Ultrasound Controller

Manual

AQ M-Tech AB

Ultrasound Controller

D72, DP72, D128, G72, GP72, G128, GS72

AQ M-Tech AB

- **Manual version** **6.32**
- **Software version** **6.3x**
- **D72 hardware version** **RevE**
- **DP72 hardware version** **RevE**
- **D128 hardware version** **RevA**
- **G72 hardware version** **RevA**
- **GP72 hardware version** **RevA**
- **GSD file version** **6.0**

The manual version should conform to the software and hardware version of the Ultrasound Controller.

The software version of the Ultrasound Controller is shown briefly on the display when power is switched on. It can also be found in the HELP-menu. This manual is available at www.aggroup.com/en/agm-tech/aq-m-tech

Dec 2022

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1. Manufacturer information

AQ M-Tech AB, (previously AQ Elteknik AB) operates a policy of on-going development and reserves the right to make changes and improvements to any of the products described in this manual without prior notice. Under no circumstances shall AQ M-Tech be held responsible for any loss or indirect damage howsoever caused. The content of this document is provided as it is. AQ M-Tech AB reserves the right to revise this document or withdraw it at any time without prior notice.

Manufacturer Declaration of Conformity

Manufacturer AQ M-Tech AB, Sweden declares, that the product: Ultrasound Controller marked with CE-label conforms with the following standards: EN 61000-6-2, EN 61000-6-4, EN55011 (Group 1, Class B).

Ultrasound Controller marked with  conforms to WEEE directive 2012/19/EU. The Ultrasound Controller also conforms to RoHS directive (EU) 2015/863. When the Ultrasound Controller is to be discarded, send it back to AQ M-Tech AB for safe disposal.

Limited Warranty

AQ M-Tech AB warrants to the original end user that the Ultrasound Controller is free from any defects in materials or workmanship for a period of one year from the date of purchase. During the warranty period, should the Ultrasound Controller have indications of failure due to faulty workmanship or materials, AQ M-Tech AB will replace it with no charge. This warranty shall not apply if the Ultrasound Controller is modified, misused or subjected to abnormal working conditions. Replacement as provided under this warranty is the only remedy of the purchaser. The purchaser pays freight to AQ M-Tech AB. AQ M-Tech AB shall in no event be held liable for indirect or consequential damages of any kind or character to the purchaser.

Warning

The Ultrasound Controller is intended to be used with the Air Sensor or the Level Switch, all of them manufactured by AQ M-Tech AB. AQ M-Tech AB takes no responsibility for any possible damage that could happen if any other sensor not manufactured by AQ M-Tech AB is connected to the Ultrasound Controller.

It is not allowed to repair or modify sensors or Ultrasound Controller.

Certificate of Quality and Function

AQ M-Tech AB guaranties that the Ultrasound Controller has passed function and quality tests.

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2. Introduction

Ultrasound Controller

Ultrasound Controller uses ultrasound to make measurements of liquids. It can detect bubbles in flowing liquid or it can detect presence of liquid behind a container wall or it can measure continuous liquid level. The Ultrasound Controller has four different modes of operation:

Air Sensor mode: The Air Sensor monitors the presence of gas or particles in flowing liquid. The Air Sensor is very reliable and easy to use. Two Air Sensors can be connected to one Ultrasound Controller.

Level Switch mode: The Level Switch is a small sensor which attached to the outside of the container can sense the presence of liquid inside the container without making hole in the container. Four Level Switches can be connected to one Ultrasound Controller.

Level Sensor mode: Continuous liquid level is measured with a Level Switch attached under the container bottom (no hole in the container). High accuracy is achieved with a second Level Switch measuring liquid sound velocity. Two levels can be measured with one Ultrasound Controller.

Gel Distance Sensor mode: Continuous gel distance is measured with a Gel Distance Sensor. This mode is only available in GS72.

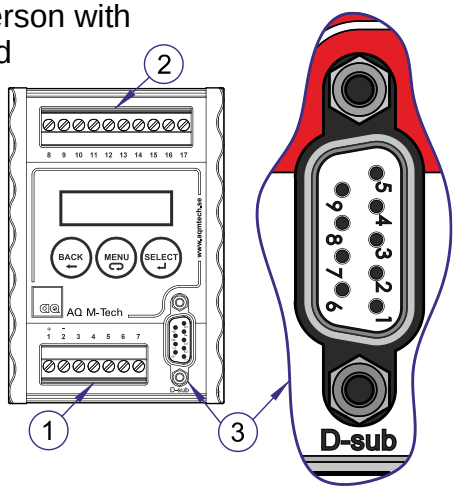
Gel Sensor mode: Gel Sensor GF90 installed inside or Level Switches attached outside the container can sense the presence of gel in the container. Four gel sensors can be connected to one Ultrasound Controller.

