Document No.: KF21-002A

Microwave Level Gauge

MD-10

User's Guide

TOKYO KEIKI

Safety Cautions

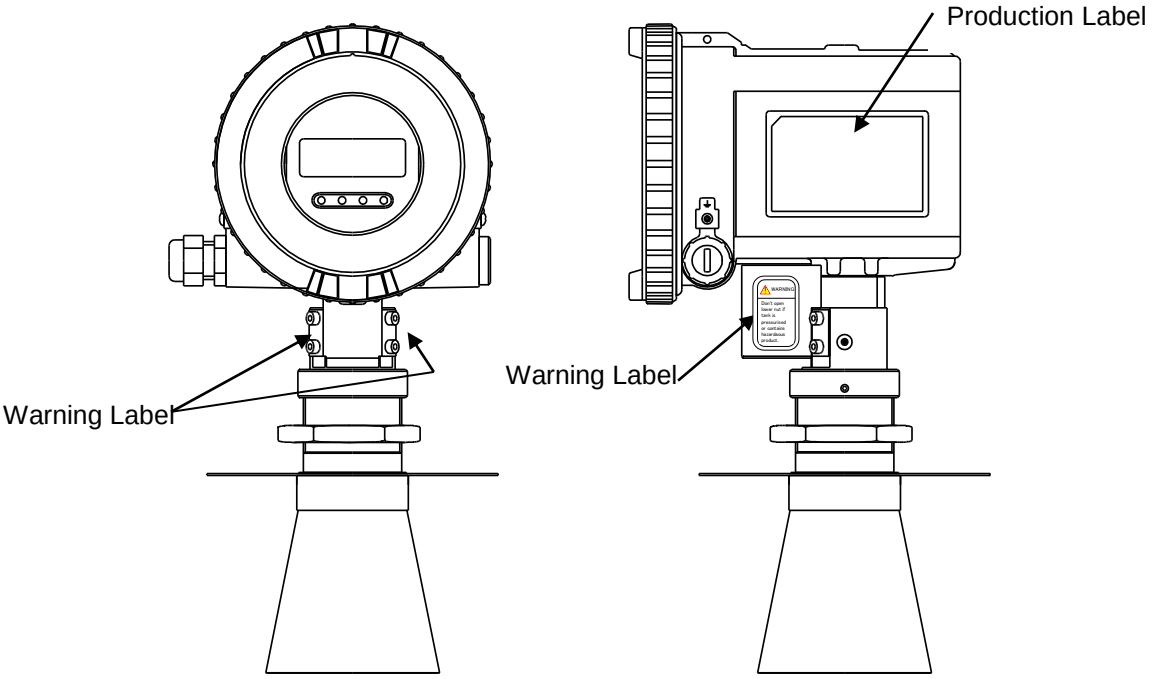
The following safety precautions contain important information pertaining to the safe use of the Microwave Level Gauge. Read this text carefully and make sure to fully understand its contents before installing and operating this equipment. Follow directions given herein at all times when operation. TOKYO KEIKI INC. is not at all liable for an injury and/or a damage resulting from misuse of this equipment by the user that is contrary to these cautionary notes.

In this manual and on the equipment, the following safety symbols are used to ensure the equipment is used safety and to protect operators and property from possible hazards or damage. Read the explanations below carefully and familiarize yourself with the symbols before reading the manual.

Safety symbols

DANGER	Indicates that incorrect usage can result directly in death or serious injury to the operator.
WARNING	Indicates that incorrect usage may result in loss of life or serious injury to the operator.
CAUTION	Indicates that incorrect usage may result in injury to the operator or damage to the equipment.

Labels and attached place

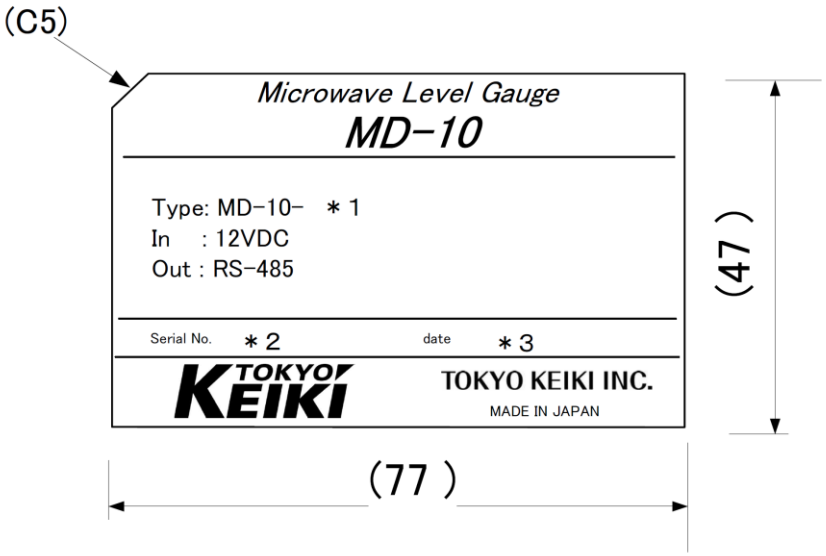


Safety Cautions

Labels attached to the equipment are as follows.

[Warning Label]
Indicates that incorrect usage may result in death or serious injury to the operator.

[Production Label]



[Earth]
[for protective earth] [for functional earth]

Safety Cautions

■ Precautions for use

	Please pay attention to the following items in order to fully demonstrate the performance of this product and use it safely.
Precautions	(1) If all of the following items are not satisfied, measurement may not be possible or incorrect measurement values may be displayed or output. -Use within the specified power supply voltage range described in the specifications. -Do not apply particularly strong vibration or shock to the main body. -Install the main unit and cable in a place that is not affected by external noise. -Use within the specified ambient temperature and humidity range of the main unit.
	(2) Please take appropriate measures when abnormal measured values are detected.
	(3) When entering the set value, read the instruction manual carefully and set it correctly. If you make an incorrect setting, measurement will not be possible, or an incorrect measured value (output signal) will be displayed or output.
	(4) Do not modify or disassemble the product. It will be the cause of the failure.
	(5) If you lose this instruction manual, please contact our distributors.

Safety Cautions

■ Proper use of the User's Guide

The following points must be observed:

(1) Carefully read the User's Guide
The contents of the User's Guide are very important. Carefully read the entire manual.

(2) Store the User's Guide in safe location.
The User's Guide is very important for the operation of the equipment. Store the manual in a safe and accessible location. The storage location and person responsible for maintaining the Guide should be considered carefully.

(3) Ensure that the User's Guide is supplied to the operator of the equipment.
The representative or dealer of this equipment must supply this User's Guide to the user who will actually operate the equipment.

(4) The User's Guide should be replaced if it is lost.
If the User's Guide is lost, contact the representative listed on the back cover. A new manual may be purchased.

(5) Make sure that the warning label does not come off.
If the warning label becomes dirty or peels off, please contact our distributor and replenish the warning label. There is a charge for the replenishment warning label.

■ Precautions of instruction manuals

This instruction manual corresponds to the version of the included device. Please note that the contents may differ from other versions of the device.
This instruction manual is created based on the standard specifications of this device.
If there is a description content different from the approved drawing due to the customer's specifications, the approved drawing will be given priority.
Company names and product names (trade names) used in this manual are registered trademarks or trademarks of each company. The TM and R marks are not shown in this manual.

■ Restrictions and cautions necessary to maintain the equipment

The following items must be observed to ensure that the equipment is maintained properly. Refer to the pages corresponding to each topic for details.

(1) Do not drop unit or subject unit to impact.
(2) Use the unit in appropriate conditions (temperature or humidity environments).
(3) Always use an appropriate power supply.
(4) Do not use a cable (signal cable) that is scratched or has its coating peeled off.
(5) Operate the device from the panel (display, key switch) with the front cover of the main unit opened. Do not operate the electronic circuits (printed circuit boards, electronic components, etc.) inside the panel.
(6) Never disassemble or modify the equipment. If the device is abnormal, please contact our distributor.

Contents

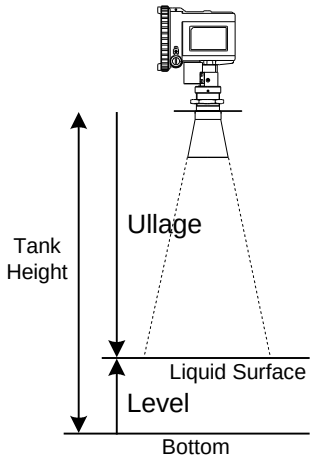
1 Product Description

The MD-10 is a loop-powered radar level gauge, which can be installed easily in a variety of applications. The MD-10 employs a non-contact radar level gauging principle based on pulsed microwave signals and is suitable for level measurement in applications such as liquids, pastes and slurries.

MD-10 uses 5.8GHz low power pulsed microwave. It provides good measurement stability, because propagation of microwaves is not affected by temperature, pressure or gas conditions in tank.

1.1 Measuring principle

The MD-10 level gauge utilizes the time-of-flight measurement principle involving short microwave pulses. Installed at the top of tanks, it emits short microwave pulses toward liquids or pastes in the tank. Reflected microwave signals from the surface are received by the antenna, and processed by electronics. The time from transmission to reception is determined by the microprocessor and converted as distance from the transmitter to the liquid surface (ullage) with output of the calculated level from the measured ullage (Level = Tank Height – Ullage).



1.2 MD-10 measuring system

MD-10 can be configured with its onboard 4 key switches or remotely from a personal computer via RS-485 interface with PC software. System configuration is shown as Fig. 1.2.1.

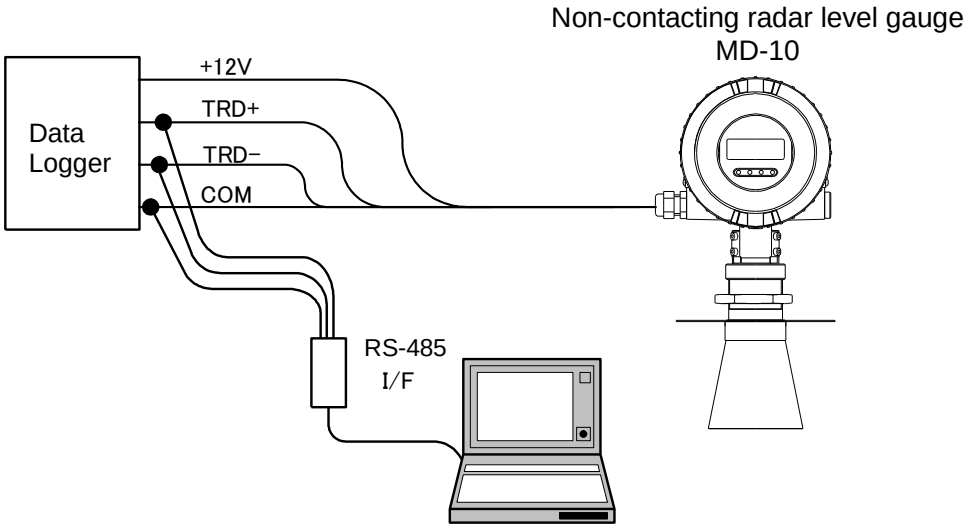


Fig. 1.2.1 System configuration

2 Mechanical Installation

2.1 Requirements

2.1.1 Cone Antenna

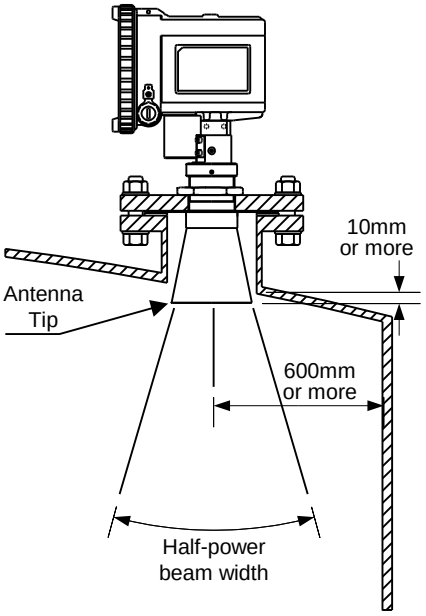
Mounting position

Do not mount the transmitter at the center of the tank or close to the tank wall as this may reduce the measuring range or accuracy and make the transmitter more sensitive to echo disturbances. We recommend that the transmitter be mounted so that the antenna tip is located at least 0.6 m from the tank wall.

Socket requirements

The antenna tip should extend past the nozzle (10 mm or more).

If the antenna tip is located inside the nozzle, echo disturbances may be generated which will negatively affect measurement performance.



Free space requirements

The transmitter should be mounted so that no obstacles are present in the radar beam.

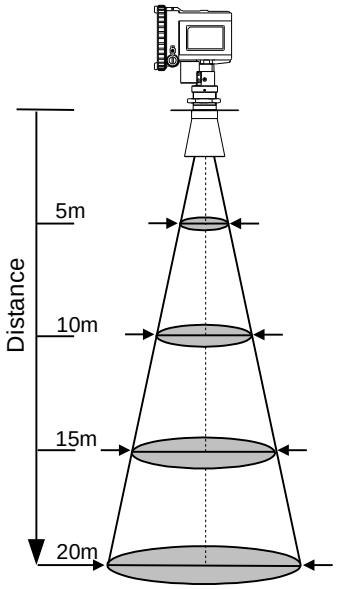
Obstacles in the radar beam may reduce the measuring range.

Antenna Type	Half Power Beam Width (Degrees)
4” cone	34
6” cone	22
8” cone	17

Half Power Beam Width.

Distance[m]	Antenna Type		
	4” cone	6” cone	8” cone
5m	2.9	1.9	1.5
10m	5.8	3.8	3.0
15m	8.8	5.7	4.4
20m	11.7	7.6	5.9

Diameter of radiated area (m).



2.1.2 Key factors for measurement

1. The strength of the microwave reflection from the liquid surface is proportional to the dielectric constant Er (Epsilon) of the target fluid. The higher the fluid's dielectric constant, the wider the measurable range.

