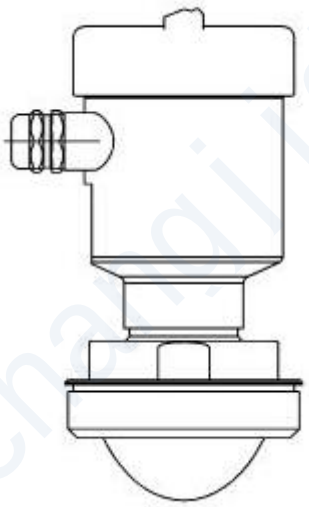
LM78xx series

76-81GHz FMCW Level Radar
Operating Instructions



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1. Products | introduction

1. 1 Features

The LM78xx series is FMCW radar operating at 76-81 GHz, which has a maximum measuring range of 120m and nearly zero blind zone. 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 + 200℃. Built-in rich algorithm ensure stable output even in the application with fast agitator.

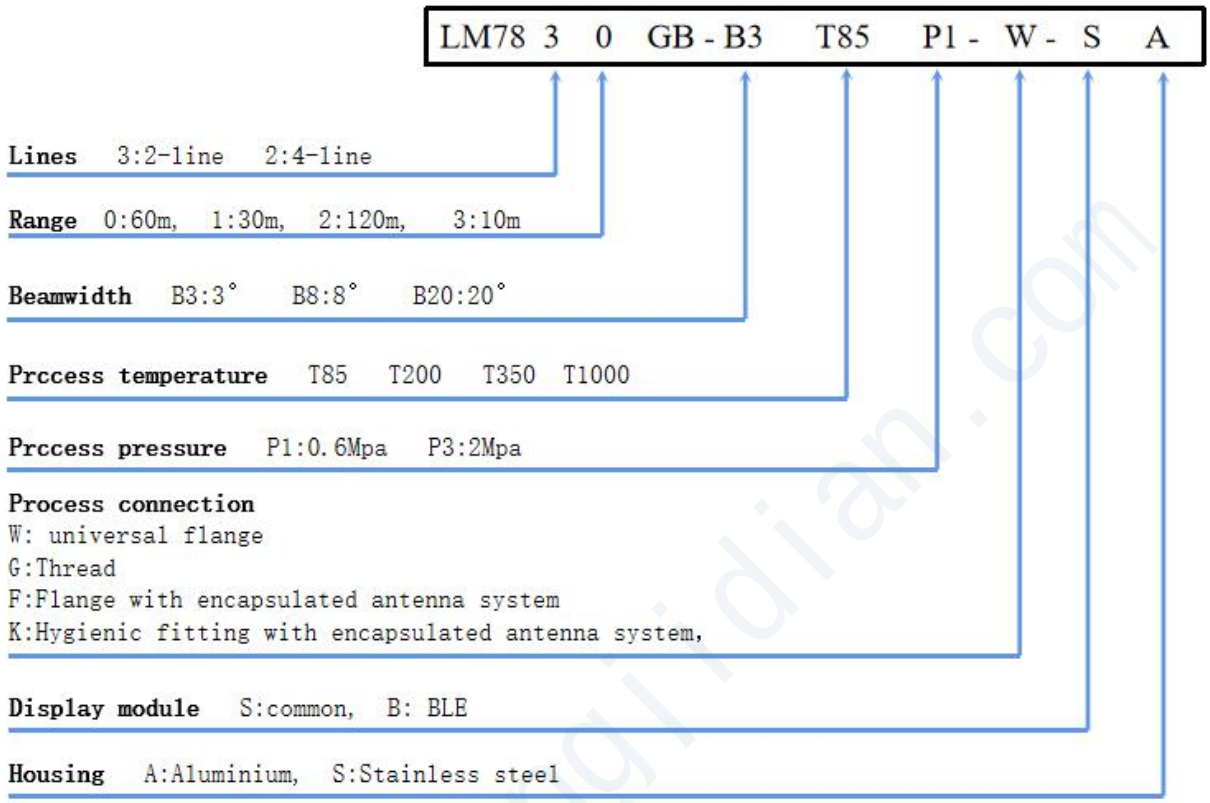
The main benefits:

- Based on the self-developed CMOS millimeter wave RF chip, a more compact RF architecture, a higher signal-to-noise ratio, and nearly zero 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.
- Remote debugging and remote upgrading is supported to reduce the cost of field personnel.

Communication and Programming

LM78xx supports 485 modbus protocol (4-wire), TTL serial-port (2-wire) protocol, and hart (2-wire) protocol. It is very easy to install and configure by debug software on PC. Or you can modify the built-in parameters either locally via the push buttons. Or you can use cell phone to control LM78xx via Bluetooth.

1.2 LM78xx series selection guide



2. Technical specifications

Table 2.1 LM78xx Technical Specifications

Frequency	76GHz ~ 81GHz, 5GHz FMCW bandwidth
Measuring range	LM78x0: 0.3 m ~ 60m LM78x1: 0.08m~30m LM78x2: 0.6m ~ 120m
Measurement accuracy	±1mm
Beam angle	3°/8°
Minimum measured dielectric constant	>=2
Power	15~28VDC
Communication	LM782x: MODBUS LM783x: HART/Series
Signal output	LM782x: 4 ~ 20mA or RS-485 LM783x: 4~20mA
Fault output	3.8mA, 4mA, 20mA, 21mA, hold
Field operation / programming	128 × 64 dot matrix display / 4 buttons PC software Bluetooth
humidity	≤95%RH
Enclosure	Aluminum alloy, stainless steel
Antenna type	Lens antenna/anti-corrosive antenna / flange isolated by quartz
Process temperature	T0:-40~85℃; T1:-40~200℃; T2:-40~500℃; T3:-40~1000℃
Process pressure	-0.1~2MPa
Product Size	Ø100*270mm
Cable entry	M20*1.5
Recommended cables	AWG18 or 0.75mm²
Protection class	IP67
Explosion-proof grade	ExdiaIICT6
Installation method	Thread or flange
Weight	2.480Kg/2.995Kg
Packing box size	370*270*180mm

3. Dimension

Based on different process connection and beamwidth, LM78xx has 10 kinds of structure, as shown below.

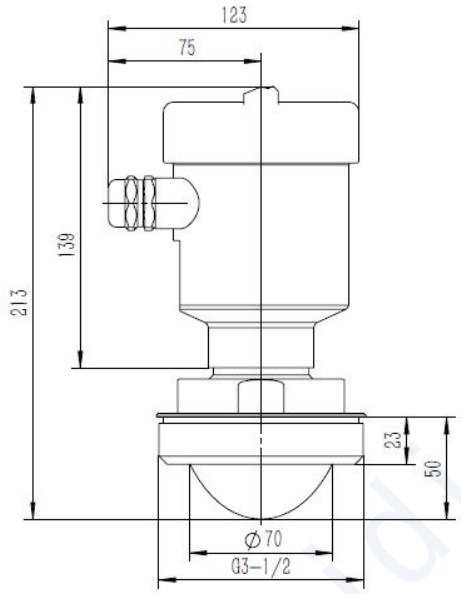


Fig 3-1 Thread connection with 3°beamwidth

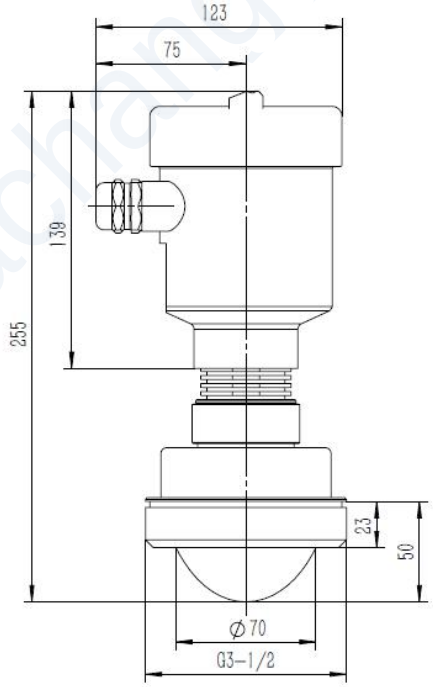
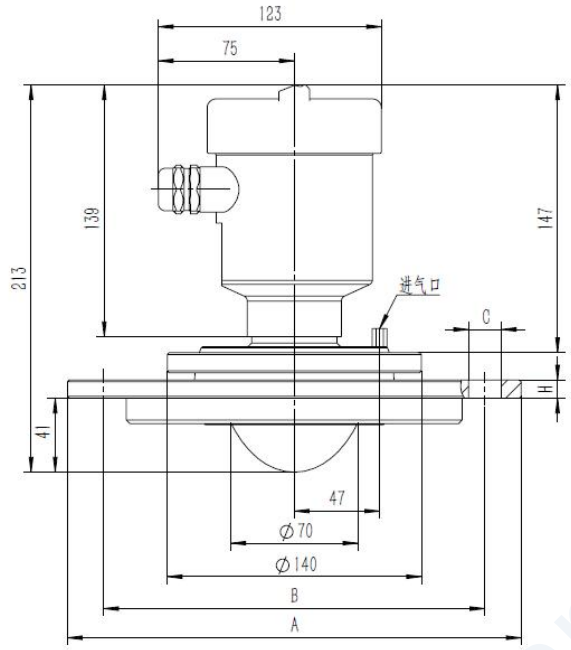
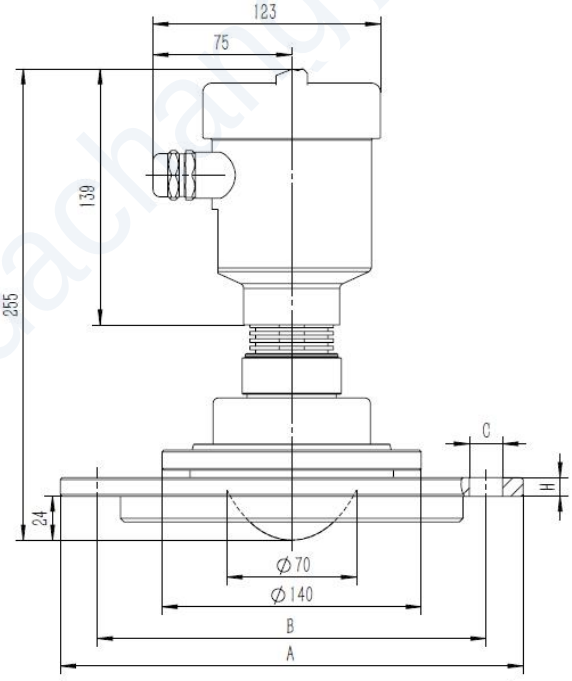


