

Ultrasonic Level Measurement *watersonic FMU 100 (Z)*

**For level measurement in water treatment plants
Designed for use in explosion hazardous areas**



The Watersonic FMU 100 (Z) package comprises the FMU 100 (Z) plug-in card, Monorack housing and sensor DU 100 (Z) or DU 101 (Z)

Application

The Watersonic FMU 100 (Z) ultrasonic measuring system is designed for non-contact measurement of water levels in drinking and wastewater treatment plants, pumping stations, drainage systems etc.. It comprises a plug-in FMU 100 (Z) card, Monorack housing for wall-mounting and sensor

- DU 100 (Z) for range max. 9 m or
- DU 101 (Z) for range max. 15 m.

In addition to standard analogue outputs, three relays with freely selectable switch points are available for control of level and pump or valve sequences.

Features and Benefits

- Economical stand-alone units for water applications with 0/4...20 mA, 0/2...10 V signal output and 3 relays.
- Rugged, seawater-proof sensor to IP 68 with one-piece diaphragm and seal: resistant to aggressive vapours and condensates.
- Continuous measurement of liquids in tanks, reservoirs, etc. of all shapes and sizes.
- Measurement independent of fluid properties (density, conductivity) and pressure.
- Self-monitoring with immediate indication of fault condition.
- Intrinsically safe Z-versions designed for [EEx ia] IIC applications. All versions with electrically isolated sensor circuit.

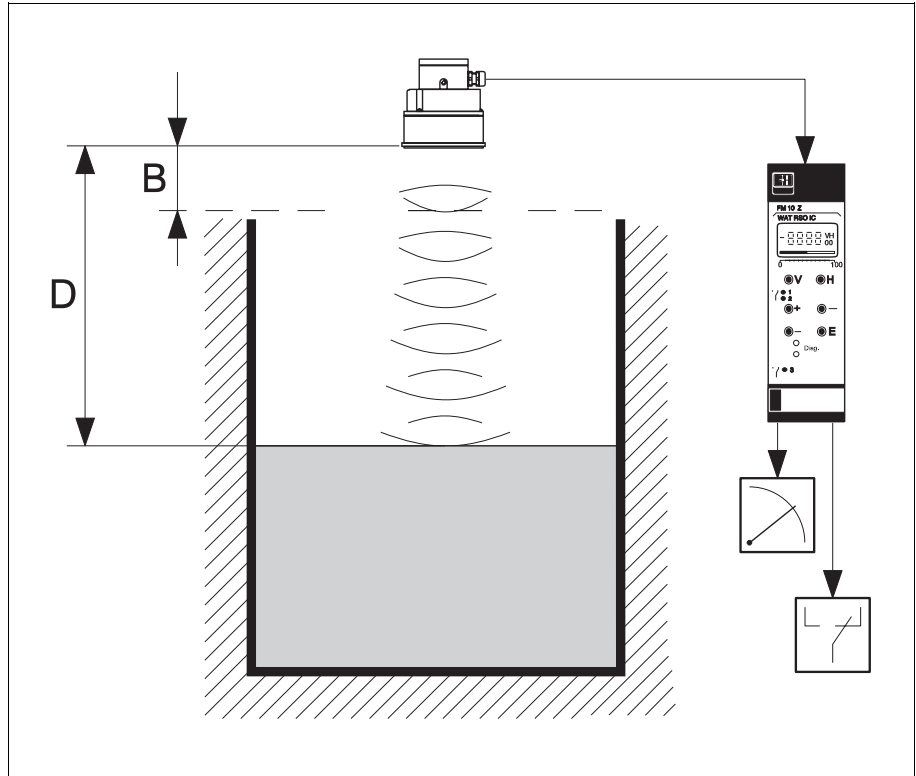
Endress + Hauser

Nothing beats know-how



Measuring Principle

Ultrasonic measuring principle
 D = Distance sensor – product surface
 B = Blocking distance



Ultrasonic Measurement

A sensor mounted above the product directs an ultrasonic pulse through the air towards the product surface.

The product surface partially or fully reflects the pulse back to the sensor. This echo is detected by the same sensor, now acting as a directional microphone, and converted into an electrical signal.

The time between transmission and reception of the pulse - the *run time* - is directly proportional to the distance between the sensor and the product surface. The distance D is determined from the velocity of sound c and the run time t by the formula:

$$D = c \cdot t/2$$

For C = 340 m/s, a run time of 10 ms corresponds to a transmission path of 3.4 m and thus to a distance of 1.7 m.

Measuring Range

After the ultrasonic pulse has been emitted the sensor requires time - the *ringing time* - to stop vibrating. Consequently there is a zone immediately below the sensor from which returning echoes cannot be detected. This so-called *blocking distance* determines the start of the measuring range.

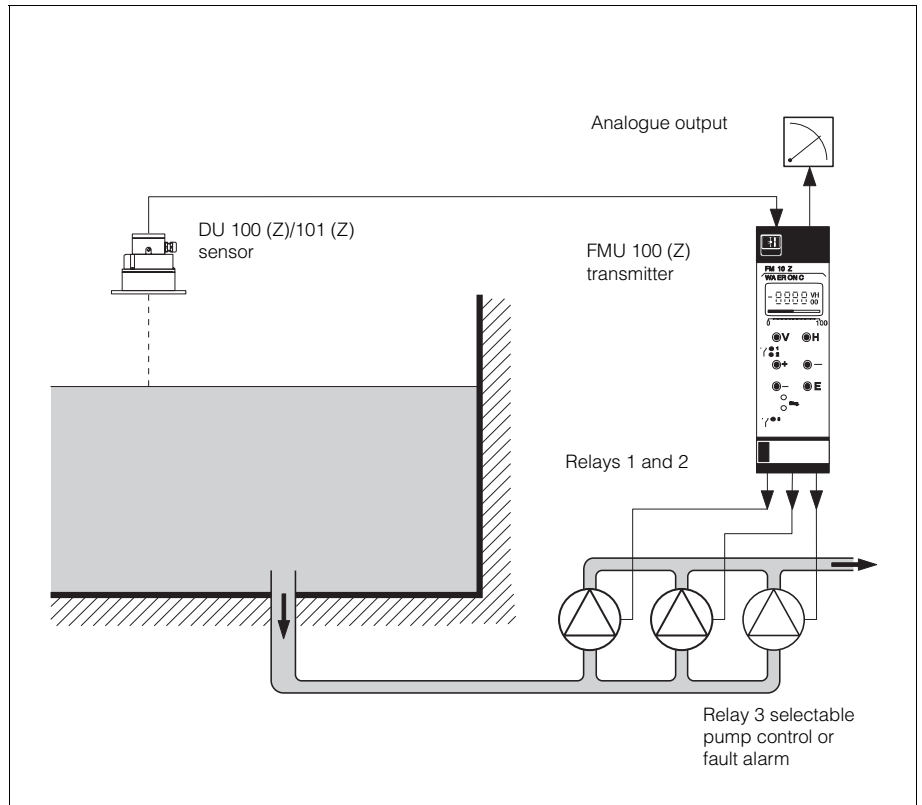
The end of the measuring range is determined by the attenuation of the ultrasonic pulse by the air as well as by the strength of the reflection from the product surface.

