor measurement real-time signal information. All items are read-only.



Static information Menu：

Unit No.: Serial number of calculator.

Firmware: Firmware version.

Work Time: The cumulative working time of calculator from the first power-on operation, unit is hours.

Sensor No.: Serial number of sensor.

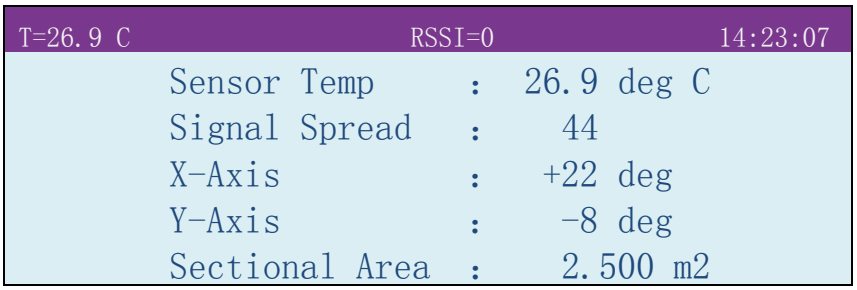
Sensor Vol: Detected power supply voltage inside the sensor, unit is V.

Buttons Introduction under this menu:

Up button, Down button, ENT button: no use.

Func button, left button: go to the first level menu page.

Right button: Enter dynamic information menu. As below figure:



Dynamic information Menu：

Sensor Temp: Sensor ambient temperature, accuracy is 0.1 ° C, same as the top information row.

Signal Spread: ultrasonic signal quality, no unit, the smaller the better.A good flow would return a spread value of around 50, anything above 100 would be considered poor. (pls check 3.7 to get more details)

X-Axis：The X-axis inclination of sensor, units is degree.

Y-Axis：The Y-axis inclination of sensor, units is degree. (pls check 3.6 to get more details)

Sectional Area: Cross-sectional area is calculated according to the measurement type and liquid level, the unit is m2.

Note: The installation position of the equipment can be adjusted according to the Angle between X-axis and Y-axis. Incorrect installation will affect the accuracy of the ultrasonic depth sensor.

Buttons Introduction under this menu:

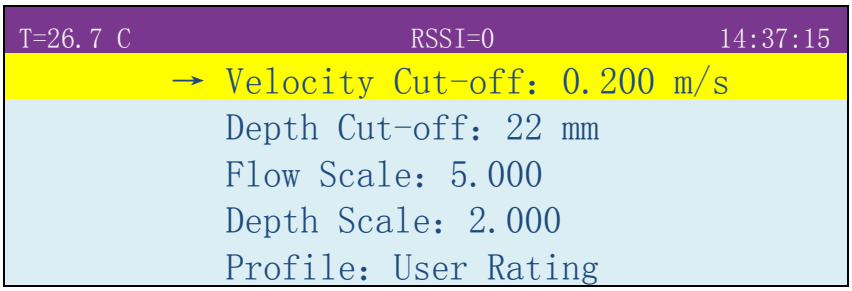
Up button, Down button, right button: no use.

Func button: go to the first level menu page.

Left button: Enter Static information menu.

6.2.4 User Setting

The second item in the first level menu is the user setting, and the first item in the second level menu is the basic setting. As below figure:



Velocity Cut-off：When the measured velocity less than setting value, the velocity will display 0. The default value is 0.2m/s, and the data range can be set from 0 to 9.999m/s.

Depth Cut-off: when the measured liquid level is lower than this value, the calculator depth will display 0mm. The default value is 22mm, and the data range can be set from 0 to 999mm.

Flow Scale: The flow scale factor is used to modify the measurement flow results. Factory default value is 1.000, and the data range can be set from 0 to 9.999.

Depth Scale: The flow scale factor is used to modify the measurement depth results. Factory default value is 1.000, and the data range can be set from 0 to 9.999.

Profile: The meter supports three measurement types, pipe, rectangle and user rating. The figure of menu structure as below:

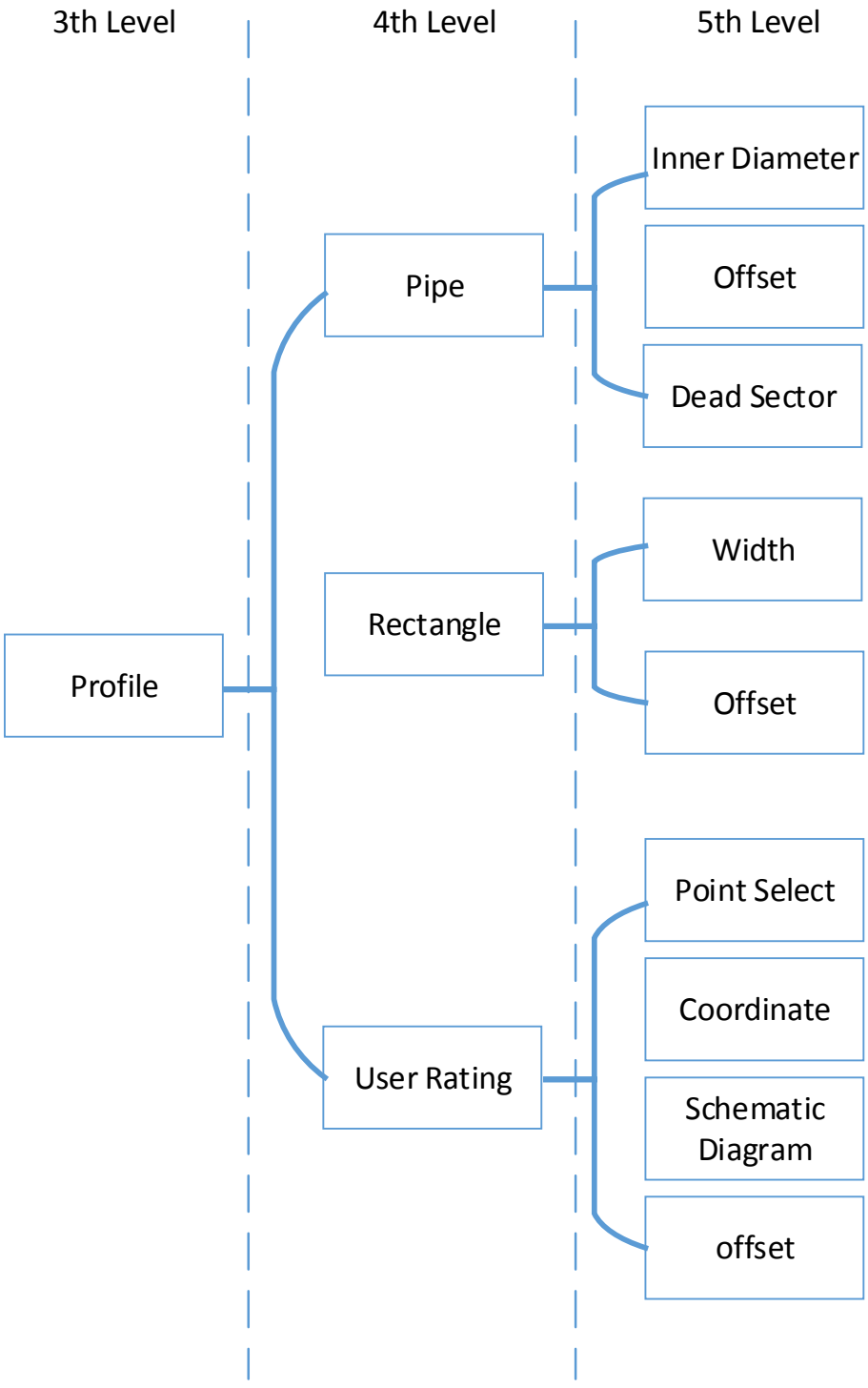


Figure 6.2.2 Profile Menu Structure

Note: The corresponding measurement type must be set before the corresponding sub-menu can be displayed and set.

6.2.4.1 Partially Filled Pipe Examples

Offset (mm)	This defines the offset from the bottom of the pipe to the position of the Ultrflow 6537 pressure depth sensor.
Inner Diameter (mm)	Pipe inner diameter.
Dead Sector (mm)	The dead band due to siltation (if any).

Pipe Example

Pipe is 1800mm in diameter.
The pressure depth sensor is mounted 100mm up from the bottom and there is 75mm of silt in the pipe.

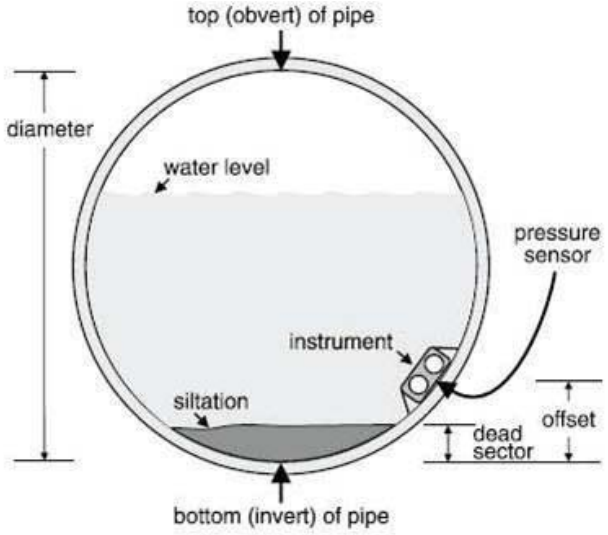
Flow Calculator Setting:

Select “pipe” in Profile;

