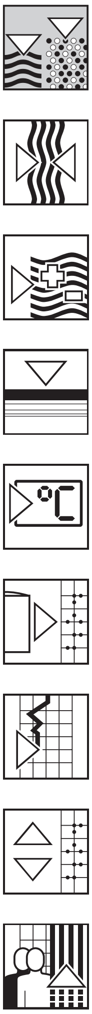
Technical
Information
TI 129F/00/en

Ultrasonic Level Measurement
DU 60 Z and DU 61 Z Sensors

Modular design, corrosion-resistant
Approved for explosion hazardous areas



DU 61 Z
Measuring range
approx. 20 m

DU 60 Z
Measuring range
approx. 12 m

Advantages of Ultrasonics
- Wide range of applications – from liquids through pastes to bulk solids
- Measurement accuracy unaffected by product properties such as density or conductivity
- No recalibration necessary on change of product

Application
- Non-contact, continuous level measurement in explosion hazardous areas.
- Measuring range in liquids:
  DU 60 Z up to 12 m
  DU 61 Z up to 20 m
  depending on measuring conditions
- Operating pressure p_e max. 3 bar
- Operating temperature: –20...+80°C

Principle Sensor Features
- Resistant to aggressive vapours and condensates
- *One-piece* sealing face and diaphragm
- Seawater-proof housing
- Modular design with slip-on flange for all international standards
- Intrinsically safe sensor acc. to ATEX II 2 G EEx ia IIC T6...T5 for connection to Nivosonic FMU 673 Z or FMU 678 Z transmitters
- Electrical isolation of sensor circuits
- Degree of protection IP 68

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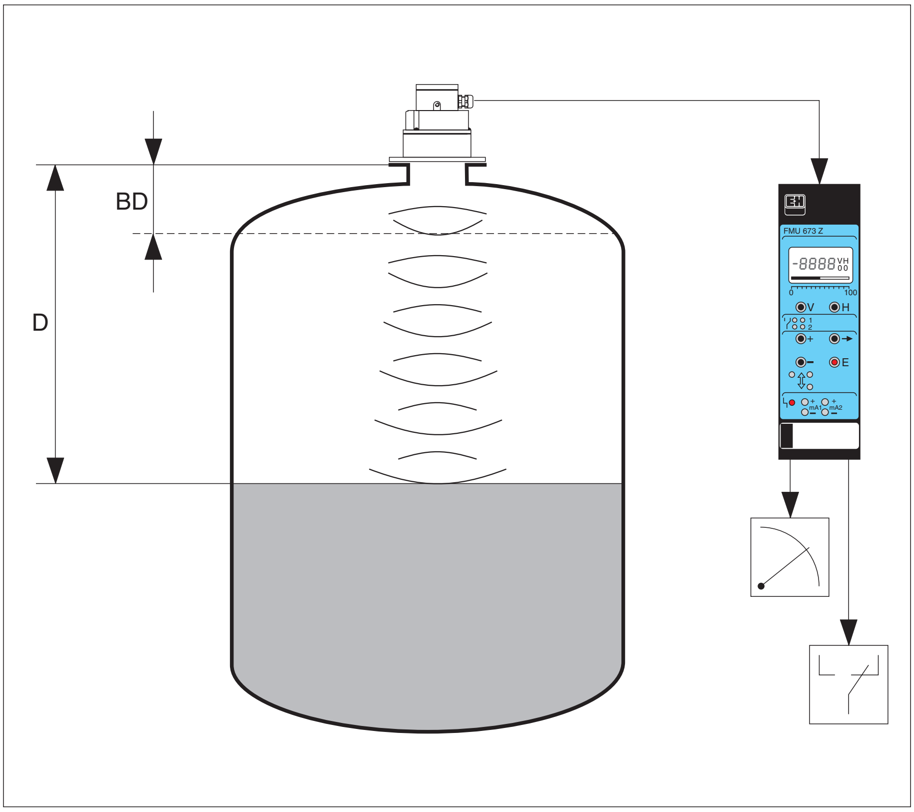
Measuring Principle



Ultrasonic measuring principle
D = Distance sensor – product surface
BD = 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:

$$D = c * t/2$$

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

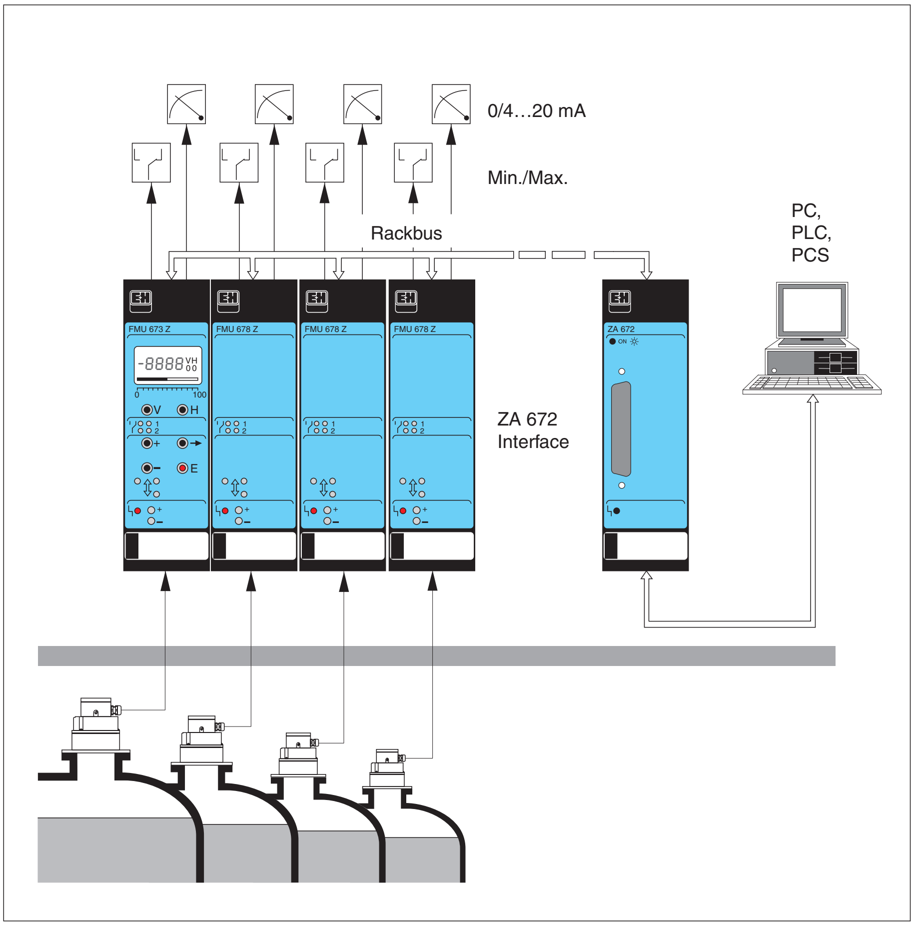
After the ultrasonic pulse has been emitted the sensor requires time – the *ringing time* – to stop vibrating. Consequently there is a zone immediately below the sensor from which returning echoes cannot be detected. This so-called *blocking distance* determines the start of the measuring range.