Performance

- The measurement is independent of product properties such as specific gravity, conductivity, viscosity and dielectric constant.
- The measurement is unaffected by changes in ambient temperature within the tank or well: the FMU 100 (Z) transmitter compensates by using the information delivered by the temperature sensor built into the DU 100 (Z)/101 (Z).
- Depending on the DU... sensor employed, the measuring range is up to 9 m or up to 15 m.

Measuring System

Typical Watersonic FMU 100 (Z) system application: the three pumps are controlled by the relays which switch according to the water level indicated by the DU 100 (Z)/101 (Z) sensor



Input Signal

A three-core installation cable connects the FMU 100 (Z) transmitter to the DU 100 (Z)/101 (Z) ultrasonic sensor. The FMU 100 (Z) transmitter in Monorack housing supplies power and the sensor sends back an echo signal. This is converted to a level or volume indication. The measured value is displayed at the front panel.

Signal evaluation

Standard 0/4...20 mA and 0/2...10 V outputs, proportional to level or volume, are provided.

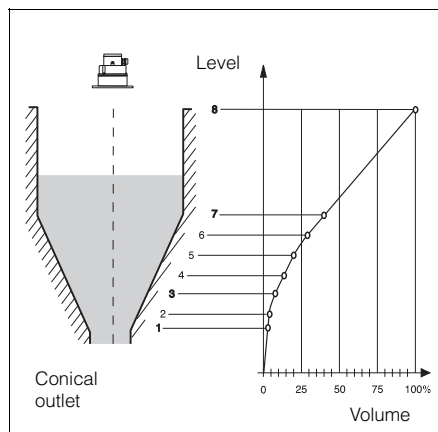
- Any initial or end of range value can be accurately set.

Up to three relays operate in minimum or maximum fail-safe mode. The relays can switch pumps on and off when the level falls below or rises above the switch point or if a fault condition is detected.

- The relays switch individually or in sequence as required.
- A preset delay prevents overloading on pump start-up when two relays trip simultaneously.

Vessel Linearization

Volume is calculated from level via the vessel characteristic which describes the shape of the vessel.



It is possible to enter vessel characteristics for up to 30 break points.

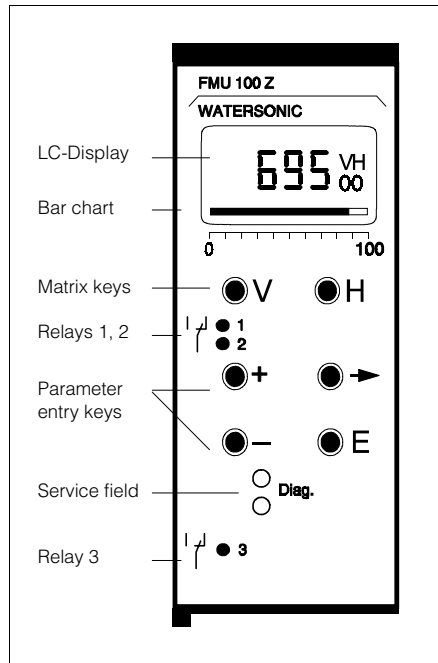
These are obtained by filling the vessel or from drawings provided by the user.

Function Monitoring

The FMU 100 (Z) transmitter continuously monitors all signal lines from sensor to analogue outputs and fails to safe if a fault is detected.

- All LEDs flash on fault condition.
- The analogue signal drives to -10 % or +110 % level or holds the last measured value.
- The relays respond according to the selected fail-safe mode.
- When used as fault alarm the 3rd relay de-energises

Operation



Front panel of the FMU 100(Z) transmitter

- Keys V and H select the matrix field
- Parameters are entered using the »+«, »-«, »» and »E« keys

Direct Programming

The FMU 100 (Z) transmitter is programmed and interrogated at the front panel.

- Six keys access a parameter matrix, defined by a vertical (V) and horizontal (H) position, in which the relevant data can be entered.
- The selected matrix field is indicated in the LC-display preventing entry and reading errors.
- During operation level, volume, temperature, echo damping, signal/noise ratio, and output current parameters are available for display.
- A horizontal 10-step LCD bar strip indicates level or volume as a function of the current output.

Operational Status

The operational status of the transmitter is indicated by means of 3 LEDs, which can be clearly seen from a distance.

- The yellow LEDs in the central field indicate the output status of relays 1 and 2: when lit energised.
- When relay 3 is used as a fault alarm, the yellow LED in the diagnostics field lights for a fault condition. For pump control a lit LED indicates energised status.
- Should a fault condition arise when all relays are being used for pump control, all LEDs flash.