2. A larger antenna enables more stable measurement and a wider measuring range.

3. Compared to calm fluid surfaces, measuring ranges of turbulent surfaces are reduced due to poorer reflection.

4. Deposit buildup on the antenna, foaming on liquid surfaces, powder granules in air suspension and other interior tank conditions may affect measuring range and performance.

5. Obstructions in the microwave radiating area or target fluid surface areas less than the radiating area will reduce microwave reflection and decrease and narrow the measurable range.

2.2 Tools

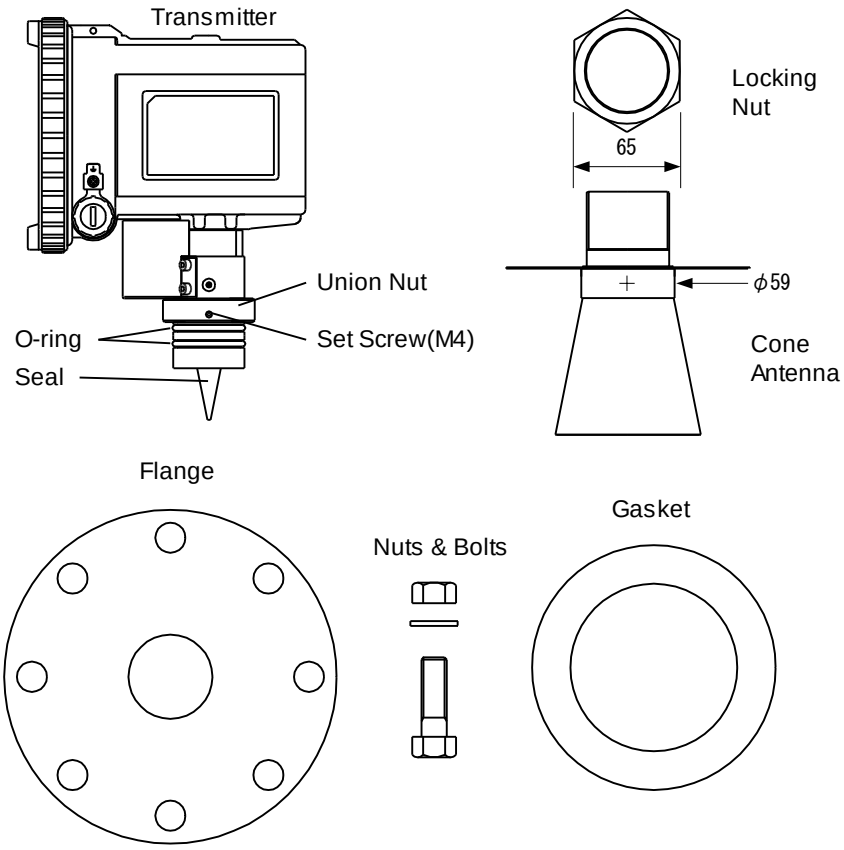
The following tools are needed for installation of MD-10:

- Hexagon socket screw keys(-4)
- Adjustable wrench (for locking nut)
- Pipe wrench (for neck of cone antenna)
- Screwdriver (-) width 3mm

2.3 Mounting cone antenna

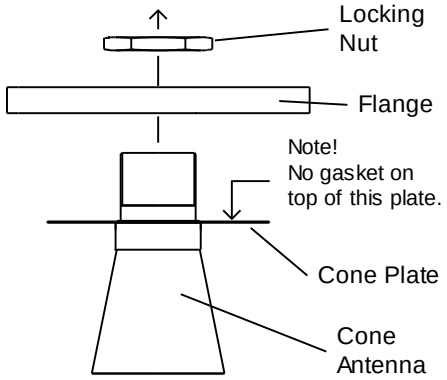
WARNING
Do not damage the PTFE seal and O-ring during mounting. Damaged seals may cause gas leakage when the MD-10 is installed on pressurized tanks.

1. Check and confirm the parts described below which are required for installation of the cone antenna.



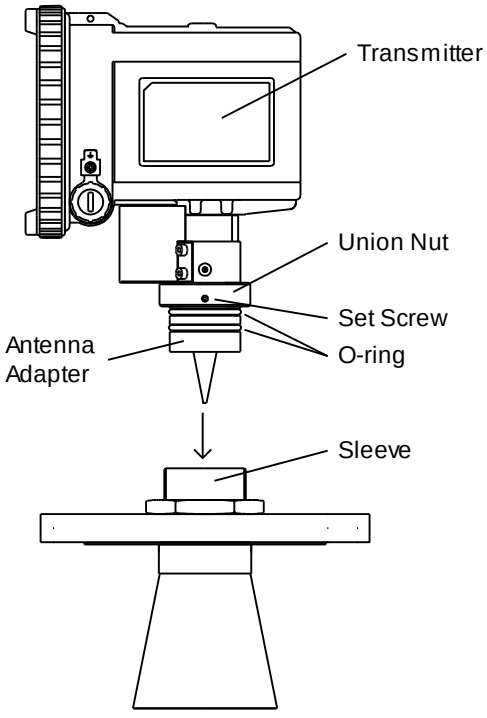
2. Mount the flange on top of the cone plate.
   Secure the flange with the locking nut.
   Make sure that the nut is fitted tightly to the flange.

> **WARNING**
>
> Make sure that the bottom side of the flange is flat and all parts are clean and dry as problems related to this may result in gas leakage when the MD-10 is installed on pressurized tanks.



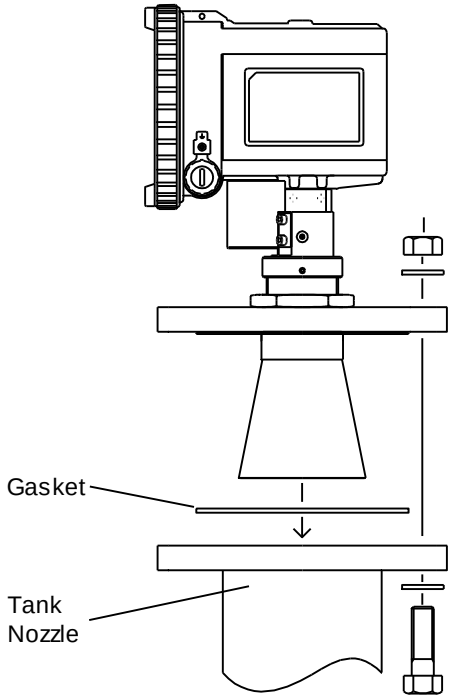
3. Carefully insert the antenna adapter of the transmitter into the sleeve.
   Secure the antenna adapter with the union nut.
   Make sure that the antenna adapter fits inside of the cone antenna.
   Secure the union nut with the set screw.

> **WARNING**
>
> Make sure that the O-ring inside of the sleeve is clean as improper sealing may lead to gas leakage problems when the MD-10 is installed on pressurized tanks.



4. Place the gasket on the tank nozzle.
   Carefully fit the flange and the cone antenna on the tank nozzle.
   Tighten the assembly with the screws and nuts.

WARNING
Do not loosen the union nut when the tank is pressurized.



When an obstacle adversely affects the measurement performance, the transmitter may be turned to improve it. Install the cable to be connected so that it can rotate with a margin of about 1 m.

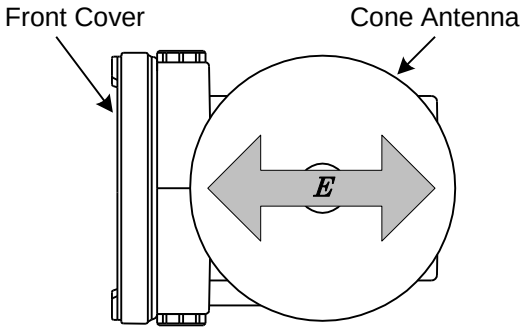
2.4 Installation hints

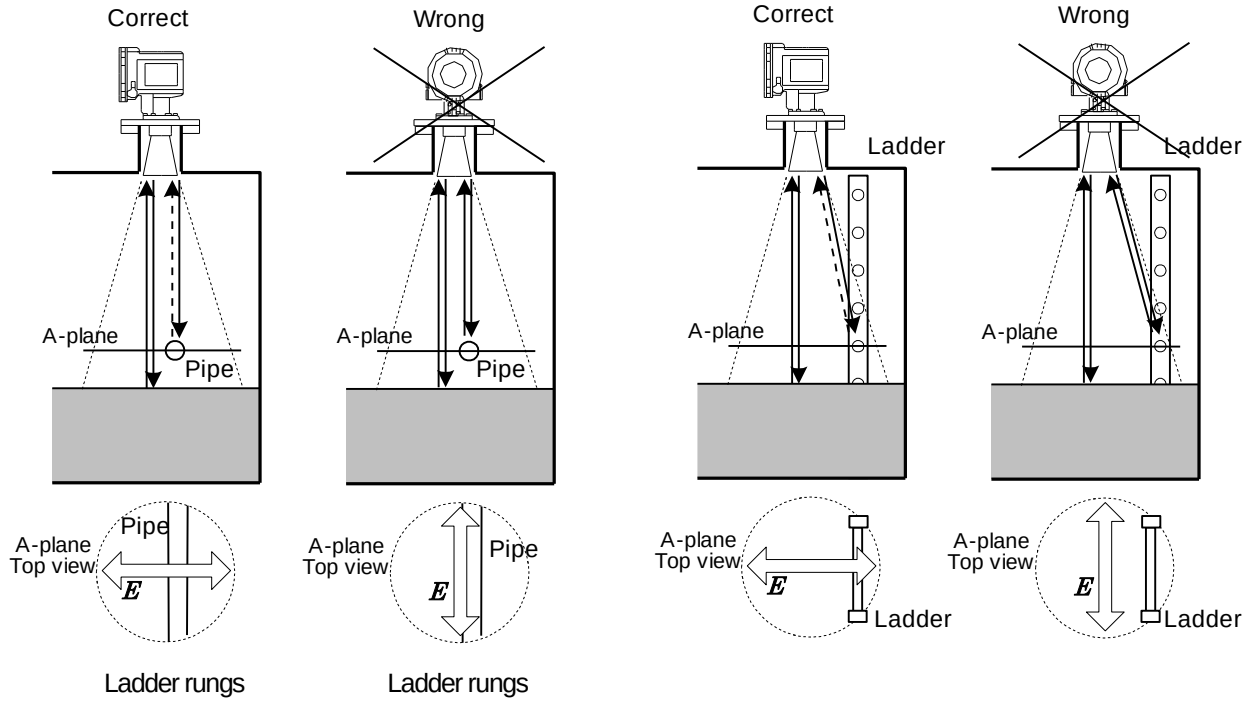
Obstacles in the radar beam may generate signal reflections (false echoes) which may be larger than the reflected signals from the surface of the liquid. The MD-10 may erroneously interpret such false echoes as reflections from the liquid surface. To reduce the influence of false echoes, attenuate such signals using the following methods.

2.4.1 Thin pipe or ladder

Microwave reflections from elongated metal objects such as thin pipes or ladders rungs are largest when the axis of such objects are in parallel with the electric field. The orientation of the electric field generated by the MD-10 is as shown in the right figure.

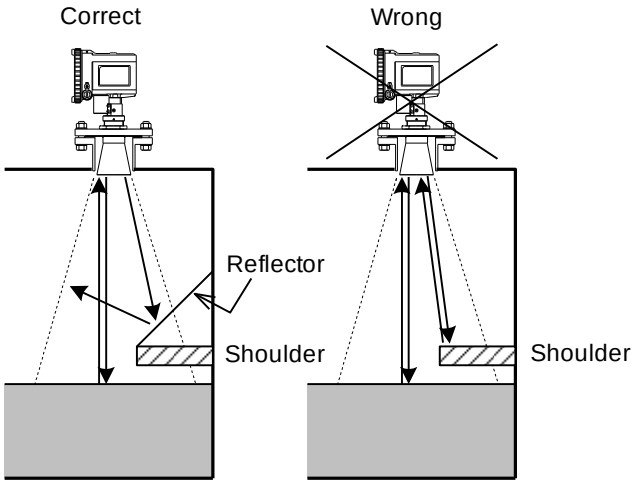
Mount the MD-10 so that the electric field is not in parallel with the axis of the obstacle which reduces the affect of the false echo emitted by it.





2.4.2 Shoulders and Struts

Install a reflector (flat metal plate) above the obstacle as shown in the figure.



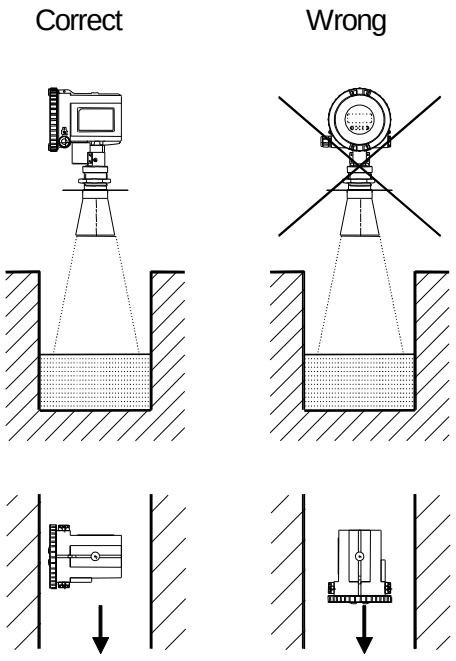
> **WARNING**
> Measuring range may be reduced if there are obstacles in the radar beam.

2.4.3 Center of the Tank

When the MD is installed at the center of the tank, measurement may be adversely affected or become unstable because of microwave side-lobes (non-main beams). Thus, center-of-tank installations should be avoided.