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.

Requirements

The primary requirement for good ultrasonic measurement is reflection at the product surface:
- For liquids, there may be no closed, thick foam layer on the product surface.
- For bulk solids, the surface roughness (particle size) must exceed 3 mm or the surface must reflect directly to the sensor.

Measuring System



In addition to the features listed below, the Nivosonic FMU transmitters can be integrated via the Rackbus and ZA 672 interface into a computer control system.

Nivosonic FMU 673 Z/678 Z
The ultrasonic sensor is powered and controlled by the Nivosonic FMU transmitter. It provides the transmitter with digital information which is converted to a level or content value. An integrated temperature sensor, located behind the diaphragm, measures the temperature of the air above the product.

The Nivosonic FMU 673 Z/678 Z transmitter performs the following functions:
- Measured value display.
- Linearization of the vessel characteristic.
- Compensation of temperature dependent ultrasonic run times.
- If necessary, suppression of spurious echoes caused by fixtures etc. within the vessel.

The velocity of sound and temperature dependence are set for air at the factory (c = 331.6 m/s at 0°C and 0.6 ms^{-1}/°C or 0.17%). The values are programmable and can be set for other gas mixtures.

Measurement Accuracy
Measurement accuracy is unaffected by the strength of the reflected signal.
- The effect of pressure changes within the operating range in air or nitrogen is $\leq$ 0.1%.
- A constant temperature and velocity of sound allows error limits of $\leq$ 1% to be attained.
- The resolution of the measurement is 1.7 cm for a sound velocity of 340 m/s.

Inhomogenous Gases
If a pronounced temperature or concentration gradient exists in the gas above the product surface, its effect must be estimated and programmed in the Nivosonic FMU transmitter.
- For nitrogen layers above the product surface the effect is +1% only.
- For liquids with high partial pressures, e.g. benzene, check whether there is a concentration gradient.

Planning

Maximum Measuring Range
The measuring range depends upon:
- The strength of the reflection from the product surface.
- The attenuation of the ultrasonic pulse within the tank or silo.
- The level of background interference e.g. filling noise.
- Interference echos caused by fixtures etc. in the tank or silo.

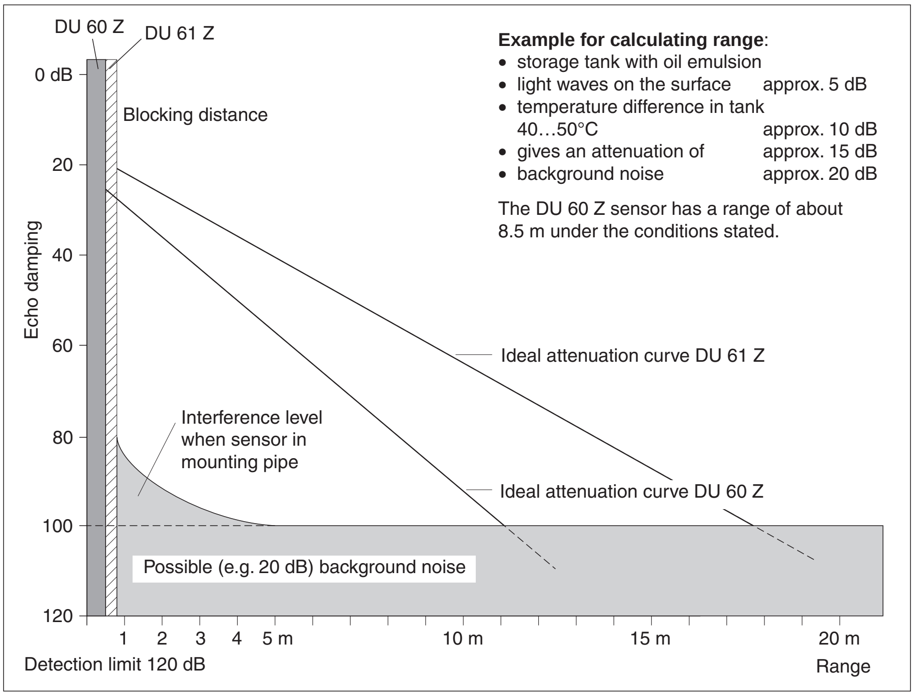
The first two factors are determined by the application and cannot be directly influenced. Their effect can, however, be estimated from the table below.

Interference echoes can be avoided by following the recommendations in this brochure.

Attenuation
The diagram shows ideal attenuation curves for the DU 60 Z/61 Z sensors:
- Check the factors affecting your measurement in the table below.
- Shift the ideal attenuation curve down by the sum of their attenuation values.
- Check your background noise level (in the diagram approx. 20 dB) and subtract it from the theoretical detection limit of 120 dB.
- The intersection of the curve and background noise gives the maximum measuring range – see example.