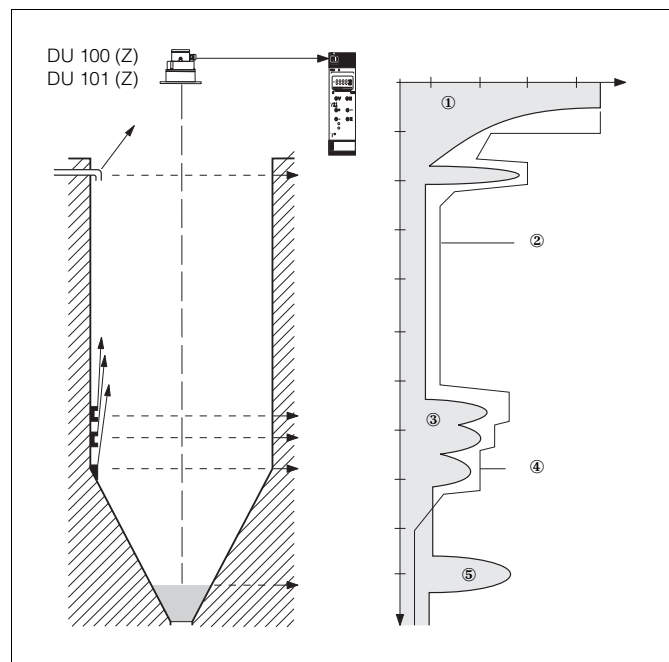
Interference Echo Suppression

The echo suppression function ensures that measurements can still be made when interference echoes, caused by permanent fixtures, are present in the signal.

- The detection threshold is automatically adjusted to the echo profile so that interference echoes are no longer registered and processed.

Suppression of interference echoes from fixtures:

- ① Transmission pulse and signal decay
- ② Time-dependent identification threshold
- ③ Interference echo
- ④ Echo suppression by temporary increase of threshold
- ⑤ Strong echo from product surface



Pump Control

Operating Modes

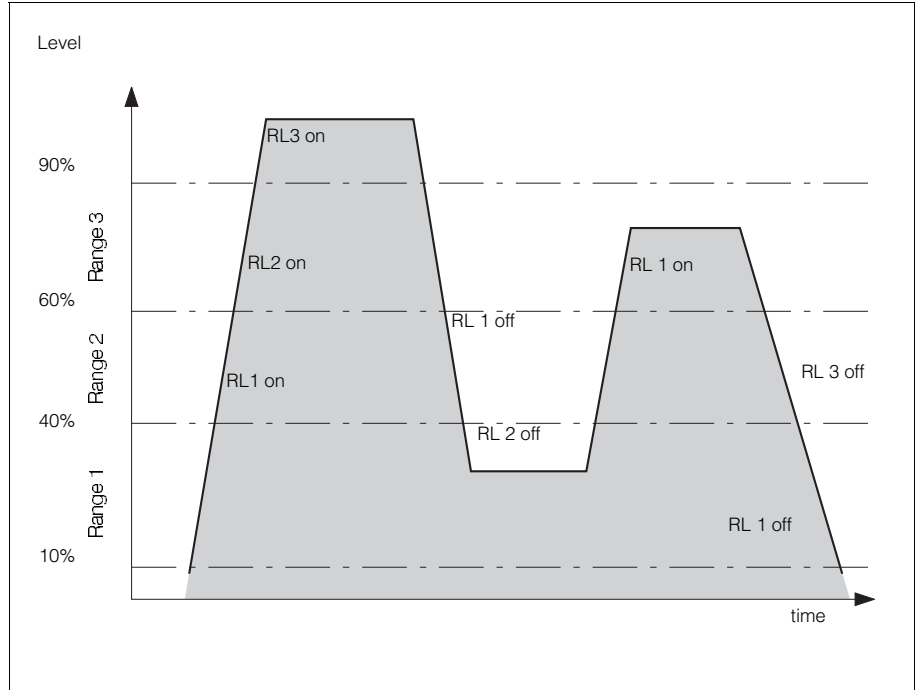
The FMU 100 (Z) transmitter is equipped with three relays which can be used to control levels by switching pumps on and off. The switching range is defined by two switch points. Relay 3 can be assigned to fault indication or pump control as required. Possible modes are:

- Sequential pump control using two or three relays: the pumps are switched on and off alternately as the switch points are passed.
- Independent control using two relays: the third can e.g. be used as a minimum limit indicator to prevent dry-running of the pump or as a fault indicator for the Watersonic FMU 100 (Z) system.

Sequential pump control
The three control ranges defined for pump switching are not assigned to specific relays.

- As the level rises, the pumps are switched on in turn.
- As the level falls they are switched off in the same order.

The alternation between pumps ensures even loading and decreased pump wear.



Max. and Min. Fail-safe Mode

Each relay can be individually set to minimum or maximum fail-safe mode.

- In maximum fail-safe mode the relay de-energises when the level rises above the upper switch point and on fault condition.
- In minimum fail-safe mode the relay de-energises when the level falls below the lower switch point and on fault condition.
- On power failure all relays de-energise.

Overspill Protection/Dry Running

When all three relays are used for pump control:

- Fault conditions can be detected via the 4...20 mA signal which drops to -10% or jumps to +110% (or holds the last value) as set.
- It is recommended that an independent (conductance) system is installed as maximum or minimum switch to prevent overflows or pumps from running dry.

Truth table for relay status as a function of level and fail-safe mode.

Minimum fail-safe mode			Maximum fail-safe mode		
Level	Relay	LED	Level	Relay	LED
< Switch point 2	De-energised z18 d20 z20 z22 d24 z24 z26 d28 z28	Off 	< Switch point 2	Energised z18 d20 z20 z22 d24 z24 z26 d28 z28	On
> Switch point 1	Energised z18 d20 z20 z22 d24 z24 z26 d28 z28	On 	> Switch point 1	De-energised z18 d20 z20 z22 d24 z24 z26 d28 z28	Off

Planning

Sensor Position

If the tank or basin contains internal fittings, e.g ladders, bracing, pipework, correct positioning of the sensor is essential if interference echoes are to be kept to a minimum:

- Check that the ultrasonic pulse arrives unhindered at the product surface.

