Technical
Information
TI 215F/00/en

Operating Instructions
015081-1008

Ultrasonic Level Measurement *Sensors DU 40 C, DU 41 C*

Continuous, non-contact level measurement in tanks and silos containing liquids and bulk solids

Application
The DU 40 C and DU 41 C ultrasonic sensors are used for continuous, non-contact measurement.

- DU 40 C:
  for liquid tanks up to 10 m (30 ft),
  for bulk solids silos up to 5 m (15 ft)

- DU 41 C:
  for liquid tanks up to 20 m (60 ft),
  for bulk solids silos up to 10 m (30 ft)

Examples:
Corrosive liquids such as acids and alkalis.
Coarse and lumpy bulk solids such as grain, coal, ore, rubble and gravel.

Features and Benefits
- Sensor housing and flange in polypropylene – especially resistant to corrosive vapours.
- Unaffected by condensation due to automatic resonance frequency control.

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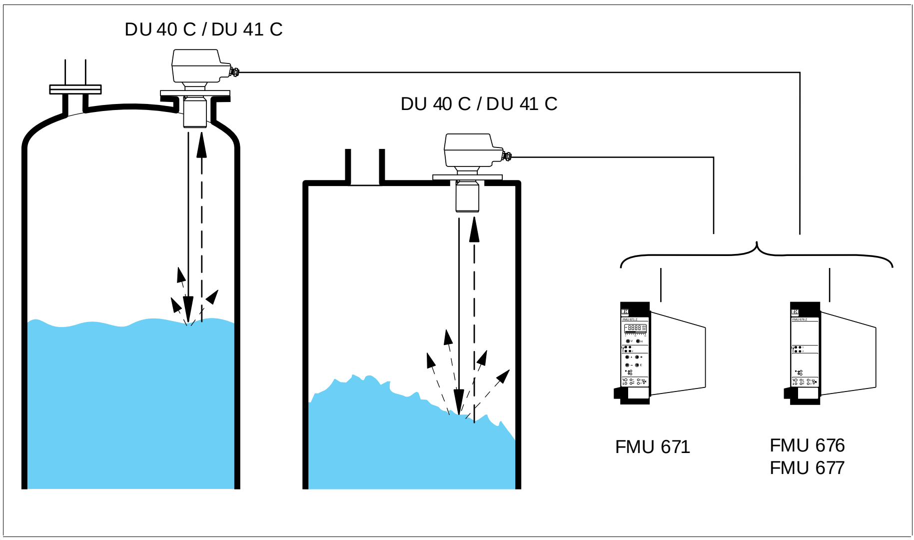
Nothing beats know-how

Measuring System

Components of the measuring system:
• Nivosonic FMU 671, FMU 676 or FMU 677 transmitter mounted in the control room
and
• DU 40 C or DU 41 C ultrasonic sensor mounted on the tank or silo

A temperature probe is integrated into the sensor in order to compensate for variations in the run time of the ultrasonic pulses caused by temperature fluctuations.

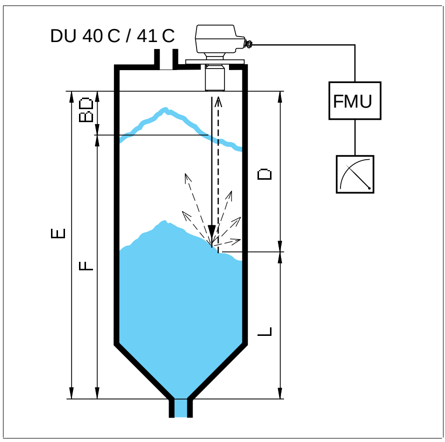


Measuring system for continuous, non-contact level measurement using ultrasonic waves in tanks and silos

Operating Principle

The emitter in the sensor is excited electrically and sends an ultrasonic pulse in the direction of the surface of the product which partially reflects the pulse. This echo is detected by the same sensor, now acting as a directional microphone, and then converted back into an electrical signal. The time between transmission and reception of the pulse (the sonic run time) is directly proportional to the distance between the sensor and the product surface. This distance D is determined by the velocity of sound c and the run time t using the formula:

$$D = \frac{c \cdot t}{2}$$



Measuring system and function
BD=blocking distance (maximum level)
D = distance from sensor to surface of material
L = level in tank or silo
F = maximum level (100%, Full)
E = zero point of measurement (0%, Empty)

Measuring Range

The measuring range is limited by the attenuation of the sonic pulse in air and the interference characteristics of the surface of the material.