Echo attenuation as a function of distance for ideal reflection and atmosphere

In mounting pipe the sensor generates an interference signal which decreases with increasing path



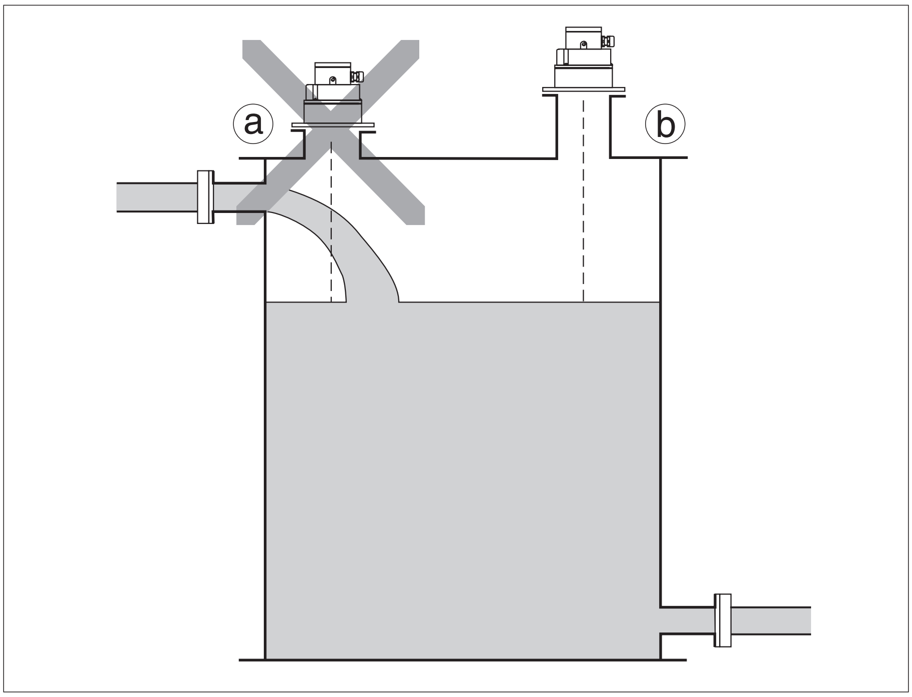
Attenuation in dB for interference effects in tanks and silos

Effects in liquid tanks		Attenuation dB	Effects in bulk solid silos		Attenuation dB
Temperature layers			**Temperature layers**		
Difference in air	up to 20 °C	0	Difference in air	up to 20 °C	0
temperature between	up to 40 °C	5 ...10	temperature between	up to 40 °C	5 ...10
sensor and product	up to 60 °C	10 ... 20	sensor and product	up to 60 °C	10 ... 20
surface			surface		
Filling curtain			**Filling curtain**		
Outside detection range		0	Outside detection range		0
Small amount inside detection range		5 ...10	Small amount inside detection range		5 ...10
Large amount inside detection range		10 ... 20	Large amount inside detection range		10 ... 20
Foam			**Dust**		
Please consult Endress+Hauser			No dust		0
			Light dust		5
			Heavy dust		5 ... 10
Liquid surface			**Solids surface**		
Calm		0	Coarse, hard		20
Heavy waves		5 ...10	Coarse, soft		20 ... 40
Very turbulent (e.g. agitator blades)		10 ... 20	(e.g. peat, dust-covered clinker)		

Recommendations

Liquid Tanks

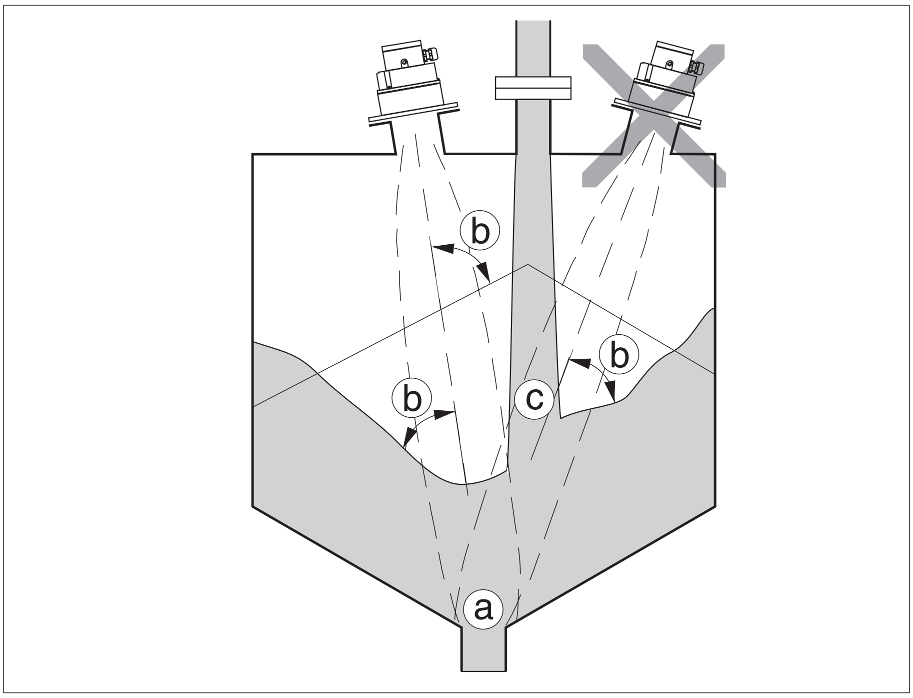
- Do not install the sensor directly above the inflow nozzle (a).
- Plan mounting pipes (b) such that even in the event of overfilling, the level does not come within the blocking distance.



Do not measure through the filling curtain

Bulk Solid Silos

- Direct the sensor to the centre of the outflow funnel (a) so that an echo is received when the silo is empty.
- To ensure accurate readings, keep away from the sidewalls and select the largest angle possible (b) to the filling mound or outflow funnel.
- Avoid measuring through the filling curtain (c).