The **software version** of the Ultrasound Controller is shown briefly on the display when power is switched on. The software version can also be found in the HELP-menu. Software versions may differ slightly and therefore it is usually better to use a manual version corresponding to the software version, even though a later manual version can have less errors.

Installing Ultrasound Controller D72, G72

The Ultrasound Controller should be protected from dust and water. It is made to be attached to a DIN-rail, to which it snaps easily and can be removed by pushing up and bending the top out. Usually it is installed in an electric cabinet. The connector terminals can be removed by pulling the connector straight out. Connections for terminal 1-7 and D-sub, see table. Connections for terminal 8-17 depend on the selected mode, see table in the corresponding chapter.

The Ultrasound Controller should be installed in accordance with national regulations. A person with the required knowledge should perform the installation.



1 Terminal
2 Terminal for sensors
3 D-sub

D72 G72 terminal	Description
1	+ supply PLUS 24V
2	– supply MINUS
3	Relay common
4	Relay 1
5	Relay 2
6	Relay 3
7	Relay 4
D-sub 1	Cable screen
D-sub 2	
D-sub 3	Reserved
D-sub 4	+ 4-20mA output B
D-sub 5	mA output MINUS
D-sub 6	
D-sub 7	
D-sub 8	Reserved
D-sub 9	+ 4-20mA output A

Installing Ultrasound Controller DP72, GP72

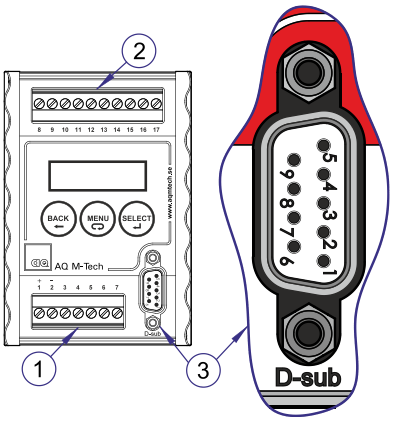
The Ultrasound Controller DP72 and GP72 should be protected from dust and water. It is made to be attached to a DIN-rail, to which it snaps easily and can be removed by pushing up and bending the top out. Usually it is installed in an electric cabinet. The green connector terminals can be removed by pulling the connector out. Connections for terminal 1-7 and D-sub, see table. Connections for terminal 8-17 depend on the selected mode, see table in the corresponding chapter.

The Ultrasound Controller should be installed in accordance with national regulations. A person with the required knowledge should perform the installation.

1 Terminal

2 Terminal (for Sensors)

3 D-sub



DP72 GP72 terminal	Description
1	+ supply PLUS
2	– supply MINUS
3	Relay common
4	Relay 1
5	Relay 2
6	Relay 3
7	Relay 4
D-sub 1	Cable screen
D-sub 2	
D-sub 3	Profibus B+
D-sub 4	+ 4-20mA output B
D-sub 5	mA output MINUS
D-sub 6	+5V output
D-sub 7	
D-sub 8	Profibus A-
D-sub 9	+ 4-20mA output A

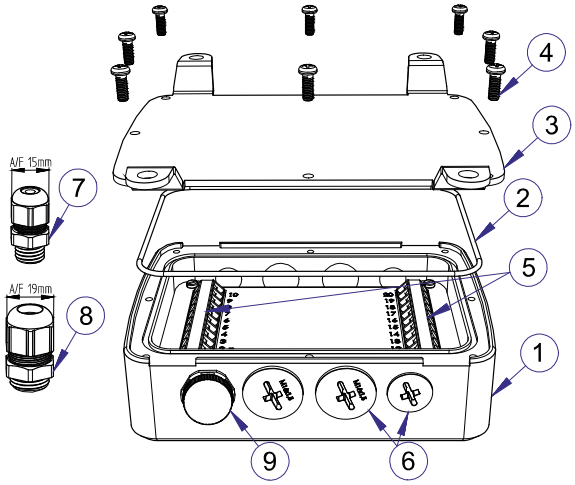
Installing Ultrasound Controller D128, G128

The Ultrasound Controller D128 and G128 is protected according to IP65 and can be installed outside a protecting cabinet. The bottom plate must be removed in order to access the terminals. Remove dummy covering and insert cable glands as needed. There are 3 small and 4 big cable glands. There should be only one cable in each cable gland to achieve full IP65 protection. The pressure compensation element can be moved to different place but must not be removed completely. Make sure the gasket is in place when screwing the bottom plate. Connections for terminal 1-10, see table. Connections for terminal 11-20 depend on the selected mode, see table in the corresponding chapter.