Measurement Conditions

Ultrasonic measurement ultimately depends upon an echo signal being received from the surface of the material.

• Liquids
The sensor must be vertically aligned directly above the surface of the material.
The surface must not be covered by a thick layer of foam.

• Bulk Solids
A sufficiently large number of scattered echoes coming from the surface of the product will be received by the sensor if the surface coarseness of the filling mound is larger than 4 mm (diffuse reflection).
With fine-grained or powdery solids, e.g. quartz, sand, cement, plastic powder, raw meal, etc., correct functioning of the sensor depends on the profile of the surface (mirror reflection).

Blocking Distance

Due to the decay characteristic of the sensor, there is an area immediately below it in which no pulses can be received. This blocking distance BD is the minimum distance between the sensor and the maximum product level in the tank or silo.
For the DU 40 C sensor, this blocking distance is approx. 0.5 m (1.6 ft); for the DU 41 C approx. 0.8 m (2.6 ft).

Project Planning

Maximum Possible Range

The measurement range depends upon the following factors:

- the strength of the signal coming from the surface of the material (scattered echoes)
- attenuation of the signal in the area between the sensor and material
- background echoes due to e.g. the filling process
- interference echoes coming from internal structures within the tank or silo

The first three factors are dependent upon the conditions of the application. Interference echoes can be reduced by following the recommendations given in this brochure.

Conditions are favourable when:

- the lower edge of the sensor protrudes into the tank or silo
- the area of detection does not include any internal structures or the filling curtain
- the surface of the liquid is calm and not covered with a layer of foam
- little vapour is present in the tank
- the bulk solid is hard and coarse-grained
- no dust is present in the silo
- the temperature difference in the tank or silo is small

To calculate the range of the ultrasonic sensor for your particular application:

- Refer to the table to identify which factors affect the measurement.
- Add together the corresponding attenuation values (dB).

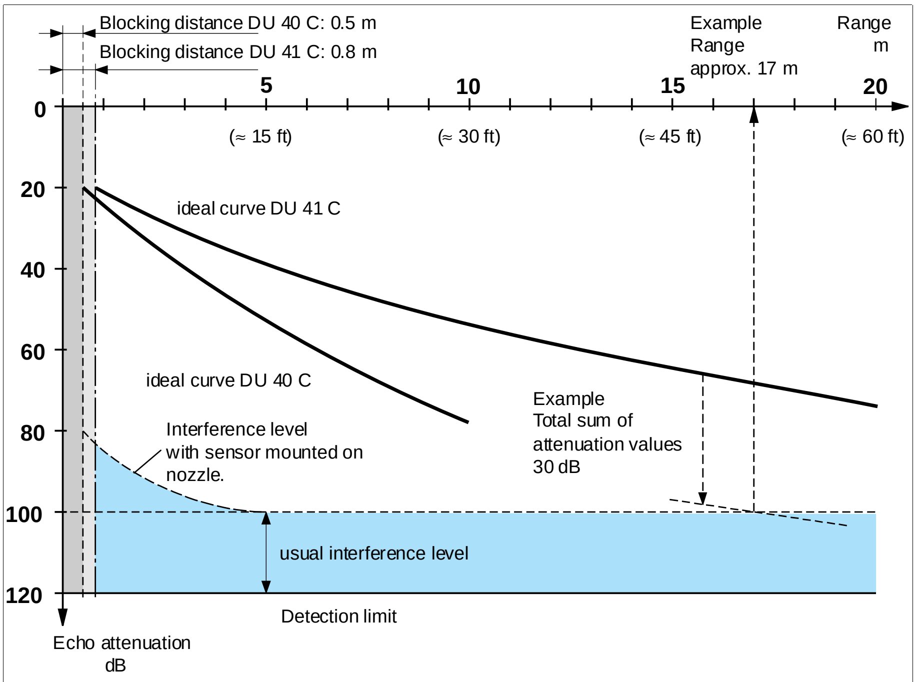
The diagram shows the ideal echo attenuation curves for the sensors DU 40 C and DU 41 C.