For bulk solids, a nearly normal angle of 90° incidence ensures a strong echo

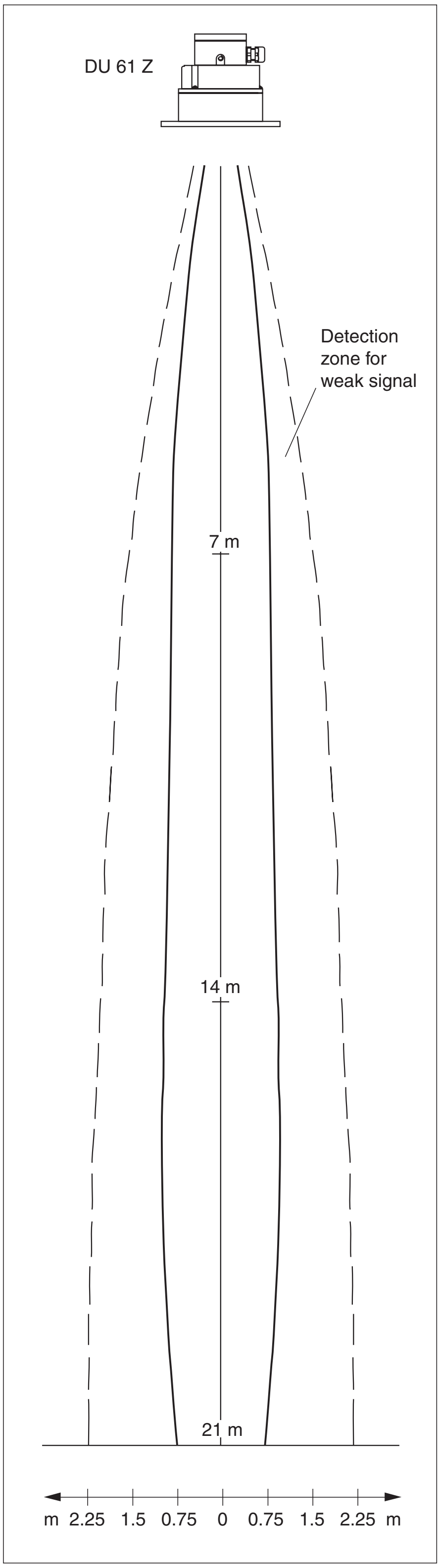
Internal Fittings

Sensor Position

If the tank or silo contains internal fittings, 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.

Measuring range and detection zone DU 61 Z (lines of equal attenuation)



Ultrasonic Beam

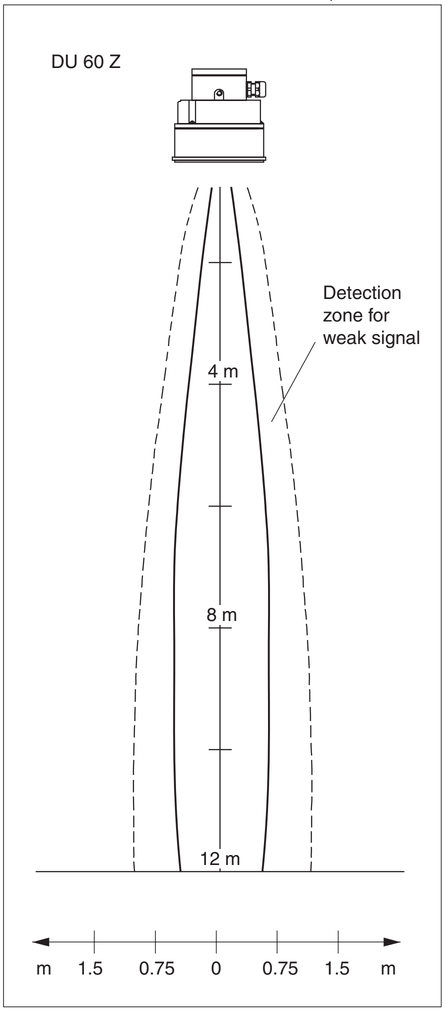
The ultrasonic pulse leaves the sensor as a directed beam which slowly widens as it travels towards the product surface. Any object lying within the beam will produce an echo which may be received by the sensor.

- Edges, internal fittings etc. lying within the beam in the first third of selected measuring range are most critical since the sonic energy is still highly concentrated here and due to the short distance, the echoes are only weakly attenuated: 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:

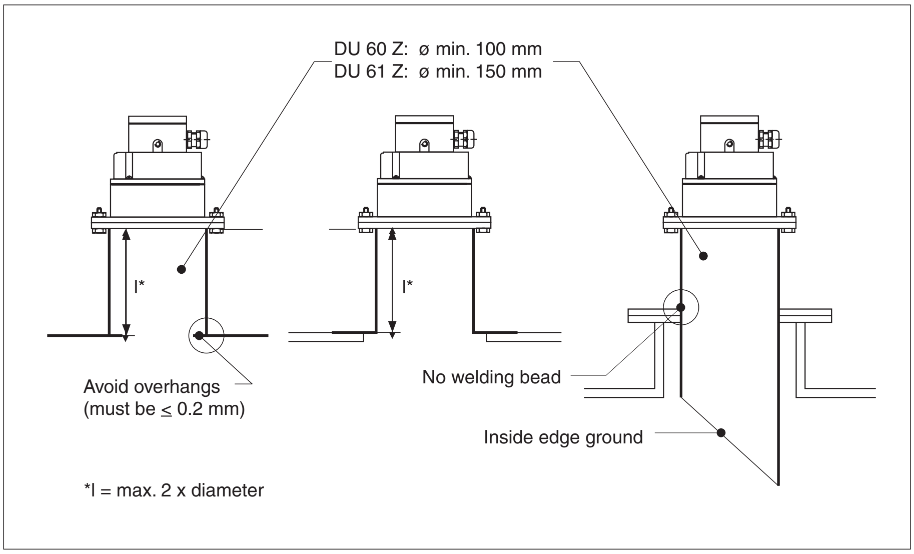
- Any object within the central detection zone (full line in the illustrations) will produce a strong echo.
- Echoes from the second zone are important to measurement only when the signal from the surface of the product is relatively weak.