Set “1800” in innner Diameter

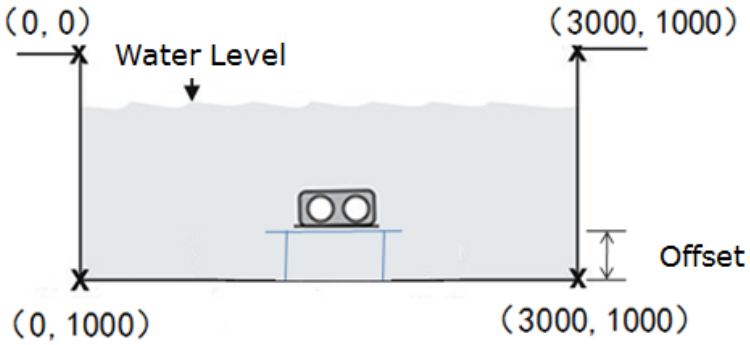
Set “100” in Offset;

Set “0075” in Dead sector



6.2.4.2 Rectangle Examples

The open channel is 3000mm width. A Ultraflow QSD 6537 sensor is mounted with bracket as below picture. The bracket height is 250mm
No silt (dead sector) in channel.



Offset (mm): This defines the offset from the bottom of the channel to the position of the Ultraflow QSD 6537 pressure depth sensor.
Flow Calculator Setting:

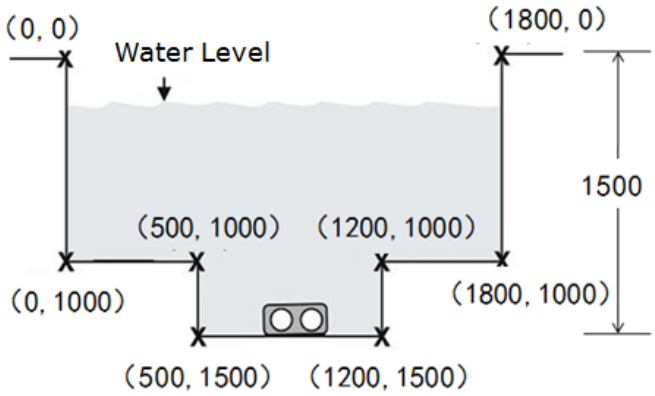
Select “rectangle” in Profile;
Set “3000” in width
Set “250” in Offset

6.2.4.3 User Rating Examples

The channel is as shown. A Ultraflow QSD 6537 sensor is mounted at the bottom.
No silt (dead sector) in channel.

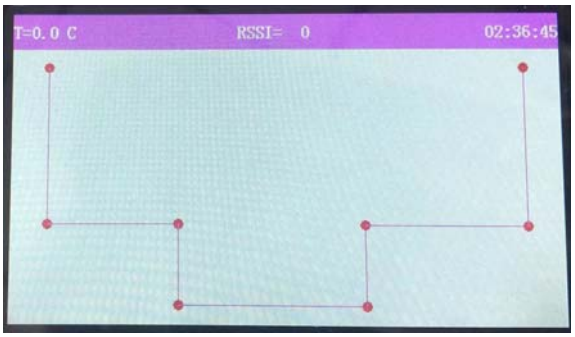
Offset: The height between the position of the device pressure sensor and the coordinate (0,0) point (top left point)

Select “user rating” in Profile;



The coordinate (0,0) point (top left point) is the system default and no change is required.
Set Point 01 “0000，1000”;
Set Point 02 “0500，1000”;
Set Point 03 “0500，1500”;
Set Point 04 “1200，1500”;
Set Point 05 “1200，1000”;
Set Point 06 “1800，1000”;
Set Point 07 “1800，0000”;
Set Offset: 1500 mm

After setting all coordinates, enter the menu of schematic diagram to check the shape of set channel. If it is not as expected, it should be modified by user.



Note:

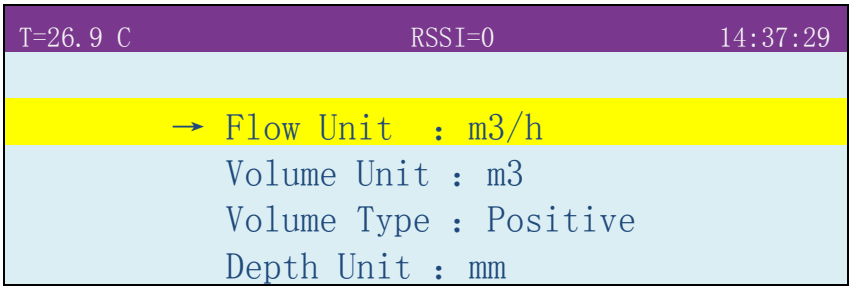
When select user-rating function, this menu can input up to 20 coordinate points for channel measurement.

The coordinate (0,0) point (top left point) is the system default and no change is required.

Coordinate points should be entered in left-to-right order.

6.2.5 Unit Setting

The second item in the first level menu is user setting, and the second item in the second level menu is unit setting. As below figure:



Flow Unit： m3/h, L/s, USG/min, /min for selection.