- Move the curve downwards until it corresponds to the sum of the attenuation values.
- Subtract the value of background noise expected from the detection limit of 120 dB. The background noise, caused by filling or discharging and interference reflections coming from the silo walls, is usually approx. 20 dB.
- The maximum range is that point where the curve crosses the interference level. See example.

Is the calculated range sufficient for your specific application?

Effects		**Attenuation (dB)**
Temperature layering:		
Difference in air temperature between sensor and product surface	up to 20 °C	0
	up to 40 °C	5...10
	up to 60 °C	10...20
Filling curtain:		
outside the detection beam		0
Small amounts in the detection beam		5...10
Large amounts in the detection beam		10...20
Liquid surface:		
Calm		0
Agitated		5...10
Very agitated (e.g. agitator vessels)		10...20
Foam:		
Please contact Endress+Hauser		
Solids surface:		
Coarse, hard		20
Coarse, soft e.g. peat, dust-coated clinker		20...40
Dust:		
None		0
Light		5
Heavy		5...10
Dust		0
None		
Light		

Attenuation in dB with interference in a tank or silo.



Example for calculating the range (liquid tank):

Effects:	Attenuation
Temperature difference in the tank max. 60 °C	20 dB
Filling curtain outside the detection beam	0 dB
Agitated liquid surface	10 dB
Total sum of attenuation values	30 dB

Under these conditions the range is approx. 17 m using the sensor DU 41 C

Right:
Echo attenuation as a function of the range, with an example for calculating the range

In a nozzle, the sensor generates an interference signal which decreases with increasing path

Detection Limits and Interference Signals

If internal fixtures are present in the tank or silo, then careful alignment of the sensor is critical in order to keep the interference echoes as low as possible. The ultrasonic pulse should travel unimpeded to the surface of the material. The signal leaves the sensor as a narrow beam which widens as the distance increases. Every object within this beam gives rise to an echo which is then received by the sensor.

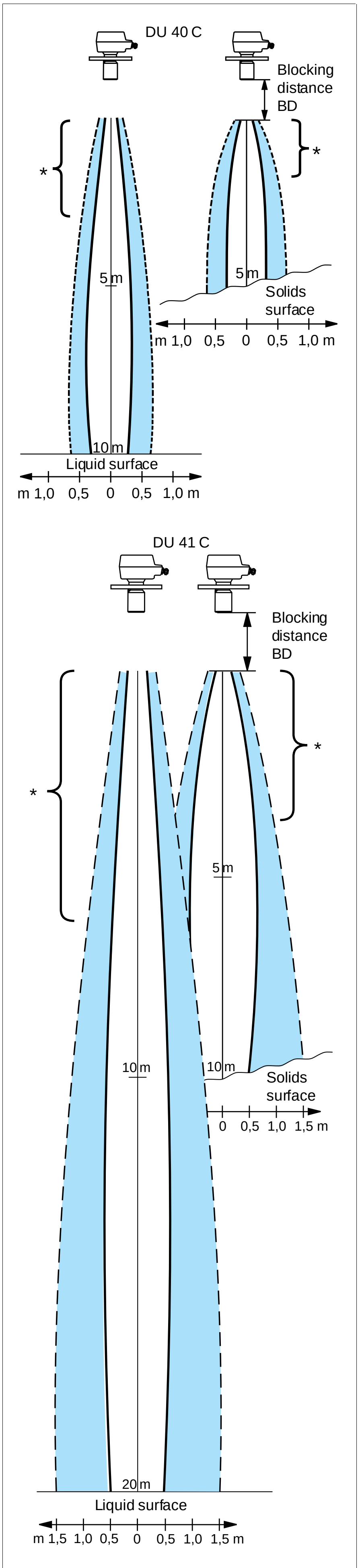
- Edges, internal fixtures, etc. within the sound cone are of greatest importance in the first third of the range as the energy of the beam is highly concentrated and, due to the short distance, the interference echoes are only weakly attenuated. Small surfaces can therefore produce strong interference echoes.
- The energy in the last third of the range is distributed over a larger area so that internal structures and edges are not as critical.
- Objects in the middle of the beam (continuous line in the diagram) produce strong echoes.
- Echoes from the edge (dashed lines) are important only when a weak working signal is received from the surface of the material.