Measuring range and detection zone DU 60 Z (lines of equal attenuation)



Sensor Positioning

Close to the sensor the ultrasonic pulse is highly energetic.
- Any edges, welds or similar projections in the mounting pipe will cause strong spurious echoes.
- Build-up from splashes or condensation will also cause echoes.
  Avoid condensation by thermally insulating the mounting pipe.



Mounting

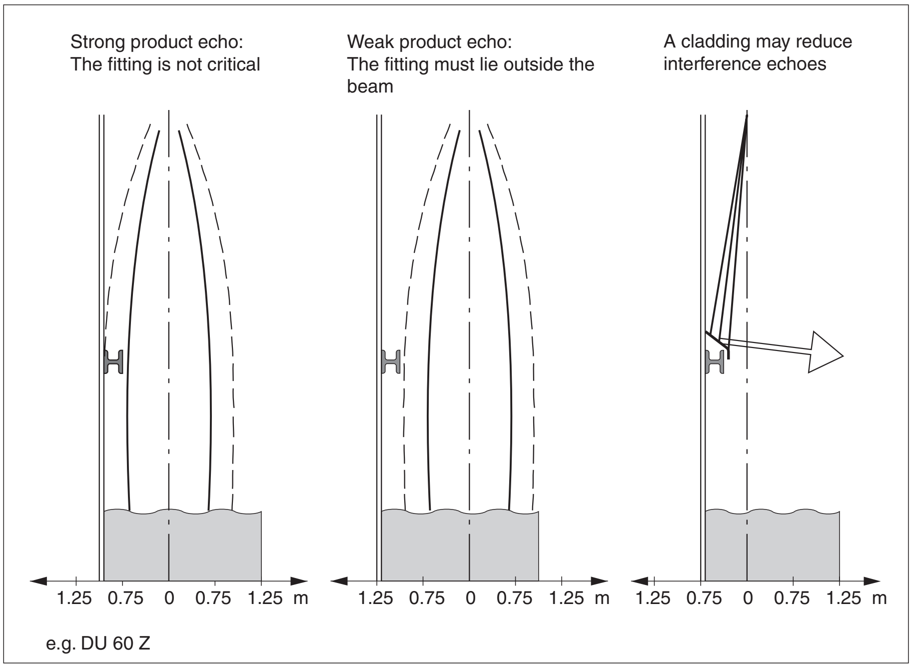
Using the slip-on flange, the sensor may be mounted:
- flush with the tank top
- on a mounting pipe.

Alternatively the mounting bracket can be used to
- hang the sensor from the top of the tank or silo.

Blocking Distance

The sensor must be mounted such that the gap between it and the maximum filling level exceeds the blocking distance.
- If this criterion is not fulfilled, incorrect measurement will result.

For weak echos, care must be taken that reflecting edges or fittings lie outside the detection zone. Alternatively, the interfering object can be covered by a suitable cladding.

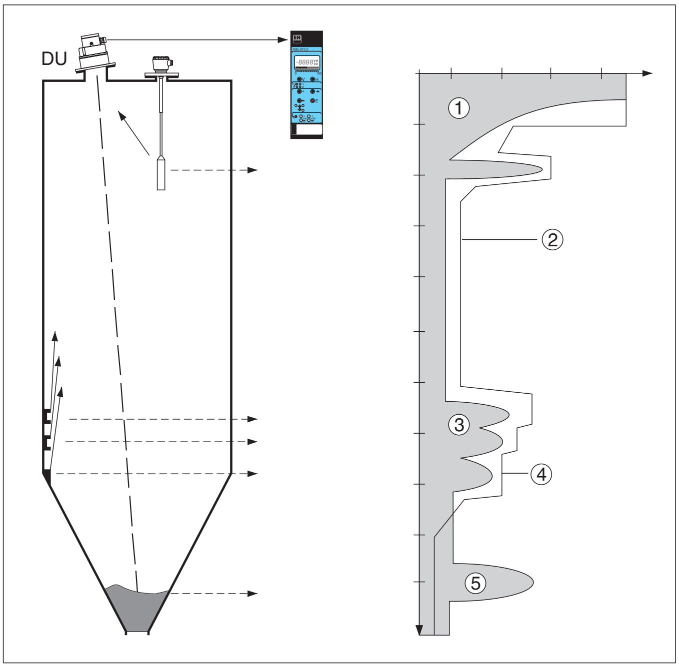


Internal Fittings

The echo from the product surface must always be stronger than any background noise.
- Check the required lateral clearance from any fittings by using the detection zone diagrams.
- Claddings can be used to direct the interference echo away from the sensor.
- Tank or silo walls with a surface roughness ≥ 0.5 mm may also cause interference echoes.

If the sensor cannot be mounted to meet the above conditions, the fixed target echoes can be suppressed by the FMU software – see »Interference Echoes«.