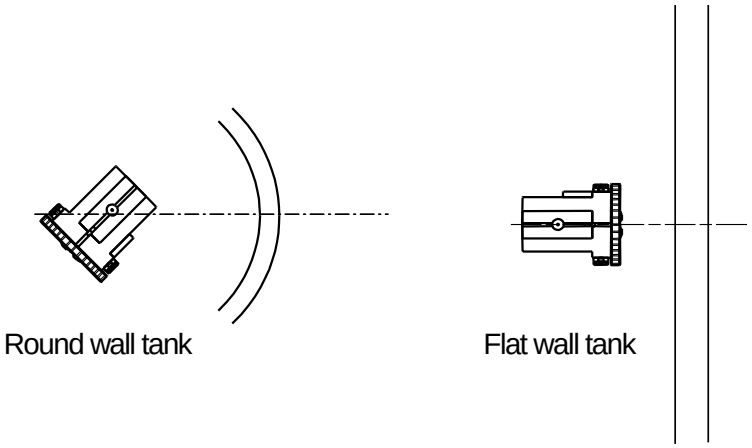
2.4.4 Narrow Channel

In case of channel applications, install the MD so the axis of the electric field is at right angle to the channel wall to avoid influences from edge reflections off channel walls and the liquid surface.



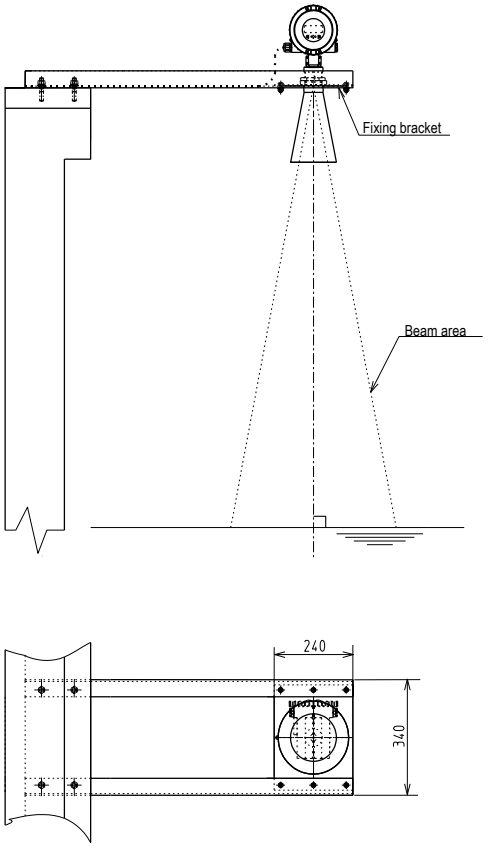
2.4.5 Tank Installation

For round tank applications, install the MD so the axis of the electric field is oriented 45 degrees to the tank wall to avoid influences from edge reflections off channel walls and the liquid surface.
For flat wall tank applications, install the MD so the axis of the electric field is perpendicular to the tank wall.



2.4.6 Open area Installation

This is an example of an open area installation.
In these types of applications, install the MRG so the axis of the microwave beam is perpendicular to the liquid surface.

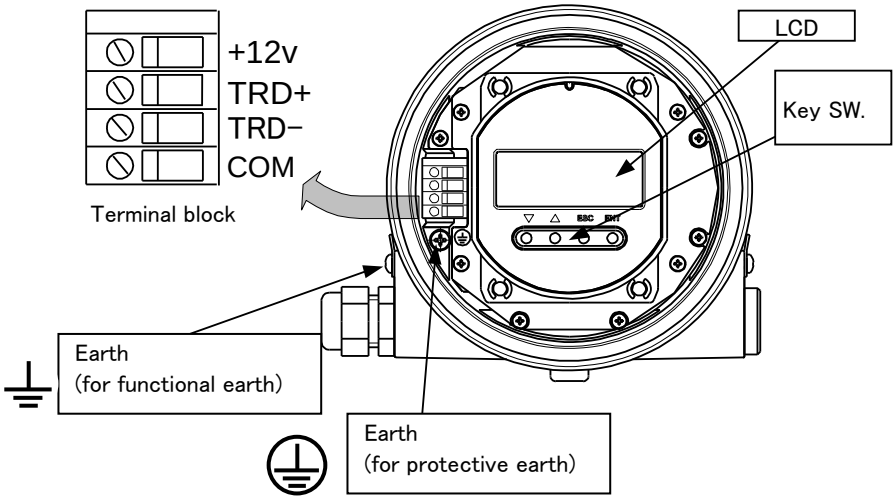


3 Electrical Installation

3.1 Connection of MD-10

⚠ CAUTION
Handle the front cover with care as the glass panel and gasket are removable. The glass panel and gasket are fixed in place when the cover is screwed onto the case and tightened. The gasket provides sealing between the housing and front cover and as such the front cover should be securely and firmly screwed onto the case.

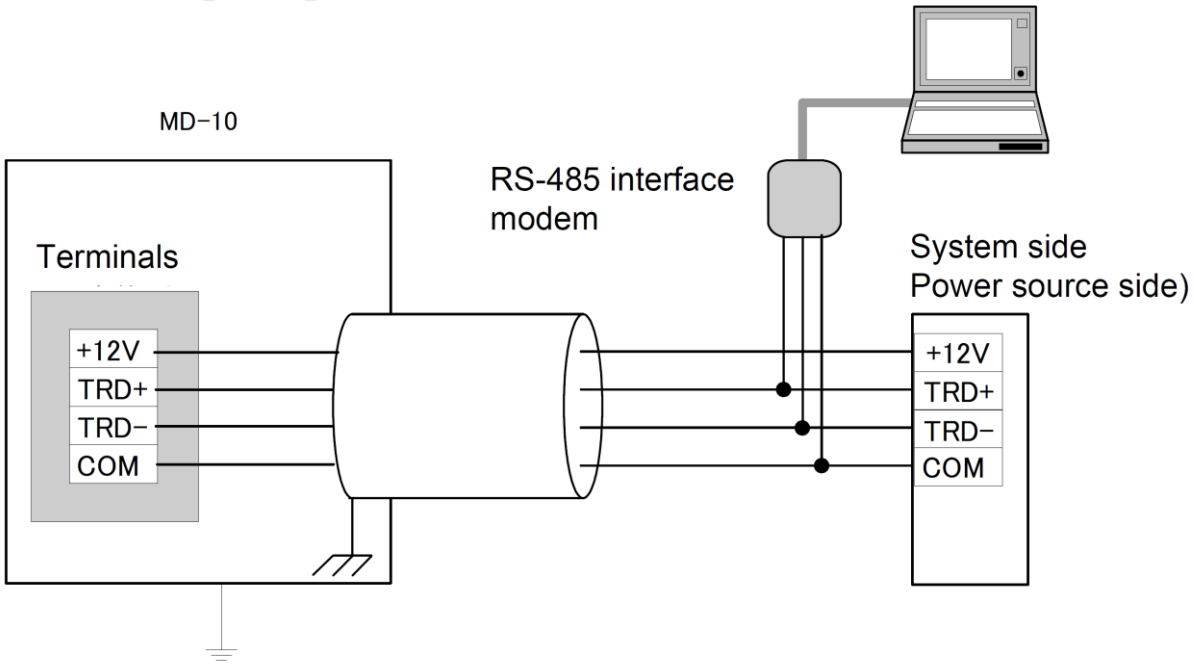
1. Unscrew and remove the front cover.
2. Pass the cable through the entry and connect it to the terminal block.
3. Connect the shield to the protective earth terminal.
4. Replace the front cover and firmly screw it onto the case.
5. Ground using the functional earth terminal near the cable entry.



An example of connecting the radio wave level meter MD-10 to a power supply, a personal computer for setting, etc. is shown below.

* We have confirmed the operation of the RS-485 interface with the following products.
  Manufacturer: CONTEC / Model number: COM-1PD (USB) H /
  Data transfer mode: Half-duplex

Connecting through PC with RS485 interface modem.



Example of system configuration

3.2 Cables

Cable	Use shielded 4-core cable for connection.
	Cross-sectional area of conductor is 0.2…2.5mm^2. (AWG24 …14)
Cable entry	2×M20×1.5 (cable diameter 10mm max.)

3.3 Load

The MD-10 RS-485 communication circuit is a half-duplex fail-safe bias circuit AC termination. (R = 120Ω, C = 0.1uF)
When terminating, connect a 120Ω terminating resistor.
The cable length should be within 200m regardless of whether it is terminated or opened.

3.4 Power supply

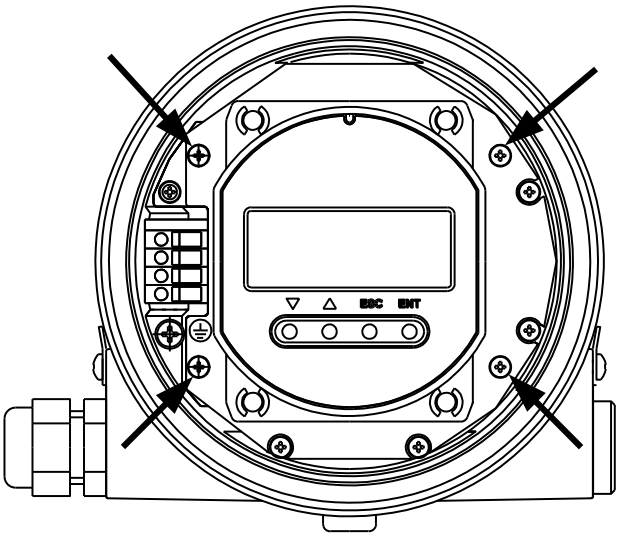
Power: 10 ... 16VDC
Current capacity: 200mA or more (recommended)
Note: An inrush current is generated when the product is turned on. Therefore, we recommend a current capacity of 200mA or more for the power supply to prevent voltage drop. For the current consumption during operation, see "6.1 Functional Performance Specifications". It changes depending on the presence or absence of a terminating resistor and the communication status.

3.5 Grounding

The terminal must be connected to earth ground prior to connection to any other equipment.

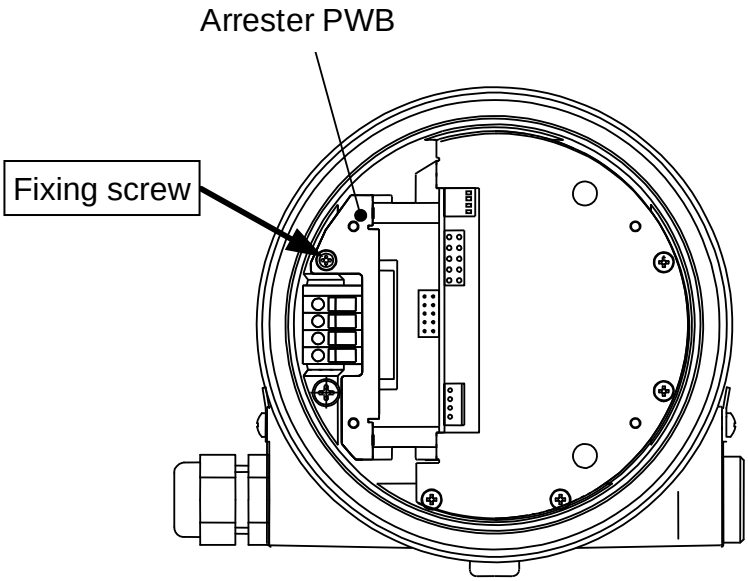
3.6 Arrester replacement

Step 1; Loosen the 4 screws indicated by the arrows in the schematic below and remove the LCD panel.



Step 2; Loosen the Arrester PWB fixing screw indicated by the arrow.

Step 3; Remove and replace the Arrester PWB.



Step 4; Tighten the Arrester PWB fixing screw.

Step 5; Tighten the LCD panel fixing screw.
Please be sure that the LCD panel is positioned correctly.

4 Configuration method

It is a simple task to configure the MD-10.
The MD-10 can be configured with:

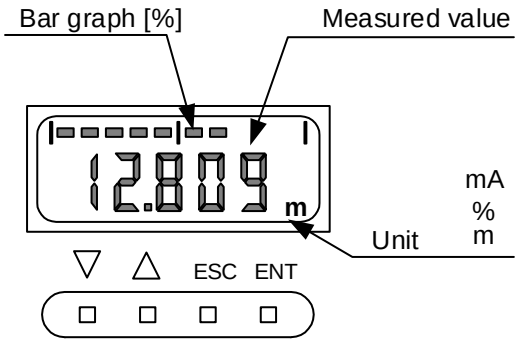
Display Panel & Key SW on MD-10
PC (Setup Software)

4.1 Display panel & Key SW.

4.1.1 Display

Bar graph, measured data and units are displayed during normal operation. Blinking display of the last measured value indicates that gauge is in search mode.

When the key SW is used in configuration mode, the menu number or registered data is displayed.

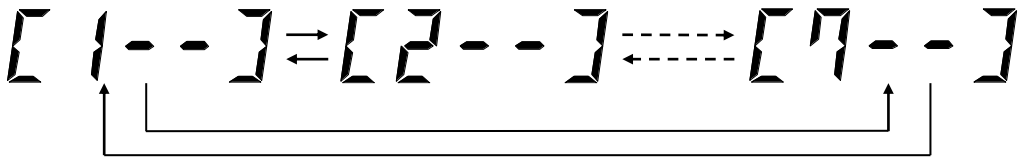


4.1.2 Key SW.

Setting data input method

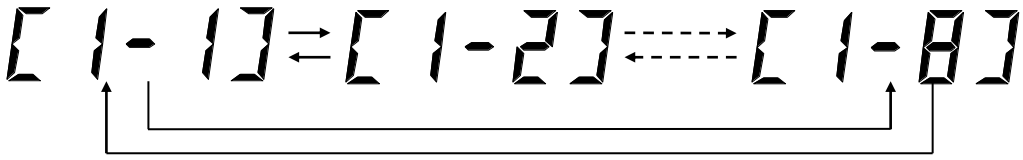
(1) Start the setting from the state where the measured value is displayed on the display.
(2) Press the ENT key to enter the setting mode.
(3) When you enter the setting mode, the following display will be displayed and the menu number will be displayed.
The display below indicates that entered into the menu number 1.

(4) Press the △ key to increase the menu number. You can reduce the menu number with the ▽ key. Please refer to the key parameter list for the menu contents.