Accuracy

- The effect of pressure variations is less than 0.1% (in air or nitrogen).
- A constant temperature and sound velocity within the measuring path enable a high degree of accuracy to be achieved; error limits less than 1%. The effects of large temperature variations within the measuring path and changing gas mixtures must be calculated and the Nivosonic programmed accordingly. A nitrogen atmosphere increases the sound velocity by +1% only. With liquids having a high partial pressure, the gas composition must be determined to see if it remains constant.
- The resolution is 1.7 cm at a sound velocity of 340 m/s.

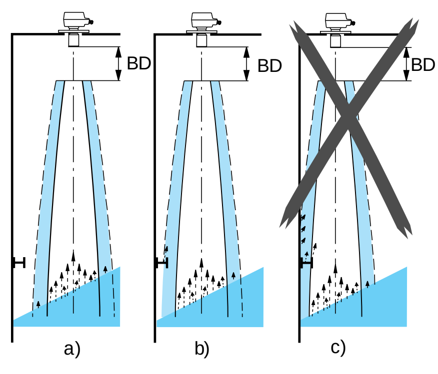
Right:
Detection zone is dependent on the range
(lines of equal attenuation)

1 m ≈ 3 ft

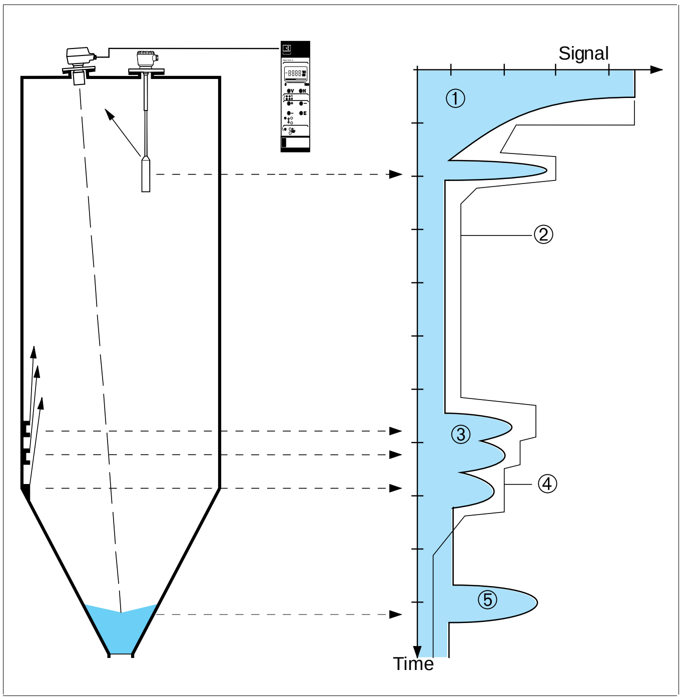


* Interference echoes should in particular be avoided in this region

Left:
Avoid interference echoes from internal structures and rough silo walls!
a) Ideal mounting, no interference echo
b) Non-critical mounting, weak interference echo only
c) Incorrect mounting, strong interference echo from internal structures and uneven wall (e.g. welding seams)



Suppression of interference echoes from internal fixtures:
① Decay curve of the sensor
② Time dependent threshold which an echo signal must overstep in order to be detected by the evaluating unit.
③ Interference echoes
④ Interference echo suppression (with characteristic detection threshold)
⑤ Working signal from the material surface

