80GHz FMCW

RADAR LEVEL SENSOR

Operating Manual

Version:202410

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1. Products Introduction

Features

The DAR8X series is FMCW radar operating at 76-81 GHz, which has a maximum measuring range of 120m and a minimum blind zone of 8cm. It supports 4-wire and 2-wire applications. Higher operating frequency and shorter wavelength make it ideal for solid applications, including those with extreme dust and high temperature to + 1200℃. The radar consists of an electronic circuit coupled to a lens antenna and flange for quick and easy positioning.

The main benefits of using 80 GHz over devices using lower frequency are:

- Based on the self-developed CMOS millimeter wave RF chip, a more compact RF architecture, a higher signal-to-noise ratio, and a smaller blind zone are realized.
- 5GHz working bandwidth means higher measurement resolution and accuracy.
- 3°antenna beam angle, so the interference in the environment has less impact on the instrument, and the installation is more convenient.
- Shorter wavelength yields good reflection properties on sloped solids, so aiming towards material angle of repose is usually not necessary.
- Support remote debugging and remote upgrading to reduce the cost of field personnel.

Communication and Programming

The debugging can be done by LCD on site, or through the software on PC .

The communication between DAR-8X and PC can be fulfilled by the following ways:

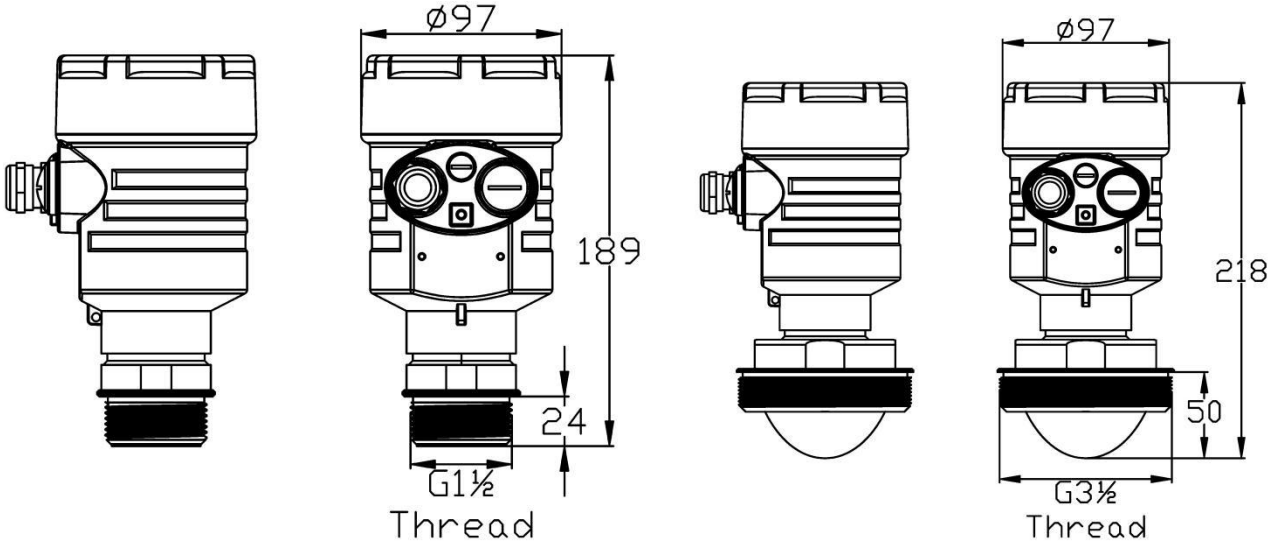
1. USB to RS485 serial line (4-wire) ;
2. USB to TTL serial line (2-wire);
3. USB to Hart-Modem (2-wire).

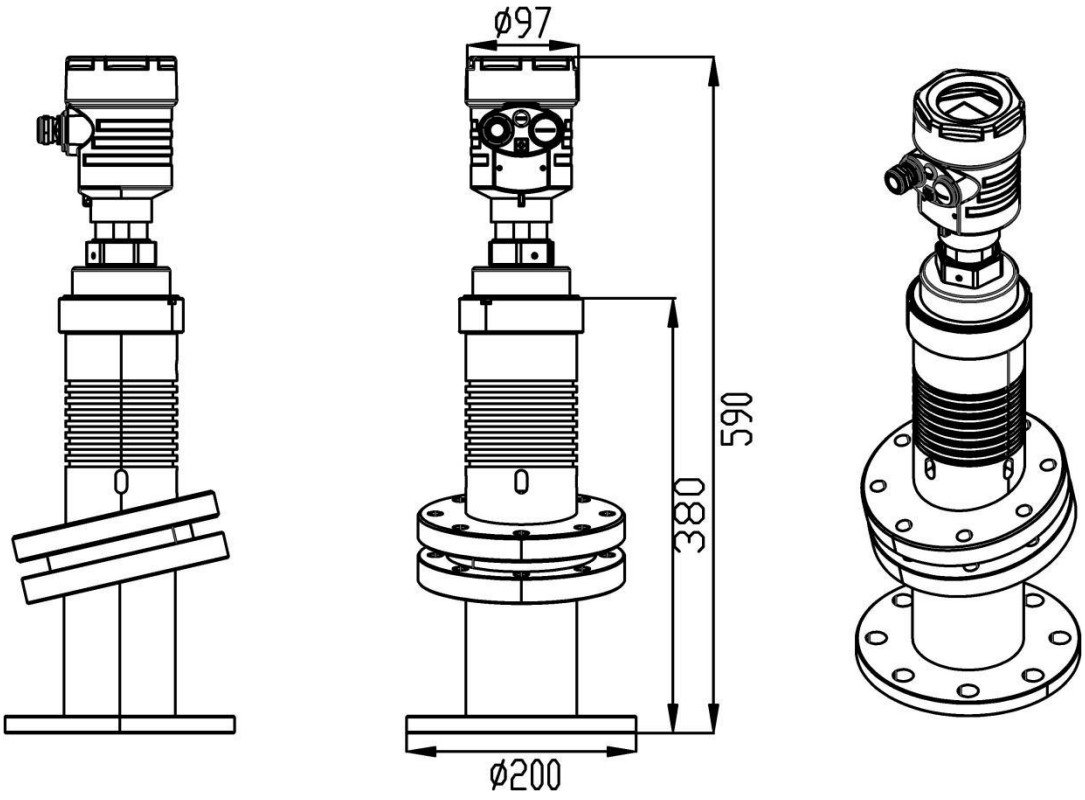
Also it supports bluetooth debugging by mobile as optional , much easier and convenient. And also could reach the remote debugging by 4G network.