(5) Confirm the menu number with the ENT key.
(6) The submenu number is displayed.

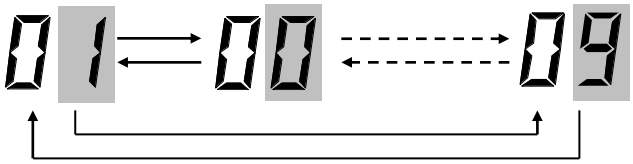
(7) Press the △ key to increase the submenu number. You can reduce the submenu number with the ▽ key.
The submenu number changes from 1 to a maximum of 9 depending on the menu item. Please refer to the key parameter list for the contents of the submenu.



(8) When the submenu you want to change is selected, press the ENT key.
(9) The current setting value is displayed.

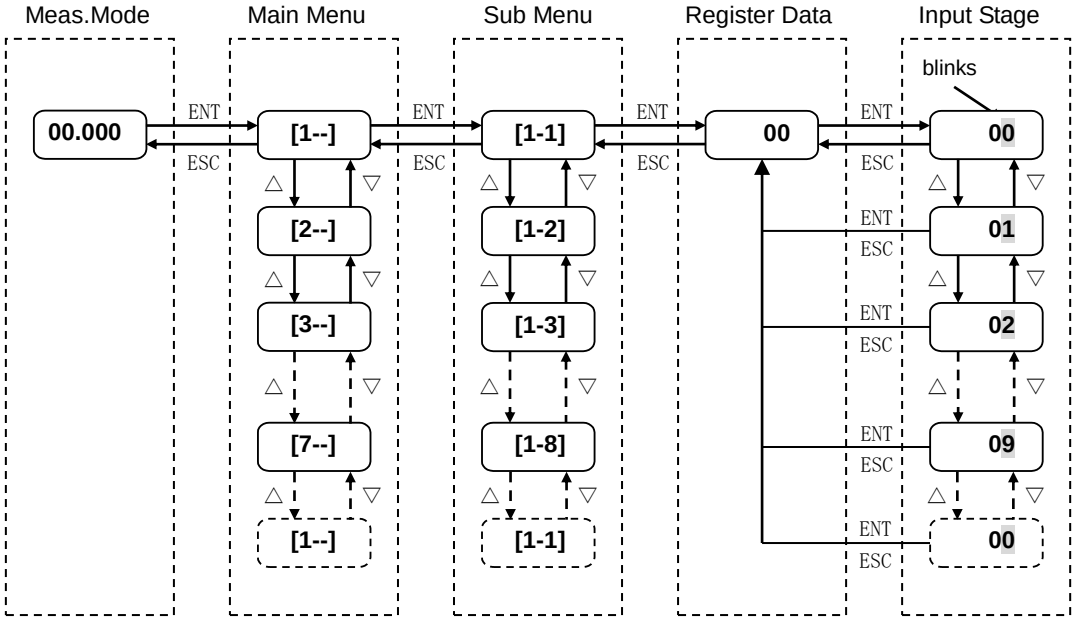
(10) If you want to change the setting value, enter the new setting value according to the key parameter list.
(11) When you press the ENT key, the last digit of the current value flashes.
You can change the number of the blinking digit.

(12) Enter the new setting value with the △ and ▽ keys.



(13) When the setting value to be entered is displayed, press the ENT key. Blinking moves to the next digit.
(14) After entering all the digits, press the ENT key to confirm the set value to be entered.
(15) Next, press the ESC key to return to the submenu number display.
(16) To change the set value of another submenu number, enter the submenu number you want to change with the △ and ▽ keys, and press the ENT key.
(17) Changing the set value is as explained above.
(18) After changing the submenu, press the ESC key to return to the submenu number display.
(19) Press the ESC key again to return to the menu number display.
(20) To change the settings of other menus, use the △ and ▽ keys to select the new menu number you want to set.
(21) After that, select the submenu and enter the setting value. The change of the setting value is as described above.
(22) Press the ESC key to exit the menu number display.
(23) Press the ESC key to return to the measurement mode and display the measured value.

The following flow shows a series of setting procedures.



4.1.3 Examples

When R-constant is set to 6.275m from the default value.

Step	Key	Display	Description
1	—	7.956 m	Measuring level(m) (Normal operation mode)
2	ENT	[1--]	Main menu number (Configration mode)
3	ENT	[1-1]	Sub menu number
4	△	[1-2]	Changing submenu number
5	△	[1-3]	Changing submenu number
6	△	[1-4]	Changing submenu number
7	△	[1-5]	Changing submenu number
8	ENT	10.000	Default value
9	ENT	10.000	"0" blinks
10	△× 5	10.005	× 5 : Push 5 times
11	ENT	10.005	Press ENT to confirm the value
12	△× 7	10.075	× 7 : Push 7 times
13	ENT	10.075	Press ENT to confirm the value
14	△× 2	10.275	× 2 : Push 2 times
15	ENT	10.275	Press ENT to confirm the value
16	▽× 4	16.275	× 4 : Push 4 times
17	ENT	16.275	Press ENT to confirm the value
18	▽	06.275	× 1 : Push 1 times
19	ENT	06.275	Press ENT to confirm the value
20	ESC	[1-5]	Sub menu number
21	ESC	[1--]	Main menu number
22	ESC	4.231	Measuring level(m) (Normal operation mode)

4.1.4 Parameter instructions

[1--] CONFIGURATION Settings

[1-1] Output Parameter: LCD display

Parameter	Value	Description
0 (Default Value)	Level	Level value from target
1	Ullage	Distance between measuring reference point and target
2	Volume (%)	Volume rate value (%)
3	Invalid	Invalid setting for MD-10
4	Amplitude	Signal strength (dB)
5	Max. Volume	Max value of volume settings

[1-2] Antenna type

Parameter	Value
0	4 inch cone
1	6 inch cone
2	8 inch cone
3	Invalid setting for MD-10
4	Invalid setting for MD-10
5	8 inch pipe
6	6 inch pipe
7	4 inch pipe
8-15	Do not select

[1-3] Measuring Unit

Parameter	Value	Description
0	m	Sets display in Metric units

[1-4] G parameter （distance between flange reference point and measuring reference point）

Parameter	Default Value	Description
-99.999-99.999	0.000	

[1-5] R parameter （Measurement range）

Parameter	Default Value	Description
0.000-99.999	20.000	

[1-6] C parameter （Below measurement range）

Parameter	Default Value	Description
0.000-99.999	0.300	

[1-7] H parameter （Deadband）

Antenna type	Parameter	Default Value	Description
4 inch cone	0.103-99.999	0.103	[m]
6 inch cone	0.223-99.999	0.223	
8 inch cone	0.343-99.999	0.343	

Note: When using a 4 inch pipe antenna, set 0.103 [m] or more.

[1-8] Offset parameter for LCD level values

Parameter	Default Value	Description
-99.999-99.999	0.000	[m]

Note: Offset affects LCD display only and does not affect analog output or other values.

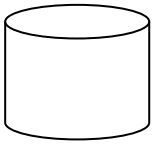
[2--] Analog Output (Invalid Settings for MD-10)

[3--] Volume Setting

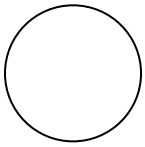
[3-1] Linearization Selection

Parameter	Value	Description
0 (Default Value)	Not Calculated	
1	Vertical Cylinder	
2	Spherical	
3	Horizontal Cylinder	
4	User Tank Table	

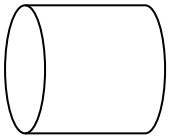
Tank Configurations



1: Vertical Cylinder



2: Spherical



3: Horizontal Cylinder

[3-2] Linearization Point Number

Parameter	Default Value	Description
0-20	0	Input required no. of points for table

[3-3] Level point （ [300] ~ [319] ）

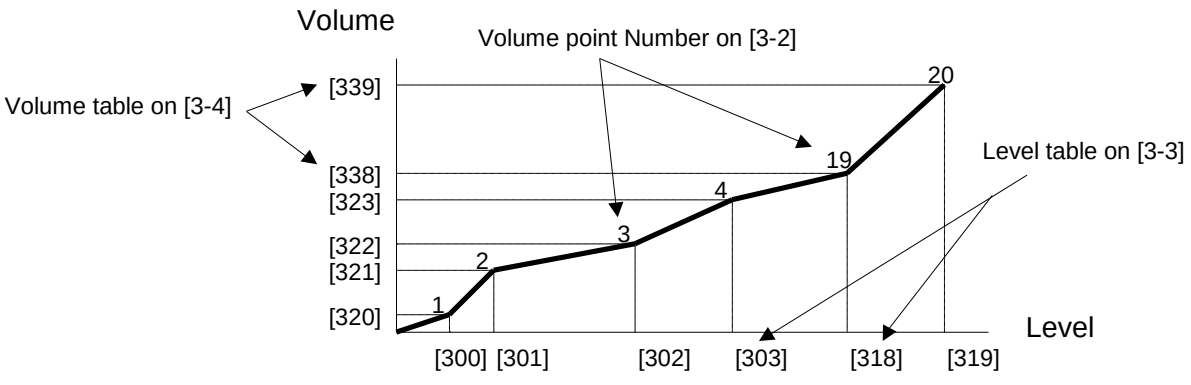
Parameter	Default Value	Description
-99.999-99.999	0.000	[m]

[3-4] Volume point （ [320] ~ [339] ）

Parameter	Default Value	Description
0-99999.99	0.00	

Display will be converted to the volumetric unit setting under [3-9].

If you create a volumetric table incorporating settings [3-2] ~ [3-4], you can produce a line chart such as that shown below which enables you to quickly calculate level and volumetric values.



Level and Volume correlation on the user tank table

[3-5] Delete all tables
Setting “1” clears table. (Delete all)

[3-6] Diameter of the tank

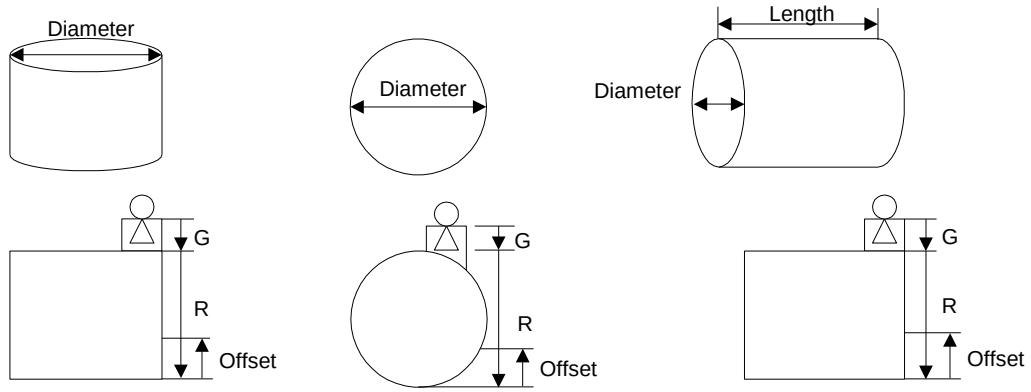
Parameter	Default Value	Description
0.000-10.000	1.000	[m]

[3-7] Length of the tank

Parameter	Default Value	Description
0.000-20.000	1.000	[m]

[3-8] Offset level

Parameter	Default Value	Description
-99.999-99.999	0.000	[m]



1: Vertical Cylinder 2: Spherical 3: Horizontal Cylinder

[3-9] Volume unit

Parameter	Value
0	m^3

[4--] Calibration

[4-1] ~ [4-2] Invalid setting for MD-10

[4-3] Offset Calibration

Parameter	Default Value	Description
-1.000-1.000	0.000	[m]

[4-4] Span Calibration

Parameter	Default Value	
0.9000-1.1000	1.0000	

[5--] Advanced Setting

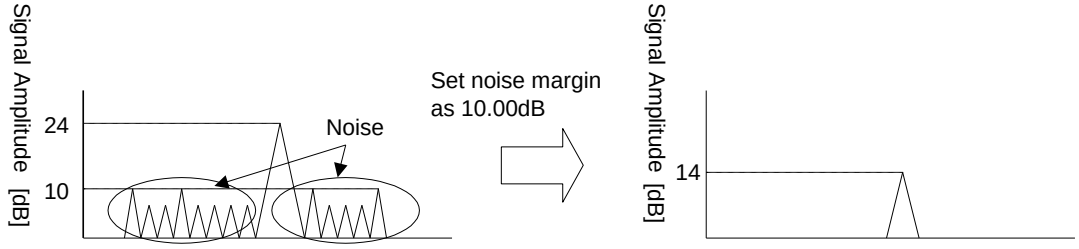
[5-1] Averaging Time

Parameter	Default Value	Description
1-120	10	Measuring value is averaged in accordance with [sec] setting

[5-2] Noise Margin

Parameter	Default Value	Description
0-100.00	3.00	Noise is eliminated in accordance with [dB] setting

When noise level is high, noise can be masked by attenuating the signal gain.
Setting other than the default value may cause unstable measurement.



[5-3] Search Delay

Parameter	Default Value	Description
0-255	120	Time delay after loss of echo until restart in accordance with [sec] setting.

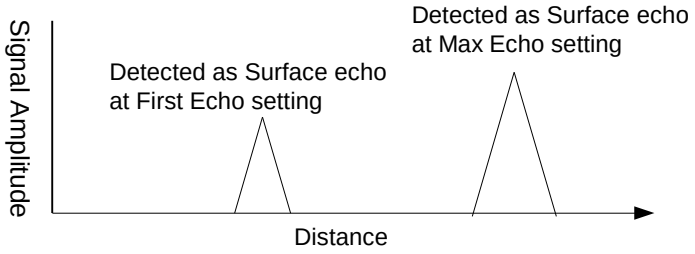
[5-4] Alarm Delay (Invalid setting for MD-10)

[5-5] Bottom Window (Invalid setting for MD-10)

[5-6] First Echo Flag

Parameter	Value	Description
0	Max Echo	This value cannot be used. (Invalid setting for MD-10)
1	First Echo	First echo defined as surface echo

Only setting “1” (First Echo) can be selected.



