Level measurement

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“Installation is the key”

“ToF (Time of Flight) and capacitive instruments are the most popular Endress+Hauser levelmeters.

ToF instruments share common concepts allowing simplified commissioning, operation and maintenance.
Though, the installation conditions are of utmost importance, especially regarding the nozzle. This is why we have decided to give you in this guide a reminder of these essential installation conditions.

For capacitive level measurement instruments, the situation is pretty different: due to the physical principle, the key point is the connection to the ground, especially in case of a non-conductive tank.

Like in the other sections, we have also recapped the main questions that you ask us. With this information, you will be able to prevent or resolve the vast majority of potential problems yourself!

There is also plenty of useful information to help you get the best from your instruments throughout their life cycle.

Note: if you are intending to replace one of your capacitive devices, please contact us. Each migration project has to be attentively examined.”

We also offer training sessions, in classroom and on site. See page ‘Training’ in the section ‘At your service’.

Contents

Basics

Information common to all types of level measurement devices

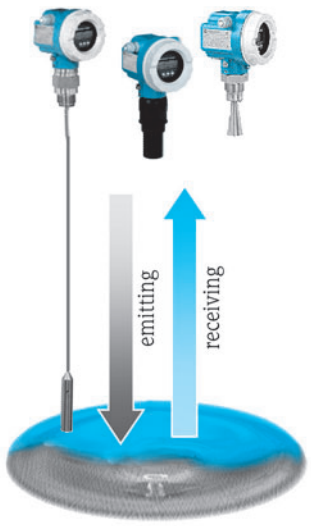


Fig. 1 : The principle - Time of Flight

The Time of Flight (ToF) principle

- Emission of ultrasound- or microwave-pulses
- Reflection of the pulses from the product surface
- Reception of the reflected pulses
- Measurement of the Time of Flight : calculation of the distance between the device and the product surface by d = (c x t)/2

Set-up - Configuration of level instruments

General note:
The respect of installation conditions are of key importance for level measurement. Once this is correctly done, the unit will work. Nevertheless it is always necessary to configure the measuring point to achieve correct measurement.

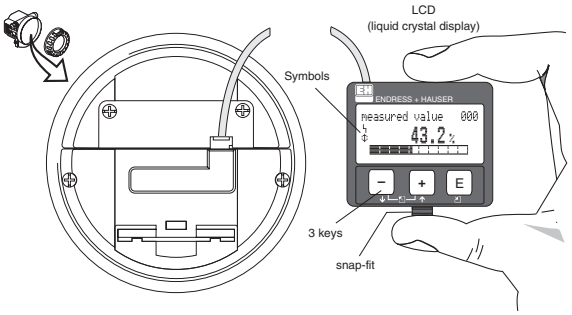


Fig. 2: On-site operation with VU331

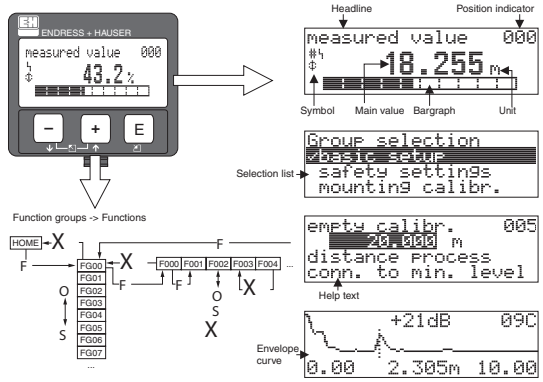


Fig. 3: The 'Basic Setup' covers 95% of the situations

All Endress+Hauser ToF level measurement devices have the same display.
The display of the process value and the configuration of the device occur locally by means of a large 4-line alphanumeric display with plain text information. The guided menu system with integrated help texts ensures quick and safe commissioning (see fig. 3).
To access the display the cover of the electronic compartment may be removed even in hazardous area (IS and XP).

The VU331 LC-Display can be removed to ease operation by simply pressing the snap-fit (see fig. 2). It is connected to the device by means of a 500 mm cable.

The LC-Display VU331 allows configuration via 3 keys directly at the instrument. All device functions can be set through a menu system. The menu consists of function groups and functions. Within a function, application parameters can be read or adjusted. The user is guided through a complete configuration procedure.

You can also configure your ToF instruments from your PC. Remote commissioning, including documentation of the measuring point and in-depth analysis functions, is supported via FieldCare Setup. See presentation of FieldCare on page (S3).

Our service team can set up any Endress+Hauser level measurement device for you and thus ensure you immediately get the best from your instrument. (see **'Commissioning'** in the 'At your service' section)

Operation and Maintenance

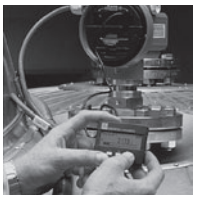
Routine maintenance
ToF devices include no wear part thus require very little maintenance. However, according to its criticality to the quality, some instruments need to be inspected or/and calibrated periodically.

Defining the right maintenance frequency taking several parameters into account is an expert's job. Endress+Hauser can also help you with this task!

To test the 4-20 mA loop (see fig. 4 and 5):
- The 2-wire, 4...20 mA with HART version includes test sockets for testing of the signal current.
- On the 4-wire versions (Levelflex and Prosonic), there are two terminals situated at the front of the electronic module.

Calibration (all devices)
Intrinsically our instruments offer long-term stability and repeatability of your measurements. Nevertheless we recommend periodic calibration for the measurement points which are critical to the process and thus are important to control the quality of your product. From on-site to accredited services, you can be sure to find the right method by reaching the right balance between the device downtime and the calibration uncertainty.

Calibration can be performed by Endress+Hauser either on site or in our accredited laboratories. (see **'Calibration'** in the 'At your service' section).



Check of the measurement (all devices)

Configuration of the level measurement instrument is often undertaken during the commissioning phase. In the majority of cases this is sufficient.
In some cases it is useful to make additional checks of your level measurement in order to:

- Validate the measured value related to the real level in the tank
- Eliminate interference echoes emitted by the installations in an empty tank (for ToF devices)

If level measurement instruments are to be recalibrated following an operational phase, this is often done by gauging the capacity of a container in liters, so there is no need to remove the device from the process. We can provide you with specific advice on this.

Maintenance planning

Do you know exactly which part of your installed instrumentation base is **critical to the operation** of the plant and how you could maintain or calibrate it more efficiently? Are you sure that your present actions are minimizing the risks of **unplanned breakdowns**? Are you sure that your present actions are the most **cost effective**?

With Endress+Hauser's Installed Base Audit, our service Consultant will help you to quickly find an answer to these questions and move forward in a controlled manner to a maintenance plan which improves plant reliability while reducing costs…
(see **'Installed Base Audit'** in the 'At your service' section).

Maintenance performing

In case you have not internally the time, the competences or the right tools to perform efficiently your maintenance, with Endress+Hauser **service contracts**, you decide the right level of maintenance support you require.

We provide regular checks on your equipment and warranty extensions providing you with complete peace of mind and cost control.

From regular support to partnership agreements, we offer four distinct levels of service… (see **'Service Contracts'** in the 'At your service' section).

Corrective maintenance - spare parts

The more critical your instrument to your process, the shorter the acceptable repair time.

- Thanks to the TOF concept, most parts can be easily replaced by the user (also for Ex) thus allowing quick repair: display, electronic module, antenna.
- Tags on each component allow easy identification of spares.
- An installation manual is provided with every spare part.

In case of a highly critical instrument, you might consider to put a complete new instrument on stock.

Instrument and spare parts availability

You will find detailed information in the next sections (Level-radar, ultrasonic level measurement etc.)

Migration

You will find detailed information in the next sections (Level-radar, ultrasonic level measurement etc.)