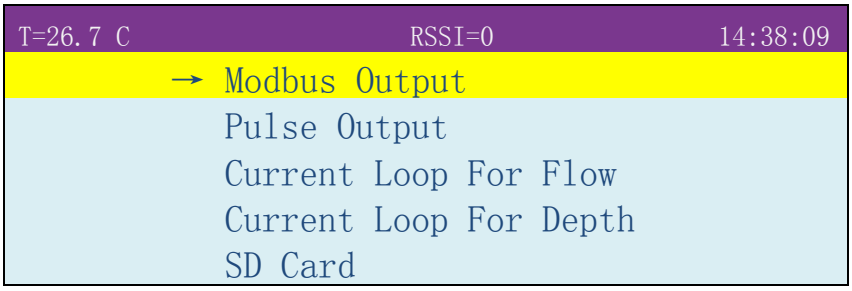
Volume Unit：m3, L, UKG, USG, FT3, A.F. for selection

Volume Unit：Positive，Negative, Net for selection

Depth Unite：mm. It is read-only

6.2.6 Output Setting

The second item in the first level menu is the user setting, and the third item in the second level menu is the output setting. As below figure:



Each item has a subordinate menu, as below figure

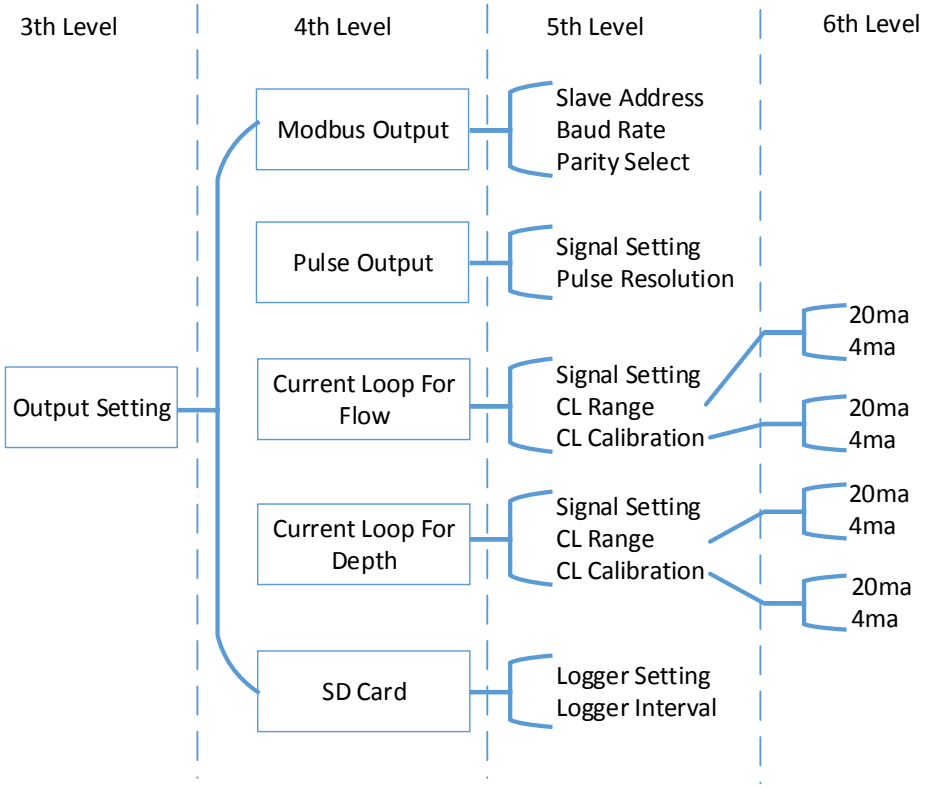


Figure 6.2.3 Output Menu Structure

Modbus output setting：

Slave address：The default is 1, with a range of 1-255

Baud Rate：The default is 9600bps, 4800/9600/19200/38400/57600/115200bps can be optional.

Parity Select：The default is None. None, ODD, Even can be optional.

Pulse Output setting：

Signal Setting：The default is Disable. Disable POS, NEG, NET can be optional.

Pulse Resolution：The default is 1m3. 1L/10L/100L/1m3/10m3/100m3 can be optional

Current Loop For Flow setting：

Signal Setting：The default is Disable. Disable, Positive, Negative can be optional.

4mA range: The default is 0, 0-9999 can be optional, unit is m3/h.

20mA range：The default is 500, 0-9999 can be optional, unit is m3/h.

4mA calibration: when the flow is at the minimum range, the current value may be at a point above or below 4mA. At this time, correction fine-tuning is required. The default is -250, with an optional range of -256--+256.

After entering the setting menu, the 4mA value that configured under the calibration value will be automatically output. When exiting the menu, the current will be automatically output according to the flow value.

20mA calibration: when the flow is at the maximum range, the current value may be at a point above or below 20mA. At this time, correction fine-tuning is required. The default is 250, with an optional range of -256--+256.

After entering the setting menu, the 20mA value that configured under the calibration value will be automatically output. When exiting the menu, the current value will be automatically output according to the flow value.

Current Loop For Depth setting：

Signal Setting：The default is Disable. Disable and Enable can be optional.

4mA Range：The default is 0, 0-9999 can be optional, unit is mm.