Interference Echoes

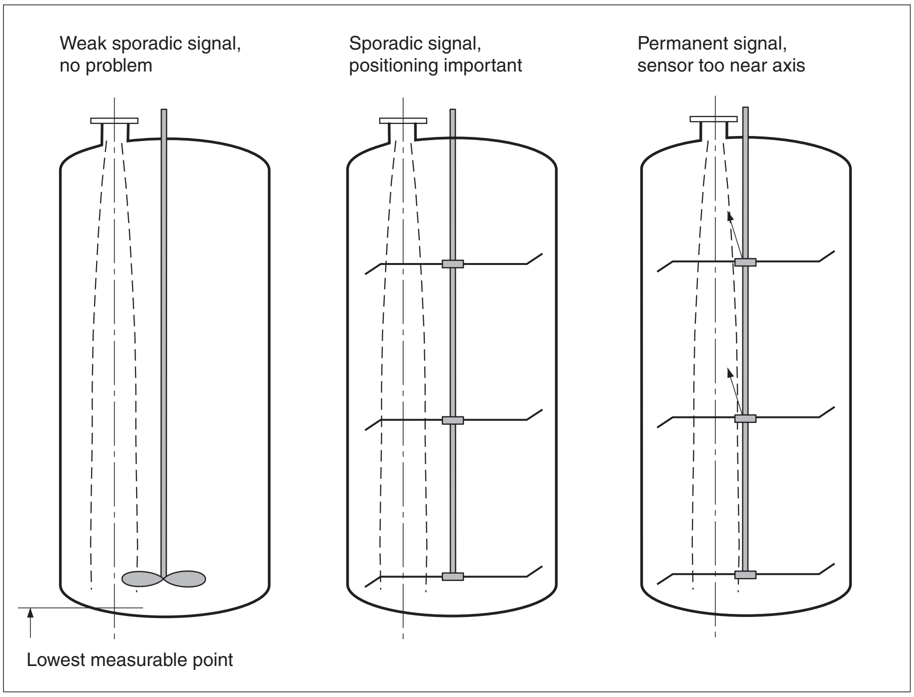


Suppression of interference echoes from fixtures:
① Transmission pulse and signal decay
② Time-dependent identification threshold
③ Interference echo
④ Echo suppression by temporary increase of threshold
⑤ Strong echo from product surface

Interference Signal Suppression
Interference echoes from stationary internal fittings can be suppressed using the »fixed target suppression« mode of the Nivosonic FMU ...

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

Sporadic Echoes



By careful placement of the sensor, problems with sporadic echos can be minimised

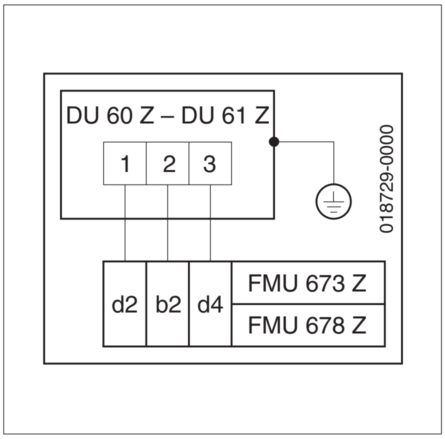
Stirrers etc.
Moving internal fittings may produce sporadic echoes.

- If the sensor is mounted too near the axis of the stirrer, the interference will be permanent.
- If the stirrer blades are offset, position the sensor such that the interval between echoes is as long as possible.
- Interference from e.g. stirrer blades can be suppressed by the signal statistic of the Nivosonic FMU 673 Z/678 Z transmitter.

Electrical Installation

Sensor Connection

- Power is supplied by the Nivosonic FMU 673 Z/678 Z
- Use commercial 3-core installation cable
- Max. line resistance 25 Ω per core
- When installing in explosion hazardous areas, observe the relevant regulations (s. XA 229F-A)



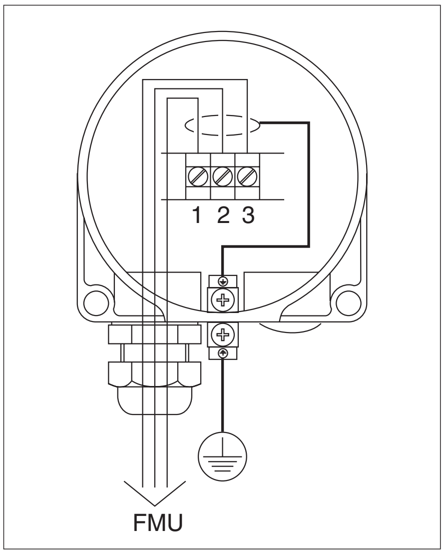
Connection diagram
Sensor – Nivosonic
FMU 673 Z/678 Z

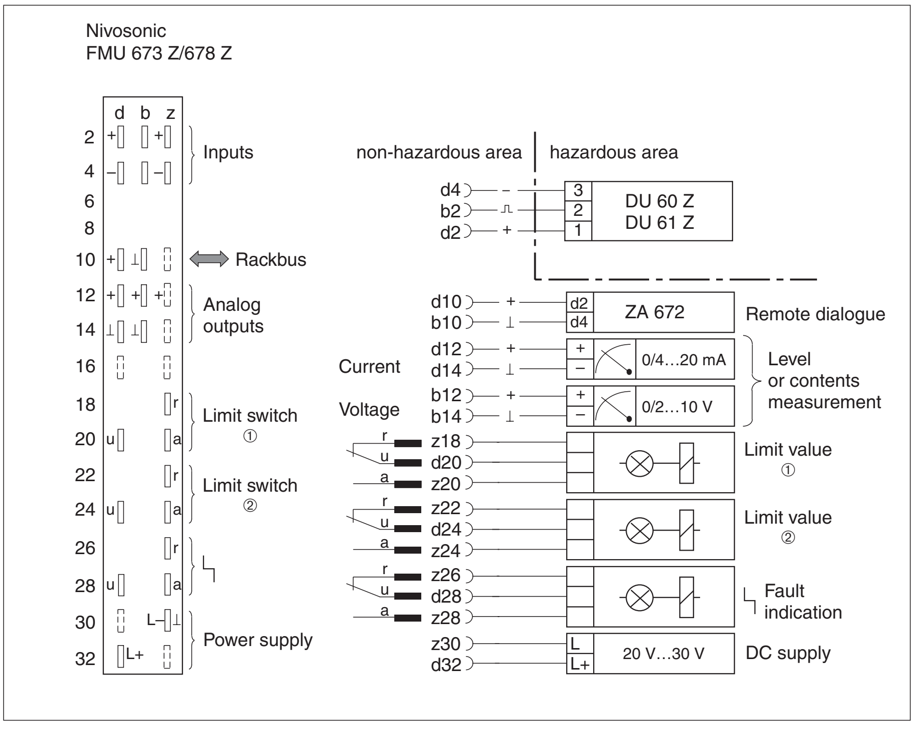
To Prevent Interference

The following measures are recommended to prevent interference e.g. caused by electrical or magnetic fields in the path of the cabling or by RFI near to the sensor:

- Use screened cabling.
- Connect screening to the inner ground terminal of the DU 60/61 Z sensor; *not* to the Nivosonic FMU…
- Connect the ground or potential compensation cable to the outer ground terminal of the sensor.