2. Technical Specifications

Frequency	76GHz ~ 81GHz, 5GHz FMCW bandwidth
Measuring range	0.08 m ~30m, 0.3 m~60m, 0.6m~120m
Measurement accuracy	＜2mm
Beam angle	3°
Minimum measured dielectric constant	>1.5
Power	15~28VDC / 220VAC
Communication	4-20mA HART/RS485
Fault output	3.8mA, 4mA,20mA,21mA, hold
Field operation / programming	128 × 64 dot matrix display / 4 buttons ; PC software
Humidity/Temperature	81:-40~120℃/≤95%RH;82:-40~1200℃
Enclosure	Aluminum alloy
Antenna type	Lens antenna, can be equipped with antenna cover / anti-corrosive antenna / flange isolated by quartz
Process pressure	-0.1~2MPa
Product Size	Ø100*270mm
Cable entry	M20*1.5
Recommended cables	AWG18 or 0.75mm²
Protection class	IP68
Explosion-proof grade	Ex d ia IIC T6 Gb；Ex tb IIIC T80℃ Db
Installation method	Thread or flange
Weight	2.480Kg/2.995Kg
Packing box size	370*270*180mm

3. Dimensions





4. Install

The main concern of installation is to aim to the material surface vertically and on the other hand to avoid false echoes. Typical scenes are list below for correct installation.

- Keep the antenna beam free of any interference such as ladders, pipes, steps, as shown in Fig.1.

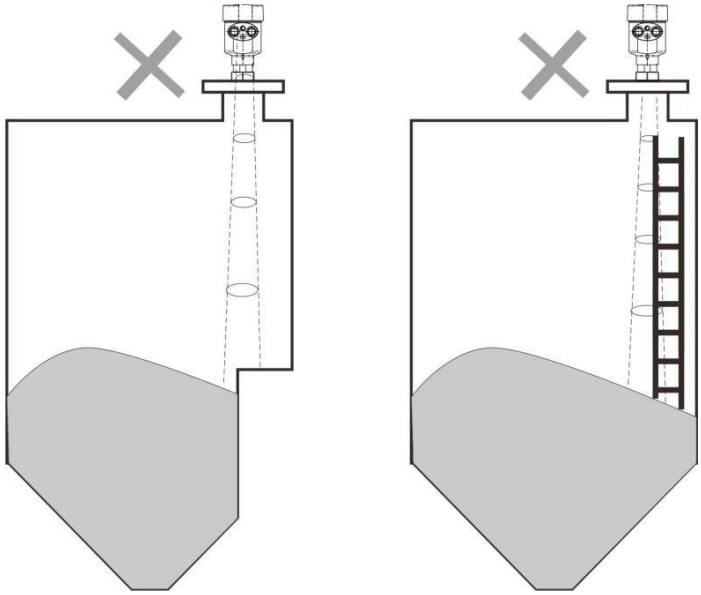


Fig.1 Example for avoiding false echo

- Avoid the contact between antenna beam and feeding flow, as shown in Fig.2.

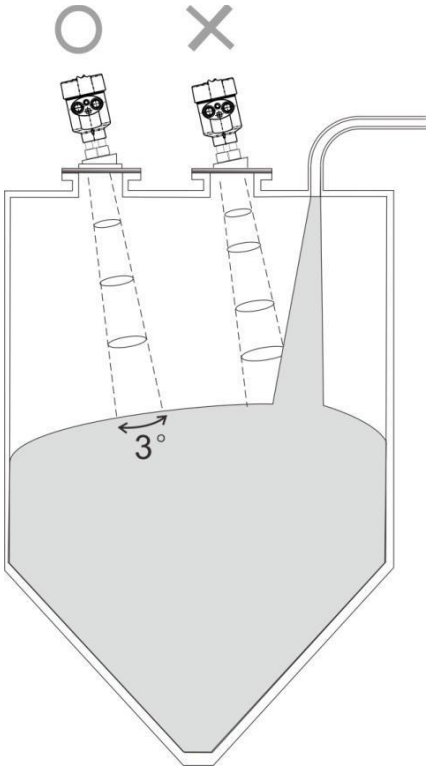


Fig.2 Example for avoiding false echoes

- At least 200mm away from the wall for avoiding false echo and measuring mistake.

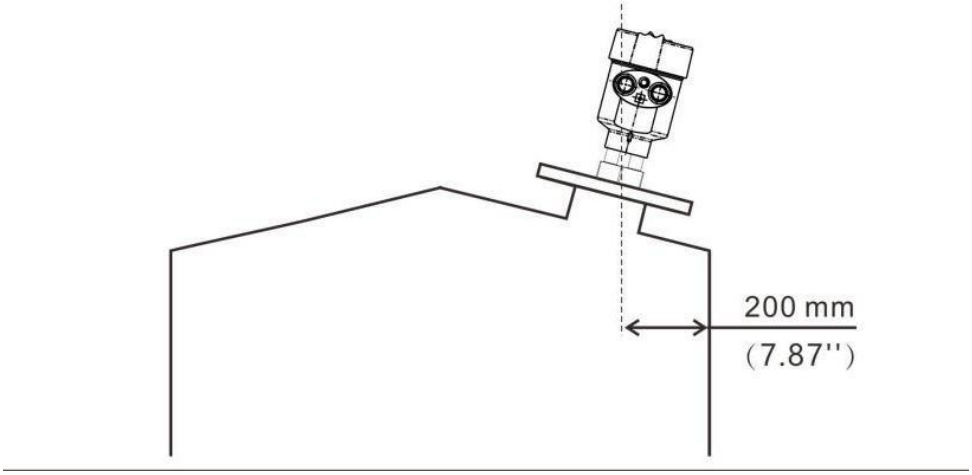


Fig.3 Example for avoiding false echo

- Aiming the antenna beam to the bottom of tapered vessel for avoiding false echo when the level is at the bottom of the tapered vessel.