Fig 3-2 Thread connection with 3° beamwidth(200℃ resistance)



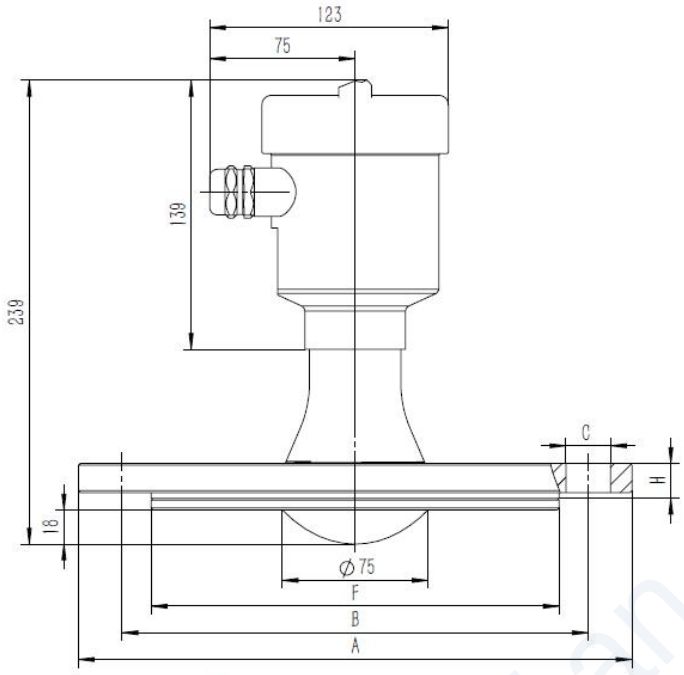
	A	B	C	H
DN80	ϕ190	ϕ150	4−ϕ18	15
DN100	ϕ210	ϕ170	4−ϕ18	15
DN125	ϕ240	ϕ200	8−ϕ18	17
DN150	ϕ265	ϕ225	8−ϕ18	17
DN200	ϕ320	ϕ280	8−ϕ18	19

Fig 3-3 Universal Type



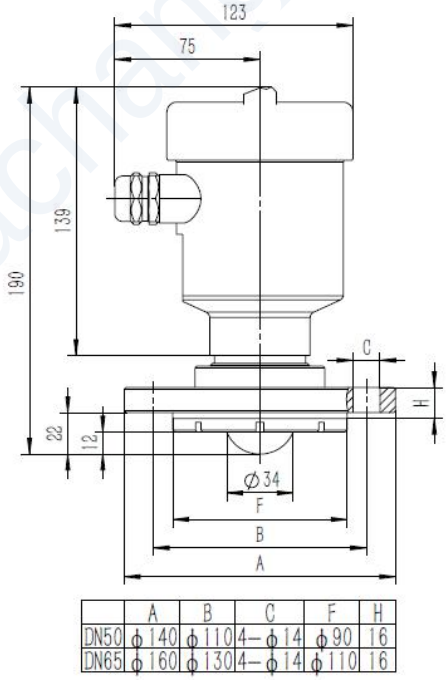
	A	B	C	H
DN80	ϕ190	ϕ150	4−ϕ18	15
DN100	ϕ210	ϕ170	4−ϕ18	15
DN125	ϕ240	ϕ200	8−ϕ18	17
DN150	ϕ265	ϕ225	8−ϕ18	17
DN200	ϕ320	ϕ280	8−ϕ18	19

Fig 3-4 Universal Type(200℃ resistance)



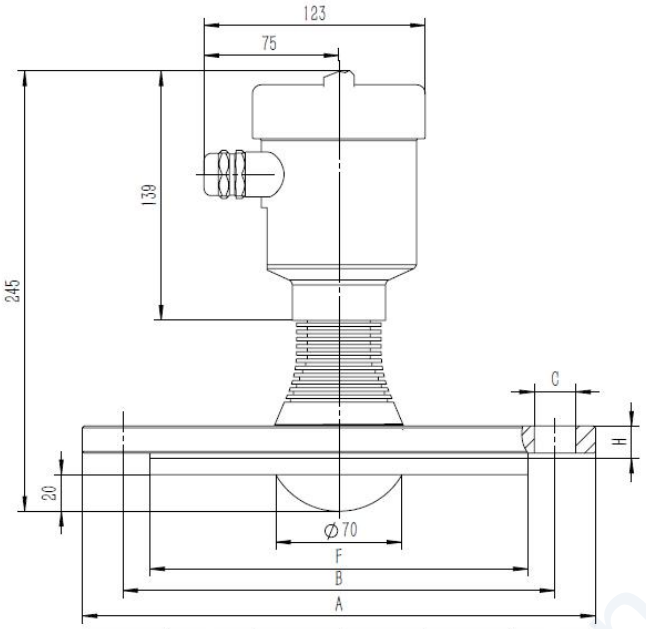
	A	B	C	F	H
DN80	ϕ190	ϕ150	4−ϕ18	ϕ128	18
DN100	ϕ210	ϕ170	4−ϕ18	ϕ148	18
DN125	ϕ240	ϕ200	8−ϕ18	ϕ178	20
DN150	ϕ265	ϕ225	8−ϕ18	ϕ202	20
DN200	ϕ320	ϕ280	8−ϕ18	ϕ258	22

Fig 3-5 Flange with encapsulated antenna system and 3° beamwidth



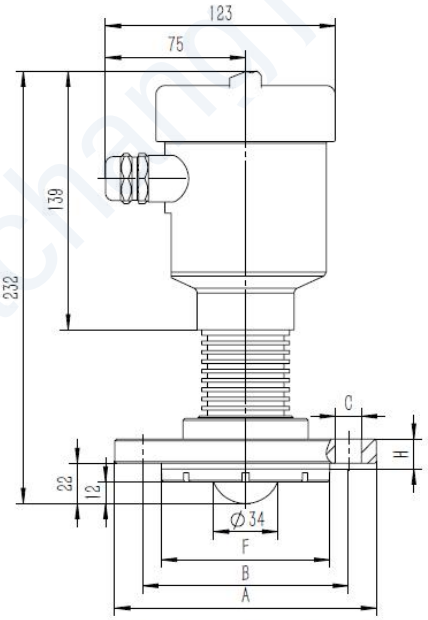
	A	B	C	F	H
DN50	ϕ140	ϕ110	4−ϕ14	ϕ90	16
DN65	ϕ160	ϕ130	4−ϕ14	ϕ110	16

Fig 3-6 Flange with encapsulated antenna system and 8° beamwidth



	A	B	C	F	H
DN80	ϕ200	ϕ160	8−ϕ18	ϕ138	20
DN100	ϕ220	ϕ180	8−ϕ18	ϕ158	22
DN125	ϕ250	ϕ210	8−ϕ18	ϕ188	22
DN150	ϕ285	ϕ240	8−ϕ22	ϕ212	24
DN200	ϕ340	ϕ295	12−ϕ22	ϕ268	26

Fig 3-7 Flange with encapsulated antenna system and 3° beamwidth（200℃ resistance）



	A	B	C	F	H
DN50	ϕ140	ϕ110	4−ϕ14	ϕ90	16
DN65	ϕ160	ϕ130	4−ϕ14	ϕ110	16

Fig 3-8 Flange with encapsulated antenna system and 8° beamwidth（200℃ resistance）