Re-engineering

See our advice in the next sections. See also our online Applicator tool.
https://wapps.endress.com/applicator9x

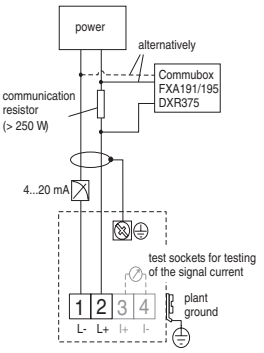


Fig. 4: Terminal assignment - 2-wire, 4...20 mA with HART

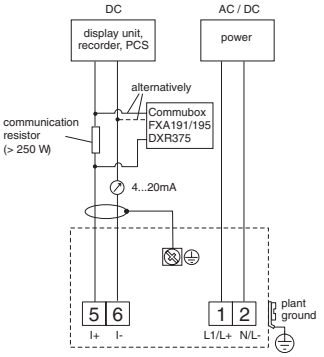


Fig. 5: Terminal assignment - 4-wire, AC/DC power, 4...20 mA with HART

Level-radar
Micropilot series

It has been already several years since Micropilot M instruments constitute the main part of the current range of level-radar measurement. FMR 230 (horn antenna) and 231 (rod antenna) instruments use 6 GHz waves, while FMR 240 (horn antenna, 244 (horn antenna encapsulated in PTFE), 245 (flat antenna) and 250 (level-radar measurement on solids) use 26 GHz waves.

In this section, you will find essential information and advice that will help you to perform the optimum follow-up of your Micropilot M instruments throughout their lifecycle.

"90% of the success of the set up depend on proper installation"

Measuring principle

The Micropilot is a 'downward-looking' measuring system, operating based on the time-of-flight method. It measures the distance from the reference point (process connection) to the product surface. Radar impulses are emitted by an antenna, reflected off the product surface and received again by the radar system.

Input (see fig. 1)
The reflected radar impulses are received by the antenna and transmitted into the electronics. A microprocessor evaluates the signal and identifies the level echo caused by the reflection of the radar impulse at the product surface. The unambiguous signal identification is accomplished by the PulseMaster® eXact software, based on many years of experience with time-of-flight technology.
The distance D to the product surface is proportional to the time of flight t of the impulse:
$D = c \cdot t/2$,
with c being the speed of light.
Based on the known empty distance E, the level L is calculated:
$L = E - D$
Refer to figure 1 for the reference point for E.
The Micropilot is equipped with functions to suppress interference echoes. The user can activate these functions. They ensure that interference echoes (i.e. from edges and weld seams) are not interpreted as level echo.

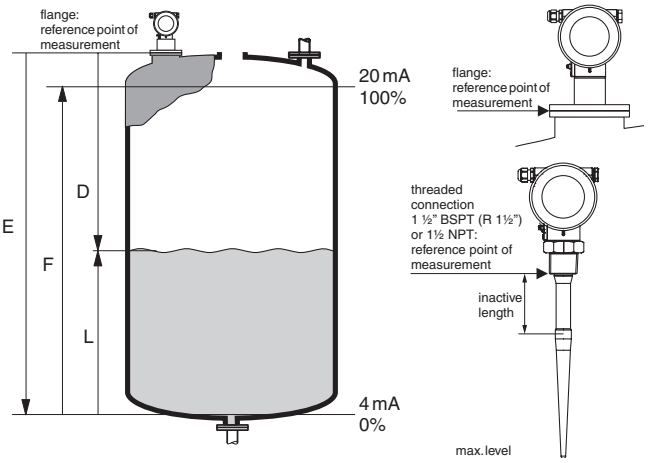


Figure 1: Measuring principle

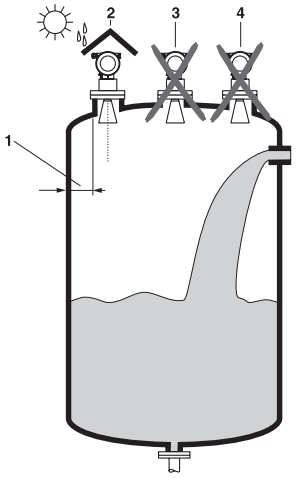


Figure 2: Orientation

Installation conditions

Because most problems reported by the users are due to uncorrect installation and/or initial calibration, we remind hereafter the essential points that must be considered.

Orientation (see fig. 2)
- Recommended distance (1) wall – outer edge of nozzle: ~1/6 of tank diameter. Nevertheless the device should not be installed closer than 30 cm (FMR230/231) resp. 15 cm (FMR240/244/245) to the tankwall.
- Not in the centre (3), interference can cause signal loss.
- Not above the fill stream (4).
- It is recommended to use a weather protection cover (2) in order to protect the transmitter from direct sun or rain. Assembly and disassembly is simply done by means of a tension clamp.

Tank installations (see fig. 3)
- Avoid any installations (1), like limit switches, temperature sensors, etc., inside the signal beam.
- Symmetrical installations (2), i.e. vacuum rings, heating coils, baffles, etc., can also interfere with the measurement.

Optimization options
- Antenna size: the bigger the antenna, the smaller the beam angle, the less interference echoes.
- Mapping: the measurement can be optimized by means of electronic suppression of interference echoes.
- Antenna alignment: refer to 'optimum mounting position'
- Stilling well: a stilling well can always be used to avoid interference.
- Metallic screens (3) mounted at a slope spread the radar signals and can, therefore, reduce interference echoes.

Please contact Endress+Hauser for further information.

Commissioning of two Micropilot M

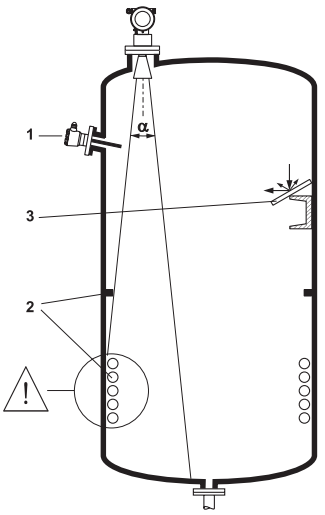


Figure 3: Tank installations

Installation in tank (free space) FMR230 - Optimum mounting position (see fig. 4)

- Observe installation instructions described above.
- Align marker towards tank wall (the marker is always exactly in the middle between two bolt-holes in the flange).
- After mounting, the housing can be turned 350° to simplify access to the display and the terminal compartment.
- The horn antenna must extend below the nozzle, otherwise use antenna extension FAR10.
- Align horn antenna vertically.

Installation in tank (free space) FMR231 - Optimum mounting position (see fig. 5)

- Observe installation instructions decribed above.
- Align marker towards tank wall (the marker is always exactly in the middle between two bolt-holes in the flange).
- Use spring washers (1).

Note!
It is recommended to retighten the flange bolts periodically, depending on process temperature and pressure. Recommended torque: 60...100 Nm.

- **After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.**
- **The inactive part of the rod antenna must extend below the nozzle.**
- **The rod antenna must be aligned vertically.**

Installation in tank (free space) FMR240, FMR244, FMR245 - Optimum mounting position (see fig. 6)

- Observe installation instructions described above.
- Align marker towards tank wall (the marker is always exactly in the middle between two bolt-holes in the flange).
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.
- For optimum measurement, the horn antenna should extend below the nozzle. Select version with 100 mm antenna extension if necessary.

Note!
Please contact Endress+Hauser for application with higher nozzle.

- **The horn antenna must be aligned vertically.** The maximum range may be reduced, if the horn antenna is not vertically aligned.

Standard installation FMR244 (see fig. 7 on next page)

- Observe installation instructions described above.
- Align marker towards tank wall.
- Install the device using the threaded boss (AF 60) only. Observe the max. torque of 20 Nm.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.
- For optimum measurement, the tip of the antenna should extend below the nozzle. Nozzle heights up to 500 mm can be accepted if this should not be possible due to mechanical reasons.

Note!
Please contact Endress+Hauser for application with higher nozzle.

- The antenna must be aligned vertically.