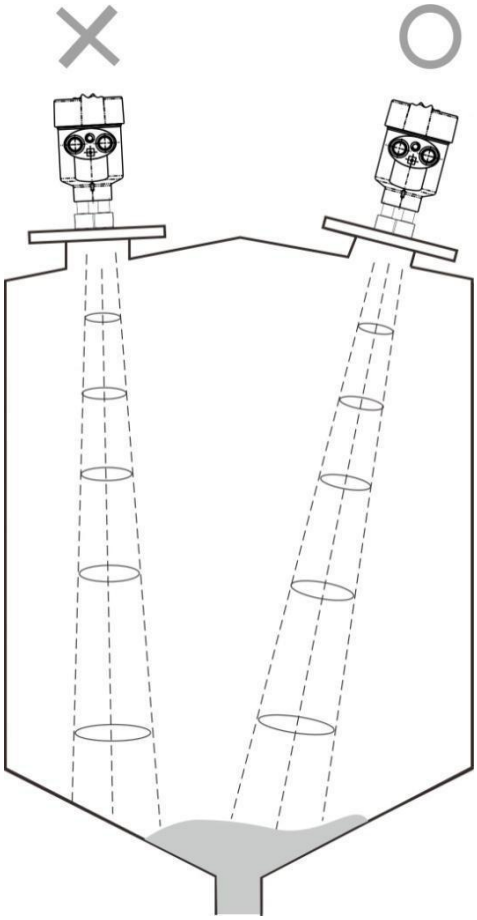
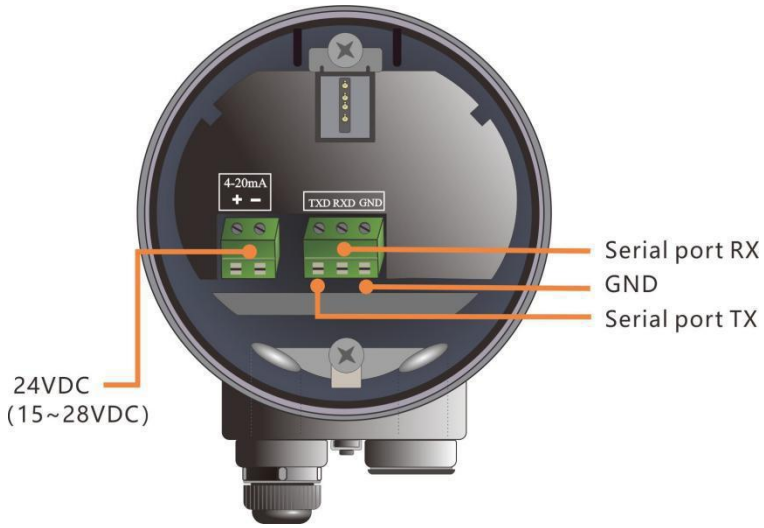


Fig.4 Example for avoiding false echo

5. Wiring

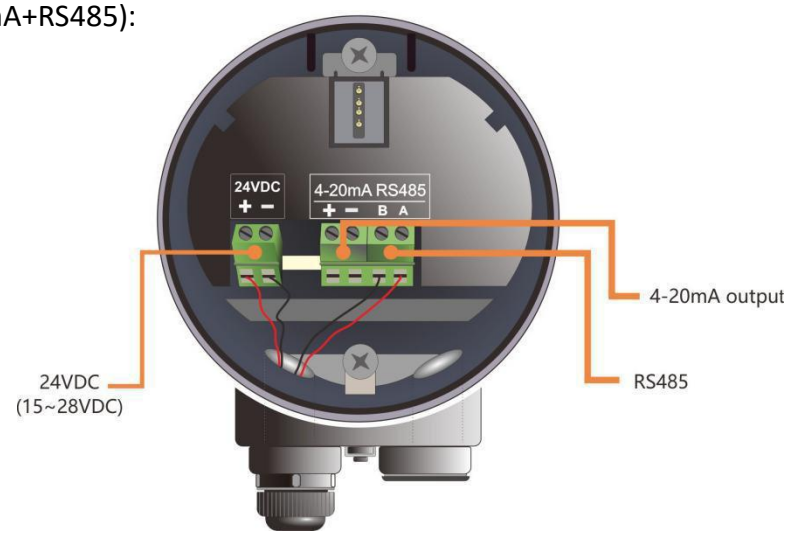
5. 1 Single chamber product wiring diagram--2 wires



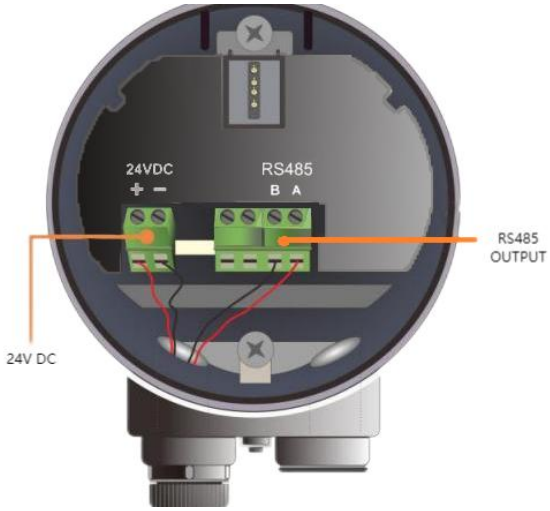
For 2-wire, besides the traditional terminals 4-20mA, it also offers serial terminals which makes the connection with popular IOT products become easier to reach remote control.

5. 2 Single chamber product wiring diagram--4 wires

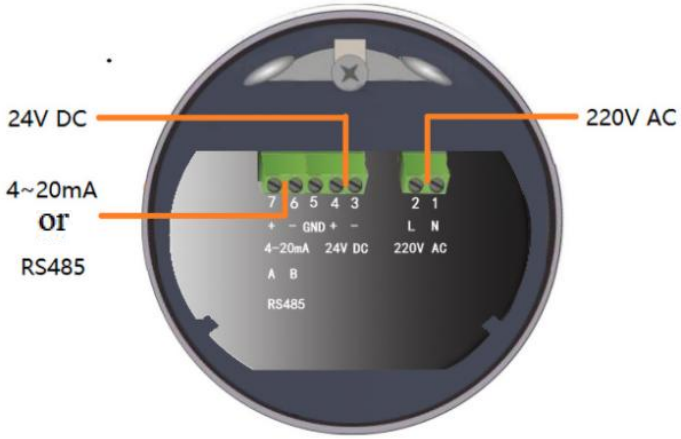
5.2.1 24VDC (4-20mA+RS485):



5.2.2 24VDC RS485:



5.3 Dual chamber product wiring diagram



6. Local Operation

DAR8x carries out its level measurement tasks according to the settings, which can be modified locally via the Local Display Module (LDM). LDM consists of an LCD (128*64dot matrix) with 4 push buttons.

6. 1 Keyboards description

System provides 5 modes of operation interfaces:

[**Run mode**]: Display system running status and current measurement result.

[**Echo mode**]: Display the real-time measured echo curve.

[**History Mode**]: Display historical measurement data recorded by the radar.
[**Setup Mode**]: Set various system parameters.
[**Input Mode**]: Input value of parameters, number or character.
The functions of the 4 keys are different under different modes.

6. 2 Instructions for measurement interface

Measurement Interface is shown below:

Keyboard	Function
ESC	-Switch to echo interface
+	-NULL
▶	-NULL
OK	-Switch to Setup Interface

(1)Real-time data: Real-Time measurement result, which is converted from the distance between sensor and surface of medium.

(2)Temperature value: Temperature of the signal processing board.

(3)Range percent: The black part represents the percentage of the current position to the full range.

(4)Communication status: It refers to the heartbeat of system communication status. Once a second means that the device is working properly, otherwise the device is abnormal.