Ultrasonic Beam

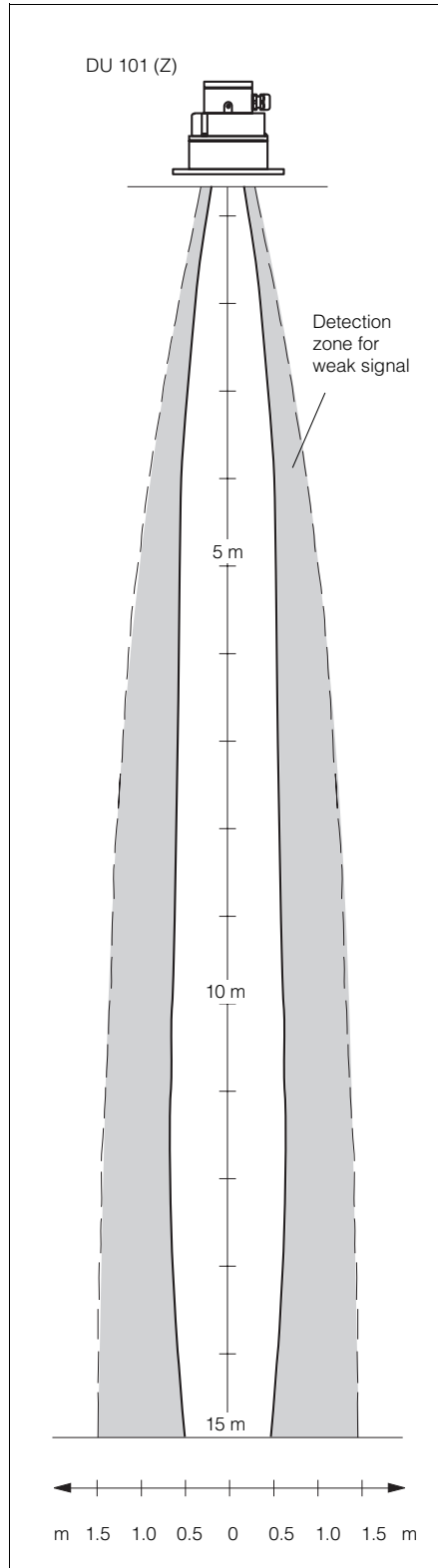
The ultrasonic pulse leaves the sensor as a directed beam which slowly widens as it travels towards the product surface. Any object lying within the beam will produce an echo which may be received by the sensor.

- Take care that no edges, fittings etc. lie within the beam for the first third of the selected measuring range, since the sonic energy is still highly concentrated here: small reflecting surfaces can cause very strong echoes.
- In the last third of the selected measuring range the sonic energy is spread across a much larger area. Here reflections from internal fittings and edges are much less critical.

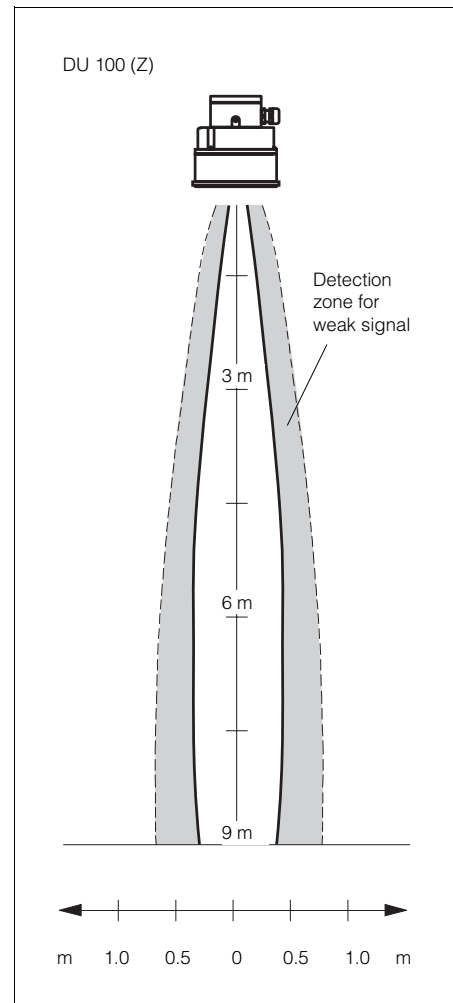
Across the beam two detection zones can be defined:

- Any object within the central detection zone (full line in the illustrations) will produce a strong echo.
- Echoes from the second zone are important to measurement only when the signal from the surface of the product is relatively weak.

Measuring range and detection zone
DU101 (Z) (lines of equal attenuation)



Measuring range and detection zone
DU 100 (Z) (lines of equal attenuation)



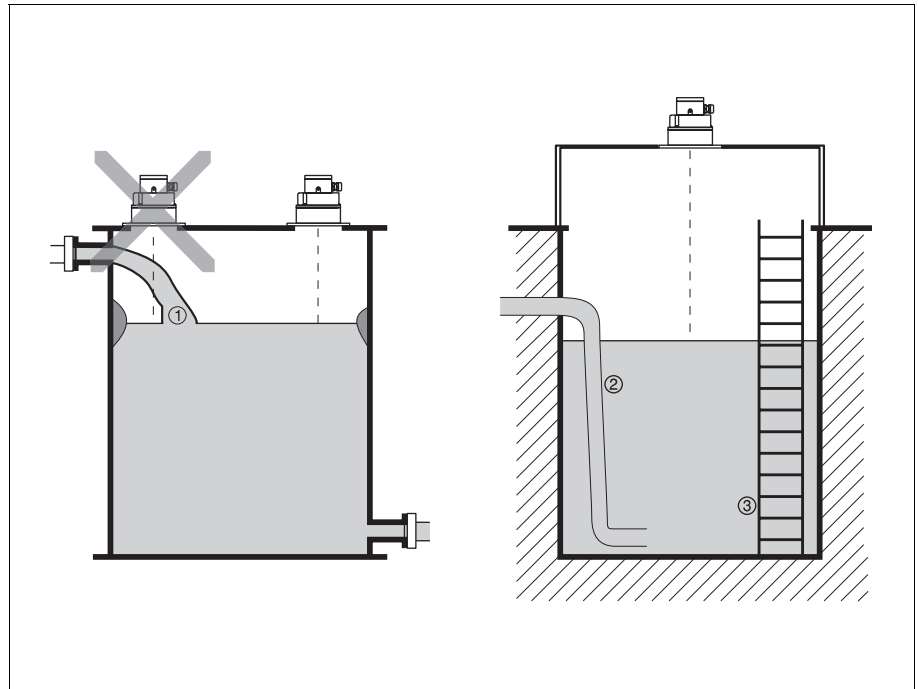
Recommendations

Internal Fittings

- Do not install the sensor directly above the inflow pipe or filling curtain ①.
- Check the required lateral clearance from any fittings such as pipework ② or ladders ③ by using the detection zone diagrams