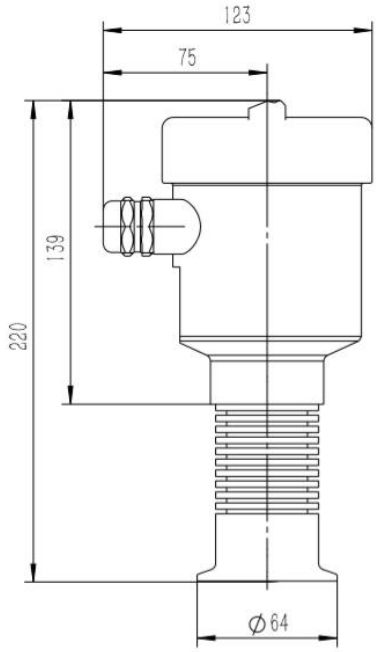


Fig 3-9 Hygienic fitting with encapsulated antenna system and 8° beamwidth（200℃ resistance）

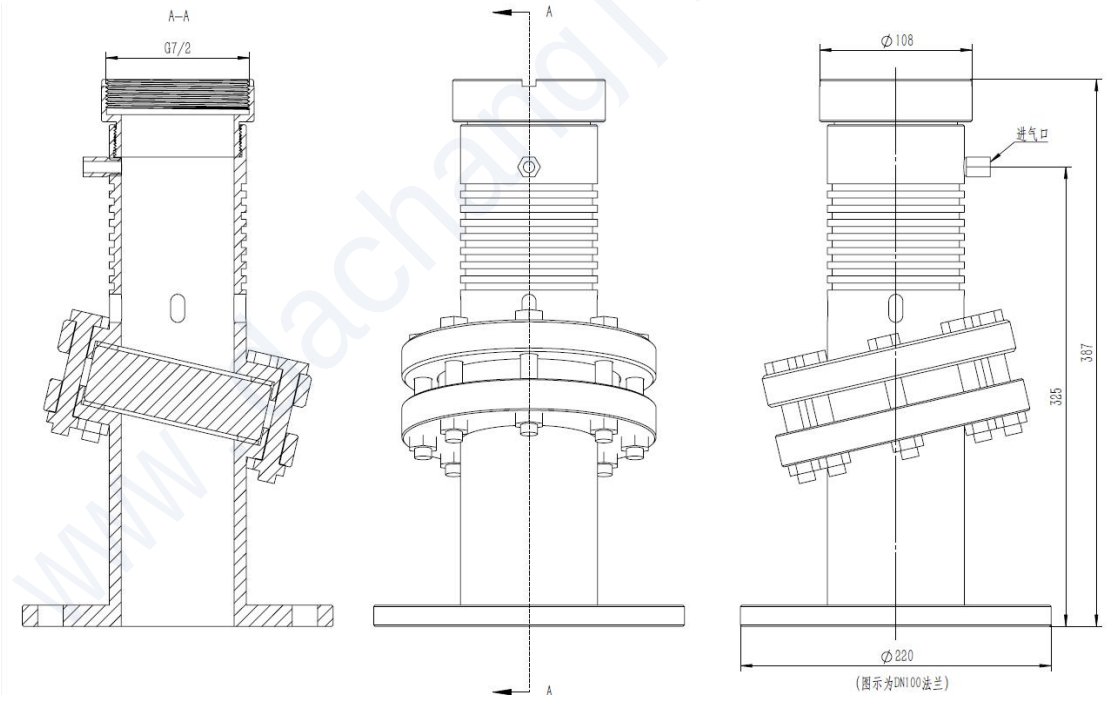


Fig 3-10 1000℃ resistance structure

4. Install

The main concern of installation is to aim to the material surface under test 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 4-1

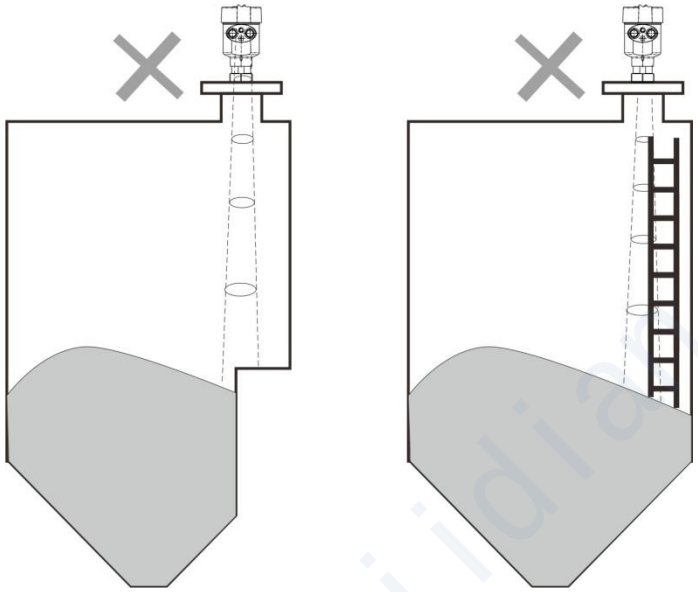


Fig 4-1 Example for avoiding false echo

- Avoid the contact between antenna beam and feeding flow, as shown in Fig 4-2

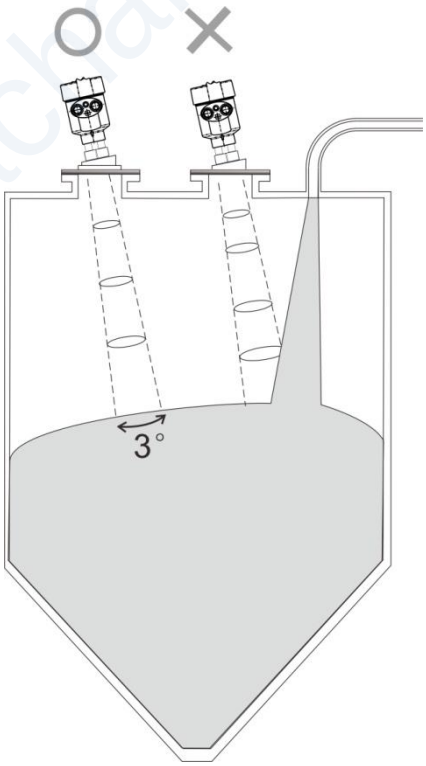


Fig 4-2 Example for avoiding false echoes

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

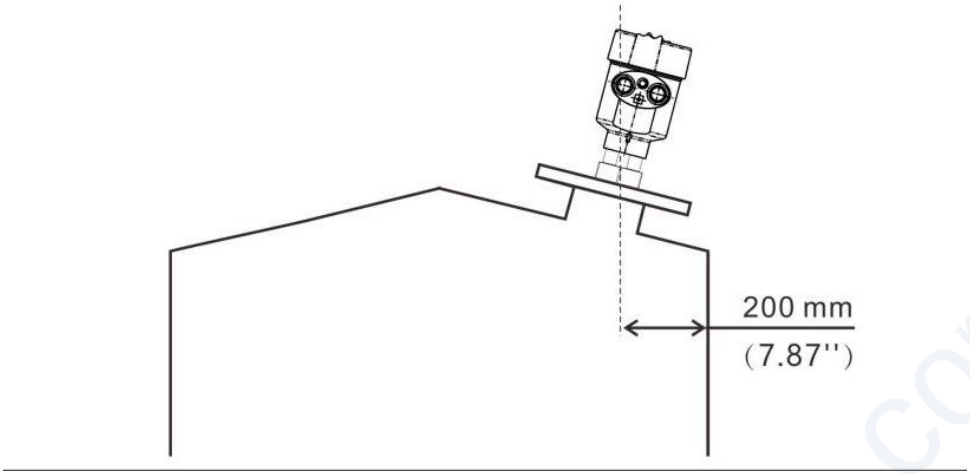


Fig 4-3 Example for avoiding false echo

- 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.