(5)Bluetooth:The Bluetooth screen has this icon, which can be used to change parameters on the phone through Bluetooth software. The regular screen does not have this icon.

(6)Current percent:The black part represents the percentage of the current position to the 20mA.

(7)Unit: It refers to the system measurement unit.

(8)Current value: It represents the ideal 4-20mA current output value, which is obtained according to the setting of High/ Low Calibration Points and Current function.

(9)Error code: specified in appendix A.

6. 3 Instructions for echo interface

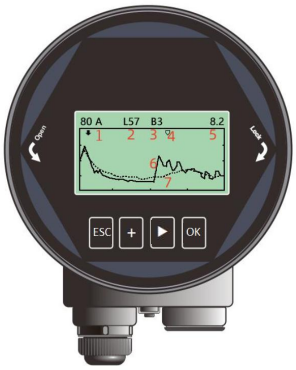


Fig.5 Echo Interface overview

Table1 key functions in Echo Interface

Keyboard	Function
ESC	-Switch to **Measurement Interface**
+	-Show grid
▶	-Full range re search for echoes
OK	-Switch the range of vertical axis

In **Measurement Interface**, press [ESC] key to enter the **Echo Interface.**

Introduction to **Echo Interface** Parameters (Refer to Figure 5):

(1) A: Automatic mode; M: Manual mode. The number in the upper left corner represents the range of the vertical axis. The manual mode is divided into three levels: 60/80/100, and is selected according to the actual signal strength display gear, clearer echo display.

(2) L: represents the current echo signal strength

(3) B: Confidence: The difference in signal strength between the solid line and the dashed line

(4) The white arrow represents the real-time position, and the black arrow represents the output position. If there is a jump in the echo, the white arrow will change before the black arrow

(5) 8.2: Indicates that the set range is 8.2 meters

(6) The solid line represents the true echo curve

(7) The dashed line represents the TVT curve

6. 4 Instructions for setup interface

- Press [OK] to switch from the **Measurement Interface** to the **Setup Interface**, as shown in the figure below:

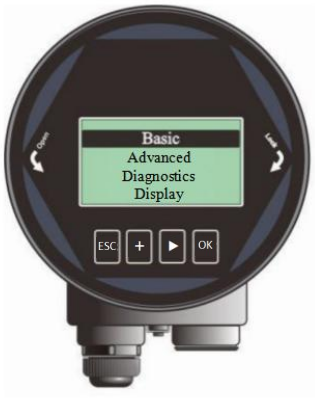


Table2 key functions in Setup Interface

Keyboard	Features
ESC	-Switch to **Measurement Interface/Exit**
+	-Move up
▸	-Move down
OK	-Enter

6.4.1 [Basic settings]

[Basic] Menu contains the necessary functions for quick start of the level meter, as shown in the following table. After selected the basic, press OK to enter into:

Table3 Menu Item for Basic

Default position	Menu Item
●	**Application type**
	Vessel type
	Material Type
	High/ Low calibration
	Near range
	Far range
	Damping
	Sensor mode

6.4.2 [Advanced settings]

[Advanced] selected, press[OK] enter into the interface of options, list as follows. It is better to do this operation by professional engineer who is familiar with the radar working principle.

Table4 Menu Item for Advanced

Default position	Options
●	**False echo**
	Reset
	Fill/ empty rate
	mA simulation
	4mA/20mA setpoint
	mA function
	Bus address
	Sensor offset
	Fail-safe mA
	Fail-safe timer
	Parameter backup

6.4.3 [Diagnostics]

[Diagnostics] Menu contains the necessary functions for historical record of the device. You can review the statistics of current and historical data.

Table5 Menu Item for Diagnostics

Default position	Menu Item
●	**Echo**
	False echo curve
	History data
	History period
	History maximum measuring
	History maximum temperature
	History Fill rate
	History empty rate

6.4.4 [Display]

[Display] could switch between Sensor Unit/ Temperature Unit/ Language/ LCD contrast. Selected the display and press OK to enter into the option list is shown in the following table:

Table6 Menu Item for display

Default position	Parent menu item	Sub menu item
●	**Sensor unit**	**m**/cm/mm/ft/in
	Temperature unit	**℃**/K
	Language	**Chinese**/English/Korean/ Russian
	LCD contrast	
	Percent current	**Closure/open**
	Backlight Setting	**Low Power/Light**
	Backlight duration	**10**

6.4.5 [Information]

[Information] contains the options for inquiring the information about the device itself, as shown in the following table:

Table7 Menu Item for Information

Default position	Menu Item
●	**Model**
	S.N
	Tag

6. 5 Basic menu introduction

Via basic settings can reach the quick start of instrument. When the level meter is powered on, LCD enters measurement interface. Press the [OK] key to enter [Basic] menu.

Note: Default settings indicated with an asterisk (*) unless explicitly stated.

6.5.1.[Application type]

Press [OK] enter into [Basic] , choose the [Application type] , press [OK] , then choose [Solid] or [Liquid] according the actual situation.

6.5.2 [Vessel Type]

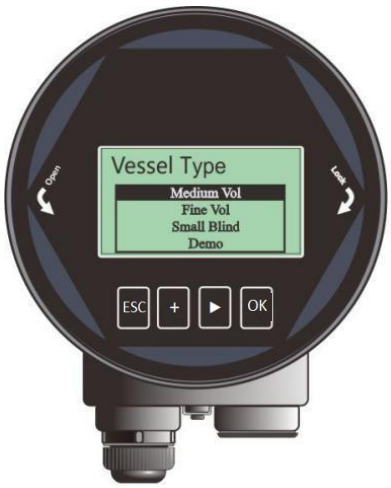


Fig.6 Vessel type overview

[Vessel Type] option has the impact on the radar algorithm based on the table below. Fill/Empty rate, damping time and tracking status are the main factors that would be changed automatically according to [Vessel Type].

Table8 details for [Vessel Type]

Parameter name	**Vessel type**
Large volume	Filling speed: 0.5m / min Damping time:10s
Medium volume*	Filling speed: 1m / min Damping time:5s
Fine volume	Filling speed: 2m / min Damping time: 2s
Agitator	Filling speed: 1m / min Damping time: 10s
Demo	Filling speed: 1m / min Damping time: 0s

6.5.3 .[Material Type]

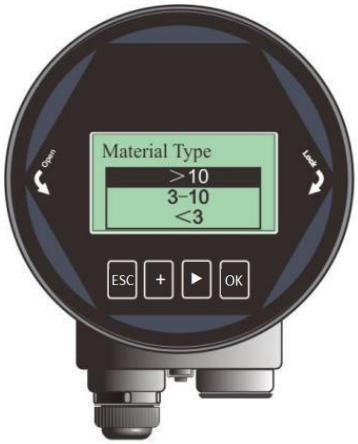


Fig.7 Material type overview

The medium type and DK value will affect the algorithm of echo wave calculation, so need to set it according the real applications.When the [Application Type] choose [Solid], the [Material Type] will show powder, small solid and large solid. When the [Application Type] choose [Liquid], the [Material Type] will show > 10, 3-10, <3.