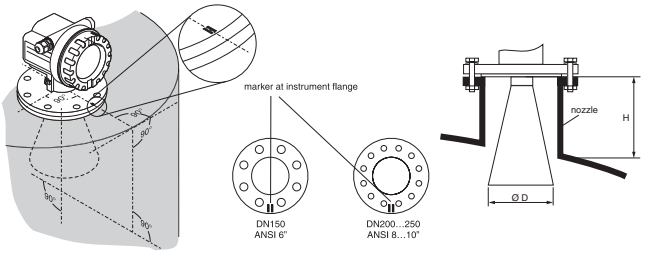


Figure 4: Optimum mounting position FMR230

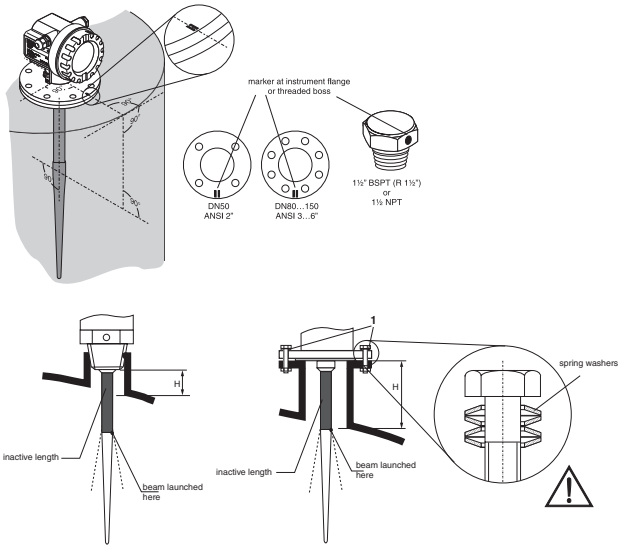


Figure 5: Optimum mounting position FMR231

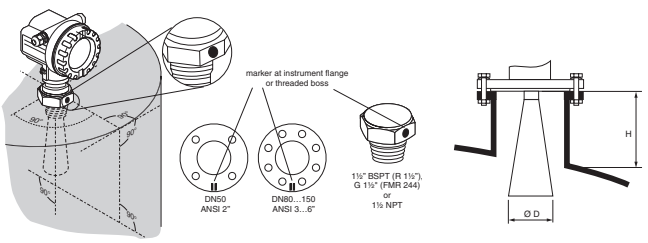


Figure 6: Installation in a tank - optimum mounting position

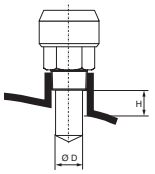


Figure 7: Standard installation FMR244

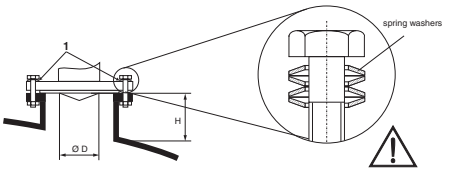


Figure 8: Standard installation FMR245

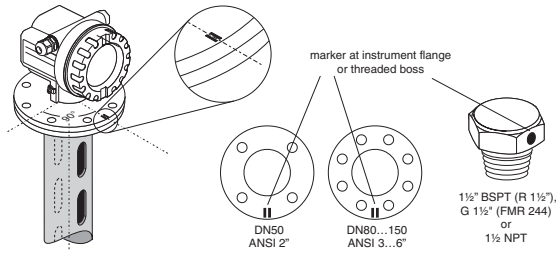


Figure 9: Installation in stilling well - optimum mounting position

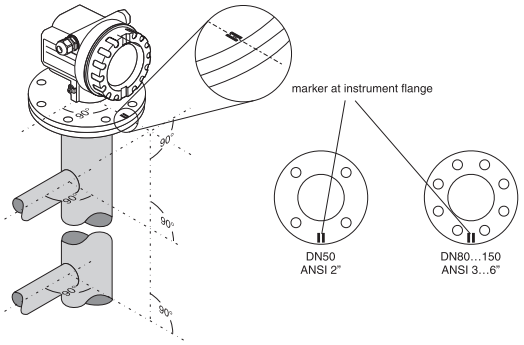
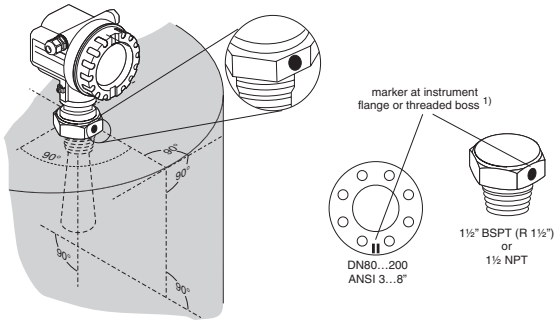
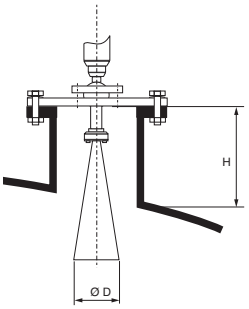


Figure 10: Installation in bypass - optimum mounting position



1) at version with top target positioner, the marker is at the housing adapter (opposite the air purge connection)

Figure 11 (above and right): Installation in vessel FMR250 - optimum mounting position



Standard installation FMR245 (see fig. 8)

- Observe installation instructions described above.
- Align marker towards tank wall.
- The marker is always exactly in the middle between two bolt-holes in the flange.
- Use spring washers (1)

Note!
It is recommended to retighten the flange bolts periodically, depending on process temperature and pressure. Recommended torque: 60...100 Nm.

- **After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.**
- The antenna must be aligned vertically. Caution! The maximum range may be reduced, if the antenna is not vertically aligned.

Note! Please contact Endress+Hauser for application with higher nozzle.

Installation in stilling well FMR230, FMR240, FMR244, FMR245 (see fig. 9)

- Align marker toward slots.
- The marker is always exactly in the middle between two bolt-holes in the flange.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.
- Measurements can be performed through an open full bore ball valve without any problems.
- Additional installation instructions on Page20.

Recommendations for the stilling well

- Metal (no enamel coating, plastic on request).
- Constant diameter.
- Diameter of stilling well not larger than antenna diameter.
- Weld seam as smooth as possible and on the same axis as the slots.
- Slots offset 180° (not 90°).
- Slot width respectively diameter of holes max. 1/10 of pipe diameter, de-burred. Length and number do not have any influence on the measurement.
- Select horn antenna as big as possible. For intermediate sizes (i.e. 180 mm) select next larger antenna and adapt it mechanically (FMR230/FMR240 only).
- At any transition (i.e. when using a ball valve or mending pipe segments), no gap may be created exceeding 1 mm (0.04").
- The stilling well must be smooth on the inside (average roughness Rz ≤ 6.3 µm). Use extruded or parallel welded stainless steel pipe. An extension of the pipe is possible with welded flanges or pipe sleeves. Flange and pipe have to be properly aligned at the inside.
- Do not weld through the pipe wall. The inside of the stilling well must remain smooth. In case of unintentional welding through the pipe, the weld seam and any unevenness on the inside need to be carefully removed and smoothened. Otherwise, strong interference echoes will be generated and material build-up will be promoted.
- Particularly on smaller nominal widths it needs to be observed that flanges are welded to the pipe such that they allow for a correct orientation (marker aligned toward slots).

Installation in bypass FMR230, FMR240, FMR245 (see fig. 10)

- Align marker perpendicular (90°) to tank connectors.
- The marker is always exactly in the middle between two bolt-holes in the flange.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.
- The horn must be aligned vertically.
- Measurements can be performed through an open full bore ball valve without any problems.
- Additional installation instructions described above.

Recommendations for the bypass pipe

- Metal (no plastic or enamel coating)
- Constant diameter
- Select horn antenna as big as possible. For intermediate sizes (i.e. 95 mm) select next larger antenna and adapt it mechanically (FMR230/FMR240 only).
- At any transition (i.e. when using a ball valve or mending pipe segments), no gap may be created exceeding 1 mm (0.04»).
- In the area of the tank connections (~ ±20 cm / 8») a reduced accuracy of the measurement has to be expected.

Installation in vessel FMR250 with horn antenna (see fig.11)

- Observe installation instructions described above.
- Align marker towards vessel wall (the marker is always exactly in the middle between two bolt-holes in the flange.
- After mounting, the housing can be turned 350° in order to simplify access to the display and the terminal compartment.
- The horn antenna should protrude from the nozzle. If this is not possible for mechanical reasons, larger nozzle heights can be accepted.

Note!
- Please contact Endress+Hauser for application with higher nozzle.
- Ideally, the horn antenna should be installed vertically. To avoid interference reflections or for optimum alignment within the vessel, the FMR250 with optional top target positioner can be swiveled by 15° in all directions.

Set-up - Configuration

See 'Basics'.

The 'Basic setup' menu enables a quick and simple commissioning. The software helps the user to enter the main parameters which cover 95% of the cases. By entering the data carefully, you will avoid many problems.

Note for FMR244/245: Please take a blocking distance of 0.2 m into account. (See details on the blocking distance in chapter Ultrasonic level measurement - page 16).

Our service team can set up any Endress+Hauser device for you and thus ensure you immediately get the best from your instrument.
(see **'Commissioning'** in the 'At your service' section)

Operation and Maintenance

See 'Basics' (page 11).