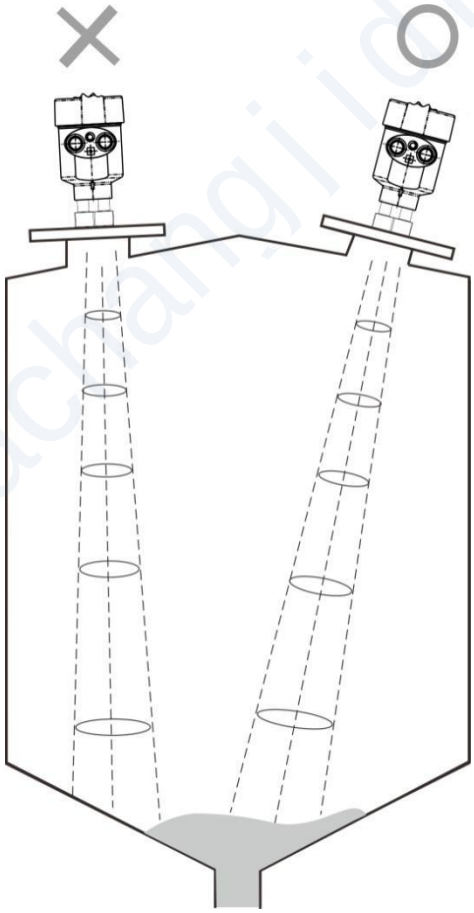


Fig 4-4 Example for avoiding false echo

5. Wiring

5. 1 4-wire product

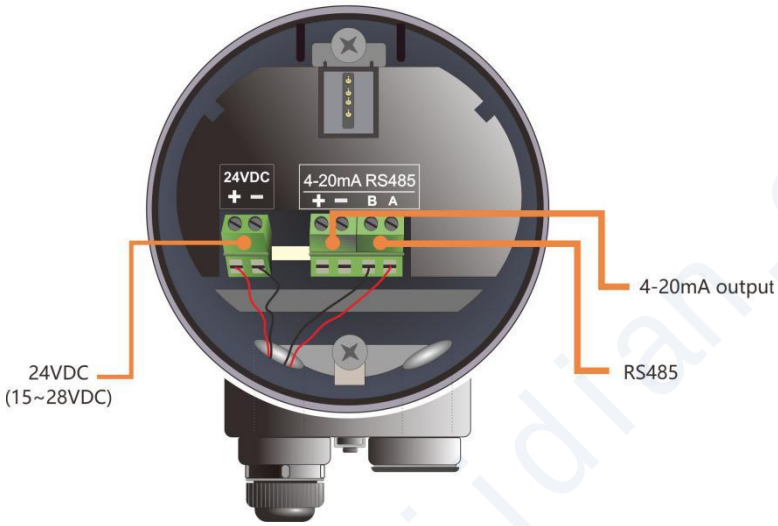


Fig 5-1 wiring diagram

5. 2 2-wire product

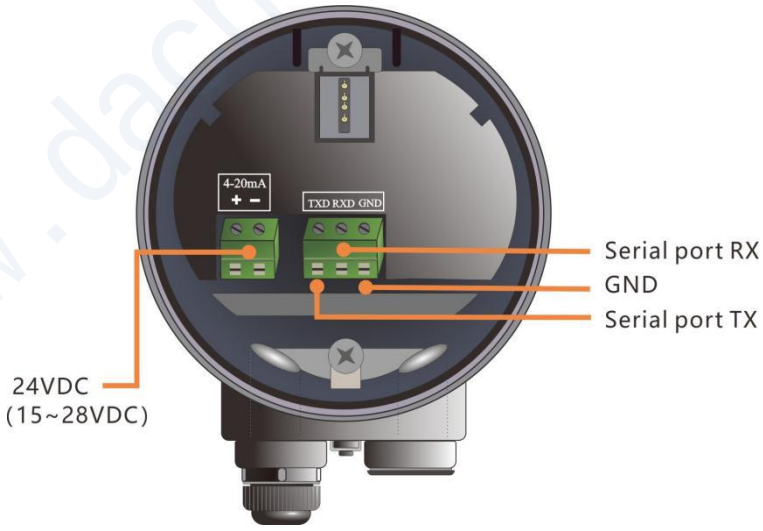


Fig 5-2 wiring diagram

6. Local operation

LM78xx carries out its level measurement tasks according to settings, which can be modified locally via the Local Display Module (LDM). LDM consists of an LCD with 4 push buttons.

6. 1 Interface Description

LDM has 5 kinds of display interface:
[**Main Interface**]: Display system running status and current measurement result.
[**Echo Interface**]: Display the real-time measured echo curve and Time-Vary Threshold (TVT).
[**Setup Interface**]: Set various system parameters.
[**Input Interface**]: Take the task of input.
The functions of the 4 keys are different in different display interface.

6. 2 Instructions for measurement interface

Measurement Interface is shown below:

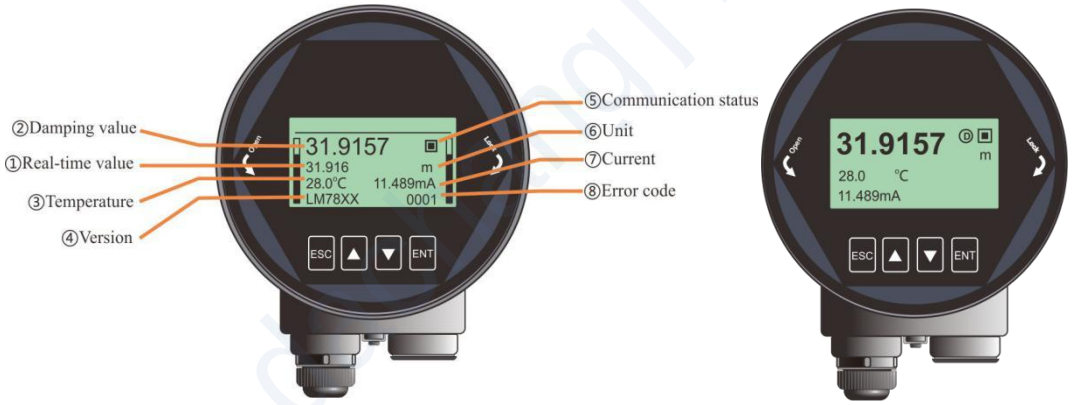


Fig 6-1 Measurement Interface overview

Table 6.1 Keys function in Measurement Interface

Keyboard	**Features**
ESC	-Switch to echo interface
UP	-Parameter overview
DN	-Simplified Main interface
ENT	-Switch to Setup Interface

(1)It is the Real-Time measurement result, which is converted from the distance information of real-time measurement, corresponding to section 6.5.1.6.
(2) It is the **damping value** which is the smooth output of the real-time measurement through the damping filter. See section 6.5.1.5 for details.
(3) It refers to the temperature of the signal processing board.

(4) It refers to product model defined in section **1.2**.
(5) It refers to the heartbeat of system communication status. Once a second means that the device is working properly, otherwise the device is abnormal.
(6)It refers to the system measurement unit, see section **6.4.2** for details.
(7)It represents the ideal 4-20mA current output value, which is obtained according to the setting of **High/ Low Calibration Points** and **Current function**. It should be nearly the same as the real output current. See section **6.5.4 (6-8)** for details**.**
(8)It is the error code, refer to **Error Code** for specific meaning.

6. 3 Instructions for Echo interface

Fig 6-2 Echo Interface overview

Table 6.2 Keys function in Echo Interface

keyboard	**Features**
ESC	-Switch to **Measurement Interface**
UP	-No use
DN	-Toggle on/off TVT curve
ENT	-NULL

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

■ ① indicates the maximum echo intensity in the measurement range. For a metal plate at 10m, the echo intensity should be at least 80dB.

■ ③ indicates the echo intensity which is selected by the algorithm. The strength should be at least 30dB for stable operation.

■ Time Varying Threshold (TVT) and the real-time echo curve are represented in dash line and solid line respectively in Fig6-2. Details for TVT refer to section 6.5.4.10-12.

■ ②Hollow arrow means the real time position and the solid arrow means the damping position. So the hollow one changes faster than the solid one.

6. 4 Instructions for Setup interface

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

Fig 6-3 Setup interface overview

Table 6.3 Keys function in Setup interface

keyboard	**Features**
ESC	-Switch to **Measurement Interface/Exit**
UP	-Move up
DN	-Move down
ENT	-Enter

6.4.1 [Basic]

[Basic] Menu contains the necessary functions for quick start of the level meter, as shown in the following table. The options list is shown in the table below:

Table 6.4 Menu Item for Basic

Default position	**Menu Item**
●	**Application**
	Vessel type
	Material Type / Dielectric Constant
	Low/High Calib.
	Near Range
	Far Range
	Damping
	Sensor mode

6.4.2 [Advanced]

[Advanced] contains various advanced settings for complicate environment or demand. The option list is shown in the following table:

Table 6.5 Menu Item for Advanced

Default position	**Menu Item**

●	**False Echo**
	Factory.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. One can review the statistics of current and historical data.

Table 6.6 Menu Item for Diagnostics

Default position	Menu Item
●	**Echo**
	False echo curve
	Historical data
	Historical period
	Historical maximum measurement
	Historical maximum temperature
	Historical Fill rate
	Historical Empty rate

6.4.4 [Display]

[Display] Menu contains the necessary functions for setting the system unit. The option list is shown in the following table:

Table 6.7 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/ Korea
	LCD contrast	

6.4.5 [Information]

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

Table 6.8 Menu Item for Information

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

6. 5 Menu options

6.5.1.1. Basic

When the level meter is powered on, LCD enters measurement interface. Press the [ENT] key to enter [Basic] menu.

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

6.5.1.2. Application

LM78xx series integrate adaptive algorithm designed for solid and liquid. Corresponding with [Vessel Type] and [Material Type] , One single instrument is enough to cover most of the application. Save your time on choosing.

Fig 6-4 Application

6.5.1.3. [Vessel Type]

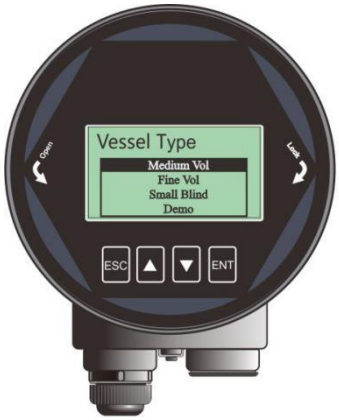


Fig 6-5 Vessel type overview

[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].