These measures ensure that the sensors correspond to industrial (NAMUR) and European EMC Standards EN 50081-1 for interference emission and EN 50082-2 for interference immunitiy.
For general information on EMC (test methods, installation hints) see TI 241F/00/e.





Connection diagram
Nivosonic
FMU 673 Z/678 Z

Technical Data

Housing
- Material: Crastin (PBTP)
- Sealing face and diaphragm: PVDF
- Slip-on flange: see product structure
- Protection: IP 68
- Weight: approx. 4 kg

Slip-On Flange
- Standard connections to DIN, JIS or ANSI
- Material: polypropylene, painted steel or stainless steel – see page 11
- Counterflange on tank
  – DU 60 Z with ID min. 100 mm
  – DU 61 Z with ID min. 150 mm

Ultrasonics

	DU 60 Z	DU 61 Z
• Range:	12 m*	20 m*
• Frequency:	38 kHz	31 kHz
• Pulse frequency:	4 Hz	2 Hz
• Blocking distance:	0.5 m	0.8 m
• Angle of emission at –3 dB:	5°	8°

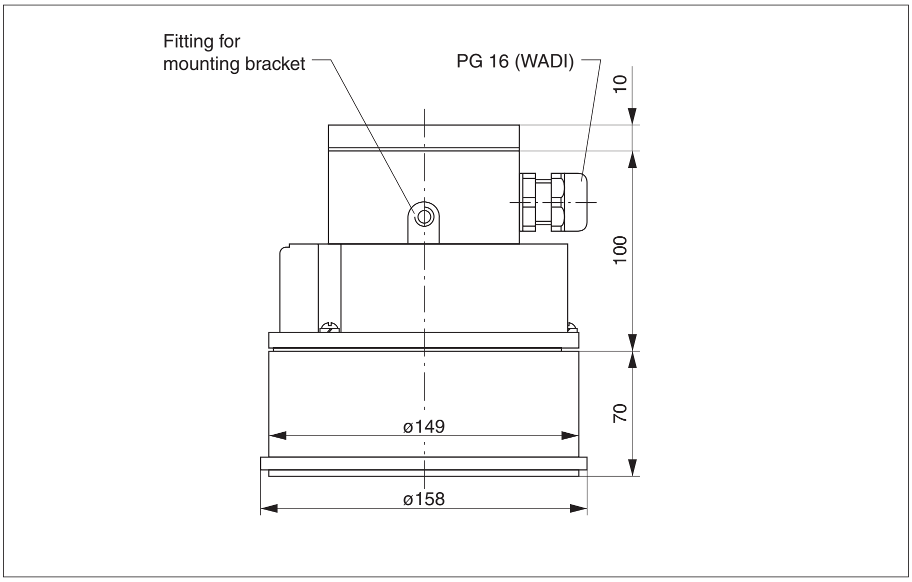
* Under ideal measurement conditions

Operating Conditions
- Operating pressure p_e
  with metal slip-on flange
  max. 3 bar;
  with polypropylene slip-on flange
  max. 0.5 bar
- Static pressure with steel flange:
  DU 60 Z: 60 s at 60°C up to 9 bar
  DU 61 Z: 60 s at 80°C up to 9 bar
- Operating temperature: –20…+80°C

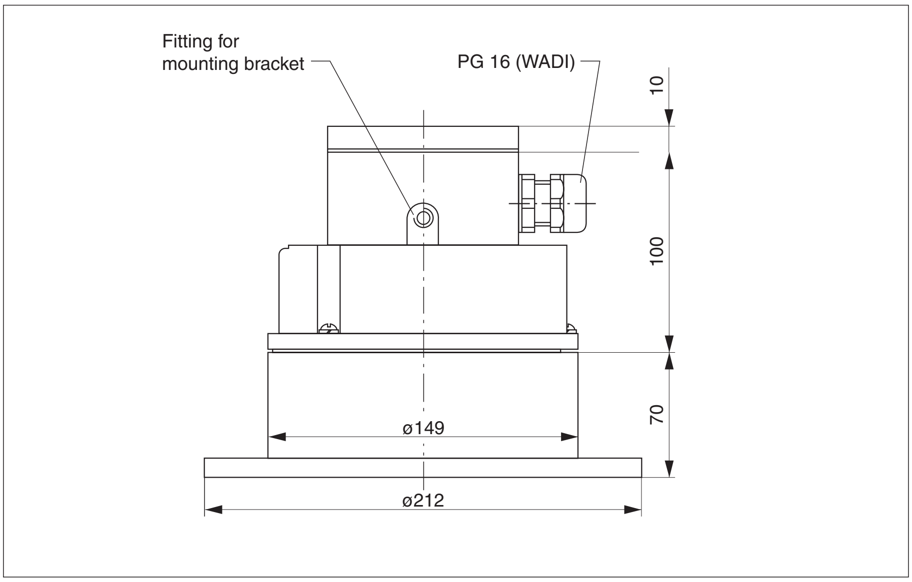
For used at higher pressures or temperatures please contact Endress+Hauser

- Electromagnetic compatibility (EMC): Interference emission to EN 50 081-1, Interference immunity to EN 50 082-2 and Industrial Standard NAMUR, with 10 V/m.