20mA range：The default is 500, 0-9999 can be optional, unit is mm.

4mA calibration: when the Depth is at the minimum range, the current value may be at a point above or below 4mA. At this time, correction fine-tuning is required. The default is -250, with an optional range of -256--+256.

After entering the setting menu, the 4mA value that configured under the calibration value will be automatically output. When exiting the menu, the current value will be automatically output according to the depth value.

20mA calibration: when the depth is at the maximum range, the current value may be at a point above or below 20mA. At this time, correction fine-tuning is required. The default is 250, with an optional range of -256--+256.

After entering the setting menu, the 20mA value that configured under the calibration value will be automatically output. When exiting the menu, the current value will be automatically output according to the depth value.

Buttons Introduction under flow and depth calibration menu:

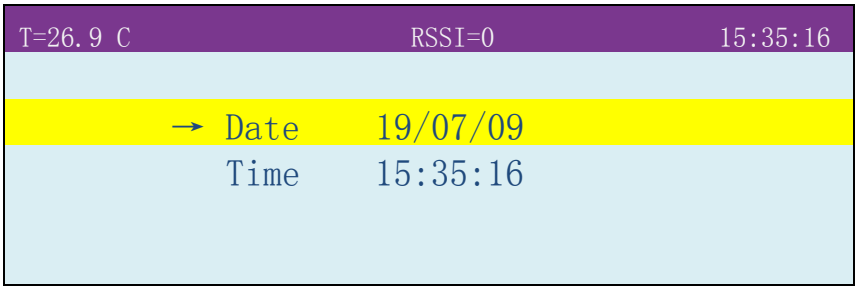
Left button, right button: no use.
Func button: go to the first level menu page.
ENT button: save the enter data.
Up button, down button: add or subtract the value by one for one time.

SD Card setting：
Logger Setting：The default is off, On and Off can be optional.
Logger Interval: Format as hh: mm: ss, default data is 1 minute, 5 seconds to 100 hours can be optional.

The data stored in SD card is CSV format, and the file name is "day-month-year. csv". For example, the file name is 02-01-2019.csv on January 2nd, 2019.
Each data item contains the following:
Date -Time - Flow - Unit - Vel - Unit - NET -Unit - POS - Unit - NEG - Unit - Depth - Unit - COND - T[C]

6.2.7 Time Setting

The second item in the first level menu is the user setting, and the fourth item in the second level menu is the time setting. As below figure:



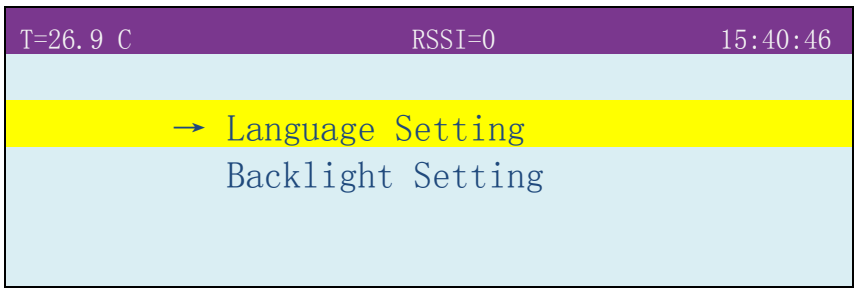
Date： YY/MM/DD

Time： HH：MM：SS.

When ENT key is used to confirm, it will be synchronized to the top information row.

6.2.8 Other Setting

The second item in the first level menu is user Settings, and the fifth item in the second level menu is other Settings. As below figure:



Language Setting： The default language is English, English and Chinese can be optional.

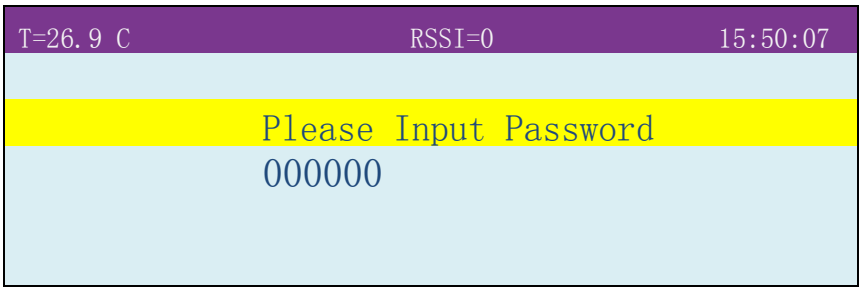
Backlight Setting: There are two sub-menus as below:

Duration: The default is always off. Always Off/10s/30s/60s/120s/Always On can be optional. The screen will darken after the special time for save power, if no key operation during this time.

Brightness: The default is 66. Setting range is 0-99, setting 0 will not black the screen, but the backlight brightness is low.

6.2.9 Factory Setting

The third item in the first level menu is the factory setting. Enter the factory menu a six-digit password is required. .As below figure:



If the password is incorrect, the user will be asked to re-enter it until it is correct, and the user can always return to the superior menu through the FUNC key.
The factory setting is only used by the factory staff to modify and calibrate the equipment parameters, so it is not open to ordinary users.