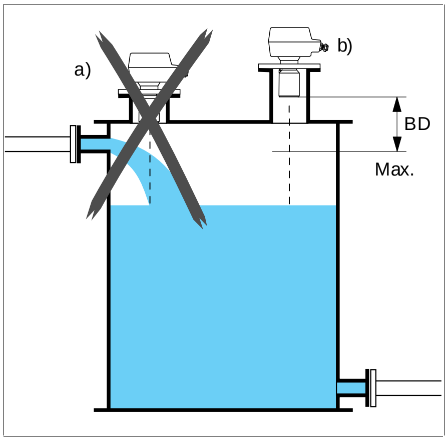


Interference Suppression

Interference echoes coming from internal fixtures can be suppressed with the Nivosonic FMU 671...677 using "fixed target suppression".
This enables the detection level to be automatically adjusted to the interference profile so that these signals are no longer included and used for further signal processing.
Please note that adjusting the detection level to the interference profile shortens the measuring range.
With weak working signals (e.g. in cement silos), the interference level should be kept as low as possible by mounting and aligning the sensor correctly.

Mounting

a) Do not measure through the filling curtain
b) Distance BD (blocking distance) to maximum level must be upheld. See diagram on the next page for the height and shape of the nozzle.



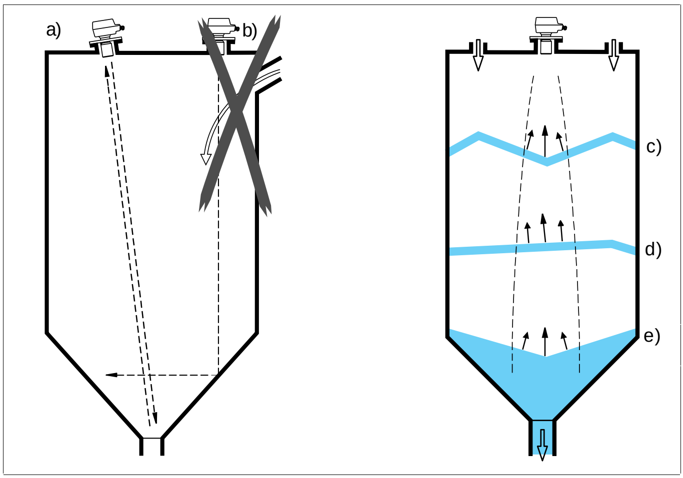
Mounting on a Tank

- Align the sensor ensuring that it is perpendicular to the surface of the liquid.
- Avoid measurement through the filling curtain.
- The sensor should be mounted so that the blocking distance is not overstepped even when the tank overfills.
- Note the sizes recommended for nozzles.

Mounting on a Silo

- Align the sensor with the centre of the outlet cone so that an echo is reflected even when the silo is empty.
- Avoid measurements through the filling stream.
- No diffuse reflections are produced from the smooth surfaces of very fine-grained or dusty bulk solids. The wave is reflected back in a similar way to light (angle of incidence = angle of reflection) so that selecting the installation point is critical for carrying out measurement.
  Please refer to the diagram, below right.

Left:
a) Correct mounting: As far as possible from the silo wall and material inlet. The centre of the outlet cone also produces an echo which is received by the sensor even when the silo is empty.
b) Incorrect mounting
1. Detection through the filling curtain
2. The echo is reflected to the side when the silo is empty and receives no signal



Right:
Installation point with powdery bulk solids.
c) A trough between mounds produces a strong echo in the direction of the sensor.
d) Shallow slopes up to 5° still reflect enough of the signal in the direction of the sensor.
e) The centre of the outlet cone produces a sufficiently strong echo in the direction of the sensor.