Table 6.9 Details for [Vessel Type]

Parameter name	Vessel type	
Large volume	Filling speed: 0.1m / min Damping time:60s	Filling speed: 0.1m / min Damping time:60s
Medium volume*	Filling speed: 1m / min Damping time:10s	Filling speed: 1m / min Damping time:10s
Fine volume	Filling speed: 10m / min Damping time: 0s	Filling speed: 10m / min Damping time: 0s
Fast Fill(solid app)		Fast fill but slow empty
Agitator(liquid app)		Ripple and fluctuant
Demo	Damping time: 0s	Damping time: 0s

6.5.1.4. [Material Type/Dielectric Constant]

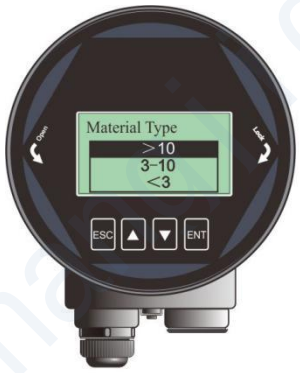


Fig 6-6 Material type overview

[Material Type] The setting is extremely important in complicate application such as low Dk liquid measurement. It should be selected according to the application.

Table 6.10 Details for [Material type]

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

6.5.1.5. [Low/High calibration point]

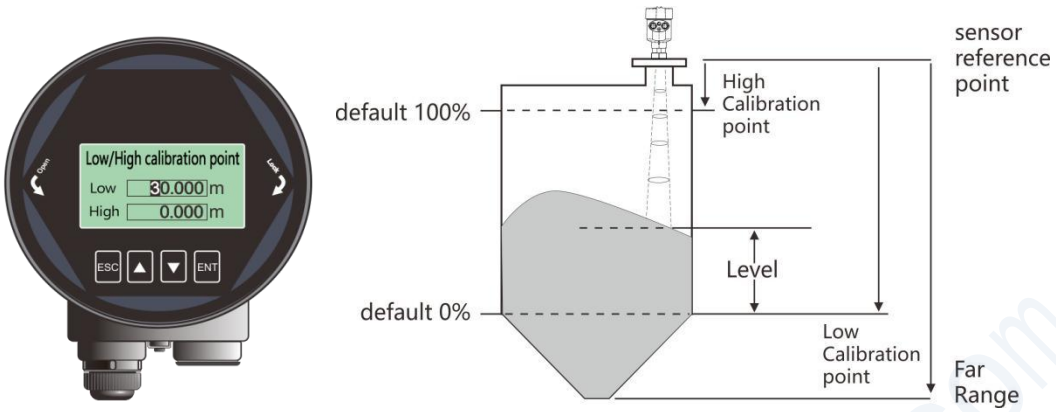


Fig 6-7 Low calibration point

[**Low/High calibration point**] maps the corresponding relationship between the measured value and the current output (4-20mA). the detail relationship is shown in the figure above.

For example, the tank is 5m high and level information need to be output. Just input low calibration point=5m, high calibration point=0m.

6.5.1.6. [Near range] and [Far range]

Only the Echoes between the ranges from [**Near Range**] to [**Far Range**] would be considered and has the possibility to be chosen by the algorithm. It exclude the interference echo within the [**Near Range**] and those outside the [**Fear Range**]. Reasonable setting is helpful for long term stable running. It should be noticed that these options are not related to the measurement limitation of the instrument, "**Blind zone**" and "**Maximum range**".

Fig 6-8 Near range and Far range

6.5.1.7. [Damping]

[Damping] smooths out the response to a sudden change in level. In five time constants, the output rises exponentially: from 63% of the change in the first constant, to almost 100% at the end of the fifth time constant. It is helpful to smooths the historical data curve on DCS. The larger, the smoother.

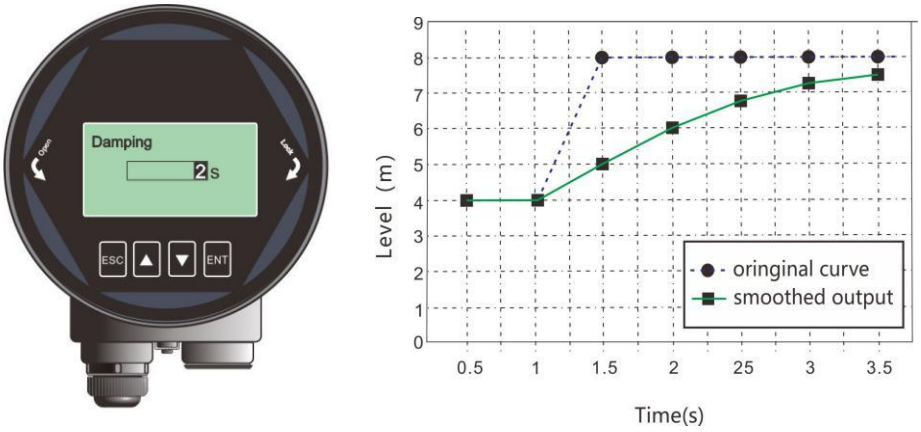


Fig 6-9 Damping

Table 6.11 Details for [Damping]

Parameter name	Damping
Parameter range (s)	0~600
Default (s)	60
Related parameters	Null
Option meaning	Smooth out the response to a sudden change in level.
Special matters	Null

6.5.1.8. [Sensor Mode]

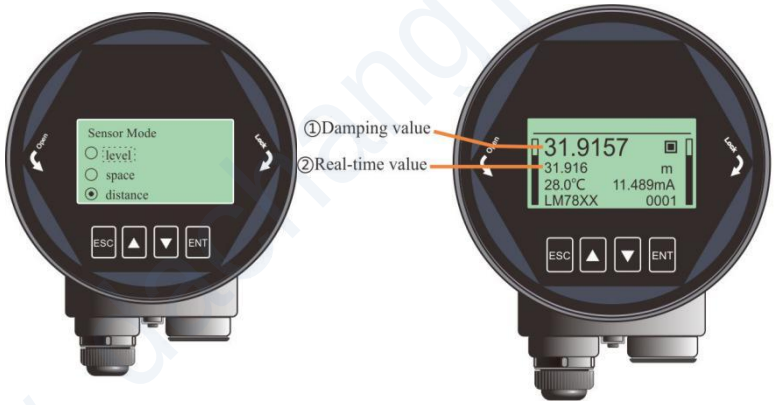


Fig 6-10 Sensor mode

[Sensor mode] decides the specific display form of the **real-time value** and **damping value**. There are three kinds of forms: LEVEL, SPACE and DISTANCE**.** Detailed definition and calculation method is shown in the table below:

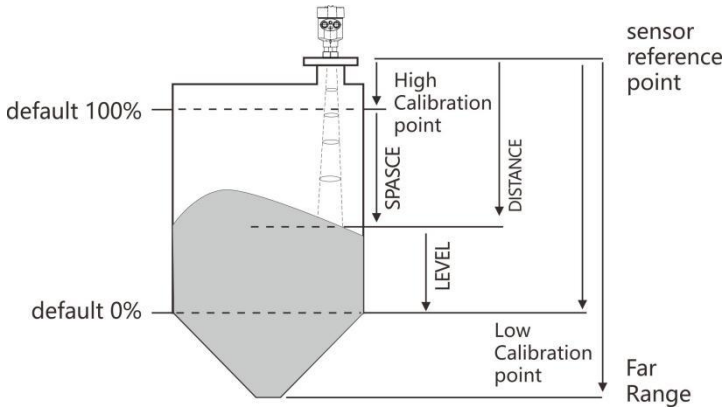


Fig 6-11 Definition for LEVEL, SPACE, DISTANCE

Table 6.12 Details for [Sensor mode]

Parameter name	Sensor mode
Default	Distance
Related parameters	Null
Option meaning	**Level**: Distance from **Low Calibration Point** to material surface. **Space**: Distance from **High Calibration Point** to material surface. **Distance**: Distance from Sensor Reference Point to material surface.
Special matters	(1)In Distance mode: **real-time value** = measured distance. (2)In Level mode: **Real-time value** = [**low cal.**]-measured distance. If the measured distance is greater than [**low cal.**], LEVEL=0. (3)In Space mode: **Real-time value** = measured distance-[**high cal.**]. If the measured distance is smaller than [**high cal.**], SPACE=0.

6. 5. 2 Advanced

6.5.2.1. [False Echo]

Fig 6-12 False Echo

[False Echo] is used to form a specific TVT for the current environment with known obstructions or interference, and together with [False echo range] and [False echo mode]. It suppresses the unwanted

echoes wherever it appears. Ideally the vessel should be empty or almost empty and thus all the potential false echoes would be learned. And if there is an agitator, it should be running. Example of False Echo Learning is shown in Fig 6-13. It contains three submenu and the detailed explanation are shown in the table below.