Note for FMR250: In extremely dusty applications, the integrated air purge connection can prevent clogging of the antenna (see fig. 12). Pulsed operation is recommended.
- Pulsed operation: max. pressure of purge air: 6 bar abs.
- Permanent operation: recommended pressure range of the purge air: 200...500 mbar.

Caution! Make sure to use dry purge air.

Calibration
See 'Basics' (page 10).

Corrective maintenance - Spare parts
See 'Basics' (page 11).

Note for all radar devices: The replacement of either the electronic module or the HF module requires a reprogramming. Some of the default parameters have to be modified. The relevant procedure is delivered with the new module.

Note for FMR240/244/245/250: The replacement of the electronic module requires specific attention. If it contains software with versions 1.02.xx or 1.04.xx, you need to replace also the HF module.

Instrument and spare parts availability

Your instrument	Spare part availability	New generation
Micropilot II/FMR230V	NO - since 09/2005	Micropilot M
Micropilot II/FMR231E	NO - since 09/2005	Micropilot M

If you want to get more information about spare parts availability, please call our hotline xxxx xxx xxxx.

Re-engineering

Instruments that operate at 26 GHz used to be selected for storage applications. However, thanks to the recent redevelopment, from software version1.05.xx, the new 26 GHz instruments can now be used on process applications. Please consult us.

Instruments that operate at 6 GHz, whose cost is higher, keep used on demanding processes (with turbulent surface or foam formation).

See also our online Applicator tool.
https://wapps.endress.com/applicator9x

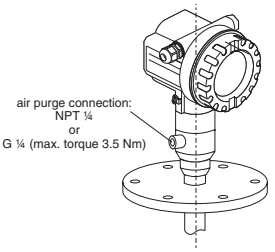
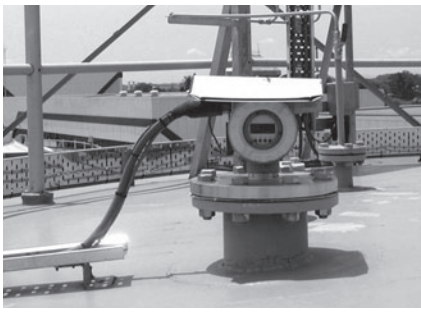


Figure 12: FMR250 integrated air purge connection



Guided level-radar
Levelflex series

The current guided level-radar Levelflex M range comprises:
- **FMP40 for general applications in liquids and solids**
- **FMP41C for corrosive liquids and for high hygienic requirements**
- **FMP45 mainly in liquids with pressures up to 400 bar and temperatures from -200 ... +400°C**
- **New FMP43 (from 01/07/07) for pharma requirements**

With this section we aim at providing efficient help to Levelflex M users throughout the life cycle.

"Consider blocking distances and pay attention to the nozzle"

Measuring principle

The Levelflex is a 'downward-looking' measuring system that functions according to the ToF method (ToF = Time of Flight). The distance from the reference point (process connection of the measuring device) to the product surface is measured. High-frequency pulses are injected to a probe and led along the probe. The pulses are reflected by the product surface, received by the electronic evaluation unit and converted into level information.
This method is also known as TDR (Time Domain Reflectometry).

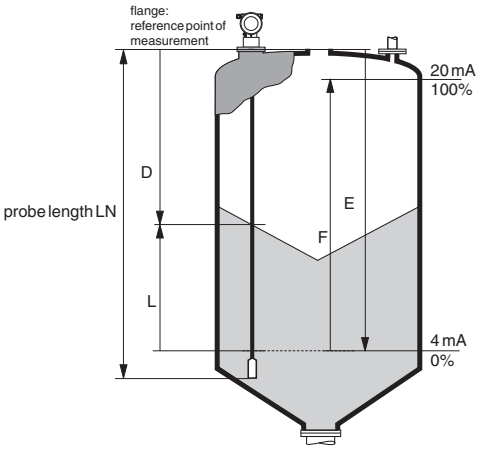


Figure 1: Measuring principle

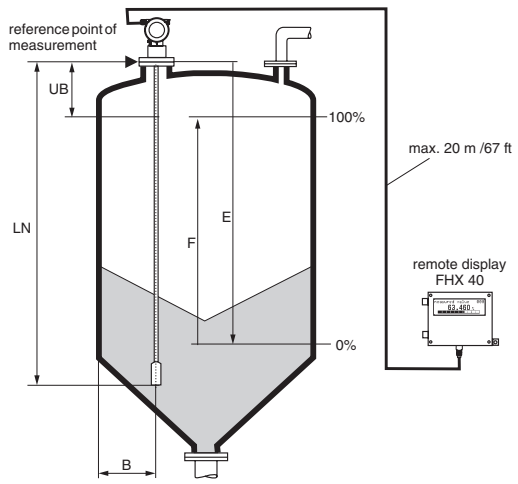


Figure 2: Upper blocking distance
F = measuring span
E = empty distance (= zero)
UB = upper blocking distance
LN = probe length
B = minimum distance of the probe to the container wall

Input (see fig. 1)
The reflected pulses are transmitted from the probe to the electronics. There, a microprocessor analyses the signals and identifies the level echo, which was generated by the reflection of the high-frequency pulses at the product surface. This clear signal finding benefits from the more than 30 years of experience with pulse time-of-flight procedures that have been integrated into the development of the PulseMaster® Software.

Distance D to the product surface is proportional to the time of flight t of the impulse:
$D = c \cdot t/2$,
with c being the speed of light. Based on the known empty distance E, level L is calculated:
$L = E - D$
Reference point for E see fig. 1.

The Levelflex comes with functions to suppress interference echoes (e.g. internals and struts).

Installation conditions

Upper blocking distance (see fig. 2)
The upper blocking distance (UB) is the minimum distance from the reference point of the measurement (mounting flange) to the maximum level. Within the blocking distance, a reliable measurement can not be guaranteed (see table p.17).

Lower blocking distance
At the lowest part of the probe an exact measurement is not possible. The following measuring error is present in the vicinity of the probe end: (see fig. 3)

Check of a Levelflex at a chemical plant

FMP40	UB [m] min
Rope probe	0.2 (1)
6 mm rod probe	0.2 (1)
16 mm rod robe	0.2 (1)
Coax probe	0

(1) The indicated blocking distances are prearised. At media with DK > 7, the upper blocking distance UB can be reduced for rod and rope probes on 0.1 m. The upper blocking distance UB can be entered manually.

LBD [m]	if DC>7	if DC<7
Rope probe	0.02	0.25
Rod or coax probe	0.02	0.05

If ε_r (dielectric coefficient) value is less than 7 for rope probes, then measurement is not possible in the area of the straining weight (0 ... 250 mm from end of probe; lower blocking distance)(see table).

General installation instructions (for bulk solids + fluids)

We remind you hereafter the most important instructions (see fig. 4):

- Do not mount rod or rope probes in the filling curtain (2)
- Mount rod and rope probes away from the wall (B) at such a distance that, in the event of build-up on the wall, there is still a minimum distance of 100 mm between the probe and the build-up.
- In the case of bulk solids in concrete silos, a large distance (B) should be observed between the probe and the concrete wall, if possible ≥ 1 m, but at least 0.5 m.
- In metal and plastic silos, the probe can be mounted very close to the wall (0.2m), but ensure that the probe does not touch the wall.
- Minimum distance of probe end to the container floor (C):
  – Rope probe: 150 mm
  – Rod probe: 50 mm
  – Coax probe: 10 mm
- If the product becomes highly electrostatically charged during processing, an earthing chain should be mounted in the filling curtain or the end of the probe should be grounded.

Type of probe installation (see fig. 5)

- Probes are mounted to the process connection with threaded connections or flanges and are usually also secured with these. If during this installation there is the danger that the probe end moves so much that it touches the tank floor or cone at times, the probe must, if necessary, be shortened and fixed down. The easiest way to fix the rope probes is to screw them to the internal thread on the lower end of the weight.
- The ideal installation is mounting in a screwed joint / screw-in sleeve which is internally flush with the container ceiling.
- If installation takes place in a nozzle, the nozzle should be 50 ... 150 mm in diameter and should not be more than 150 mm high. Installation adapters are available for other dimensions.
- Installation with welding boss is strongly recommended when the product ε_r (dielectric coefficient) is low. “90% of the problems encountered in case of a low ε_r are due to a bad nozzle”.