Table9 Details for [Material type]

Material type (Solid)	**Dielectric constant(Liquid)**
Powder	> 10
Small solid	3-10
Large solid	<3

6.5.4.[High/ Low Calibration]

6.5.4.1 [Low Calibration]

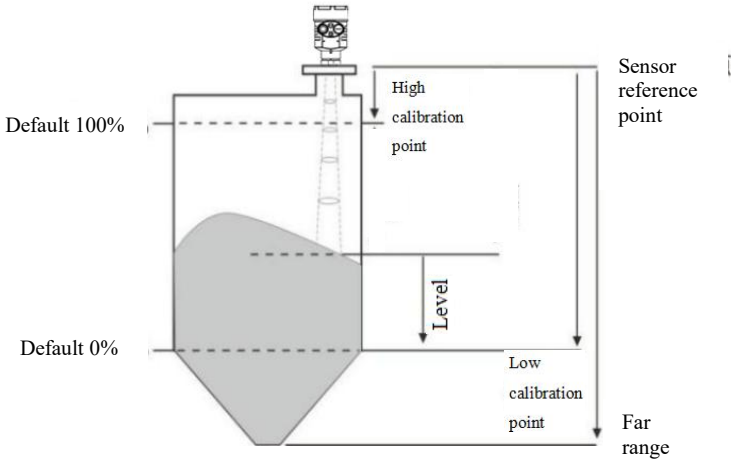


Fig.8 Low calibration point

[**Low calibration**] relates to the range setting. It maps the corresponding relationship between the measured value and the current output (4-20mA) together with [**High calibration**]. Detailed input limitation for [**low cal.**] and the relationship between [**low cal.**] and [4ma/20ma setpoint] is summarized in following table.

Table10 Details for [Low calibration]

Parameter name	**Low calibration**		
Value Range (m)	1m ~ **full range**		
Default value (m)	30	60	120
Related parameters	(1) If [**low cal.**] is less than ([**high ca**l.]+0.5), it will be set to ([**high ca**l.]+0.5). (2) In **Level** mode, the **4mA setpoint** will be automatically changed when changing **Low calibration**. (3) In **Distance** mode， the **20mA setpoint** will be automatically changed when changing **Low calibration**.		
Option meaning	(1) In **Level** mode, it corresponds to [**4ma setpoint**]. (2) In **Distance** mode, it corresponds to [**20ma setpoint**].		
Note	(1) No relation with far range. (2)Related to the Real-Time value and current output.		

6.5.4.2.[High calibration]

Fig.9 High calibration point

[**High calibration**] maps the corresponding relationship between the measured value and the current output (4-20mA) with [**low cal.**]. Detailed input limitation for [**high cal.**] and the relationship between [**high cal.**] and [4ma/20ma setpoint] is summarized in the following table:

Table11 Details for [High calibration]

Parameter name	**High calibration point**
Value range (m)	0 ~ (**low cal.**-0.5m)
Default value (m)	0
Related parameters	(1) If [**high cal.**] is greater than ([**low cal.**]-0.5m), it will be set to ([**low cal.**]-0.5). (2) In **Level** mode，the **20mA setpoint** will be automatically changed when changing **High calibration**. (3) In **Distance** mode, the **4mA setpoint** will be automatically changed

Option meaning	(1)In **Level** mode, it corresponds to [**20ma setpoint**]. (2)In **Distance** mode, it corresponds to [**4ma setpoint**].
Special matters	(1)No relation with **near range**. (2) Impact on the **real-time value** and current output.

6.5.5.[Near range]

Enter into [Basic], select [Near range], press [OK] enter into the edit interface of Near range.

Table12 Details for [Near range]

Parameter	**Near range**		
Parameter range (m）	0~（**range**-0.5）		
Default （m）	0.08（0-30）	0.3（0-60）	0.6（0-120）
Configuration	If near range > (range -0.5m), then near range =(range - 0.5m)		
Meaning	It will ignore the echo wave which is within the near range when signal algorithm processing, so could use this option to avoid the interference near the sensor.		
Notice	This near range is not the measuring limit of sensor at the near-end, it is only used for specify the algorithm calculation area. Instrument measuring limit refer to technical spec.		

6.5.6. [Far range]

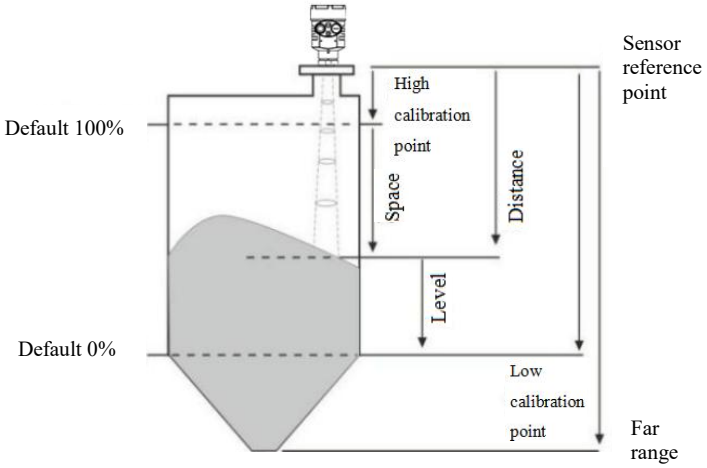


Table13 Details for [Far range]

Parameter	Ranges		
Value range m	1-30	1-60	1-120
Default	30m	60m	120m
Related configuration	1. If range is < than (near range + 0.5m) , the range will be set at (near range + 0.5m) automatically . 2. If current function output is distance, modify the range will change the 4mA value automatically.		

6.5.7. [Damping]

[Damping] The function of damping time is to smooth out sudden changes in the measurement results, which is the damping filter. For example if the damping time is 2s, the level of measurement occurs sudden change at time t, the output will generate slow change. Within the first 2s, it will finish 63%. and it will reach 100% within 10s. The damping time could be 0-600s, default is 5s.