[5-7] Double Bounce Check ON/OFF

Parameter	Value	Description
0	ON	In case of water level rose rapidly, it may be detect wrong echo. This function prevents such wrong detection. Setting “0” in “Spiral Search Mode” (Menu code:[5-8]), this function validates.
1 (Default Value)	OFF	Setting “1”, this function invalidates.

[5-8] Search Type 1) 2)

Parameter	Value	Description
0	Linear 2 Search	Search surface echo from the sensor position towards the end of the detection range. When surface echo detected in the same position two times, liquid level position is determined.
1	Linear 1 Search	Search surface echo from the sensor position towards the end of the detection range. When surface echo detected first time, liquid level position is determined.
2	Spiral Search	Search surface echo nearby the last detected position at startup.

Note1: Select the search type according to the installation environment. See section [5.9 Select search type] for details.
Note2: See section [5.10 Key Parameter List] for Default Value.

[6--] Noise

[6-1] Noise table number

Parameter	Default Value	Description
0-10	0	Input required no. of points for table When value is ‘0’, [6-2][6-3] cannot be set.

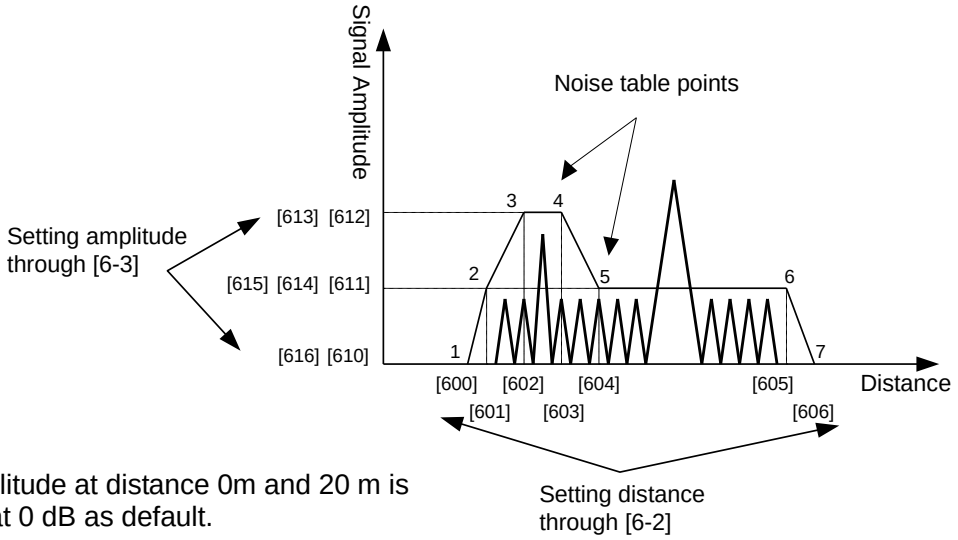
[6-2] Noise table （ [600] ~ [609] ）

Parameter	Default Value	Description
-99.999-99.999	0.000	Noise position by distance [m]

[6-3] Amplitude threshold （ [610] ~ [619] ）

Parameter	Default Value	Description
0-100.00	0.00	[dB]

If you create a noise table incorporating settings [6-1] ~ [6-3], you can produce a line chart such as that shown below which enables you to eliminate lower signal strength noises below the line.



Amplitude at distance 0m and 20 m is set at 0 dB as default.

[6-4] Delete All

Parameter	Value	Description
0	Do not delete	
1	Delete All	Setting “1” clears noise table

[7--] Other

[7-1] Password: **not normally used**

[7-2] Re-search

Setting “1” executes surface echo re-search.

[7-3] User Reset

Setting “1” initializes set value. (factory default setting)
Be careful when using this function.

[7-4] Error Status

Indication	Error status
E-00	No error.
E-01	(not allocated)
E-02	Internal Error. (PCB) Critical Error. Please contact service.
E-03	Internal Error. (Microwave Device) Critical Error. Please contact service.
E-04	Noise Table Error. Incorrect setting on noise table. Set up correctly.
E-05	Tank Table Error. Incorrect setting on noise table. Set up correctly.

[7-5] Software Version

[7-6] Hardware Reset

Setting “1” executes hardware reset.

4.2 Key Parameter List

Title	Menu Code	Parameters	Sub Menu Code	Sub Parameter	Lowest Menu Code	Default Value	Input Value
CONFIGURATION	[1--]	Output Parameter	[1-1]			0(Level)	0: Level 1: Ullage 2: Volume(%) 3: Invalid 4: Amplitude 5: Max. Volume
		Antenna Type	[1-2]			-	0: 4 inch Cone Antenna 1: 6 inch Cone Antenna 2: 8 inch Cone Antenna 3: Invalid 4: Invalid 5: 8 inch Pipe Antenna 6: 6 inch Pipe Antenna 7: 4 inch Pipe Antenna 8-15: Do not select
		Meas. Unit	[1-3]			0(meter)	0: meter
		G	[1-4]			0.000	-99.999 to 99.999m
		R	[1-5]			20.000	0 to 99.999m
		C	[1-6]			0.300	0 to 99.999m
		H 4 inch Cone	[1-7]			0.103	0.103 to 99.999m
		6 inch Cone				0.223	0.223 to 99.999m
		8 inch Cone				0.343	0.343 to 99.999m
		Offset of level value on LCD	[1-8]			0.000	-99.999 to 99.999m
ANALOG	[2--]	Invalid					
VOLUME	[3--]	Linearisation Selection	[3-1]			0 (Not Calculate)	0: Not Calculate 1: Horizontal Cylinder 2: Spherical 3: Vertical Cylinder 4: User Tank Table
		Linearisation Point Number	[3-2]			0	0 to 20
		Volume table	[3-3]	Level Point	[300]-[319]	0.000	-99.999 to 99.999
		Volume table	[3-4]	Volume Point	[320]-[339]	0.00	0.00 to 99999.99
		Delete All	[3-5]			-	Execute by 1
		Diameter	[3-6]			1.000	0.000 to 10.000m
		Length	[3-7]			1.000	0.000 to 20.000m
		Offset Level	[3-8]			0.000	-99.999 to 99.999
		Volume Unit	[3-9]			0(m3)	0: m3

Title	Menu Code	Parameters	Sub Menu Code	Sub Parameter	Lowest Menu Code	Default Value	Input Value
CALIBRATION	[4--]	-	[4-1]	Invalid			
		-	[4-2]	Invalid			
		Offset Calibration	[4-3]			0.000	-1.000 to 1.000m
		Span Calibration	[4-4]			1.0000	0.9000 to 1.1000
ADVANCE	[5--]	Averaging Times	[5-1]			10	1 to 120sec
		Noise Margin	[5-2]			3.00	0 to 100.00dB
		Research Delay	[5-3]			120	0 to 255sec
		-	[5-4]	Invalid			
		-	[5-5]	Invalid			
		First Echo Flag	[5-6]			1 (First echo)	1: First echo
		Double Bounce Check ON/OFF	[5-7]			1 (OFF)	0: ON 1: OFF
		Search Type	[5-8]			see Note1	0: Linear 2 Search 1: Linear 1 Search 2: Spiral Search
NOISE	[6--]	Noise Table Number	[6-1]			0	0 to 10
		Input	[6-2]	Noise Table	[600]-[609]	0.000	-99.999 to 99.999m
			[6-3]	Amplitude Threshold	[610]-[619]	0.00	0 to 100.00dB
		Delete All	[6-4]			-	Execute by 1
ELSE	[7--]	Password	[7-1]			-	not normally used
		Re-Search	[7-2]			-	Execute by 1
		User Reset	[7-3]			-	Execute by 1
		Error Status	[7-4]			-	
		Software Revision	[7-5]			-	
		Hardware Reset	[7-6]			-	Execute by 1

Note1: Default value of Search Type in software V2.22 or later is “1” (Linear 1 Search). Default value of Search Type in software V2.21 or earlier is “0” (Linear 2 Search).

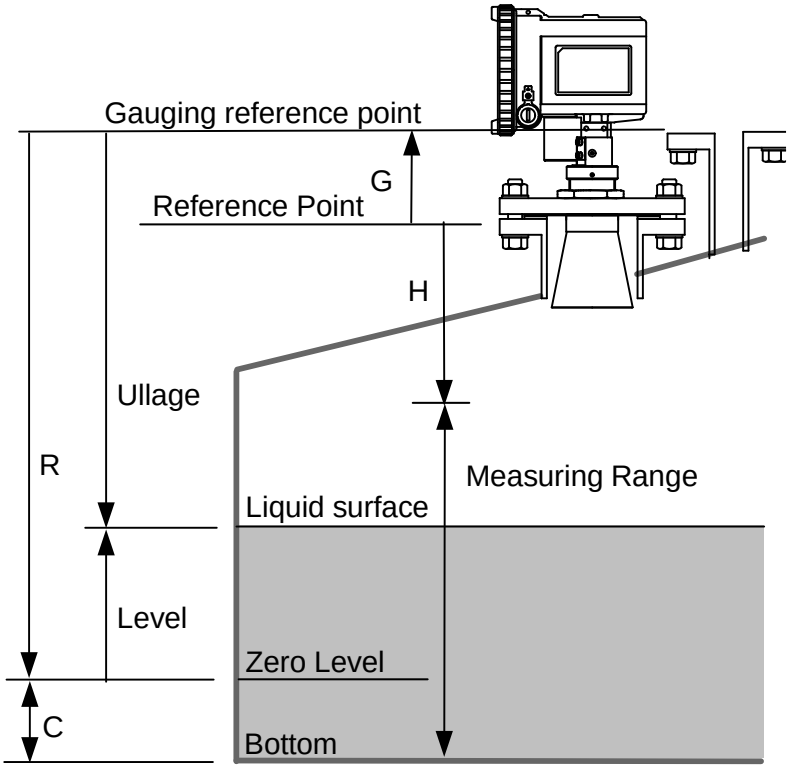
5 Configuration

5.1 Basic settings

Set up the following parameters

- Output Parameter	Select measurement value displayed on the LCD.
- Meas. Unit	Select measurement unit, meter.
- Antenna Type	Select type of antenna.
- G	Set the distance from Gauging reference point to Reference point.
- R	Set the distance from Reference point to level zero.
- C	Set the distance from level zero to bottom of tank. ('C' is normally set to '0'. If it is necessary to measure negative level, please set the distance.)
- H	Set the distance from ref. point to measurement range. (see 5.2.1)

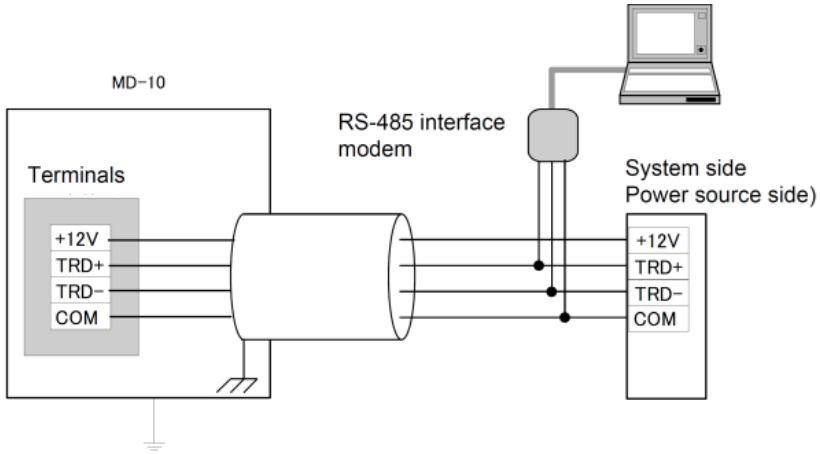
Parameters of tank dimensions are optimized for your application.



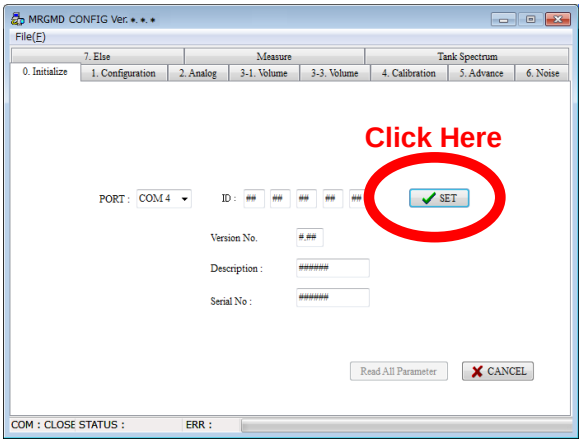
Configuration with PC software

- PC connection
  PC configuration software can also be used for commissioning.

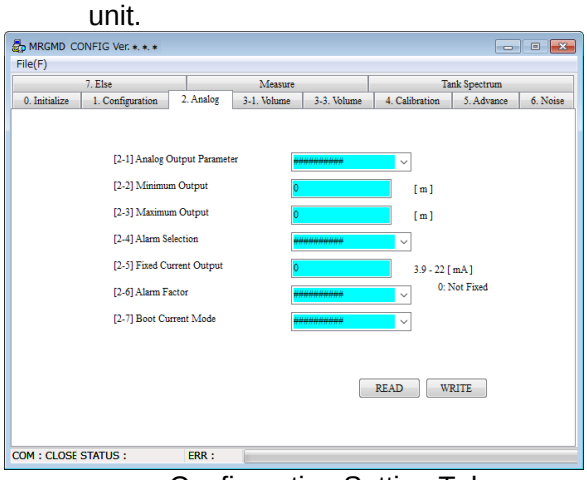
1) Connect RS485 modem as shown below.