Installation in concrete silos (see fig. 6)

Installation, for example, into a thick concrete ceiling should be made flush with the lower edge. Alternatively, the probe can also be installed into a pipe that must not protrude over the lower edge of the silo ceiling. The pipe should be kept at a

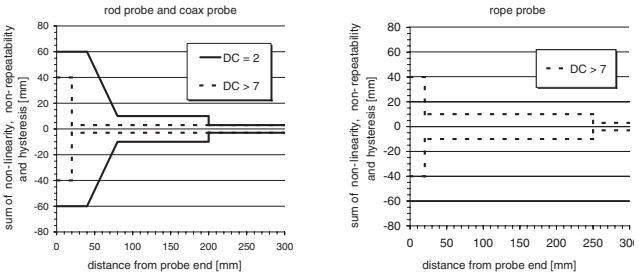


Figure 3: Measuring error in the vicinity of the probe end

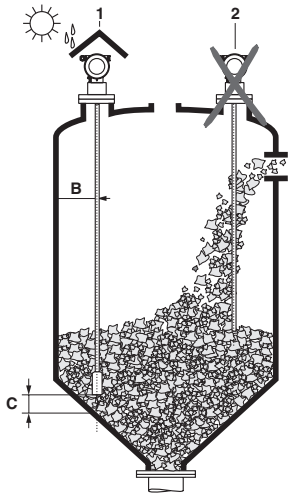


Figure 4: General installation conditions
1 = correct installation

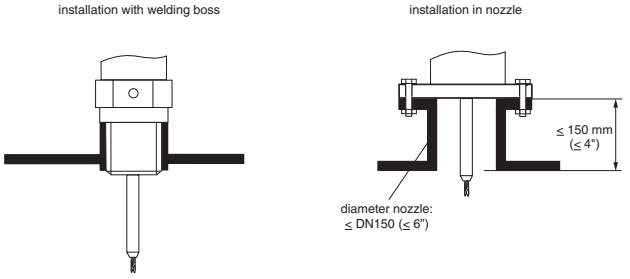


Figure 5: Type of probe installation

minimum length. Installation suggestions see diagram. The centering disk should be used for tube diameter > 150 mm to prevent build-up in the inner part of the tube.

Installation in plastic containers (see fig. 7)
Please note that the 'guided level-radar' measuring principle requires a metal surface at the process connection! When installing the rod and rope probes in plastic silos, whose silo cover is also made of plastic or silos with wood cover, the probes must either be mounted in a ≥ DN50 / 2" metal flange, or a metal sheet with diameter of ≥ 200 mm must be mounted under the screw-in piece.

Set-up - Configuration

See 'Basics'.

The 'Basic setup' menu enables a quick and simple commissioning. The software helps the user to enter the main parameters which cover 95% of the cases. By entering the data carefully, you will avoid many problems.

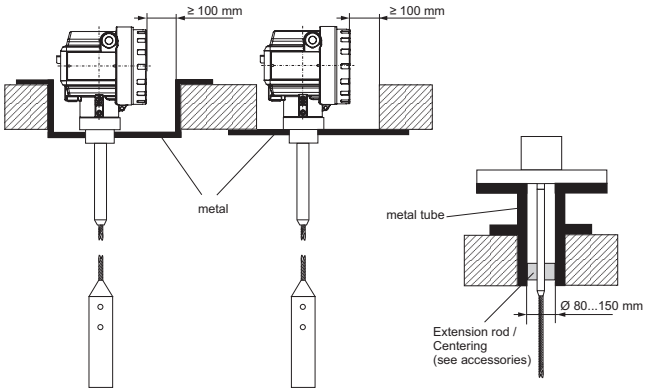


Figure 6: Installation in concrete silos

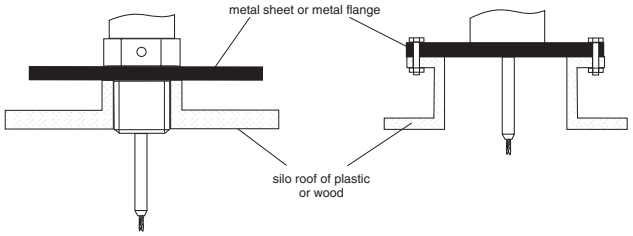


Figure 7: Installation in plastic containers

Our service team can set up any Endress+Hauser device for you and thus ensure you immediately get the best from your instrument.
(see **'Commissioning'** in the 'At your service' section)

Operation and Maintenance

Maintenance
See 'Basics' (page 11).

Calibration
See 'Basics' (page 10).

Corrective maintenance - Spare parts
See 'Basics' (page 11)

Note for all radar devices: the replacement of either the electronic module or the HF module requires reprogramming. Some of the default parameters have to be modified . The relevant procedure is delivered with the new module.

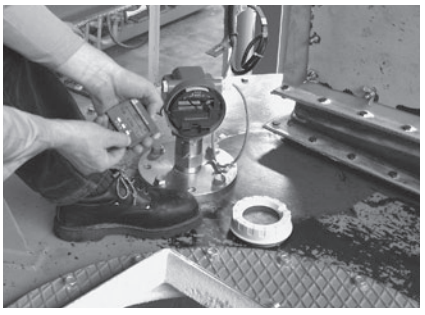
Instrument and spare parts availability

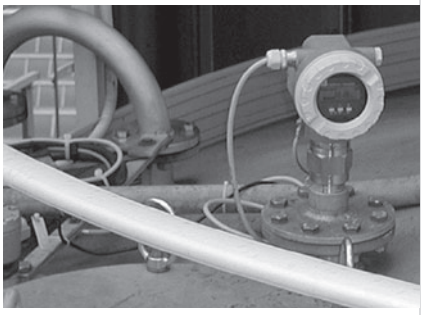
Your instrument	Spare part availability	New generation
Levelflex FMP232E	NO - since 10/2005	FMP40
Levelflex FMP332E	NO - since 10/2005	FMP40

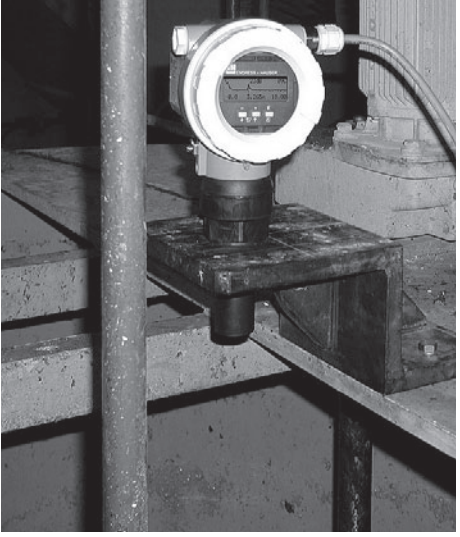
If you want to get more information about spare parts availability, please call our hotline xxxx xxx xxxx.

Re-engineering

FMP45, which is even more robust, can replace a FMP40.







Ultrasonic level measurement

Prosonic series

The current ultrasonic transmitters Prosonic range comprises the Prosonic M FMU40/41/42/43/44 and Prosonic S FMU90.

With this section we aim at:
- **providing efficient help to Prosonic M users throughout the life cycle**
- **answering to the most frequent questions asked by the users of Prosonic S FMU86x, and giving them key information to successfully migrate to FMU90**

"The installation of the sensor and the presence of foam or bubbles have a strong impact on the measurement"

Measuring principle

Time-of-flight method
The Prosonic M sensor emits ultrasonic pulses in the direction of the product surface. There, they are reflected back and received by the sensor. The Prosonic M measures the time t between pulse emissionand reception. The instrument uses time t (and the velocity of sound c) to calculate distance D between the sensor membrane and the product surface:
$D = c \cdot t/2$
As the device knows the empty distance E from a user entry, it can calculate the level as follows:
$L = E - D$
An integrated temperature sensor compensates changes in the velocity of sound caused by temperature changes.