Mount the sensor so that it points to the bottom of the tank or basin. Avoid:

- water inlet curtains
- piping
- internal fittings such as bracings and ladders



Sensor Mounting

- Several possibilities exist for mounting:
- For tanks, the slip-on flange ① can be used. A well-finished mounting pipe, with max. length 2x sensor diameter, can be used if necessary. For flange dimensions see p 11.
 - For open tanks, wells and sumps a simple angle iron construction can be used ②. The sensor is secured by two M10 bolts.
 - For covered wells and sumps where access is difficult, the sensor can be suspended from a rail by the mounting bracket ③.

Blocking Distance

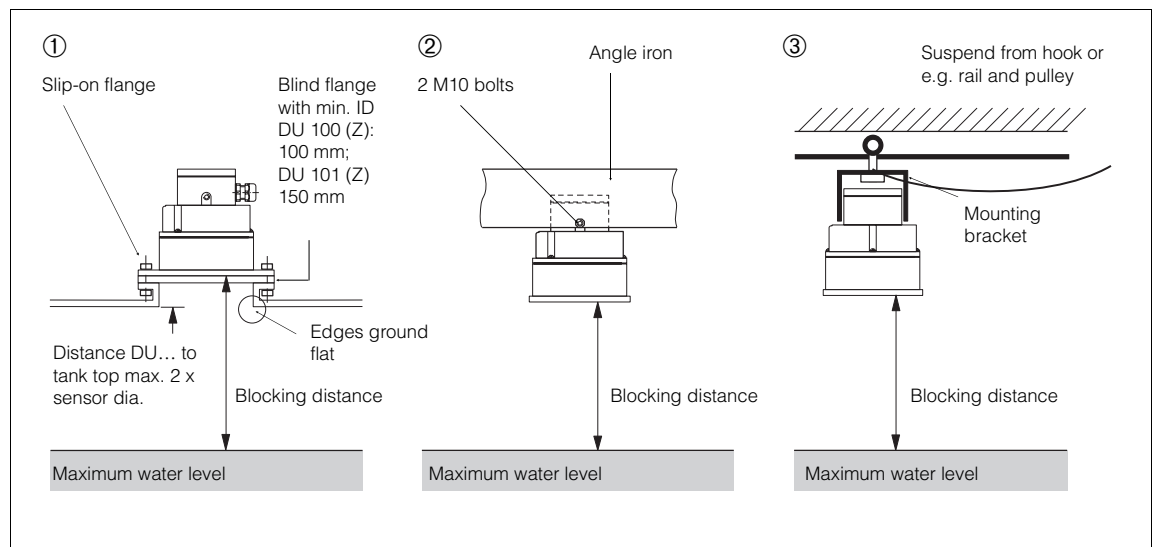
- Plan mountings such that even in the event of overflowing, the level does not come within the blocking distance.
- If this criterion is not fulfilled, incorrect measurement will result.

Sensor Orientation

- Mount the sensor pointing directly downwards.
- Choose a position where internal fittings are avoided.
 - For conical outlets check that the sensor points to the very bottom of the shaft, so that a signal is also received when the tank is empty.

Suggestions for sensor mounting

- ① with slip-on flange
- ② with angle irons on an arm or gantry
- ③ movable on a rail, suspended from the mounting bracket



Electrical Connection

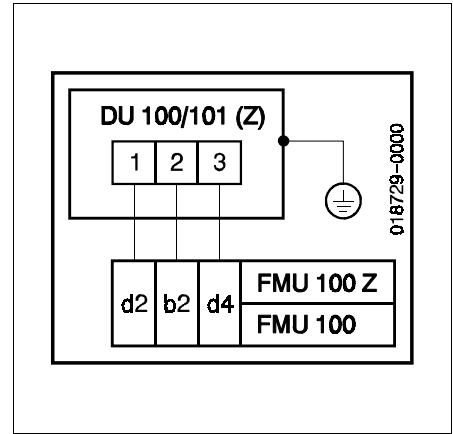
Sensor Connection

- Power is supplied by the FMU 100 (Z) transmitter in Monorack housing.
- Use commercial 3-core installation cable.
- The max. line resistance 25 Ω/core.
- When installing in explosion hazardous areas (Ex-versions only), observe the relevant regulations.

Electromagnetic Interference

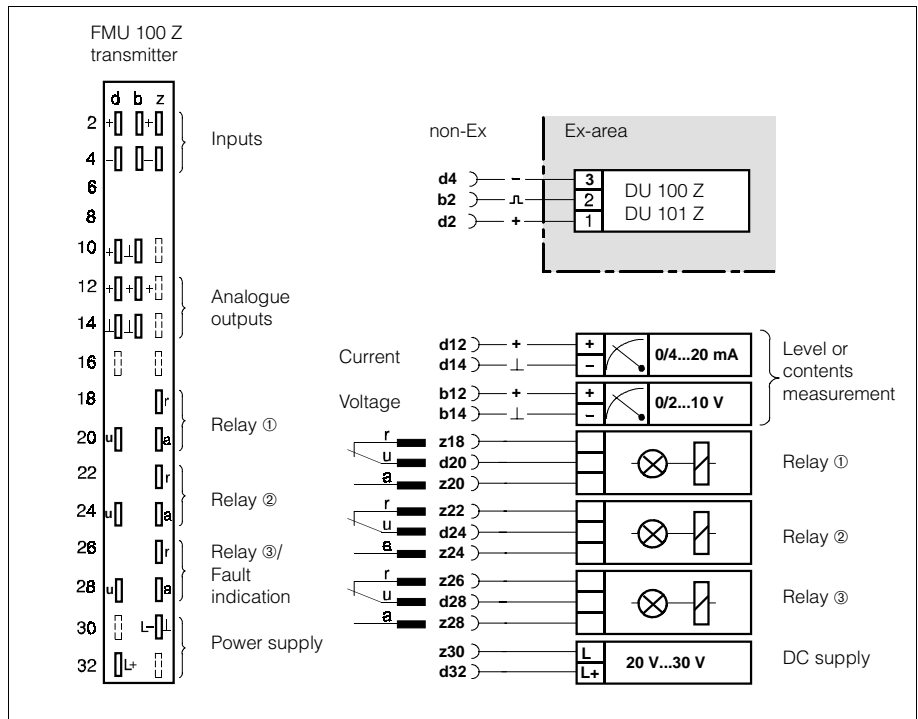
In case of electromagnetic interference:

- use shielded cable
- connect to the DU ... internal ground terminal, not to the Watersonic
- connect any potential equalization cable to the DU... external ground terminal

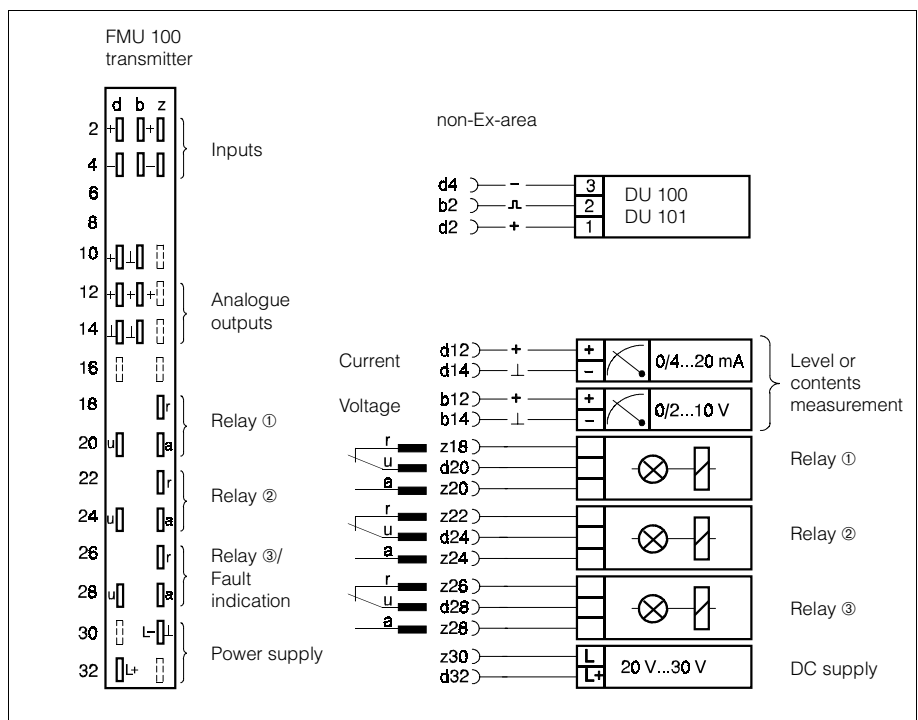


Connection diagram
Sensor — FMU 100 (Z)
transmitter

Connection diagram
FMU 100 Z transmitter



Connection diagram
FMU 100 transmitter



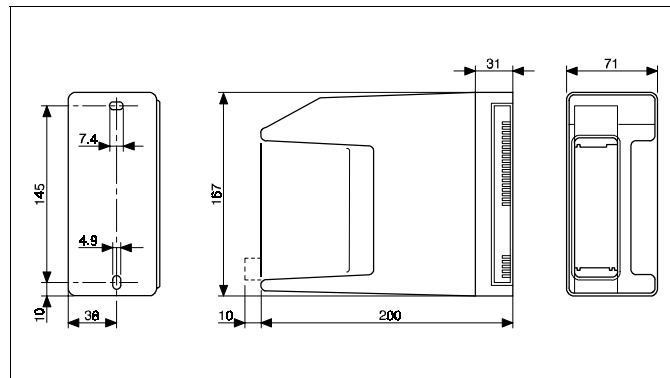
Technical Data Watersonic FMU 100 (Z)

Construction

- Design: wall-mounted housing
- Front panel: black synthetic with blue field inlay, grip and markings,
 - Protection: IP 20 (DIN 40050)
- Housing: ABS, grey with black base,
 - Protection: IP 40 on flat wall, IP 30 when rail-mounted
- Dimensions: see diagram
- Weight: approx. 1.2 kg/3 lbs
- Operating temperature: -20°C...+60°C
Storage temperature: -20°C...+ 85°C



Protective Monorack housing



Dimensions (mm) of Monorack housing for FMU 100 (Z) transmitter

Protective Housing (Accessory)

- Aluminium housing, for 2 Watersonic units.
- Construction: pollution and sea-water resistant aluminium base, transparent PVC cover with cellular rubber seal
- Protection: IP 55 (DIN 40050)
- Dimensions: 209 x 258 x 235 mm
- Weight: 2.9 kg/6 lbs.
- Operating temperature:
 - 20°C...+50°C with 1 Monorack
 - 20°C...+40°C with 2 Monorack

Plug connection

- Multipoint plug: conforming to DIN 41612, Part 3, Type F (30-pole)
 - see Connection Diagram
- Index pins for Z-version coding supplied for insertion at positions 1 and 28

Power Supply

- 220...240 V AC (+15%, - 10%), 50/60 Hz switchable to 110...127 V AC (+15% , - 10%) or 100 VAC ±10%, 50/60 Hz switchable to 200 V AC ±10% or 42...48 V AC (+15%, - 10%), 50/60 Hz switchable to 24...28 V AC (+15%, - 10%) or 24 V DC, residual ripple < 600 mV, 100 Hz
- Output current: max. 130 mA
- Power consumption: max. 5.5 W

Signal Inputs

- Electrically isolated from the rest of the circuitry.
- For Z-versions, intrinsically safe, designed to conform to (EEx-ia) IIC
- Probes:
 - DU 100 Z and 101 Z for FMU 100 Z
 - DU 100 and DU 101 for FMU 100