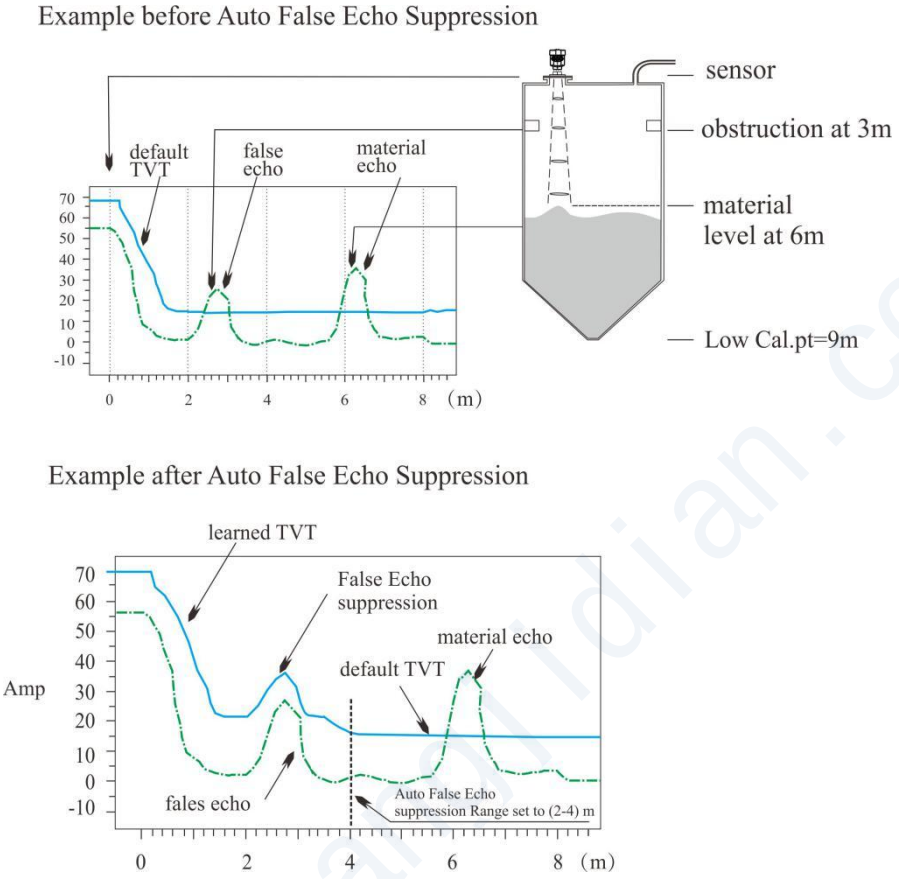


Fig 6-13 Example of False Echo Learning

Note: A Time Varying Threshold (TVT) hovers above the echo profile to screen out unwanted reflections (false echoes). In most cases the material echo is the only one which rises above the default TVT.

Table 6.13 Details for False echo mode

	Full range*	Include region	Exclude region
New	false echo is learned from [**near range**] to [**far range**]	False echo is learned within 2m ~ 4m and the rest remains the same.	False echo is learned within full range exclude 2~4m and the rest remains the same.
Clear	Clear false echoes learned from [**near range**] to [**far range**]	Clear the false echo within 2m ~ 4m and the rest remains the same.	False echo is cleared within full range exclude 2m~4m, the rest remains the same.

6.5.2.2. [Factory 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 **Main Interface** automatically.

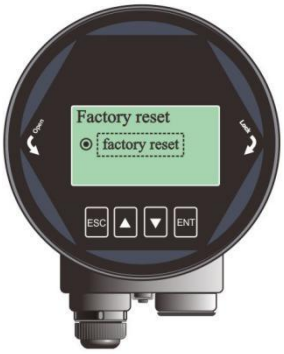


Fig 6-14 Factory reset

6.5.2.3. [Fill/Empty rate]

[Fill/Empty rate] is used to adjust the response rate of the level meter to the increases and the decrease of the actual material level. It need to be set according to the actual situation. There is no need to be so accurate but it should be faster than the real rate. The default setting would be applied as in Section 6.5.1.2 if you don't specify this option. The maximum rate is 300m/min.

Fig 6-15 Fill/Empty rate

6.5.2.4. [mA simulation]

[mA simulation] is used to check the loop current output accuracy. The loop current will keep the value set by [mA simulation] for testing. Once you exit the interface shown in Fig 6-16, calibration is over and the loop current would be set according to [mA function], which means that the instrument continues the normal measurement.

Fig 6-16 Current simulation

6.5.2.5. [4mA/20Ma setpoint]

Set the 4mA and 20mA setpoint individually and thus the default corresponding relationship between 4mA/20mA and [**low/high cal.**] would be discarded as a result. It is not recommended to set this option when just normal level measurement task is carried on.

Fig 6-17 4mA/20mA setpoint

6.5.2.6. [mA function]

[mA function] decides real-time output loop current according to [**4mA/20mA setpoint**].

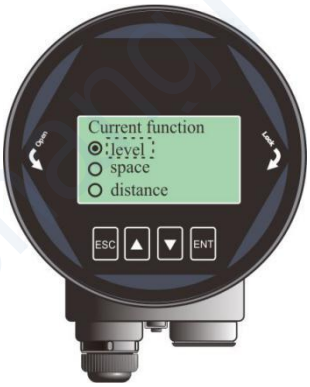


Fig 6-18 Current function

In different options, 4mA (0%) and 20mA (100%) position is shown in the figure. Choose the option according actual need.

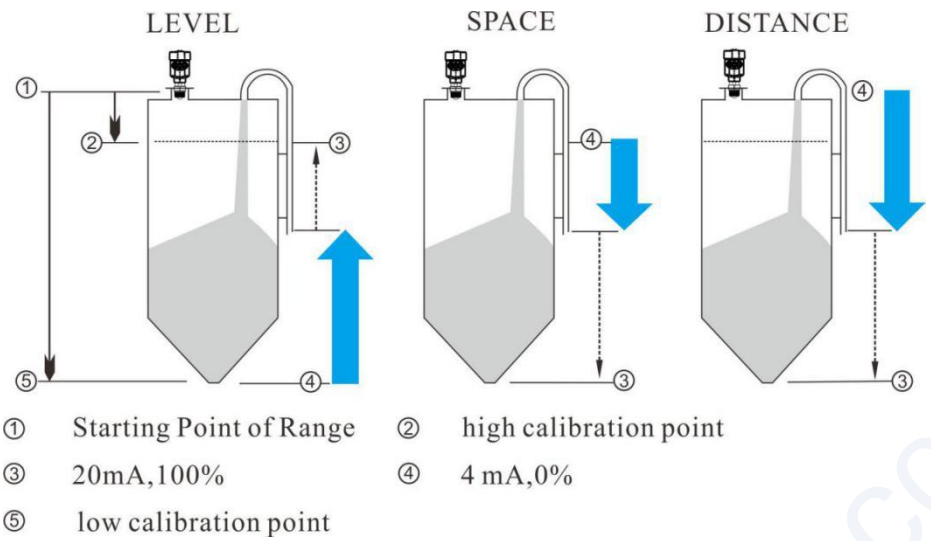


Fig 6-19 Corresponding relationship between **4/20mA setpoint** and **low/high calibration point**

6.5.2.7. [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.

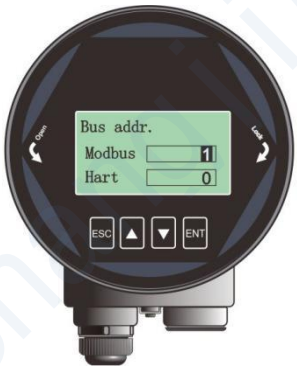


Fig 6-20 Bus address

Table 6.14 Details for [Bus address]

	LM782x(four line type)	LM783x(two line type)
Parameter name	Bus address	Hart address
Parameter range	1-247	0-15
Defaults	1	0
Related parameters	Null	Null
Option meaning	Set the Modbus address.	Set the Hart short address.
Special matters	System will reboot after setting	System will reboot after setting. Output Current will be fixed at 4mA when non-zero values is set.

6.5.2.8. [Sensor Offset]

[Sensor Offset] is used to compensate the shift of sensor reference point according to actual

requirement. The default reference point is calibrated to the front end of the lens point “a”. If sensor reference point need to be set to point “b”, just input “h1”; or if it need to be set to point “c”, just input “-h2”. The maximum negative offset is limited -(Self_offset), which is around 0.2m.

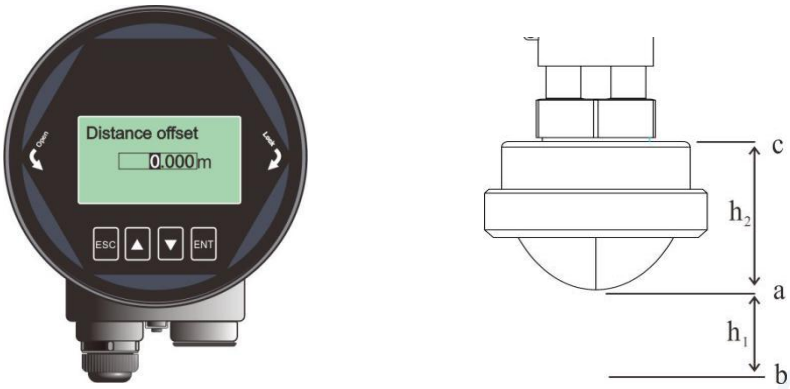


Fig 6-21 Distance Offset

Table 6.15 Details for [Distance Offset]

Parameter name	Distance offset
Parameter range (m)	-(Self_offset)~ 10m
Default value (m)	0
Related parameters	Null
Option meaning	Compensate the shift of the sensor reference point.
Special matters	Null

6.5.2.9. [Fail-safe mode]

[Fail-safe mode] is used to set the output current when the level meter encounters the status of lost of echo. The “Keep” option indicates the last valid measured current would be output during this period.