Explosion Protection
- ATEX II 2 G EEx ia IIC T6...T5 (s. XA 229F-A)
- CSA Cl. 1, Div. 1, Gr. A-D



DU 60 Z sensor
dimensions in mm

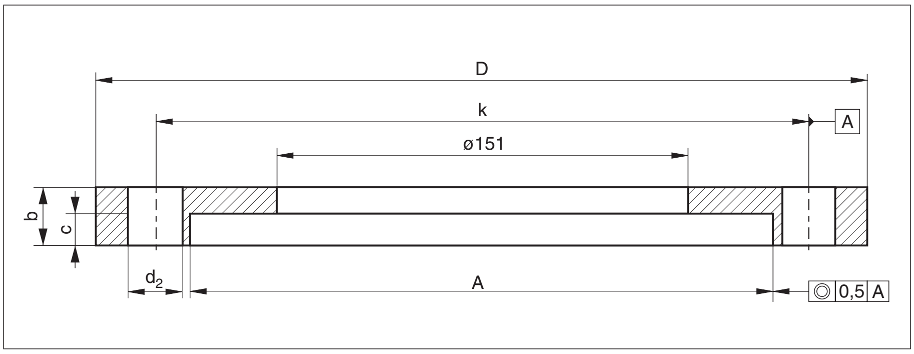


DU 61 Z sensor
dimensions in mm

Process Connections

Slip-On Flange FAU 60 for DU 60 Z
- DN 100 PN 16 (Code D0)
- JIS 100 K 16 (Code J0)
- ANSI 4" 150 psi (Code A0)

Slip-On Flange FAU 60 for DU 61 Z
- DN 150 PN 16 (Code D1)
- JIS 150 K 16 (Code J1)
- ANSI 6" 150 psi (Code A1)



Slip-on flange dimensions

Key to slip-on flange drawing for DU 60 Z

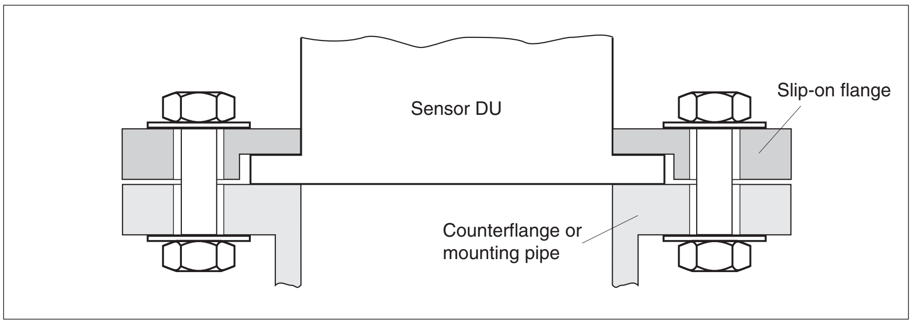
Order No.	A	b	C	ø D	ø d_2	k	No. d_2	Material	Standard
FAU 60 D0 P	160	20	9.2	220	18	180	8	PP	DN 100 PN 16 (DIN 2527)
FAU 60 D0 S								St/painted	
FAU 60 D0 R								1.4571	
FAU 60 A0 P		23.9		228.6		190.5		PP	ANSI 4" 150 psi (ANSI B 16.5)
FAU 60 A0 S								St/painted	
FAU 60 A0 R								1.4571	
FAU 60 J0 P		22		225	23	185		PP	JIS 16 K-100 (JIS B 2210)
FAU 60 J0 S								St/painted	
FAU 60 J0 R								1.4571	

Key to slip-on flange drawing for DU 61 Z

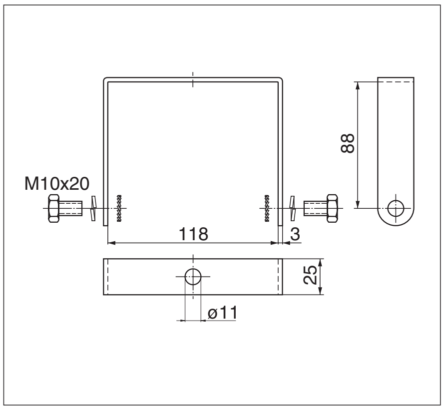
Order No.	A	b	C	ø D	ø d_2	k	No. d_2	Material	Standard
FAU 60 D1 P	215	22	11.5	285	22	240	8	PP	DN 150 PN 16 (DIN 2527)
FAU 60 D1 S								St/painted	
FAU 60 D1 R								1.4571	
FAU 60 A1 P		25.4		279.4		241.3		PP	ANSI 6" 150 psi (ANSI B 16.5)
FAU 60 A1 S								St/painted	
FAU 60 A1 R								1.4571	
FAU 60 J1 P		24		305	25	260	12	PP	JIS 16 K-150 (JIS B 2210)
FAU 60 J1 S								St/painted	
FAU 60 J1 R								1.4571	

Suggestion for sensor mounting:
The DU 60 Z cannot be used with a DN 150 counterflange since there is no corresponding sealing surface.

Tighten the screws on opposite sides first; torque approx. 50…70 Nm.



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.
Order No.: 918815-0000



Mounting bracket dimensions in mm

Product Structure

Sensor DU 60 Z

Certificate
U CSA Class I, Div. 1, Groups A-D
S ATEX II 2 G EEx ia IIC T6...T5, s. XA 229F-A

Material diaphragm
1 PVDF

DU 60 Z – ☐☐ Product designation

Sensor DU 61 Z

Certificate
U CSA Class I, Div. 1, Groups A-D
S ATEX II 2 G EEx ia IIC T6...T5, s. XA 229F-A

Material diaphragm
1 PVDF

DU 61 Z – ☐☐ Product designation

Slip-on Flange FAU 60 for DU 60 Z and DU 61 Z

Process connection
D0 DN 100 PN 16
A0 ANSI 4" 150 psi
J0 JIS 16 K-100
D1 DN 150 PN 16
A1 ANSI 6" 150 psi
J1 JIS 16 K-150
Y9 others

Material
P Polypropylene (p_e max. 0.5 bar)
S Steel/painted
R stainless steel 1.4571
Y others

FAU 60 – ☐☐ Product designation

Supplementary Documentation

- ❑ Ultrasonic measurement
Product Information PI 004F/00/en
- ❑ Nivosonic FMU 673 Z/678 Z
Technical Information TI 128F/00/en
- ❑ Nivosonic FMU 673 Z/678 Z
Operating Instructions BA 027F/00/en
- ❑ Ultrasonic sensor DU 51 Z
Technical Information TI 078F/00/en

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