Signal outputs

- Current output:
 - 0...20 mA/4...20 mA selectable, R_L max. 500 Ω
- Voltage output:
 - 0...10 V/2...10 V selectable, R_L min. 2 k Ω

Relays

- Two independent relays each with a potential-free change-over contact; freely selectable switching range.
- Third relay with potential-free change-over contact , for fault indication or pump control as desired
- Fail-safe mode:
 - Minimum or maximum, selectable
- Pump control: individual or sequential assignment for 2 or 3 relays as required
- Switching capacity:
 - max. 2.5 A, max. 250 V AC (for CSA max. 125 V AC)
 - max. 300 VA at $\cos \varphi > 0.7$
 - max. 100 V DC, max. 90 W

Certificate

- Transmitter FMU 100 Z:
 - PTB No. Ex-92.C.2026 X

Subject to technical change

DU 100 (Z), DU 101 (Z) Sensors

Housing

- Material: Crastin
- Sealing face and diaphragm: PVDF
- Protection IP 68
- Weight: ca. 4 kg/9 lbs
- Dimensions: see below

Operating Conditions

- Operating pressure with metal slip-on flange: $p_e = \text{max. } 3 \text{ bar}$
with polypropylene flange:
 $p_e = \text{max. } 0.5 \text{ bar}$
- Temperature: $-20 \dots +80 \text{ }^\circ\text{C}$

Slip-On Flange

- Standard connections to DIN, JIS or ANSI
- Materials: polypropylene, coated steel or stainless steel - see page 11 -
- Counterflange on tank:
DU 100 (Z) with ID min. 100 mm
DU 101 (Z) with ID min. 150 mm

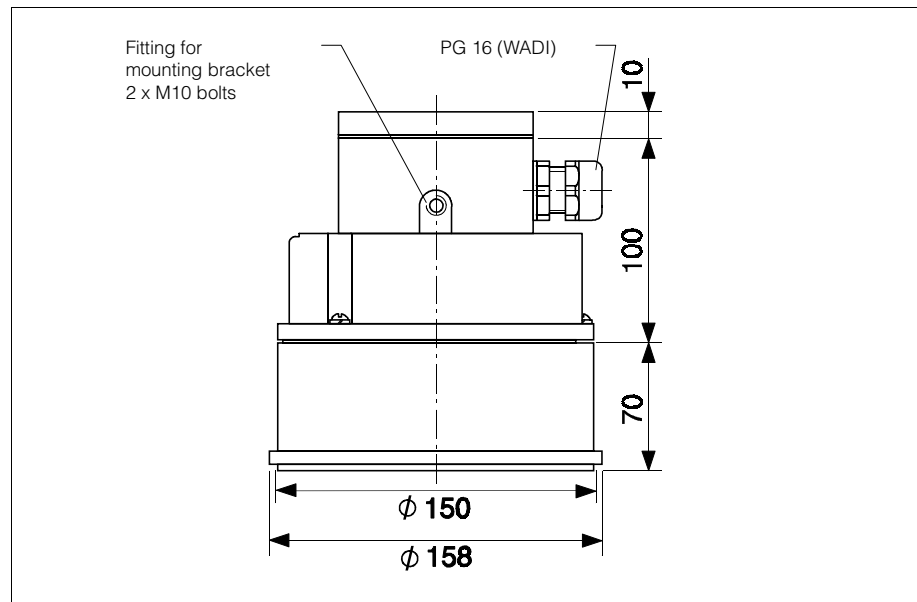
Ultrasonics

- | | DU 100 (Z) | DU 101 (Z) |
|-------------------------------|------------|------------|
| • Range: | 9m/29 ft | 15m/49 ft |
| • Frequency: | 38 kHz | 31 kHz |
| • Pulse frequency: | 4 Hz | 2 Hz |
| • Blocking distance: | 0.5m | 0.8m |
| • Angle of emission at -3 dB: | 5° | 8° |

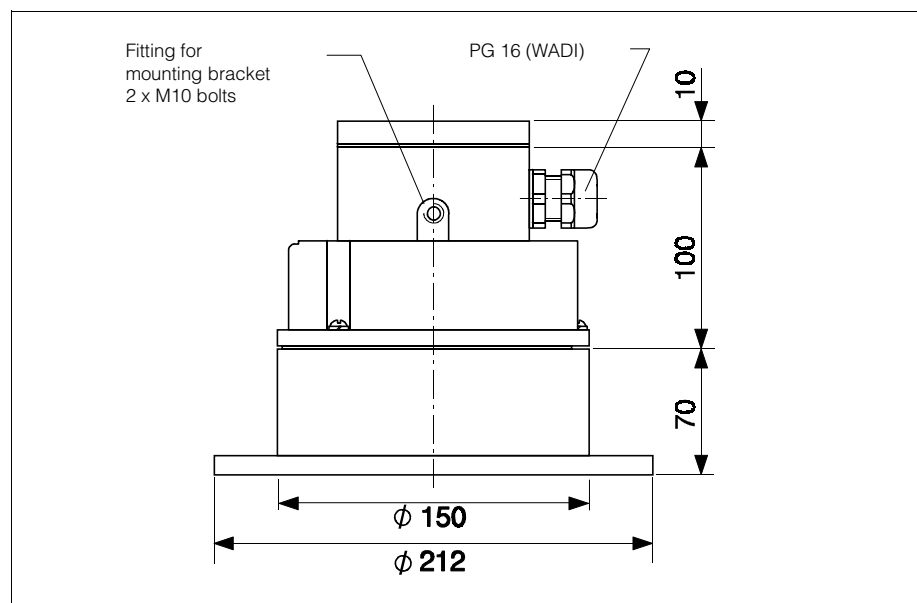
Certificates

- DU 100 Z or DU 101 Z sensor, EEx ia IIC T5, used with FMU 100 Z transmitter in Monorack housing: PTB No. Ex-92.C.2027
- FMU 100 Z: PTB No. Ex-92.C.2026 X