Fig 6-22 Fail-safe mode

6.5.2.10. [Fail-safe Timer]

It is also known as lost of echo timer (LOE timer). Fail-safe mode would be turned on when [Fail-safe Timer] expires. The default value is 100s and the range is 0-1000s.

Fig 6-23 Fail-safe timer

6.5.2.11. [Parameter backup]

This option backup all the settings in the current instrument to the memory of the display module. And this display module can be used to configure other instruments on the same type of tank in the same site. “Read” backups all the setting to the LCD and “Write” send out the parameters to a new instrument.

Fig 6-24 Parameter backup

6. 5. 3 Diagnostics

6.5.3.1. [Echo curve]

Refer to [**Echo Interface]**.

6.5.3.2. [False echo curve]

Refer to 6.5.2.1 [**False Echo]**.

6.5.3.3. [Historical data]

According to [Historical period], [Historical data] shows the historical trend of the measurement. The data on the right is newer. The number in the upper left corner shows the maximum peak in the curve and [Historical period] is shown in the upper right corner. Maximum statistical period is 360 hours,

i.e. 15 days.

Fig 6-25 Historical period

6.5.3.4. [Historical period]

[Historical period] sets the time range of [Historical data]. Only even number from 2 to 360 is accepted and the unit is hour.

Fig 6-26 Historical period

6.5.3.5. [History Maximum Measurement]

[Historical Maximum Measurement] shows the statistical results of the measured maximum and minimum level since last [Clean]. [Clean] clears the statistical results and then the recording will be restarted.

Fig 6-27 History Maximum Measurement

6.5.3.6. [Historical Maximum Temperature]

[Historical Maximum Temperature] shows the statistical results of the MCU operating temperature since last [Clean].

Fig 6-28 History Maximum Temperature

6.5.3.7. [Historical Fill Rate]

[Historical Fill Rate] shows the statistical results of measured maximum and minimum fill rate of the material.

Fig 6-29 Historical Fill rate

6.5.3.8. [Historical Empty Rate]

[Historical Empty Rate] shows the statistical results of measured maximum and minimum filling rate of the material.

Fig 6-30 Historical Empty Rate

6. 5. 4 Display

6.5.4.1. [Sensor unit]

[Sensor Unit] defines the unit of the **real-time value** and **damping value shown in Measurement Interface**.

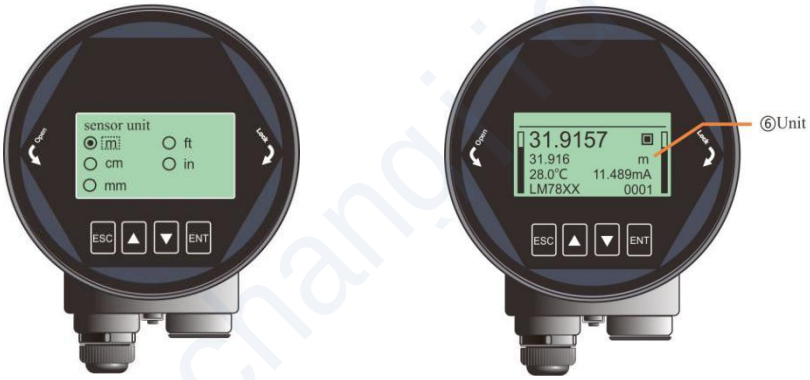


Fig 6-31 Sensor unit

6.5.4.2. [Temperature unit]

[Temperature Unit] defines the unit of temperature shown **in Measurement Interface**.

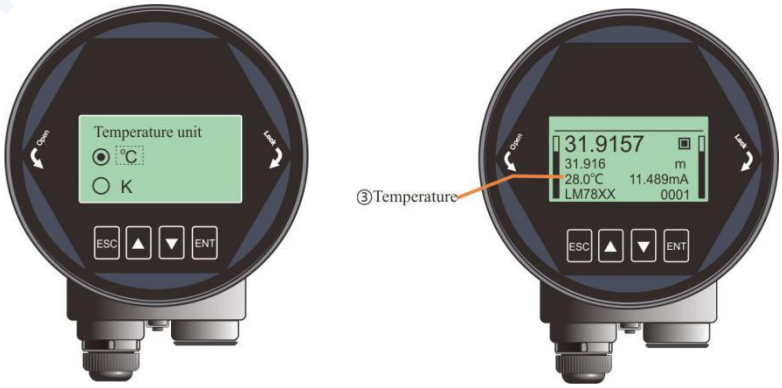


Fig 6-32 Temperature unit

6.5.4.3. [Language]

[Language] selects the system language to be used on LCD.

Fig 6-33 Language

6.5.4.4. [LCD contrast]

This option is used to adjust the contrast of LCD.

6. 5. 5 Information

6.5.5.1. [Model]

[Model] shows the product model which can be set by the debug software on PC.

Fig 6-34 Sensor model

6.5.5.2. [S.N]

[S. N] indicates the unique number of this instrument.

Fig 6-35 Serial NO.

6.5.5.3. [Tag]

[Tag] can be used to set the unique identification for each instrument. It contains 16 characters and each character can be set to '0' ~ '9' or 'a' to 'z'.

Fig 6-36 Tag

6. 6 Keyboard input method

This section is to introduce the method of inputting digital number for setup in [**Input Interface**],

(1) Press [DN] to shift the cursor to the right.

Fig 6-37 Shift the cursor

(2) Press [UP] to cycle from 0 to 9.

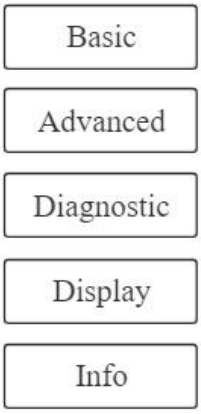
Fig 6-38 Cycle from 0 to 9

(3) Press [ENT] to complete the setting and "OK" will be displayed in the lower right corner of the LCD for 1 second, which means setting is accomplished.