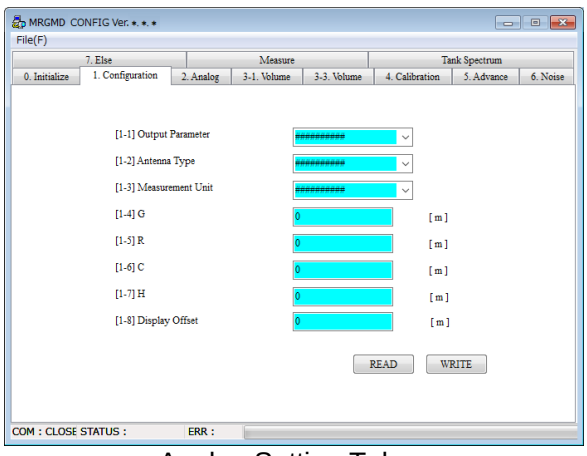
2) Open the software. Enter RS485 modem port number and click the “set” button. When communication is completed successfully, ID, Version No and Product Name will appear in the boxes.



3) By selecting other tabs such as the sample below, you can set any parameter. Any action requires “READ” parameters from the main unit, before changing values (pressing the “ENTER” key may be required to set value changes) and clicking “WRITE” to the main unit.



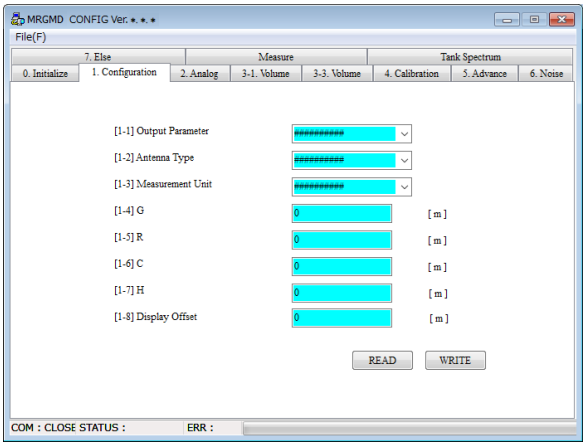
Configuration Setting Tab



Analog Setting Tab

5.2 Negative level point measurement

Value 'C' defines below zero level. When C values are set, the LCD or PC communication will show negative values.



5.3 Avoiding disturbance echoes.

There are two ways to avoid the disturbance echo problem.

5.3.1 Dead band (="H")

When there are disturbance echoes in the near zone such as stairs at the top of the tank, the gauge may capture and interpret these echoes as coming from the liquid surface.
Set up "H" to avoid this problem.
All echoes within this area would be outside of the measuring range and ignored.

5.3.2 Noise Table

If there are disturbance echoes in the effective measuring range and the gauge tracks such echoes, set up "Noise Table" parameters.
You can adjust the threshold level for sections of the measurement range with these parameters.
"Noise Table" parameters are comprised of ullage points and threshold values. Up to 10 points of values can be established respectively with linear interpolation between points. (Amplitude at distance 0m and 20 m is set at 0 dB as default.)
If disturbance echoes are tracked, you should first check the ullage and the amplitude level with the LCD display or with the configuration software.

To create a noise table, follow the steps below.

1) Enter Menu code [6-1], then set the noise table number (maximum10 points).

2) Enter Menu code [6-2], and set distance parameters into the data field in accordance with selected numbers. (For example, if "10" is set at [6-1], you will need to set data [600]~[609] for distance values.)

3) Set distance data for [600], and push ENT to complete the entry. Similarly set distance values for [601]…[609].

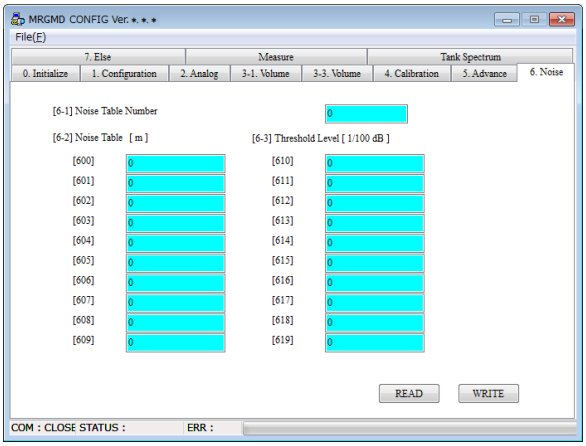
4) After completing input of distance values, the next step is entering amplitude values.

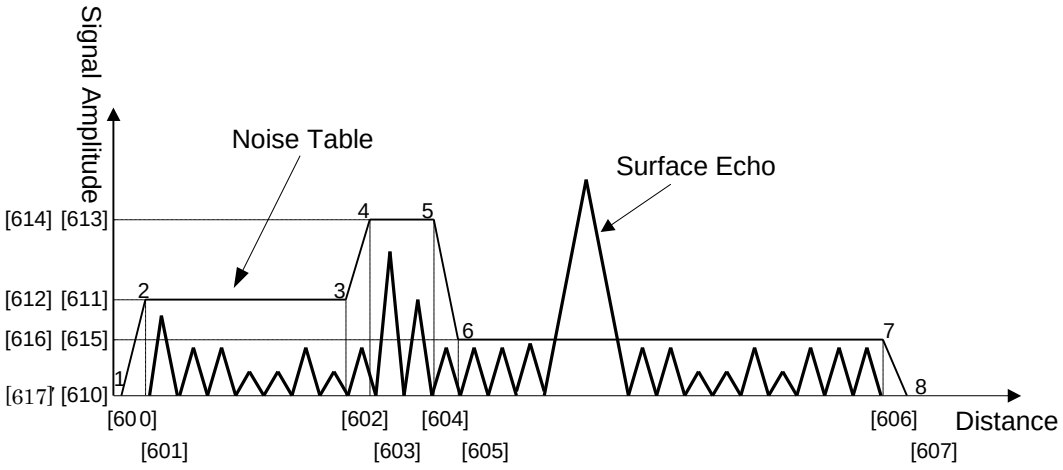
5) Return to the sub-menu by clicking the ESC key. Then enter Menu code [6-3] and set threshold level parameters into the data fields in accordance with selected numbers. For example, if “10” is set at [6-1], you will need to set data [610]~[619] for amplitude values.)

6) Amplitude points must correlate to the distances defined under [6-2]. Select table address （ex. [610] and enter amplitude data, then click ENT to complete the entry. Similarly, set amplitude data for [611]…[619].

7) After setting all data, return to the Sub-Menu by clicking the ESC key of the LCD panel. When returning to the main menu, click ESC again. Click ESC again to go to the measurement mode.

Note: When using PC configuration software, enter all data into the following menu then click “WRITE”.
Setting of distance data must be in ascending order, that is, from shortest to longest distance. Noise table error and noise table malfunction will occur if settings are mis-ordered. Error status will appear under [7-3]

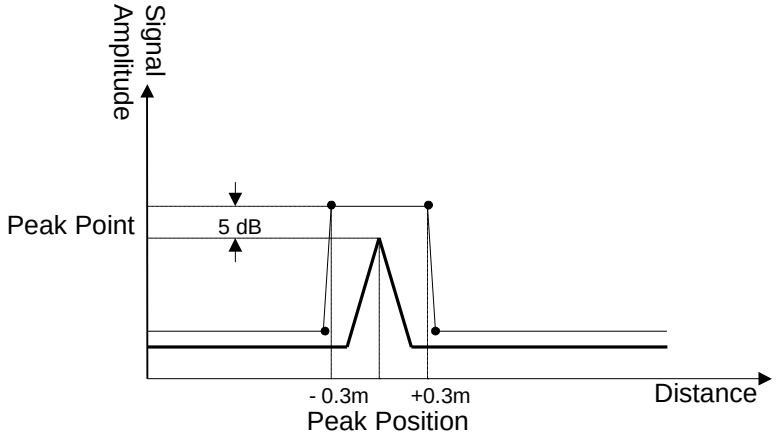




Example of a noise table is shown above. All noise lower than the noise threshold line will be ignored.

5.3.3 One point advice regarding noise table input procedure

It is necessary to provide some allowance around the echo peak and a margin of threshold for noise amplitude. These are +-0.3m and +5dB respectively.
Noise Table point “n” must also be nearer than next Noise Table point “n+1”. If this rule is not maintained, noise table errors will occur and this function will become invalid.

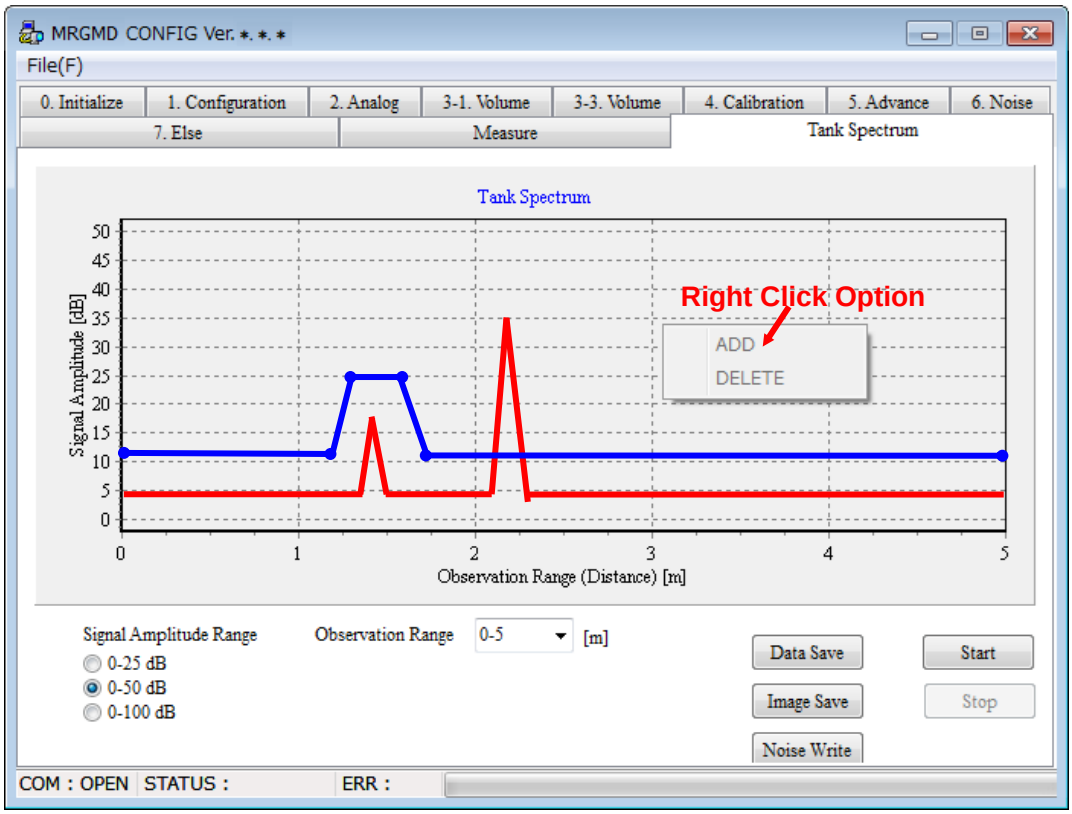


Also by using the PC configuration software, you can add or change the position of the noise table with a right click.

1) On the “Tank Spectrum” tab, when the “START” button is clicked, you may view the red line wave form data from the main unit as shown below.

2) If you would like to set the noise table manually, right click and select “ADD” at designated points for the new table. Also the table (points) can be moved by a left-click and dragging.

3) After the noise table is set, click the “Noise Write” button to complete.

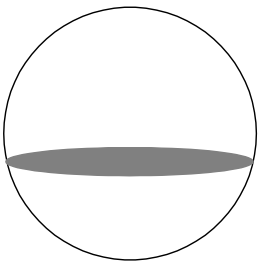


5.4 Volume calculation

There are 4 types of volume calculations which are set up by the Linearization Selection parameter.

- Spherical Tank

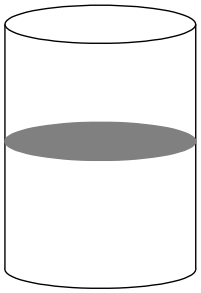
  Volume is calculated from diameter, offset level and measured level. Diameter is the diameter of the sphere and offset level is the measurement level compensation factor.



- Vertical Cylinder Tank

  Volume is calculated from diameter, offset level and measured level. Diameter is the diameter of the tank and offset level is the measurement level compensation factor.

  .



- Horizontal Cylinder Tank

  Volume is calculated from diameter, length, offset level and measured level. Diameter is the diameter of the tank and offset level is the measurement level compensation factor. Length is the horizontal length of tank as shown.

- Tank Table

  Set up Linearization Point Number.
  It is possible to set up 20 points each for level and volume respectively in the Tank Table which are linearly interpolated between points.
  More than two points must be input to set up the Tank Table. (Tank Table Error)
  Four volume units can be selected - cubic meter, gallons, barrels and cubic feet.

To create the volume table, follow the steps below.

1) Select “4” for menu code [3-1].

2) Set the required number of point settings for menu code [3-2]. (Max 20 points.)

3) Enter menu code [3-3]. Select point and set level parameters into the data field in accordance with the selected numbers. (e.g. when setting 20 points at [3-2], [300]~[319] can be set.)

4) Input Level data then click ENT to enter values for [300] ~ [319].

5) After completing input of Level data, the next step is entering the Volume data.

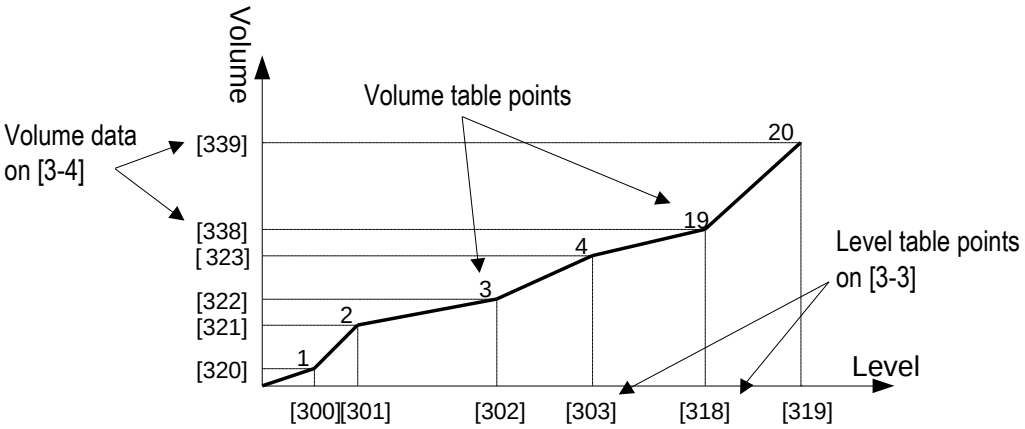
6) Return to the sub-menu by clicking the ESC key. Then enter Menu code [3-3], and set the volume parameters into the data fields in accordance with the selected numbers. (e.g. when setting 20 points” at [3-2], [320]~[329] can be set.)