Mounting Recommendations

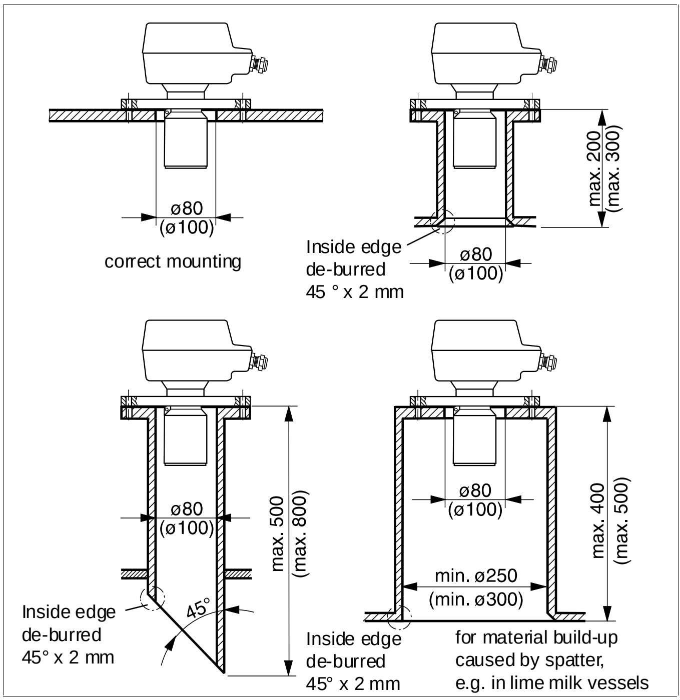
- Select the installation point so that the lower edge of the sensor is below the roof of the tank or silo.

Mounting example for *closed* tanks or silos.

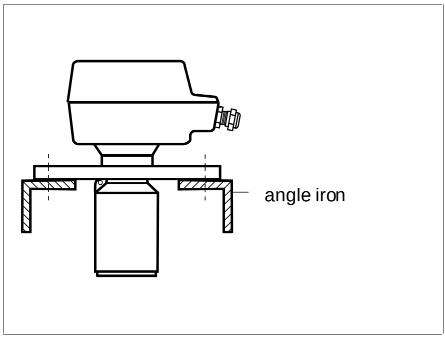
Figures without brackets refer to DU 40 C, Figures in brackets ( ) refer to DU 41 C. These apply to the smallest flange in each case

Dimensions in mm
100 mm = 3.94 in
1 in = 25.4 mm

The recommend nozzle dimensions are limits, within witch the nozzle can vary. **Select as big a nozzle diameter as possible, but keep the height as small as possible**.



Mounting example for *open* tanks or silos



This is possible when the blocking distance is not overstepped at the maximum level, i.e. when the tank or silo is full and there is still a gap of at least 50 cm (1.6 ft) with DU 40 C or 80 cm (2.6 ft) with DU 41 C between the maximum level and the sensor flange.

- If the level in the tank or silo encroaches in the blocking distance, then the sensor can be mounted on a nozzle.

Note:

- There should be no condensate and no material build-up in the nozzle.
- The nozzle should have the largest possible diameter.
- The inner surface should be as smooth as possible (no edges or welded seams). The inner edges have to de-burred.
- Insulate the nozzle when mounting in the open to prevent condensate forming in it.

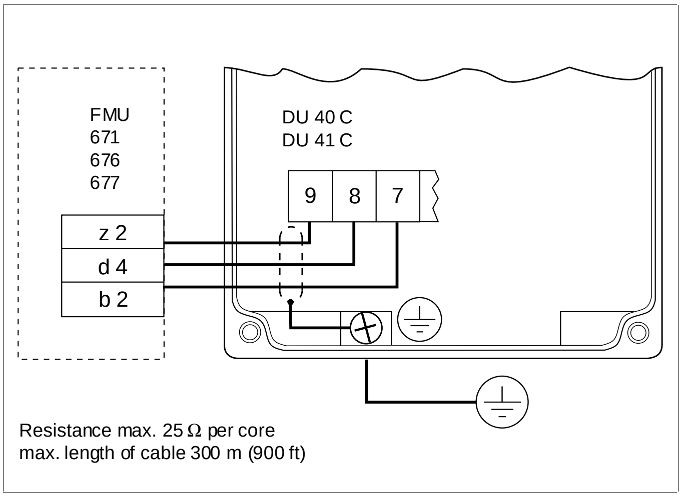
- When mounting in the open, protect the sensor by using an all-weather cover (accessory).
  This prevents build-up of condensation in the housing which is caused by wide temperature variations. It also increases the measuring accuracy of the temperature probe inside the sensor by protecting it from direct sunlight.
- Cylindrical tanks and silos:
  Avoid mounting the sensor in the centre of the roof as interference echoes and multiple echoes will arrive simultaneously. This is especially important with curved domes.
- The sensor can also be attached to two angle irons for mounting over an open silo.