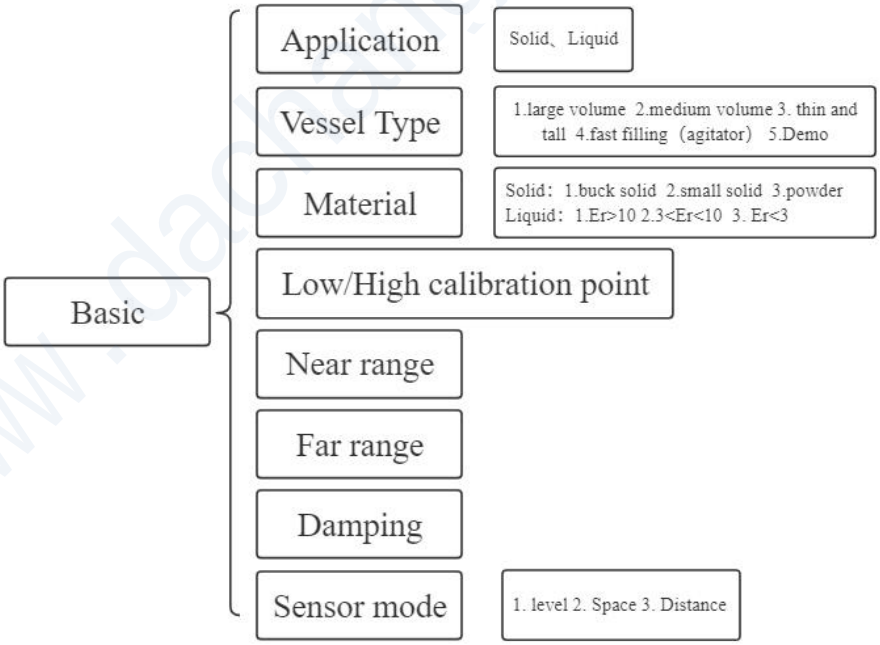
Fig 6-39 Successful setting

7. Menu tree

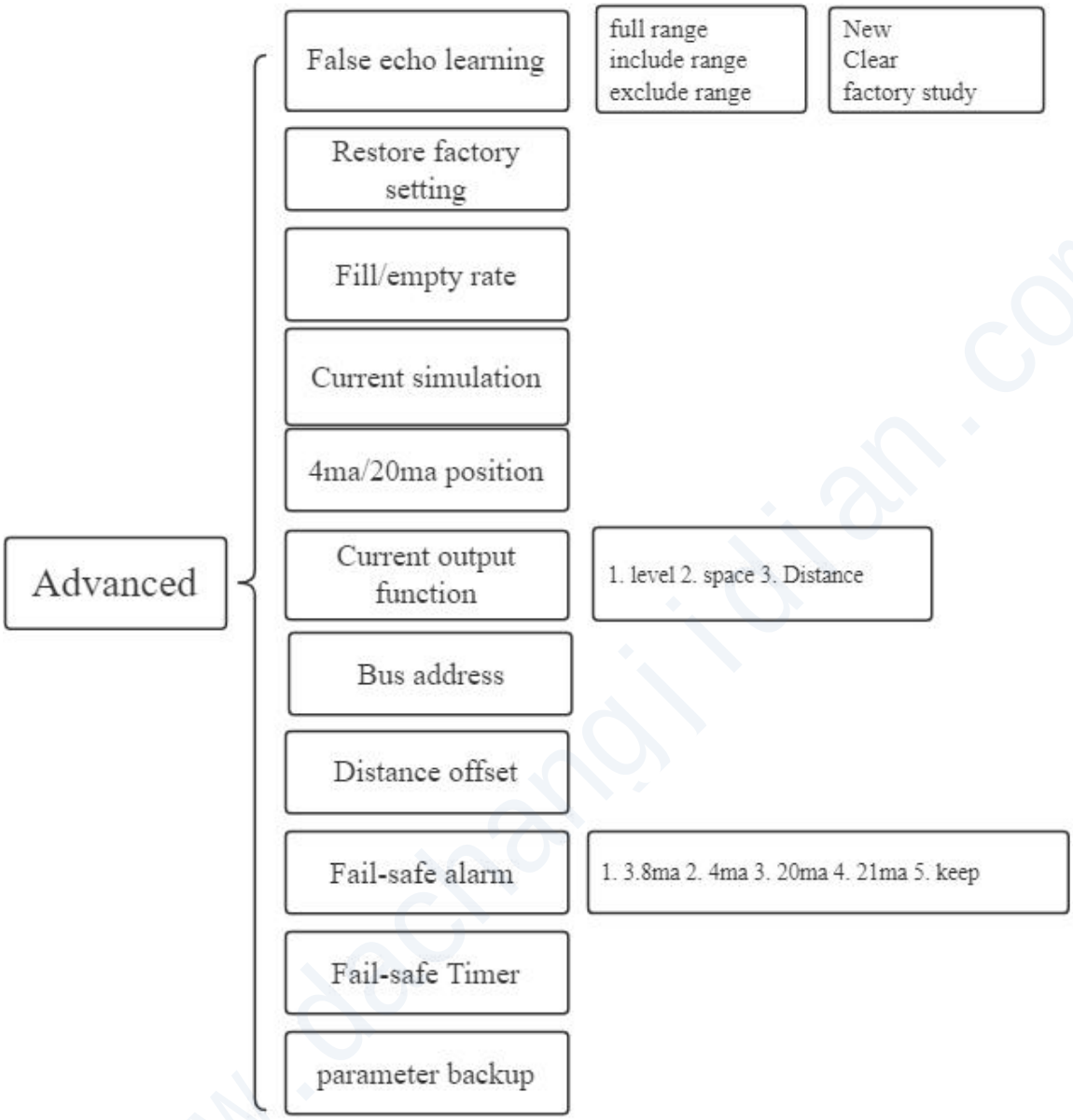
7. 1 First-level menu tree



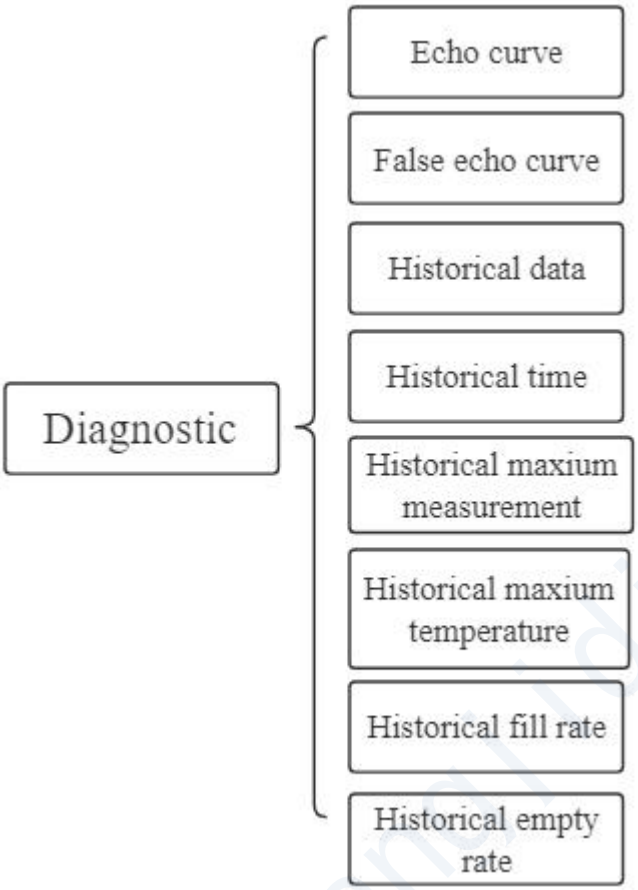
7. 2 Secondary menu tree-basic settings



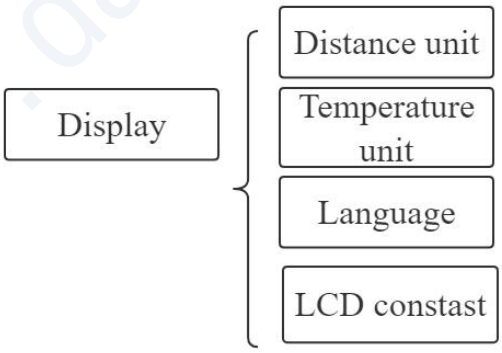
7. 3 Secondary menu tree-Advanced



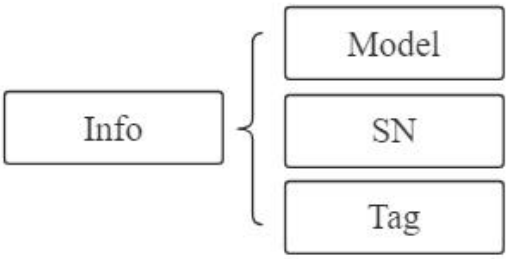
7.4 Secondary menu tree-diagnostics



7.5 Secondary menu tree-display



7. 6 Secondary menu tree-information



8. Problem Diagnosis

Phenomenon	Possible reason	Actions

9. Software Version History

core version	Release date	Update description
1.1.84	20200214	

Display version	Release date	Update description
4.2.14	20200214	

10. Error Code

Error code is displayed in the Measurement Interface as shown below

Fig 10-1 Error code

Table 10.1 Details for Error code

Index	Binary	Hex	Meaning
1	0000 0000 0000 0000	0000	Work regular
2	0000 0000 0000 0001	0001	Lost echo
3	0000 0000 0000 0010	0002	Communication err with TR
4	0000 0000 0000 0100	0004	No Factory False echo study
5	0000 0000 0000 1000	0008	4-20ma error
6	0000 0000 0001 0000	0010	Current manual output
7	0000 0000 0010 0000	0020	LCD Communication error
8	0000 0000 0100 0000	0040	Connection err with TR
9	0000 0000 1000 0000	0080	MCU Hard fault
10	0000 0001 0000 0000	0100	MCU Hard fault
11	0000 0010 0000 0000	0200	Temperature sensor error
12	0000 0100 0000 0000	0400	MCU Hard fault

11. Glossary

Beam Angle: Half power beamwidth. Lm78xx has 3°beamwidth and the divergence of the beam is only ±2.6m at a distance of 100m.

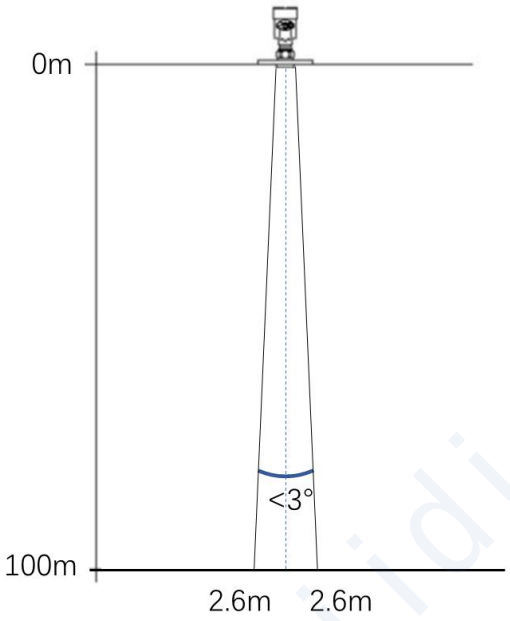


Fig 11-1 Beam spread

Range resolution： It refers to the minimum distance that two objects can be distinguished by the level radar. LM78xx 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. LM78xx's echo signal is analyzed by unique algorithm, and the accuracy is 0.5mm.

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: Generally speaking, false echoes are generated by obstacles in the container or multiple reflection.

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.