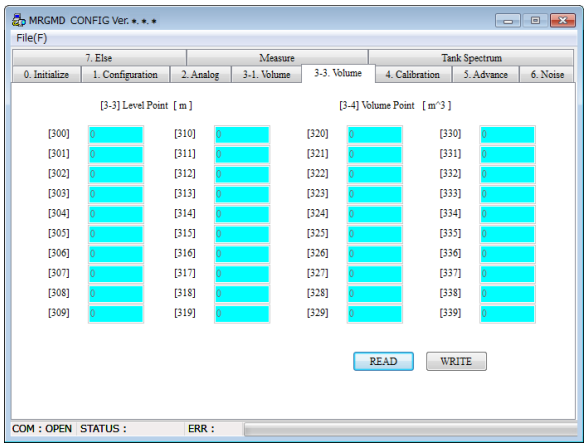
7) Volume point must correlate to the level data defined under [3-2]. Select table address (ex. [320]), enter amplitude data and click ENT to complete entry. Similarly, enter data for [321]…[329].

8) After setting all data, return to the Sub-Menu by clicking the ESC key on the LCD panel. To return to the main menu, click ESC again. Click ESC once more to go to the measurement mode.

Note: When using PC configuration software, enter all data in the following menu then click "WRITE".

Setting of distance data must be in ascending order, that is, from shortest to longest distance. Volume table error and volume table malfunction will occur if settings are mis-ordered. Error status will appear under [7-3]





5.5 Measuring value compensation

Offset level from reference point and scale factor are adjusted under [4-3] (offset) and [4-4] (scale factor).
In addition, span correction may be required when the level meter is installed with an angle. In this case, it is possible to correct with the setting item [4-4]. For example, if it is installed diagonally, the actual distance will be longer, so you can correct it by entering a number smaller than "1". This value is typically set to 1.000

5.6 Other

5.6.1 Reset

Initializes all setting values. When the setting item [7-3] is set to “1”, all the setting items are reset to Initialize all setting values

5.7 Pipe antenna setting

5.7.1 Overview

The following instructions are applicable when the MRG-10 is used in the pipe mode (hence referred to as “pipe antenna”).
Advantages and disadvantages of the pipe antenna are as follows.

1) Advantages
Existing pipe can be used as the pipe antenna.
Even if obstacles are located near to the beam area, measurement will not be affected.
Measuring coverage can be extended to low dielectric constant liquids.

2) Disadvantages
Material of the pipe (metal, etc.) must be that which can contain and channel microwaves.
Dirty, dusty conditions inside of the pipe may cause noise disturbance echoes which decrease accuracy.

5.7.2 Pipe antenna specifications

Specifications	
Antenna size	4B Cone antenna
Measurable Range	10 m
Accuracy	±10 mm (< 5 m) ±20 mm (< 10 m)
Pipe specification (metal pipe only)	ID 100mm
Max hole for air vent（per 1 m）	ϕ5 mm / 2pcs

5.7.3 Parameter setting

5.7.3.1 Antenna Type（Menu code:[1-2]）

Select the 4 inch pipe antenna.

5.7.3.2 Span calibration

• As the speed of microwaves propagated inside of pipes differ from the speed of microwaves when propagated in free spaces, a compensating coefficient must be input in the “Span Calibration” parameter (Menu code, [4-4]).

• “Span Calibration” values are derived from the inner diameter of the pipe. The following table is one example.

Inner Pipe Dia [mm]	Span Calibration
107	0.9507

• When span calibration value (‘F’) is unknown, ‘F’ can be calculated from two points - reference level value (X) and measured level value (Y) - using the following equation.

$$F = (Y_{High} - Y_{Low}) / (X_{High} - X_{Low})$$

F : Span calibration value
X_{High}: High reference level value
X_{Low} : Low reference level value
Y_{High}: High measured level value
Y_{Low}: Low measured level value

5.7.3.3 Offset compensation

・Offset setting may be required using Menu code: [4-3].
・Offset value is derived from the difference in measured level and reference level at 1 point.

5.7.4 Considerations

• Pipe material should be metal.
In cases of existing pipes of concrete or PVC material instead of metal, span calibration may not be required as their low dielectric constants allow transmission of microwaves.
However when wet, such pipe materials exhibit high reflectivity characteristics from wetted surfaces.
This affects accuracy and span calibration becomes necessary. Because of such changes in characteristics under wet conditions, non-metal pipe applications are not recommended.

• Air vents (10mm dia.) for pressure release should be incorporated and located above the tip of the antenna.

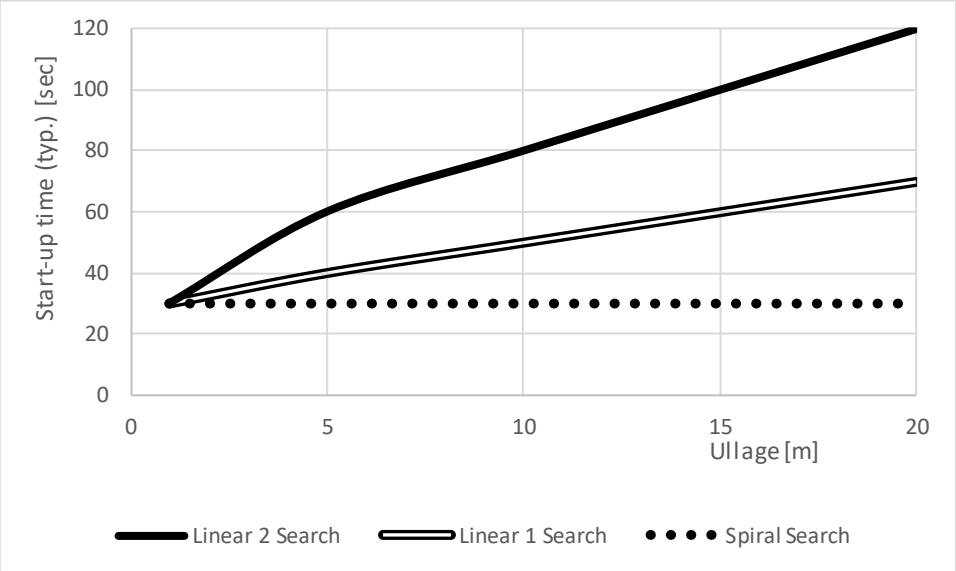
5.8 Select search type

5.8.1 Search type setting (Menu code:[5-8])

Set "Search Type" appropriately according to installation environment of the device. The start-up time (time from turning on the power of the device to outputting measured value) changes depending on the setting. Use the figure below as a reference when setting Intermittent operation cycle.

Setting (Search method)	Time for Quick Start-up (typ.)
[0] Linear 2 Search	Not Recommended 1) (80sec./10m) (120sec./20m)
[1] Linear 1 Search	Normal 1) (50sec./10m) (70sec./20m)
[2] Spiral Search	Best 2) 3) (30sec. max)

Note1: When the liquid surface is far, start-up time is longer.
Note2: Start-up time is short at all measurement ranges.
Note3: Only if the Menu code [5-7] is set to 1



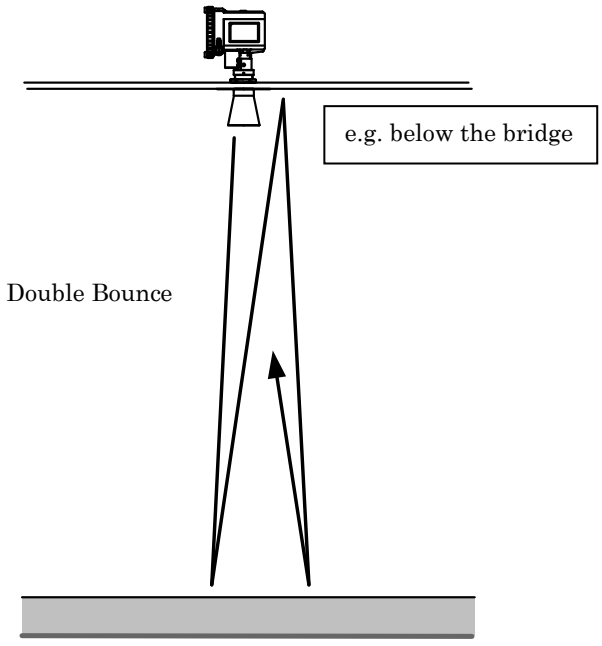
Setting (Search method)	Performance of detect level	Feature (○:Merit △:Demerit)	Usage and Install environment
[0] Linear 2 Search	Normal	○Less susceptible to “Double Bounce” 1) △May be detect near Noise	・Continuous Operation ・”Double Bounce” occur ・Liquid surface is near
[1] Linear 1 Search	Not Recommended	○Suitable for system of long cycle Intermittent operation △May be detect near noise △May be detect “Double Bounce” 2)	・Continuous Operation / Intermittent operation (10 minutes or more cycle) ・”Double Bounce” does not occur
[2] Spiral Search	Normal	○Suitable for system of short cycle Intermittent operation ○Less susceptible to near noise ○Less susceptible to “Double Bounce” when Menu code [5-7] set to 0 3) △If intermittent operation cycle exceeds 10 minutes, liquid surface can not be track at the next startup in case of water level rose rapidly. △When Menu code [5-7] set to 0, start-up time is longer. 3)	・Intermittent operation (10 minutes or less cycle) ・”double bounce” does not occur (Only if the Menu code [5-7] is set to 1)

When ”Double Bounce” occur, It may be detected incorrectly.

Note1: "Linear 2 Search" is search method that is less susceptible to “Double Bounce” because of emphasizing liquid surface detection performance.

Note2: When using "Linear 1 Search", “Double Bounce” may be detected because of emphasizing start-up time. It is recommended using under environment where “Double Bounce” does not occur.

Note3: "Spiral Search" includes a function "Double Bounce check" to suppress the influence of "Double Bounce". The function is set default value 1(OFF) because of emphasizing start-up time. When using the function "Double Bounce check", Menu code [5-7] set to 0(ON). Then start-up time is longer instead of being less susceptible to "Double Bounce".



6 Technical Information

6.1 Overview Specification

Measuring Principle	Pulse Radar	
Operating frequency	5.8 GHz	
Half-power beam width (-3dB)	4 " Cone antenna: 34 deg 6 " Cone antenna: 22 deg 8 " Cone antenna: 17 deg	
Transmission Power	35µV/m max. at 3 m	
Measuring range	20 m	
Display	5-digit LCD and bar graph (Refresh interval 1sec)	
Key switch	4 keys for configuration	
Selectable indication	Ullage / Level / Volume / Signal amplitude / Volume Max	
Unit	Level, Ullage m Volume % Amplitude dB	
Update time	1sec	
Start-up time	Refer to Chap. 5.8	
Digital Output	Signal	RS485 Half-Duplex 4 core-shielded cable φ10mm Up to 200m
	Protocol	Original open-protocol 1200bps
	Resolution	1mm
Averaging time	1..120 s	
Measured error	±10 mm *1) *2) Stilling pipe application: ±10 mm (< 5 m) / ±20 mm(< 10 m)）	
Linearity	±10 mm *1) *2)	
Repeatability	±1 mm *1) *2)	
Tracking speed	±0.4m/s as max.	
Ambient temperature effect	±0.01%FS / 10 K (FS=20m)	
Power Supply voltage	10～16 VDC	
Power consumption	3.2mA (@12V DC / Temp. 25±5℃) typ. 3.5mA (@12V DC / Temp. 25±5℃) max. 5.3mA (@10～16V DC / All Temp. range) max.	

*1) Free-space reflection from flat metal surface, ambient temperature 25 °C (77 °F), atmospheric pressure.
*2) Distance up to 0.5m is Near dead zone area.