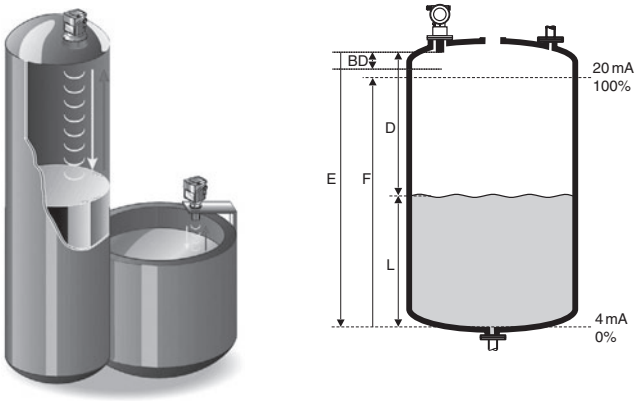


Figure 1: Measuring principle
F = span (full distance)
E = empty distance
D = distance from sensor membrane to the product surface
BD = blocking distance
L = level

Interference echo suppression
The interference echo suppression feature of Prosonic M ensures that interference echoes (e.g. from edges, welded joints and installations) are not interpreted as level echoes.

ZOOM: why is there a blocking distance?

Waves are emitted at the surface of the sensor membrane. The device is either emitting or receiving but cannot do both at the same time. In case of an obstacle located within the area between positions 1 and 2, the resulting echo would be surrounded by the residual vibration and could not be differenciated.
As it is impossible to differenciate the echo within this area, the level to be measured must not approach the membrane.
This distance is named blocking distance.

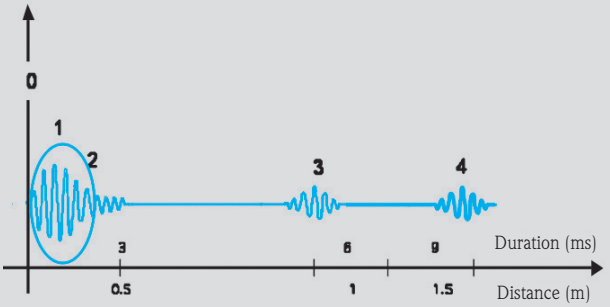


Figure 2
T0: Start of the emitted impulsion. An alternating current which frequency corresponds to the system's resonance, makes cristals oscillate.
T1: End of the emitted impulsion. Membrane continues to vibrate during 1ms and then switches to the receiving position.
T2: the residual membrane vibration is weakened enough to reflect an echo and to differenciate it.
T3: the echo comes back after 6 ms meaning the total distance represents 2 m. Therefore the product surface is located 1m under the probe.
T4: Double reflection echo or numerous reflections can sometimes be observed.

Adjustment
Enter the empty distance E and the span F to adjust the device (see fig.1).

Blocking distance
Span F may not extend into blocking distance BD. Level echos from the blocking distance cannot be evaluated due to the transient characteristics of the sensor.

Influence of foam and bubbles on the level measurement on liquids (see fig. 3)
The occasional presence of foam or the presence of a disparate foam layer at the liquid's surface has a weak impact on ultrasonic measurement. However a permanent thick foam layer absorbs ultrasonic waves and stops their reflection at the liquid's surface. If the foam is quite dense, its own surface may often become a reflector.

Installation conditions

The essentials (see fig. 4)
- Do not install the sensor in the middle of the tank (3). We recommend leaving a distance between the sensor and the tank wall (1) of 1/6 of the tank diameter.
- Use a protective cover, in order to protect the device from direct sun or rain (2).
- Avoid measurements through the filling curtain (4).
- Make sure that equipment (5) such as limit switches, temperature sensors, etc. are not located within the emitting angle α. In particular, symmetrical equipment (6) such as heating coils, baffles etc. can influence measurement.
- Align the sensor so that it is vertical to the product surface (7).
- Never install two ultrasonic measuring devices in a tank, as the two signals may affect each other.
- To estimate the detection range, use the 3 dB emitting angle α (see table 1).

Blocking distance, nozzle installation (see fig. 5 and table 2)
Install the Prosonic M at a height so that the blocking distance BD is not exceeded, even at maximum fill level. Use a pipe nozzle if you cannot maintain the blocking distance in any other way. The interior of the nozzle must be smooth and may not contain any edges or welded joints. In particular, there should be no burr on the inside of the tank side nozzle end. Note the specified limits for nozzle diameter and length. To minimise disturbing factors, we recommend an angled socket edge (ideally 45°).

If the blocking distance is undershot, it may cause device malfunction. In order to notice if the level approaches the blocking distance, you can specify a safety distance (SD). If the level is within this safety distance, the Prosonic M outputs a warning or alarm message.

Set-up - Configuration

See 'Basics'.

The 'Basic setup' menu enables a quick and simple commissioning. The software helps the user to enter the main parameters which cover 95% of the cases. By entering the data carefully, you will avoid many problems.

Our service team can set up any Endress+Hauser device for you and thus ensure you immediately get the best from your instrument. (see **'Commissioning'** in the 'At your service' section)

Operation and Maintenance

Maintenance
See 'Basics' (page 11).

We recommend a periodical inspection of the membrane and the use of a piece of rag to wipe it if necessary.

Calibration
See 'Basics' (page 10).

Corrective maintenance - Spare parts
See 'Basics' (page 11)

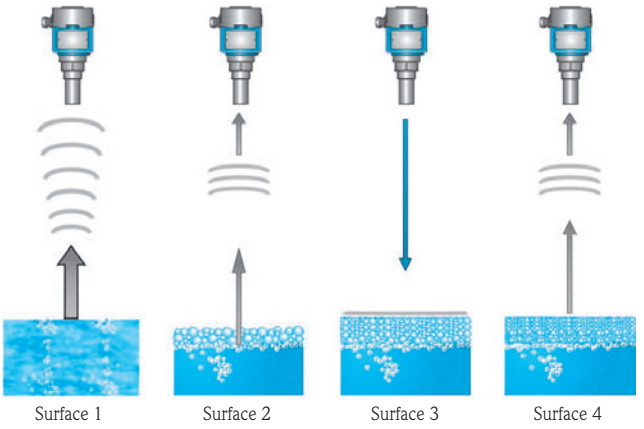


Fig. 3: reflection of ultrasonic waves on liquids
Surface 1: ideal conditions
Surface 2: very light foam with big bubbles in very thin layers
Surface 3: light foam in thick layer
Surface 4: very dense foam, small bubbles, compact

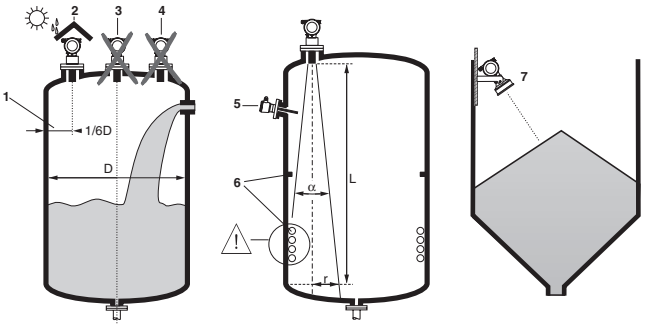


Figure 4: General installation conditions

Sensor	α	L_{max}	r_{max}
FMU40	11°	5 m	0.48 m
FMU41	11°	8 m	0.77 m
FMU42	11°	10 m	0.96 m
FMU43	6°	15 m	0.79 m
FMU44	11°	20 m	1.93 m

Table 1

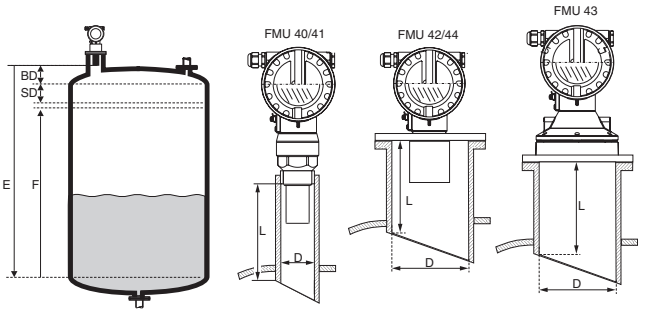


Figure 5: Blocking distance, nozzle installation
BD: blocking distance; SD: safety distance; E: empty calibration; F: full calibration (span); D: nozzle diameter; L: nozzle length

Instrument and spare parts availability

See right table.

If you want to get more information about spare parts availability, please call our hotline xxxx xxx xxxx.