7.0 COMMUNICATION

7.1 Communication Protocol

The instrument supports the Modbus RTU protocol; this is the format of choice for serial communications such as RS485/RS232 as it is the most efficient. This instrument supports standard read and write operations provided by the protocol, but does not support file transfer.

The general message structure will consist of device address, function code, data payload and the checksum.

Master Format

Device Address	Function Code	Data Payload	CRC

Device address – 1 byte field ranging from 1 to 255.
Function code – 1 byte, 0X3 for read and 0X10 for write operation.
Data payload – 0-N bytes with response data from the device.
CRC – 2 bytes computed mathematically.

Slave Response Format

Device Address	Function Code	Data Payload	CRC

Device Address –1 byte. Echo of device address sent in master message to the device
Function code – 1 byte. Echo of function code sent in master message to the device
Data payload – 0-N bytes with response from device.
CRC: 2 bytes with a value computed mathematically

7.2 Standard Message Format

Read Holding Registers is used to retrieve measurements

Message		
Address	1 byte	1-255
Function Code	1 byte	3
Data Address	2 bytes	0 to 68
Register Count	2 bytes	2 to 70
CRC	2 bytes	

Response		
Address	1 byte	1-255
Function Code	1 byte	3
Byte Count	1 byte	0 to 140
Data Payload	N bytes	
CRC	2 bytes	

*Byte count = 2*Register Count

Write Single Register is used to configure instrument settings

Message		
Address	1 byte	1-255
Function Code	1 byte	3
Data Address	2 bytes	0 to 68
Register Count	2 bytes	2 to 70
Data Value	N byte	
CRC	2 bytes	

Response		
Address	1 byte	1-255
Function Code	1 byte	16
Data Address	1 byte	0 to 68
Register Count	N bytes	0 to 70
CRC	2 bytes	

7.3 Modbus RTU Setting

Baud rates – Support Baud rates 4800/9600/19200/38400/57600/115200 bps
Data Bits – 8 data bits
Parity Bits – Even, Odd and None
Stop Bits – 1
Default settings will be 9600,8,N,1.

7.4 Modbus Registers

Register	Size (Byte)	Mode/Access	Data Type	Description
0	4	RO	float	Velocity (m/s)
2	4	RO	float	Flow (m3/h)
4	4	RO	uint	Depth (mm)
6	4	RO	float	Conductivity (uS/cm)
8	4	RO	uint	Net Volume (m3)
10	4	RO	uint	Pos. Volume (m3)
12	4	RO	uint	Neg. Volume (m3)
14	4	RO	uint	Sectional Area (m2)
16	4	RO	float	Water Temperature (ºC)
18	4	RO	uint	RSSI
20	4	RO	uint	Signal Spread
22	4	RO	uint	X-Axis Tilt (+/- deg)
24	4	RO	uint	Y-Axis Tilt (+/- deg)
26	4	RO	uint	Sensor Serial Number
28	4	RO	float	Sensor Battery Voltage (V)
30	4	RO	float	Software Version
32	4	RO	uint	Working Time (hours)
34	4	RO	uint	Calculator Serial Number
36	4	RO	uint	Calculator Status
38	4	RW	hhmmss	Time
40	4	RW	yymmdd	Data
42	4	RW	uint	Unit Control
44	4	RW	uint	Rs485 Control
46	4	RW	uint	Output Control
48	4	RW	uint	Others Control
50	4	RW	hhmmss	Logger Interval
52	4	RW	float	4-20mA (Flow) 4mA range
54	4	RW	float	4-20mA (Flow) 20mA range
56	4	RW	uint	4-20mA (Depth) 4mA range
58	4	RW	uint	4-20mA (Depth) 20mA range
60	4	RW	float	Flow Scale
62	4	RW	float	Depth Scale
64	4	RW	float	Low Flow Cut-off (m/s)
66	4	RW	uint	Brightness
68	4	RW	uint	Depth Cut-off (mm)

Note: All data types are 4-byte size, big-endian byte order.

Unit Control Register Address: 42

7	6	5	4	3	2	1	0
Volume type		Volume unit			Flow unite		

Bit [2-0]：Flow unite

000： m3/h

001： L/S

010： UKG/min
011： USG/min
Bit[5-3]：Volume unit
000： m3
001： L
010： UKG
011： USG
100： FT3
101： A.F.
Bit[7-6]：Volume type
00： Pos Volume
01： Neg Volume
10： Net Volume

R485 Control Register Address:44

15	14	13	12	11	10	9	8
Reserved			Parity		Baud Rate		
7	6	5	4	3	2	1	0
Modbus instrument Address							

Bit[7-0]：Modbus Address
Bit[10-8]：Baud Rate Selection(bps)
000:4800
001:9600
010:19200
011:38400
100:57600
101:115200
Bit[12-11]：Parity selection
00：None
01：Odd
10：Even