DU 100 (Z) sensor
dimensions in mm
1" = 25.4 mm



DU 101 (Z) sensor
dimensions in mm
1" = 25.4 mm



Accessories

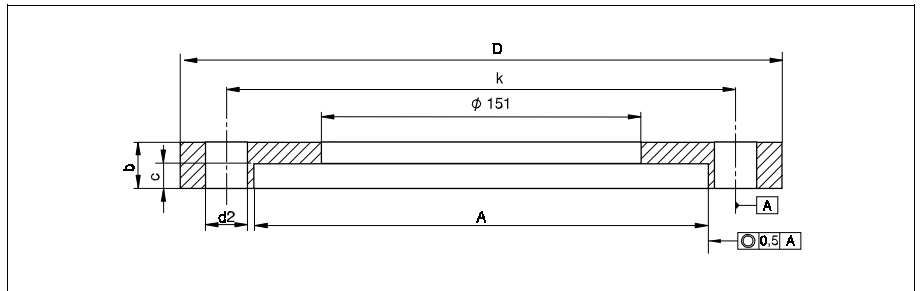
Slip-On Flange FAU 60 for DU 100 (Z)

- DN 100 PN 16 (Code D0),
- JIS 100 K 16 (Code J0) or
- ANSI 4" 150 psi (Code A0).

Slip-On Flange FAU 60 for DU 101 (Z)

- DN 150 PN 16 (Code D1),
- JIS 150 K 16 (Code J1) or
- ANSI 6" 150 psi (Code A1).

Slip-on flange dimensions (mm). Customer must provide counterflange or blind flange with bore dia.
 DU 100 (Z): ≥ 100 mm
 DU 101 (Z): ≥ 150 mm

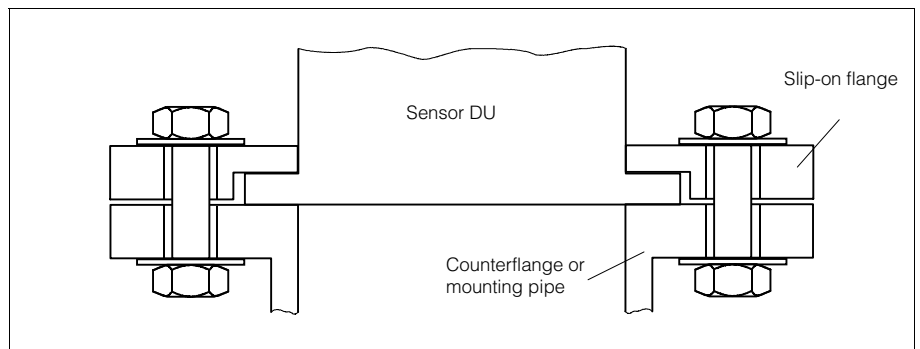


Key to slip-on flange drawing, dimensions in mm (1" = 25.4 mm) for DU 100 (Z)

Order No.	A	b	C	Ø D	Ø d2	k	No. d2	Material	Standard
DU 100 (Z)									
FAU 60 D0 P	160	20	9,2	220	18	180	8	PP	DN 100 PN 16
FAU 60 D0 S								St/Painted	
FAU 60 D0 R								1.4571	
FAU 60 A0 P	23.9			228.6		190.5		PP	ANSI 4" 150 psi
FAU 60 A0 S								St/Painted	
FAU 60 A0 R								1.4571	
FAU 60 J0 P	22			225	23	185		PP	JIS 16 K 100
FAU 60 J0 S								St/Painted	
FAU 60 J0 R								1.4571	
DU 101 (Z)									
FAU 60 D1 P	215	22	11.5	285	22	240	8	PP	DN 150 PN 16
FAU 60 D1 S								St/Painted	
FAU 60 D1 R								1.4571	
FAU 60 A1 P	25.4			279.4		241.3		PP	ANSI 6" 150 psi
FAU 60 A1 S								St/Painted	
FAU 60 A1 R								1.4571	
FAU 60 J1 P	24			305	25	260	12	PP	JIS 16 K 150
FAU 60 J1 S								St/Painted	
FAU 60 J1 R								1.4571	

Key to slip-on flange drawing, dimensions in mm (1" = 25.4 mm) for DU 101 (Z)

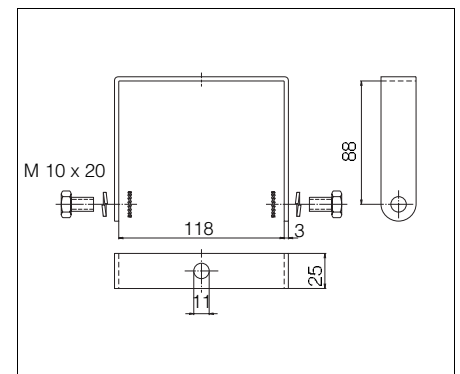
Suggestion for sensor mounting:
 The DU 100 Z cannot be used with a DN 150 counterflange since there is no corresponding sealing surface.



Mounting Bracket FAU 10

A mounting bracket is available as an alternative to the slip-on flange. It allows the sensor to be suspended from the top of the tank or silo.

Mounting bracket dimensions in mm



How to Order

Watersonic FMU 100	
Sensor	
1	DU 100
2	DU 101
Power supply	
A	110 V/220 V AC
L	100 V/200 V AC
D	24 V/48 V AC
E	24 V DC
FMU 100-	<input type="checkbox"/> <input type="checkbox"/> complete order number

Watersonic FMU 100 Z	
Sensor	
1	DU 100 Z
2	DU 101 Z
Power supply	
A	110 V/220 V AC
L	100 V/200 V AC
D	24 V/48 V AC
E	24 V DC
FMU 100Z-	<input type="checkbox"/> <input type="checkbox"/> complete order number

Accessories	
Slip on flange	Order No. FAU 60-***
Mounting bracket FAU 10	Order No. 918815-0000
Protective housing, IP 55	Order No. 918510-0000
Protective housing, IP 55, plastic coated	Order No. 918510-0001

Supplementary Documentation

- Level Measurement Programme
PP 001/00/e
- Ultrasonic Level Measurement
System Information SI 005/00/e
- Monorack Protective Housing
Technical Information TI 099F/00/en

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