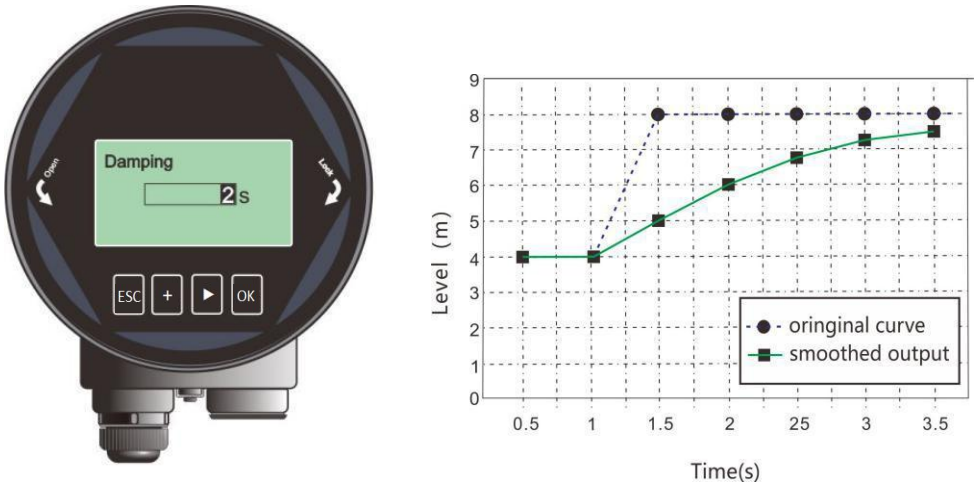


Fig.10 Damping

Table14 Details for [Damping]

Parameter name	**Damping**
Parameter range (s)	0~**600**
Default (s)	5
Related parameters	Null
Option meaning	Smooth out the response to a sudden change in level.
Special matters	Null

6.5.8.[Sensor Mode]

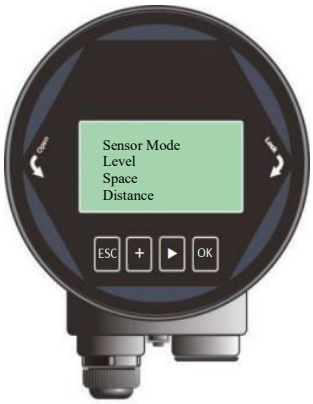


Fig.11 Sensor mode

[Sensor mode] According the demand at site, select the output type of distance at the measuring interface. The level represents the height of the material level. Distance represents the distance from the sensor probe to the surface of the material. The sum of level and distance equals the measurement range.

6.6. Advanced menu introduction

6.6.1 [False echo]

[False echo] could study the false echo waves including the known obstacles in container. And forming a screening curve for the background noise (threshold curve TVT).

The mode of false echo has three options : Full Range, Range Include, Range Exclude.

Range Include and Range Exclude need to work with the false echo begin and end. It could help to learn or delete the false echoes in different range.

For example: if there is interference signal within 2m-4m distance from the instrument, then we need to create new TVT to suppress the interference. The option steps as follows:

1. Define the Range Include in false echo mode.
2. Set the area starting from 2m ,end at 4m in the false echo area.

In the false echo learning menu, choose “create” , confirm and waiting for “ok” sign. It means TVT curve created successfully.

In the diagram below, it shows the difference between with or without false echo learning. We can see , after the learning, the curve perfectly covers the real time measuring curve . So only the real reflected echo is left and can be analyzed.

Diagram before False echo learning

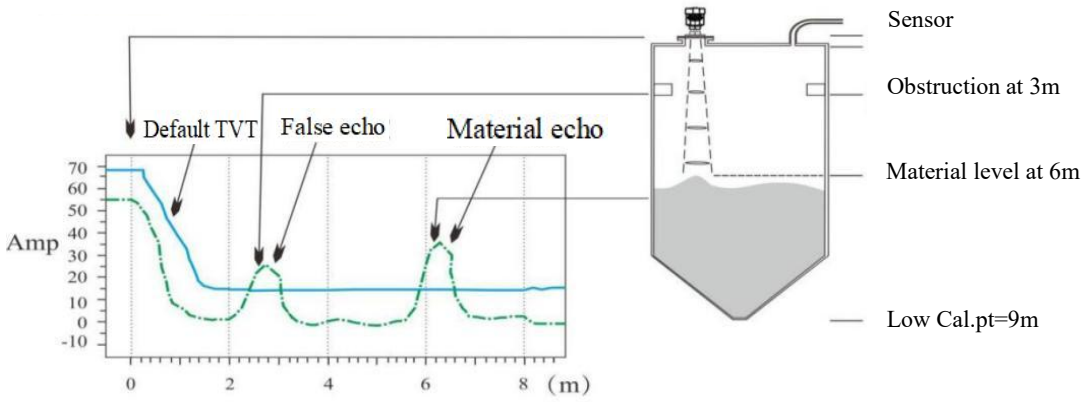
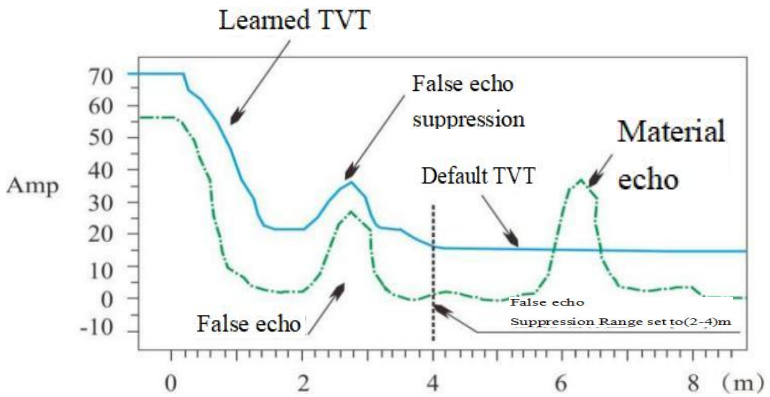


Diagram after False echo learning



6.6.2. [Reset]

It is used to restore the default factory settings of the level meter. The recovery time is about 15s to 20s. After that, LCD will jump to Measurement Interface automatically. It is recommended to used this option when the sensor can't works normally due to improper operations.

6.6.3 [Fill/ empty rate]

[Filling rate] is used to adjust the response rate of the level meter to the increases of the actual material level. The response rate will changed automatically according to the fill rate.

[Empty rate] is same as filling rate.

6.6.4[mA simulation]

[mA simulation] fix the loop current to output a specific current value, which is used to check whether the 4-20mA output loop current is accurate and normal.

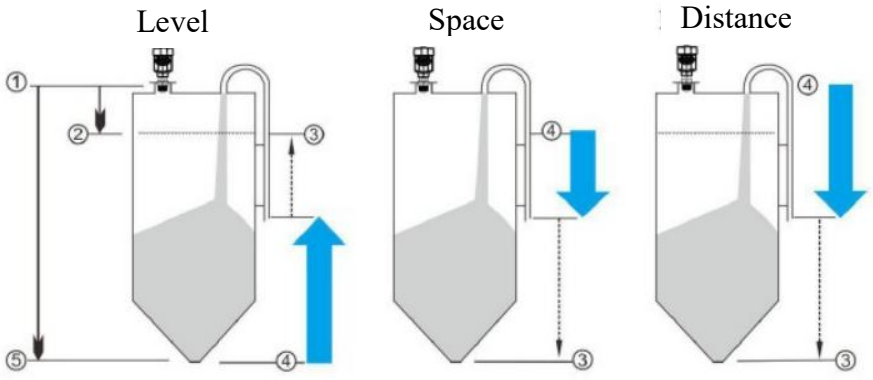
6.6.5[4mA/ 20mA setpoint]

[4ma setpoint] is the 0% position of analog quantity, user could set the point position according to the actual demand. The setting has higher priority than the default correspondence given by the current output function.