Output Register Address:46

23	22	21	20	19	18	17	16
Reserved							Logger output
15	14	13	12	11	10	9	8
Depth 20ma Fine tuning -	Depth 20ma Fine tuning +	Depth 4mA Fine tuning -	Depth 4mA Fine tuning +	Depth Current loop type	Flow 20mA Fine tuning -	Flow 20mA Fine tuning +	Flow 4mA Fine tuning -
7	6	5	4	3	2	1	0
Flow 4mA Fine tuning +	Flow current loop type		Pulse resolution			Pulse type	

Bit[1-0]：Pulse type
00：Disable

01： Pos Volume
10： Neg Volume
11： Net Volume
Bit[4-2]： Pulse resolution
000：1L
001：10L
010：100L
011：1m3
100：10m3
101：100m3
Bit[6-5]： Flow Current loop output type
00：Disable
01：Pos Flow
10：Neg Flow
Bit 7： Flow 4mA Fine tuning +
Bit 8： Flow 4mA Fine tuning -
Bit 9： Flow 20mA Fine tuning +
Bit 10：Flow 20mA Fine tuning -
Bit 11：Depth Current loop output type

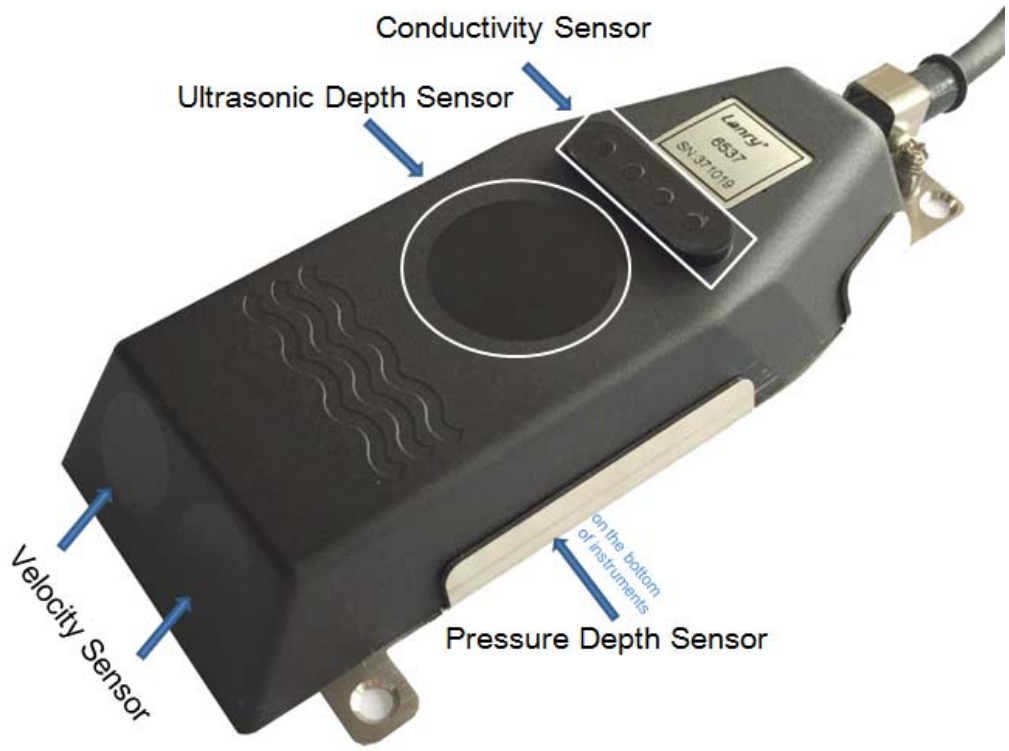
0：Disable
1：Enable
Bit 12： Depth 4mA Fine tuning +
Bit 13： Depth 4mA Fine tuning -
Bit 14： Depth 20mA Fine tuning +
Bit 15： Depth 20mA Fine tuning -
Bit 16：Logger output
0：Disable
1：Enable
Other Control Register Address:48

7	6	5	4	3	2	1	0
Reserved				Backlight			Language

Bit 0：Language
0：English
1：Chinese
Bit[3-1]：Backlight
000：Always off
001：10S
010：30S
011：60S
100：120S
101：Always on

8.0 INSTRUMENT MAINTENANCE

The Ultraflow QSD 6537 requires very little maintenance. During routine site visits the following checks can be performed:



Piezo Element Faces	Clean the instrument surfaces where the Piezo elements are located by wiping with a cloth. If needed a plastic scraper can be used to remove any bio-fouling. Take care not to scrape the surface of the instrument. Refer to the above diagram for the areas where the ultrasonic eyes and conductivity sensors reside. These areas must be kept clean. The front face of the instrument and the area above the depth Piezo should be clear.
Pressure depth Sensor	Check that the opening to the depth pressure sensor is clear of any fouling. Use a brush to clear any material.
Conductivity Electrodes	With a cloth wipe the electrode faces. Do not use abrasive materials to clean them as this will affect the calibration of the conductivity measurement.
Cable	Inspect the cable to ensure that it has not been damaged.
General Inspection	Visually check the instrument to see that it has not been damaged by heavy debris in the measured stream.