Migration

S range: FMU 860 (1-channel level measurement), 861 (flow measurement) and 862 (2 -channel level measurement) have been phased-out.
The new FMU90 transmitters associated to FDU9X sensors replace FMU86x transmitters and FDU8x sensors.
The new FMU90 transmitter is fully compatible with the FDU8x transmitters and can be used in association with FDU8x sensors.
Warning: the sensors FDU83/84/85/86 with an ATEX, FM or CSA certificate are not certified for connectiion to the FMU 90 transmitter.
On the other hand, the new FDU9x sensors cannot be used with FMU86x transmitters.

Advantages
- FMU90 offers full compatibility with the equivalent FMU86x version e.g. the 1-channel level measurement FMU90 is 100% compatible with FMU860.
- An installation on a mast can be reused. On the contrary, you will need to drill again in case of wall mounting.
- FMU 90 transmitters are available as field housing or cabinet housing (mounting on DIN rail).
- Because ISO Venturi channels were not preconfigured in the FMU861 (ISO415 to ISO480), many users have asked us about the curves and about the way to program them in the device. These channels are not preconfigured in the FMU90.
- Matrix programming has been replaced by a simplified and user-friendly programming concept on the new Prosonic S FMU90.
- Like for the old generation, the maximum distance between the transmitter and the sensor is 300 m.

Re-engineering

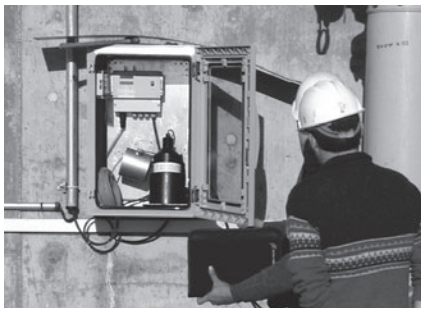
The 2-channel version of FMU90 is quite polyvalent: each channel can be affected either to flow measurement or to level measurement thus allowing three combinations: level + level, level + flow and flow + flow.

Prosonic M family	BD	Max. range liquids	Max. range bulk materials	Nozzle diameter	Max. nozzle length
FMU40	0.25 m	5 m	2 m	50 mm	approx. 80 mm
				80 mm	approx. 240 mm
				100 mm	approx. 300 mm
FMU41	0.35 m	8 m	3.5 m	80 mm	approx. 240 mm
				100 mm	approx. 300 mm
FMU42	0.4 m	10 m	5 m	80 mm	approx. 250 mm
				100 mm	approx. 300 mm
FMU43	0.6 m	15 m	7 m	min. 100 mm	approx. 300 mm
FMU44	0.5 m	20 m	10 m	min. 150 mm	approx. 400 mm

Table 2

Your instrument	Spare part availability	New generation
FMU2380	NO - since 12/2002	FMU4x*
FMU2480	NO - since 12/2002	FMU4x*
FMU2680	NO - since 12/2002	FMU4x*
FMU280	NO - since 12/2002	FMU4x*
FMU130E/A	NO - since 10/2005	FMU4x*
FMU131E/A	NO - since 10/2005	FMU4x*
FMU232	YES - until 11/2008	FMU4x*
FMU2780	NO - since 12/2002	FMU90
FMU86x	YES - until 03/2012	FMU90
FDU8x	YES - until 12/2013	FDU9x
DU41C	YES - until 12/2010	FMU44
DU60Z	NO - since 10/2006	FMU44
DU61Z	NO - since 10/2006	FMU44

* Partly compatible



Capacitive level measurement

Liquicap series

The current Endress+Hauser range of capacitive sensors comprises some seventy instruments. In the next future, this range will be shortened to:

- **Level detection for liquids: Liquicap M FTI51/52 and probe 11500Z**
- **Level detection for solids: Solicap M FTI55/56, Nivector FTC968, Minicap FTC260/262 and probes T12892 and T12894**
- **Level measurement for liquids: Liquicap T FMI21 and Liquicap M FMI51/52**

With this section we aim at:

- **providing a concise reminder of the main guidelines for an optimal use of capacitive sensors**
- **providing efficient help to Liquicap M users throughout the life cycle.**

"Ensure good connection to the ground in any case"

Measuring principle

The principle of capacitive level measurement is based on the change in capacitance of the capacitor due to the change in the level formed by the probe and the container wall (conductive material). When the probe is in air (1), a low initial capacitance is measured. When the container is filled, the capacitance of the capacitor increases the more the probe is covered (2), (3). As of a conductivity of 100 µs/cm, the measurement is independent of the value for the dielectric constant (DK) of the liquid. As a result, fluctuations in the DK value do not affect the measured value display. Furthermore, the system also prevents the effect of medium buildup or condensate near the process connection for probes with an inactive length.

Note! A ground tube is used as a counterelectrode for containers made of non-conductive materials.

Function

The selected electronic insert of the probe (e.g. FEI50H 4 to 20 mA HART) converts the measured change in capacitance of the liquid into a signal in proportion to the level (e.g. 4 to 20 mA) and thus makes it possible to measure the level.

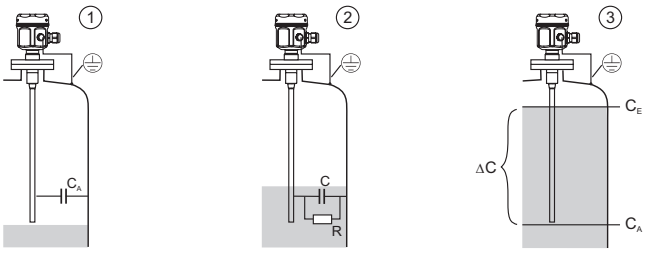


Figure 1: Measuring principle
R: Conductivity of liquid
C: Capacitance of liquid
CA: Initial capacitance (probe not covered)
CE: Final capacitance (probe covered): change in capacitance
ΔC: Change in capacitance

Phase-selective measurement

The electronic evaluation of the container capacitance works along the principle of phase-selective measurement. In this process, the amount of alternating current and the phase shift between the voltage and current is measured. With these two characteristic quantities, the capacitive idle current can be calculated by the medium capacitor and the real current by the medium resistance. Conductive buildup stuck to the probe rod/rope acts like additional medium resistance and causes an error in measurement. As the size of the medium resistance can be determined with phase-selective measurement, an algorithm is used to compensate the buildup on the probe.

Thus, Liquicap M has buildup compensation.

General installation conditions

- The probe may not come into contact with the container wall! Do not install probes in the area of the filling curtain!
- When using in agitating tanks, make sure you install at a safe distance from the agitator.
- Rod probes with a ground tube should be used in the event of severe lateral load.
- When mounting, ensure there is a good electrically conductive connection between the process connection and the tank e.g. use an electrically conductive sealing band.

For containers that conduct electricity e.g. steel tanks, see fig. 2.
For containers that do not conduct electricity e.g. plastic tanks, use a probe with ground tube and ensure proper grounding (see fig. 3).

When installing in a nozzle, use a rod probe with ground tube and inactive length (see fig. 4).

As a general rule, the probe should neither be shortened nor lengthened. Only on Liquicap T FMI21, Liquicap M fMI52 / FTI52 and Minicap FTC262 the probe may be shortened be means of a special kit.

Specific installation conditions for rod probes

The probes are 'plug and play' where the conductivity is higher than 100 µS/cm. Reported measurement errors are generally due to:

- A bad connection to the ground
- The absence of a conterelectrode or a ground tube in case of containers made of non-conductive material
- Customer's specific constraints

On conductive tanks (metal tanks)
If the process connection of the probe is insulated from the metal tank (e.g. through seal material), the ground connection at the probe housing must be connected to the tank by means of a short cable. (see fig. 5)
Note! A fully insulated rod probe may neither be shortened nor extended.
Damaged insulation probe results in an incorrect measurement result.

On non-conductive tanks (plastic tanks)
Always use a probe with ground tube (see fig. 6).

Tensioning weight (see fig.7)
The end of the probe needs to be secured when the probe could touch the silo wall or another part in the tank. This is what the internal thread in the probe weight is intended for.
The bracing can be conductive or insulating to the tank wall.
We strongly recommend to secure the end of the probe in case of high tank or silo and also in case of agitated liquid.
To avoid a too high tensile load the rope should be loose or guyed with a feather. The maximum tensile load may not exceed 200 Nm.

Set-up - Configuration

Calibration is neccessary only at startup. There will be no drift afterwards.