[20ma setpoint] is the 100% position of analog quantity. Same function as 4mA.

6.6.6[mA function]

[mA function] decides the current output of 4-20mA on the bus. According to the real- time value, current function, 4/20mA point , we could get the theoretical loop current output by linear calculation. the result will be displayed on the bus. Under different options of 4mA point, 20mA point, Low adjustment point, High adjustment point. the relation will be like the pic shows:



①Starting point of range ②High calibration point
③20mA, 100% ④ 4mA, 0%
⑤Low calibration point

6.6.7 [Bus address]

[Bus Addresses] is used to assigning address for the instrument and guarantee multiple instruments working properly on the bus. Set the bus address according to the corresponding protocol.

6.6.8 [Sensor offset]

[Sensor Offset]Used to correct the reference point of the sensor, The default reference point is calibrated to the front end of the lens point “a”. If sensor want to adjust the reference point to "b", then input h1, if want to adjust to "c", then input -h2.

If user wants to input negative value, just move the cursor to the high bit and press + button to input the negative sign and then move to right and input the data. Finally, press OK to confirm.

Fig.12 Sensor offset

6.6.9 [Fail- safe mA]

[Fail- safe mA] could set 3.8mA, 4mA, 20mA or the current value when instrument couldn’t find the echo wave. Error codes refer to Appendix A.

6.6.10[Fail- safe timer]

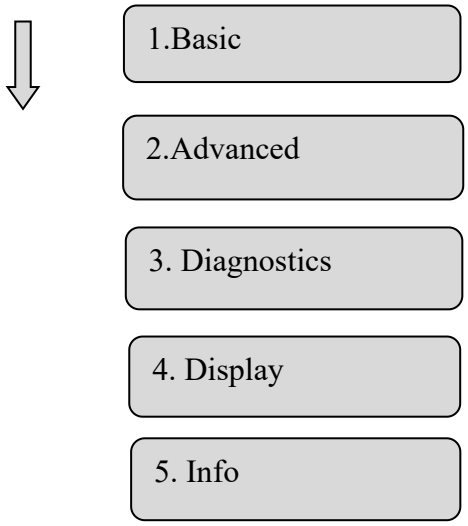
[Fail- safe timer] It is also known as lost of echo timer (LOE timer). When instrument fails continuously / When the duration of wave loss exceeds the set value of [fault timer] , the 4-20mA terminals will output the value according to [failure current output] set. Default is 100s, range is 0-1000s. Enter into [professional setting], select [fault timer].

6.6.11 [Parameter Backup]

[Parameter Backup] Select read or write.