6.2 Measuring range

Antenna type	Di-electric Constant	
	$\varepsilon_r \fallingdotseq 80$ (water)	
	Calm Surface	Disturbed Surface
4B Cone Antenna	0 ～ 20 m	0 ～ 10 m
6B Cone Antenna	0 ～ 20 m	0 ～ 15 m
8B Cone Antenna	0 ～ 20 m	0 ～ 20 m

6.3 Model Code

4B Cone Antenna	MD-10-5N1H-D-4BCA
6B Cone Antenna	MD-10-5N1H-D-6BCA
8B Cone Antenna	MD-10-5N1H-D-8BCA

6.4 Transmitter Head

Transmitter Case	Aluminum (ADC12)
Cable entry	1- M20X1.5 (cable dia. 6..10 mm)1-Blind Plug
Ground cable	Max. 4 mm^2

6.5 Antenna

6.5.1 Cone antenna

Material	316L stainless steel, PTFE
Sealing parts	FKM O-ring

6.6 Environmental Specification

Operation Temp. (TH)	-20～+70℃
Storage Temp. (TH)	-40～+80℃
Water Ingress	IP65
Vibration Resistance	IEC 60068-2-6 / 1G
EMC Directive	Immunity: EN 61000-4-4 : EN 61000-4-6 (4 core-shielded cable)

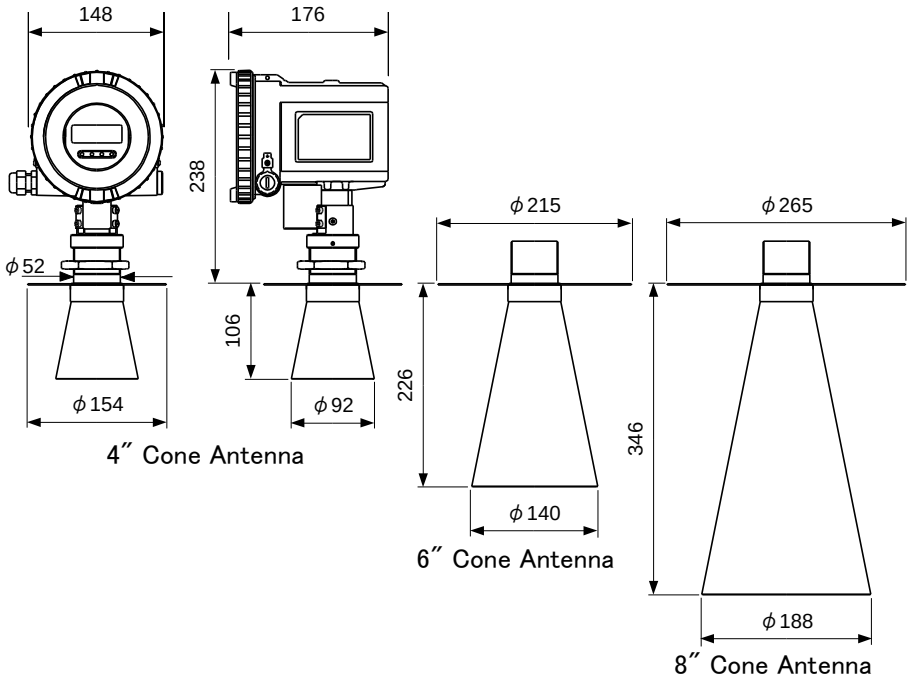
6.7 Mass

4B Cone Antenna with Transmitter Head	approx. 3.4 kg
6B Cone Antenna with Transmitter Head	approx. 3.8 kg
8B Cone Antenna with Transmitter Head	approx. 4.2 kg

6.8 Arrester Specification

IEC 61000-4-5 Level-4 (Com 4 kV / Norm 2 kV) (4 core-shielded cable)

6.9 Dimensions

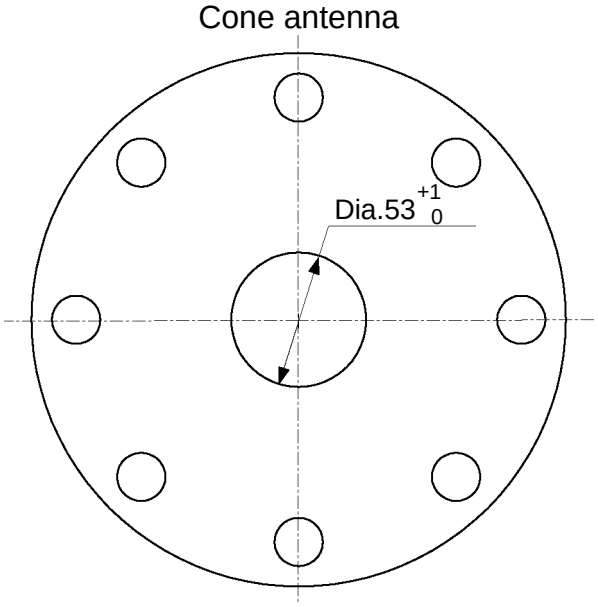


Mass

MD-10(except antenna)	2.5 kg
4” Cone antenna	0.8 kg
6” Cone antenna	1.2 kg
8” Cone antenna	1.8 kg

Flange

The MD-10 gauge is mounted with a flange of the following specifications:



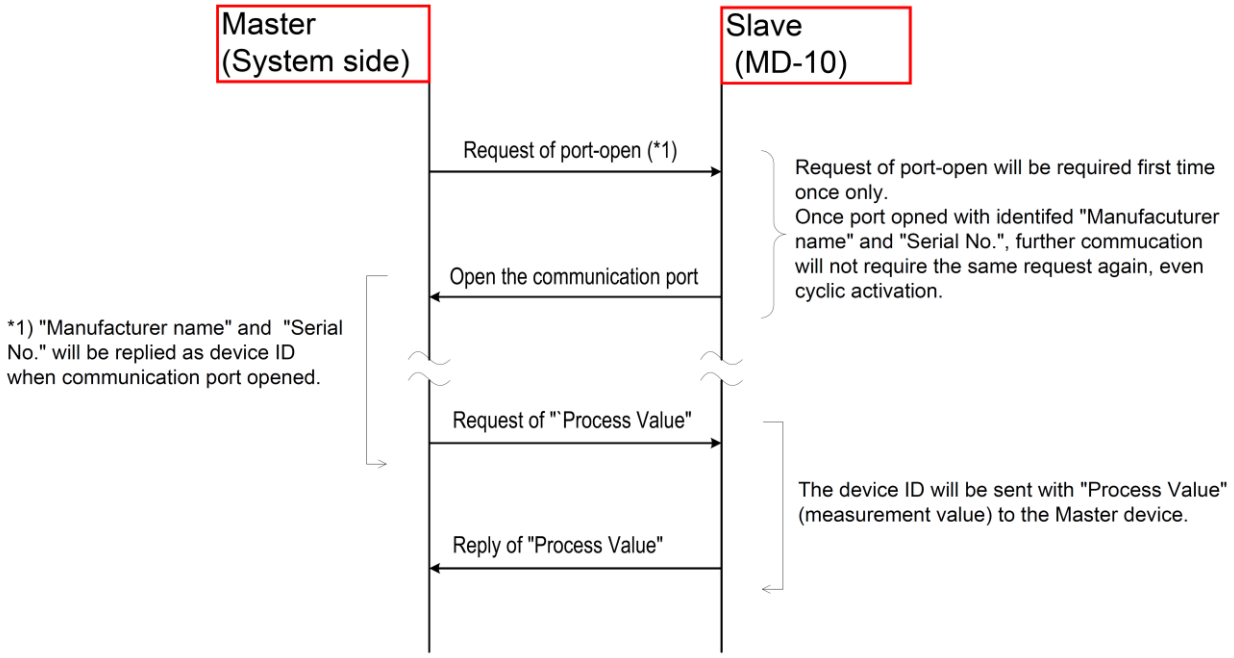
Maximum thickness : 29mm (ANSI Class-150 8”).

7. Digital Communication

7.1 Protocol

Standard	RS-485
Com Method	Two-way half-duplex communication
Synchro	Start-Stop synchronization
Baud rate	1200 bps
Data Bit	8 bit
Parity	Odd
Start Bid	1 bit(0)
Stop Bid	1 bit
Flow Control	None

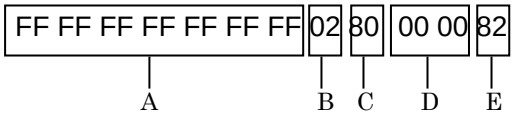
7.2 Communication Flow



7.3 Data Format

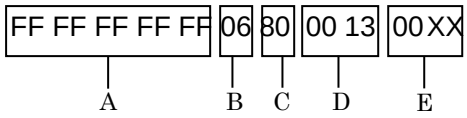
The example of byte data per message is as below.
Please ignore “Undefined value” which may change its byte in accordance with situation.

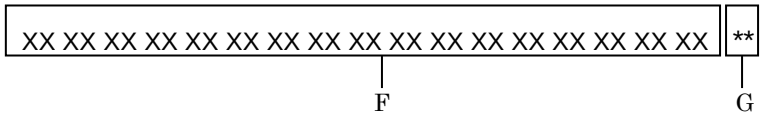
7.3.1 Request of “Port-Open” (5 bytes : excluded 0xFF)



Item	Byte	Description
A	7	Fixed value
B	1	Start byte
C	1	MSB bit which indicates primary master including address info. Note: Commissioning software is secondary master. Note: This value will be fixed to “0x00” in case of secondary master request.
D	2	Fixed for “Port-Open” request
E	1	Check sum (lower 1 byte of XOR addition value from all data B-D) Note: Fixed “0x82” for “Port-Open” request by primary master. Note: Fixed “0x02” for “Port-Open” request by secondary master.

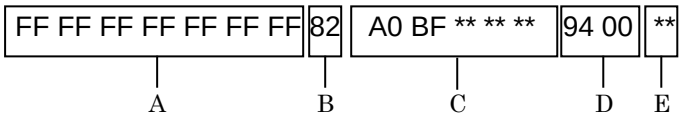
7.3.2 "Open Commnication port" (24 bytes: excluded 0xFF)





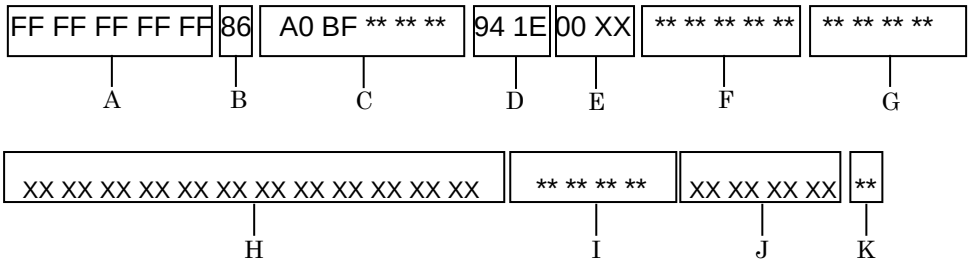
Item	Byte	Description
A	Undefined	The first byte of the data is the next byte, started after 0xFF
B	1	The first byte of the data
C	1	MSB bit which indicates primary master including address info. Note; Commissioning software is secondary master. Note; Ignore, if it is not matched. Note: This value will be fixed to "0x00" in case of secondary master request.
D	2	Fixed for "Open communication port"
E	2	Status Info ---------- Higher 1 byte : Note; Normally 0x00, otherwise it means communication error. [Bit7] On, when any error occurs between Bit0 ~Bit6 [Bit6] On, when parity error occurs [Bit5] On, when over run error occurs [Bit4] On, when flaming error occurs [Bit3] On, When check sum error occurs [Bit2] Not in use [Bit1] On, when overflow of receiving buffer occurs [Bit0] Not in use Lower 1 byte : Debag info (not in use)
F	17	Info for Manufacturer ID and Serial No.
G	1	Check sum (lower 1 byte of XOR addition value from all data B-F)

7.3.3 Request of "Process Value" (9 bytes : excluded 0xFF)



Item	Byte	Description
A	7	Fixed value
B	1	Start byte
C	5	MSB bit which indicates primary master including manufacturer's ID and Serial No. Info. ---------- 1st byte : 0xA0 (Master type + Manufacturer ID) 2nd byte : 0xBF (Master type + Manufacturer ID) 3rd byte : 10th byte at flag "F" for "Open Communication port" 4th byte : 11th byte at flag "F" for "Open Communication port" 5th byte : "12th byte at flag "F" for "Open Communication port" Note; 1st byte defines as 1st byte of flag "F" (17 byte) Note; 1st byte is fixed "0x20" in case of secondary master.
D	2	Fixed for "Request of Process Value"
E	1	Check sum (lower 1 byte of XOR addition value from all data B-D)

7.3.4 Reply of "Process Value" (39 bytes : excluded 0xFF)



Item	Byte	Description
A	Undefined	The 1st byte of the data is the next byte, started after 0xFF.
B	1	Start byte
C	5	MSB bit which indicates primary master including manufacturer's ID and Serial No. Info. Commissioning software is secondary master. ---------- 1st byte : 0xA0 (Master type + Manufacturer ID) 2nd byte : 0xBF (Master type + Manufacturer ID) 3rd byte : 10th byte at flag "F" for "Open Communication port" 4th byte : 11th byte at flag "F" for "Open Communication port" 5th byte : "12th byte at flag "F" for "Open Communication port" Note; 1st byte defines as 1st byte of flag "F" (17 byte) Note; 1st byte is fixed "0x20" in case of secondary master.
D	2	Fixed for "Reply of Process Value"
E	2	Status Info ---------- Higher 1 byte : Note; Normally 0x00, otherwise it means communication error. [Bit7] On, when any error occurs between Bit0 ~Bit6 [Bit6] On, when parity error occurs [Bit5] On, when over run error occurs [Bit4] On, when flaming error occurs [Bit3] On, When check sum error occurs [Bit2] Not in use [Bit1] On, when overflow of receiving buffer occurs [Bit0] Not in use
		Lower 1 byte : [Bit7] On, when device error occurs [Bit6:0] Debag info (not in use)
F	4	Process Value 1 (Measuring data as Level in meter)
G	4	Process Value 2 (Measuring data as Distance in meter)
H	12	Another information relates with measurement 1 ---------- 1-4 byte : Calculated tank volume (Option) 5-8 byte : % indication of Analog output value (Not in use) 9-12 byte : Analog output value (Not in use)
I	4	Process Value 3 (Signal strength in dB) (*)
J	4	Another information relates with measurement 2 (The lowest 1 byte is the last byte.) Note; Debag info (not in use)
K	1	Check sum (lower 1 byte of XOR addition value from all data B-J)

(*) IEEE754 single precision floating format (Radix: 2/ big-endian)

7.4 Timing for response

MD-10 will respond “Reply-Data” within 256ms after receiving “Request-of-PV”.

Total 60 bytes of “Request-of-PV” and “Reply-of-PV” will take time to respond for 840ms through 1200bps.
Hence time-out must be set 840ms as minimum.

7.5 Communication error

In case of communication error occurs, please set request of “Retry” accordingly.

7.6 Alarm status

In case that MD-10 can not detect liquid surface reflection, PV3 (Signal strength in dB) will be output as 0 (zero).
Hence Alarm status must be set whenever PV3 indicated as 0 (zero) except start-up period.

Document No. KF21-002A
Microwave Level Gauge MD-10
User's Guide
Jun. 2021 1st Edition
Jul. 2021 2nd Edition

TOKYO KEIKI INC.
Measurement Systems Company
2-16-46, Minami-Kamata,Ohta-ku,
Tokyo 144-8551, Japan
TEL: +81-3-3737-8621
FAX: +81-3-3737-8665
Web: https://www.tokyokeiki.jp/