Liquicap M FMIxx
For conductive liquids (>100 µS/cm), the probe is calibrated at the factory to the probe length ordered (0 % to 100 %). For nonconductive liquids (<1 µS/cm), 0%

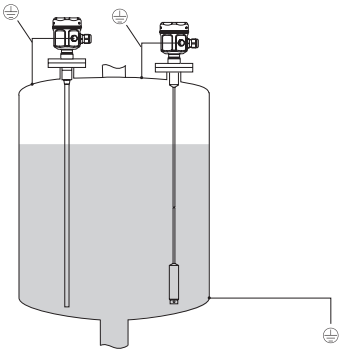


Figure 2: Installation on containers that conduct electricity

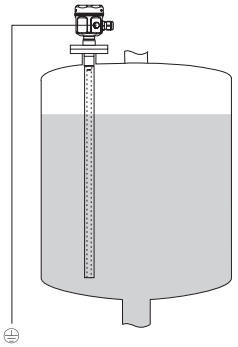


Figure 3: Installation on containers that do not conduct electricity

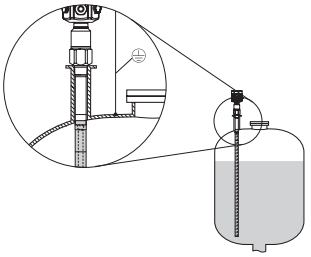


Figure 4: Installation in a nozzle

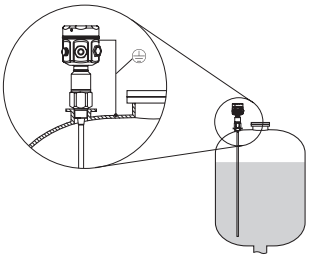


Figure 5: Installation of rod probes on conductive tanks

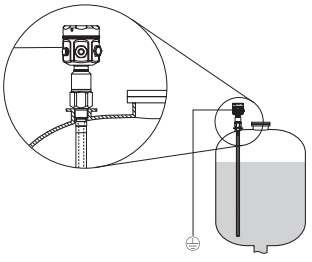


Figure 6: Installation of rod probes on non-conductive tanks

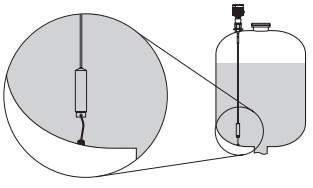


Figure 7: Tensioning weight

calibration is performed at the factory. Only the 100% calibration has to be carried out on site.

Liquicap M FTIxx and Solicap M FTIxx
Calibration at the detection point has to be carried out on site.

Liquicap T
For conductive liquids (> 30 µS/cm), the probe is calibrated at the factory to the probe length ordered (0 % to 100 %). For nonconductive liquids (< 1 µS/cm), 0% calibration is performed at the factory. Only the 100% calibration has to be carried out on site.

Other probes (T12892, T12894, 11500Z)
Calibration of the remote transmitter at the detection point has to be carried out on site.

Our service team can set up any Endress+Hauser device for you and thus ensure you immediately get the best from your instrument. (see **'Commissioning'** in the 'At your service' section)

Operation and Maintenance

Local operation directly on the electronic insert (FEI50H) (see fig. 8)

Local operation with the display (see fig. 9)
The display can be used to configure directly at the device via 3 keys. All device functions can be set via menu operation. The menu consists of function groups and functions. Application parameters can be read or set in the functions.

Remote operation with FieldCare
FieldCare is described on page S3.

Maintenance
No maintenance is necessary. You may use the 4 to 20 mA current pick-off, e.g. for full/empty calibration with multimeter. (No need to disconnect circuit!)

Adjustment
An adjustment is neccessary:
- for non-conductive liquids
- if the ε_r of the medium has changed.

Instrument and spare parts availability
See table at the right

If you want to get more information about spare parts availability, please call our hotline xxxx xxx xxxx.

Migration

Multicap is phase-out. Please consult us.

Re-engineering

Please consult us.

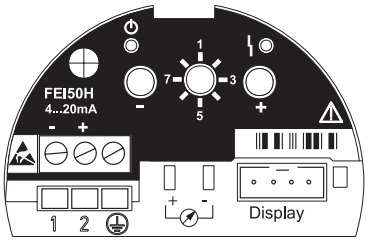


Figure 8: Local operation directly on the electronic insert
- Green LED (⏻ operational status)
- Red LED (ϟ fault message)
- Key (-)
- Key (+)
- Mode switch
  1 : Operation
  2 : Empty calibration
  3 : Full calibration
  4 : Measuring modes
  5 : Measuring range
  6 : Self-test
  7 : Reset (factory settings)
  8 : Upload sensor EEPROM
- 4 to 20 mA current pick-off, e.g. for full/empty calibration with multimeter. (No need to disconnect circuit!)
- Display connection

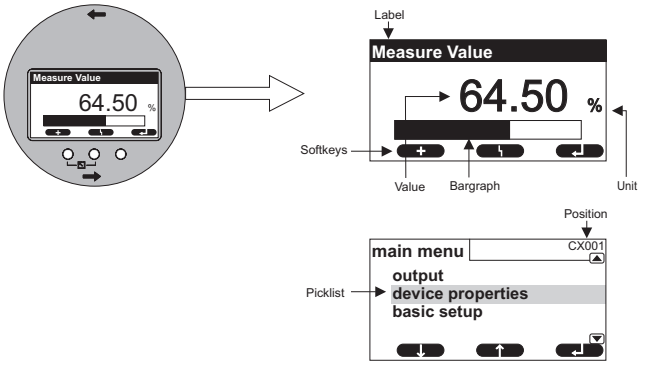
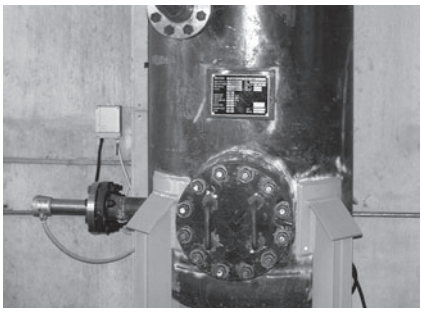


Figure 9: Local operation with the display

Your instrument	Spare part availability	New generation
Multicap family	YES - until 12/2010	Consult us



Frequently asked questions

Micropilot: How can I adjust the LCD contrast?
Press '+ ' and 'E' or '-' and 'E' simultaneously.

Micropilot: How can I unlock the hardware?
No configuration is possible if the device is locked. To unlock the hardware via the Display, enter the following code: Press '+', '-' and 'E' simultaneously.

Levelflex M: The filling level indicated by the device is too high. What can be done?
- Check the setting of the medium property and correct, if necessary.
- Carry out mapping.
  (Rope probes: mapping range 2 m,
  Rod probes: Define the total probe length as mapping range.)
  Attention: During mapping, the filling level must be below the mapping range.

Prosonic S/M and Micropilot M: The level indicated by the device is too high. What can be done?
Carry out mapping. Attention: During mapping, the filling level must be below the mapping range.

Levelflex M, Prosonic S/M and Micropilot M: The device indicates the correct value on site, but keeps on showing 4 mA at the output. What can be done?
Presumably a HART address was assigned and the device works in the Multidrop mode. Set the HART address to 0!

Prosonic FMU86X: Alignment values cannot be entered, the values keep on going back to alignment empty 10 m and alignment full 9 m.
No sensor has been selected yet. Select sensor and confirm with 'E'!

Prosonic FMU86X: Although a different endpoint of the scaling has been entered in V2H7, the device keeps on indicating in the former units in VOHO.
After changing the endpoint in V2H7, the value entered in V2HO must be confirmed with 'E'.

Prosonic FMU86X: How to shift the decimal dot?
Press '+' and '->' simultaneously.

Prosonic FMU86X: Error E641 "Echo lost". Is there a troubleshooting?
Remove the sensor and cable it directly to the transmitter. Then aim at the ground so that the membrane is approximately 1 m above the ground. If E641 diappears, it means the device is OK.

Prosonic: How can I adjust the 0% level of the tank?
As the tank is empty, read the value displayed in V0H8 and type the same value in V0H1.

Prosonic: Is there any equivalence between the parameters for FMU86X and for FMU90?
No. The approach is different.

Prosonic FMU90: the sensor is not recognized…
Check which type of sensor is connected. In case this is the old FDU8x sensor, the sensor has to be selected manually.

Capacitive measurement: I get an incorrect measured value at commissioning…
Ensure the grounding is correct. In case of a non-metal tank, ensure the installation conditions are met (see previous pages).

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