7. Menu Tree

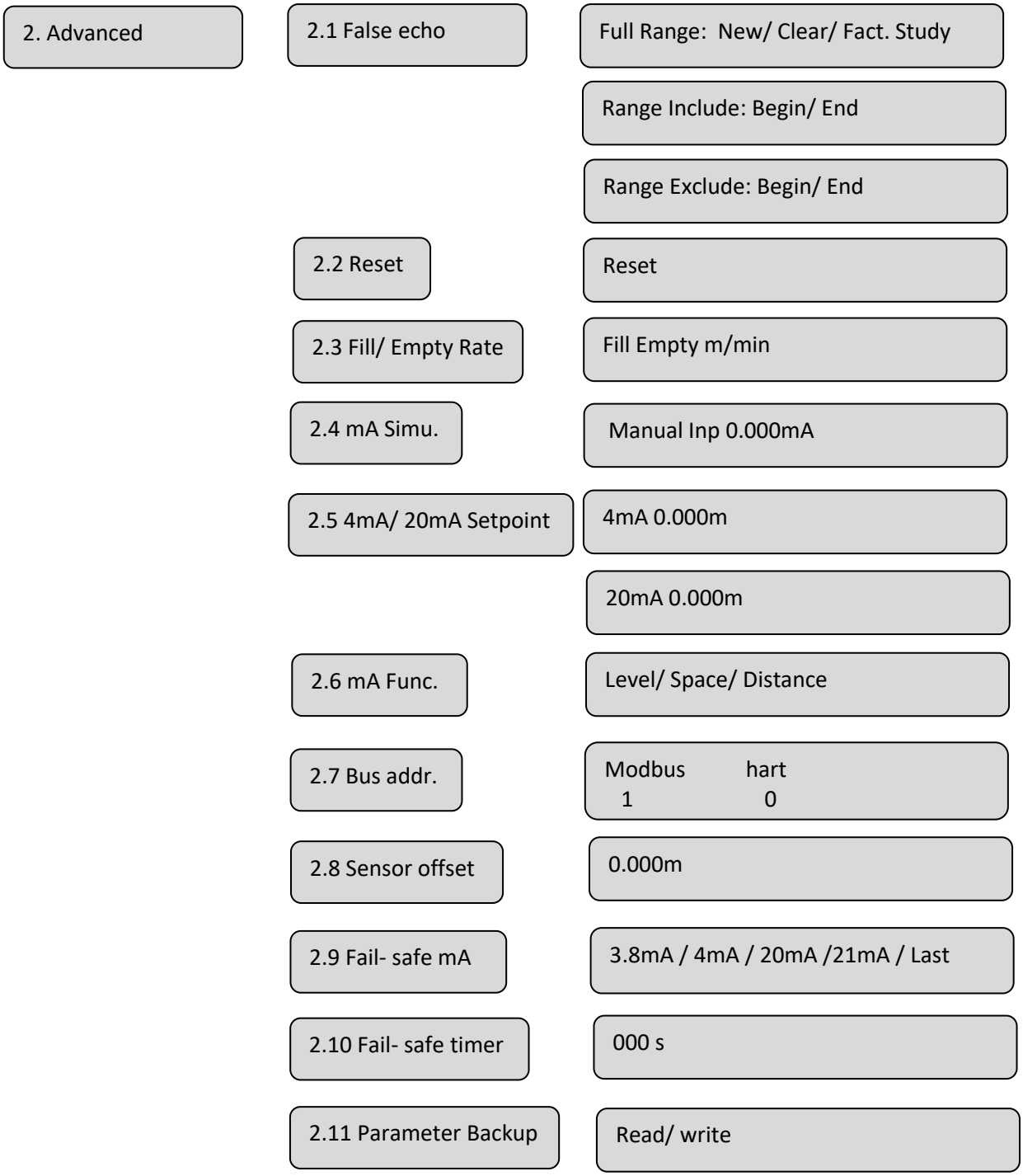
7.1 First-level menu tree view



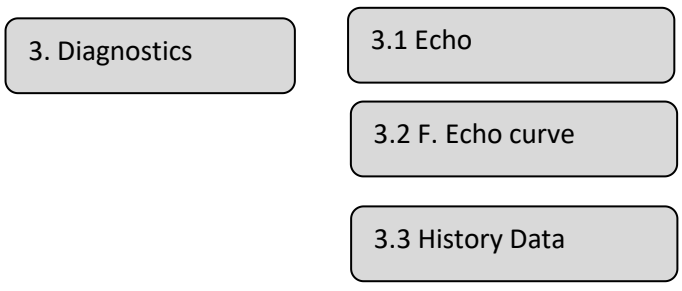
7.2 Secondary menu tree- Basic

1. Basic	1. 1 Application Type	Solid liquid
	1. 2 Vess. Type	Large vol./ Medium vol./ Fine vol./ Agitator/ Demo
	1.3 Mater. Type	Solid: Powder/ small solid/ large solid Liquid: DK＞10 / 3-10 / ＜3
	1.4 High/ Low Calib.	Low calibration / high calibration
	1. 5 Near Range	m
	1.6 Far Range	m
	1. 7 Damping	5 s
	1. 8 Sensor Mode	Level/ Space / Distance

7.3 Secondary menu tree- Advanced



7.4 Secondary menu tree- Diagnostics



	3.4 History period	X Hour
	3.5 History max measuring	High 0.000m read clear Low 0.000m
	3.6 History max temperature	High 00.0℃ read clear Low 00.0℃
	3.7 History Fill rate	High 0.000m/ min read clear Low 0.000m/ min
	3.8 History empty rate	High 0.000m/ min read clear Low 0.000m/ min

7.5 Secondary menu tree- Display

4. Display	4.1 Sensor Unit	m, cm, mm, ft, in
	4.2 Temp. Unit	℃， K
	4.3 Language	Chinese, English, Korean, Russian
	4.4 LCD contrast	xx
	4.5 Percent current	Closure, open
	4.6 Backlight Setting	Low Power, Light
	4. 7 Backlight duration	10

7.6 Secondary menu tree- Information

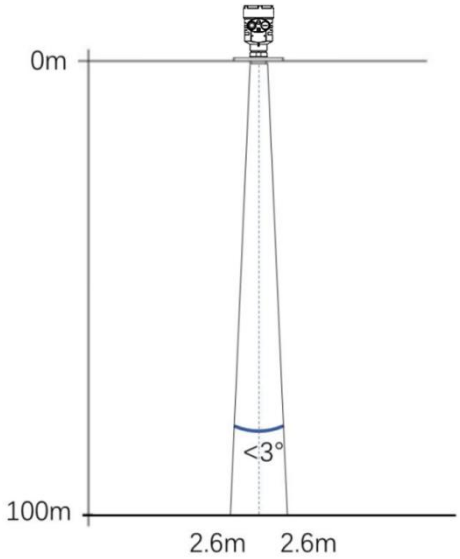
5. Info	5.1 Model	xxx
	5.2 S.N	xxx
	5.3 Tag	xxxxxxxxxxxxxxx
	5.4 BLE Name (option)	Xxxxxxxxxxx Reset
	5.5 BLE PIN Code (option)	xxxxxx

8. Appendix A : Error code

0000	Working normally
0001	No echo found within range
0002	Abnormal communication with TR
0003	Abnormal communication and no echo wave found
0004	No factory threshold learning done
0008	Abnormal current output of 4-20mA
0010	Manual current output
0020	Abnormal communication with LCD
0200	Abnormal of temperature sensor

9. Glossary

Beam Angle: Half power beam width. DAR-8X series has minimum beam angle at 3° .



Range resolution： It refers to the minimum distance that two objects can be distinguished by the level radar.DAR-8x has a 5.1GHz bandwidth, and thus the ideal **Range resolution**=C/2B≈3cm.
Measurement Accuracy: The minimum shift that can be distinguished by the level radar. DAR-8X's echo signal is analyzed by unique algorithm, and the accuracy is 0.1mm.
Agitator: the device used to mix the components in tank. It could generate fluctuation .
Ambient temperature: The temperature of the surrounding air that comes in contact with the equipment.
Blind zone: the limitation of the level meter, that is to say, the radar cannot give the right measured result within Blind zone.
dB (decibel): A unit representing the amplitude of a signal.
Dielectric constant (DK): The ability of a dielectric to store electrical energy. The increase in dielectric constant is directly proportional to the increase in reflection amplitude. The dielectric constant of air is 1.
Echo: A reflected signal with amplitude large enough to be distinguished from the transmitted signal by a certain method is called an echo.

False echo: Echoes that are not the one of the real target. Generally speaking, false echoes are generated by obstacles in the container.
Multiple echoes: Multiple echoes due to multiple reflections between the radar and the target
Polarization: The properties of the emitted electromagnetic waves, describing the direction and amplitude of the electric field vector changes over time.
Repeatability: The variance of multiple measurements of the same variable in the same situation.
Speed of light: The speed of electromagnetic waves in free space is 299,792,458 meters per second.

10. MODBUS—RTU Communication Protocol

10.1 Radar adopts serial port communication, and the default parameters are as follows：

Communication parameters	Serial port level	Baud rate	Parity	Data bit	Stop bit
Serial port	RS485	9600	None	8	1

10.2 Communication protocol format

Measurement value query command (floating point type)

(1) Request command format ：

Device address	Function code	Address	CRC
0x01(Default)	0x04	0x0A 0F 00 02	0x42 10

(2) Request command reply data format：

Device address	Function code	Length of data	Data	CRC
0x01	0x04	0x04	0xXX XX XX XX	0xXX XX

Instruction: The measurement value is Float type data, measured in meters, with a length value of 4. The data format is low 16 bit data at the beginning and high 16 bit data at the end. The significance of the measured value is determined based on the sensor mode.

Current value query command

(3) Request command format：

Device address	Function code	Address	CRC
(1 byte)	0x04	0x0A 0A 00 01	0x12 10

(4) Request command reply data format：

Device address	Function code	Length of data	Data	CRC
0x01	0x04	0x04	0xXX XX	0xXX XX

10.3 Read level

Address	Function code	Register address	Number	CRC	Instruction
01	03	0000	0001	840A	space(unit：cm)
01	03	0001	0001	D5CA	space(unit：mm)
01	03	0002	0001	25CA	level(unit：cm)
01	03	0003	0001	740A	level(unit：mm)