Mounting

Always use a gasket designed for the application when mounting flanged units to a vessel under pressure.

Tighten the screws on opposite sides first. The minimum torque for tightness is 40 Nm at an operating pressure of 1 bar. The maximum torque is 70 Nm.

Electrical Connection



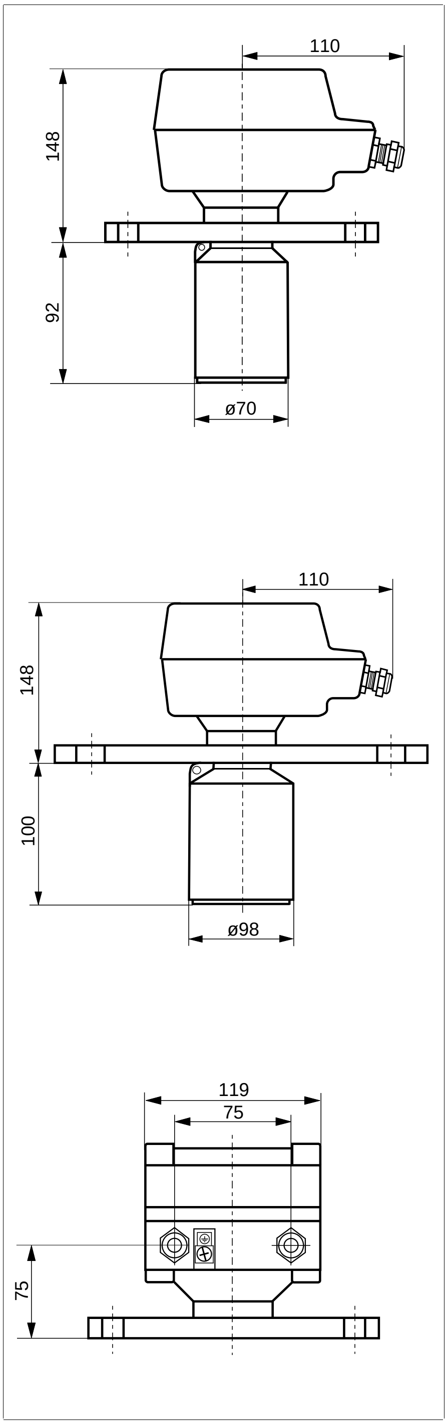
To Prevent Interference

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 40 C/DU 41 C sensor; not to the Nivosonic.
- Connect the ground or potential compensation cable to the outer ground terminal of the sensor.

These measures ensure that the sensors correspond to product family standard EN 61326-1.
For general information on EMC (test methods, installation hints) see TI 241F/00/e.

Technical Data



Dimensions
100 mm = 3.94 in
1 in = 25.4 mm

Above:
DU 40 C

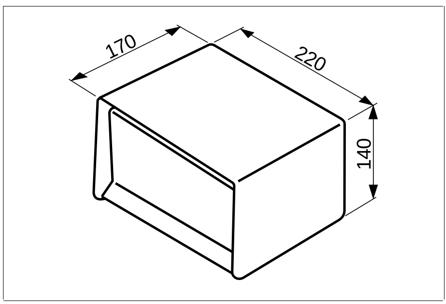
Centre:
DU 41 C

Below:
Front view
of housing

Refer to text on right and product structure on the next page for flange standards and sizes

Accessories

All-weather housing
Material: PVC, light grey
Weight: 0.9 kg
Ambient temperature:
–20°C…+80°C (0…180°F)
Order Number: 918624-0000



Protective cover

Versions

- DU 40 C
  Measuring range:
  max. 10 m (30 ft) for liquids,
  max. 5 m (15 ft) for bulk solids
  Flange: from DN 80 or 4" upwards
- DU 41 C
  Measuring range:
  max. 20 m (60 ft) for liquids,
  max. 10 m (30 ft) for bulk solids
  Flange: from DN 100 or 4" upwards