9.0 APPENDIX: FACTORS AFFECTING FLOW MEASUREMENT ACCURACY

Ultraflow QSD 6537 measures velocity to an accuracy of ±1% and depth to ±1% of range. This is logged to a resolution of 1 mm/sec and 1mm respectively.
The purpose of the Ultraflow QSD 6537 system is to produce velocity data. There are many opportunities for errors to accrue in the process and degrade the result. These can be reduced or eliminated by using the instrument properly. Some of the more significant potential error sources follow.

9.1 Accuracy Considerations

Alignment with Flow and Depth

For the calibration to be valid, the transducer needs to be horizontally and vertically aligned with the flow. While Ultraflow QSD 6537 instruments are calibrated pointing into the flow, they can be pointed downstream with little loss of calibration accuracy. You may want to do this when fouling of the sensor face is a problem. Any angled flow in the horizontal plane will reduce the recorded velocity.
The Ultraflow QSD 6537 instrument must be mounted in the water parallel to the surface for depth readings to measure accurately (~ +/- 10 deg), if not the depth may read inaccurately and therefore the recorded depth can be recording incorrectly.

Instantaneous Versus “Averaged” Velocity

When you observe Ultraflow QSD 6537 velocities, they will be seen to vary by 10% or more from scan to scan at some sites. Because Ultraflow QSD 6537 is very sensitive to variations in velocities, you are able to see the natural velocity changes in the channel.
Although the discharge in a channel may be reasonably constant for a period of time, the velocity distribution is always changing. Different velocity streams wander from side to side and bed to surface as they progress down the channel. Turbulent swirls and eddies are carried downstream for long distances while they slowly decay. Hydrographers will be used to having this action partly removed by the mechanical inertia of a current meter and the period over which a typical measurement is timed. However all will have noticed that the rate of revolutions of the current meter varies during the timing period.
Continual velocity logging at one location with a Ultraflow QSD 6537 will show these cyclic velocity pulsations. The characteristics will be different for different sites and will vary with discharge. Cycles will typically include short period fluctuations (a few seconds) overlaid on longer cyclic fluctuations (up to many minutes). Longer term pulsations may also be seen particularly in larger streams when in flood.
When comparing Ultraflow QSD 6537 velocity and mechanical current meter readings, the display should be observed long enough to estimate the mean of the readings. The Ultraflow QSD 6537 will do most of this processing internally but if an external logger is being used to record the readings averaging could also be done here this will help attenuate short frequency variations.

Conversion of Logged to Mean Velocity

The measured velocity data may have to be adjusted during post processing to reflect a mean velocity for the channel. The factors used will be site specific and have to be determined by the operator. This is done by obtaining a mean channel velocity by conventional techniques and comparing it with the average logged velocity. If necessary this process should be repeated at various discharges.

Where the relationship is complex or unstable, the accuracy of this method is compromised.
In laminar flow conditions the channel mean velocity could be expected to be between 90% and 110% of the logged velocity.
In small channels (say a 500mm diameter pipe) the factor may be close to 100% as a representative area of flow will have been “seen” by Ultraflow QSD 6537 and contributed to the logged velocity.
In larger channels only the area adjacent to Ultraflow QSD 6537 will be “seen” and the relationship will depend on how this portion relates to the vertical and horizontal velocity distribution in the channel. An instrument located in the centre of the stream would normally be in a higher velocity area. However in a deep channel Ultraflow QSD 6537 may only see the slower portion of the velocity profile.

9.2 The Speed of Sound in Water

Velocity measurements are directly related to the speed of sound in water. The factor used to scale the velocity measurement is based on the speed of sound in fresh water at 20°C (see table below). This velocity of sound gives a calibration factor of 0.550mm/sec per Hz of Doppler shift.
This calibration factor may be adjusted for other conditions, for example the calibration factor for sea water is 0.5618mm/sec/Hz.
The speed of sound varies significantly with water density. Water density is dependent on pressure, water temperature, salinity and sediment content. Of these, temperature has the most significant effect and it is measured by the Ultraflow QSD 6537 and applied in the correction of velocity measurements.
The Ultraflow QSD 6537 corrects for the variation of the speed of sound in water due to temperature using a factor of 0.00138mm/s/Hz/°C. This correction is a best fit for water temperatures between 0°C to 30°C.

The following table shows how the speed of sound varies with temperature and between fresh and sea water.

Temperature (ºC)	"Fresh Water"	"Sea Water"
0	1402	1449
5	1426	1471
10	1447	1490
15	1466	1507
20	1482	1521
25	1497	1534
30	1509	1545
35	1520	1555

Velocity of Sound in Water (m/s) at atmospheric pressure

Bubbles in the water are desirable as scatterers, but too many can affect the speed of sound. In air the speed of sound is about 350 m/s.