Operating Data

- Operating pressure p_e:
  –0.5 bar…+1 bar (–7…+15 psi)
- Operating temperature
  (air temperature) in tank or silo:
  –20°C…+80°C (0 ... 180°F)
  Further information available for higher temperatures on request
- Ambient temperature for housing:
  Nominal operating range 0…+60°C (0…140°F)
  Operating limits –20°C…+60°C.
- Air humidity in tank: 100% (0…+80°C)
- Ultrasonic run time compensation: integrated silicon temperature sensor behind sensor diaphragm
- Operating frequency DU 40 C: approx. 43 kHz
- Operating frequency DU 41 C: approx. 29 kHz
- Pulse frequency DU 40 C: ≈ 6 Hz
- Pulse frequency DU 41 C: ≈ 1.5 Hz
- Blocking distance DU 40 C: approx. 0.5 m (1.6 ft)
- Blocking distance DU 41 C: approx. 0.8 m (2.6 ft)

Materials

- Housing: aluminium (AlSi 12), with polyurethane or epoxy resin finish
- Flange: polypropylene
- Sensor: PP/glass fibre

Flange Standards and Sizes:

- DIN: DN 80 to DN 200, PN 16 to DIN 2501, Sheet 1
- ANSI: 4" to 8", 150 psi to ANSI B 16.5
- JIS: 10 K 100 or 150 to JIS B 2210, Table 3-1 ("thick")

Flange thickness differs slightly to the standard.

Electromagnetic Compatibility

EN 61326-1, Class B equipment

Transmitters

- Nivosonic FMU 671
  7 HP wide Racksyst plug-in board with adjustment elements for on-site dialogue
- Nivosonic FMU 676
  Like the FMU 671, configuration via handheld terminal
- Multipoint FMU 677
  7 HP wide Racksyst plug-in board for the Multipoint echo level system behind a common front panel.

Product Structure

Ultrasonic Sensor DU 40 C

		Weight
Certificates, Approvals		
R	Standard (non-certified)	
Process Connection (Max. Operating Pressure p_e = 1 bar)		
A	Flange DN 80 PN 16, PP	2.5 kg
B	Flange DN 100 PN 16, PP	2.6 kg
C	Flange ANSI 4" 150 psi, PP	2.7 kg
D	Flange JIS 10K 100, PP	2.6 kg
Material Exposed to Product		
1	Sensor face: PP	
Housing		
A	Aluminium lacquered, IP 65, Pg 16	
B	Aluminium coated, IP 65, Pg 16	
Y	Others on request	

1 kg = 2.2 lbs

DU 40 C | | | | | Complete Order Code

Ultrasonic Sensor DU 41 C

		Weight
Certificates, Approvals		
R	Standard (non-certified)	
Process Connection (Max. Operating Pressure p_e = 1 bar)		
A	Flange DN 100 PN 16, PP	3.3 kg
B	Flange DN 150 PN 16, PP	3.8 kg
C	Flange DN 200 PN 16, PP	4.5 kg
D	Flange ANSI 4 " 150 lbs, PP	3.3 kg
E	Flange ANSI 6 " 150 lbs, PP	3.9 kg
F	Flange ANSI 8 " 150 lbs, PP	4.9 kg
G	Flange JIS 10K 100, PP	3.3 kg
H	Flange JIS 10K 150, PP	3.8 kg
Y	Others on request	
Material Exposed to Product		
1	Sensor face, PP	
Housing		
A	Aluminium lacquered, IP 65, Pg 16	
B	Aluminium coated, IP 65, Pg 16	
Y	Others on request	

1 kg = 2.2 lbs

DU 41 C | | | | | Complete Order Code

Supplementary Documentation

Nivosonic FMU 671 transmitter (in Monorack housing) with LED display and operating elements

- ☐ Summary of non-contact level measurement using the Nivosonic ultrasonic echo measurement system
  Product Information PI 004F/00/e
- ☐ Nivosonic FMU 671, FMU 676 Transmitters for connecting to the ultrasonic sensor DU
  Technical Information TI 062F/00/e
- ☐ Multipoint echo level system for level measurement at multiple measuring points
  Technical Information TI 086F/00/e
- ☐ Chemical resistance table for polypropylene (English)
  Technical Information TI 214F/00/e
- ☐ EMC test procedures
  Technical Information TI 241F/00/e

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