The Ultrasound Controller should be installed in accordance with national regulations. A person with the required knowledge should perform the installation.

D128, G128 terminal	Description
1	+ supply PLUS
2	– supply MINUS
3	Relay common
4	Relay 1
5	Relay 2
6	Relay 3
7	Relay 4
8	mA output MINUS
9	+ 4-20mA output A
10	+ 4-20mA output B

1	Enclosure
2	Gasket
3	Bottom plate
4	Screws (x8)
5	Terminals
6	Dummy coverings
7,8	Cable glands (small and big)
9	Pressure compensation element



3. Navigating the menu system

Toggle between standby and power-on. (D128 only) 	Go back to previous menu-level or Cancel a Selected operation 	Scroll through the menu, scroll through parameter-names or scoll through parameter-values 	Select a menu or Select a parameter-value 

Keep MENU-button pressed to scroll continuously. Press also BACK-button while pressing MENU-button to scroll backwards. Menu-text, parameter-names and parameter-values as seen on the display is ***here in the manual written in blue italic.***

Sensor MODE and the start-screen

When power is applied to the Ultrasound Controller it displays the software version on the LCD-display, followed by the start-screen. Depending on which mode is set; the corresponding start-screen will be shown. The Ultrasound Controller can be set to either Air Sensor mode, Level Switch mode, Level Sensor mode or Gel Sensor mode. When the Ultrasound Controller is powered on for the first time ***Set sensor MODE*** is displayed. Press the MENU-button to scroll to the desired mode and press the SELECT-button to select it. Sensor mode can be changed again in *ADVANCED SETTINGS*. Here is a map of the menu-system:

Air Sensor mode

CALIBRATION
- Calibrate LIQUID AS 1
- Calibrate AIR AS 1
- Calibrate LIQUID AS 2
- Calibrate AIR AS 2

SHOW DATA
- Air Sensor 1
  - Calibration Data
  - Normal Measurement Data
  - Very Low Sensitivity Data
- Air Sensor 2
  - *same as above*
- AUXILIARY DATA

SETTINGS
- SET Air Sensor 1 parameters
  - SET TYPE
  - SET DIAMETER
  - SET SENSITIVITY
  - SET FILTER
  - SET FREQUENCY
- SET Air Sensor 2 parameters
  - *same as above*
- SET RELAY 1
- SET RELAY 2
- SET RELAY 3
- SET RELAY 4
- SET mA output A
- SET mA output B

HELP
- CONNECTOR Terminals 1-7
- CONNECTOR Terminals 8-17
- Information
- Software version

ADVANCED SETTINGS
- set sensor MODE
- SIMULATE
- RESTORE settings and calibrations
- PROFIBUS SETTING
  - BITRATE
  - ADDRESS
  - PARAMETER ACCESS
  - CONTROL (eabl/disabl profibus)

Level Switch mode

CALIBRATION
- CALIBRATE with AIR (empty)
  - Level Switch 1
  - Level Switch 2
  - Level Switch 3
  - Level Switch 4
  - LS1-LS4 together
- CALIBRATE with LIQUID (full)
  - *same as above*

SHOW DATA
- LevelSwitch 1
  - Echo DATA
  - WR DATA
  - Auxiliary data
- LevelSwitch 2 *same as above*
- LevelSwitch 3 *same as above*
- LevelSwitch 4 *same as above*
- Test LevelSwitch

SETTINGS
- SET parameters LevelSwitch 1
  - SET Type AND Technique
  - SET FILTER
  - SET ECHO-DISTANCE
  - SET Jacket
  - SET FREQUENCY
- SET parameters LevelSwitch 2
- SET parameters LevelSwitch 3
- SET parameters LevelSwitch 4
  - *same as above*
- SET RELAY 1
- SET RELAY 2
- SET RELAY 3
- SET RELAY 4

HELP
- CONNECTOR terminals 1-7
- CONNECTOR terminals 8-17
- Information
- Software version

ADVANCED SETTINGS
- Set sensor MODE
- SIMULATE
- RESTORE settings and calibrations
- PROFIBUS SETTING
  - BITRATE
  - ADDRESS
  - PARAMETER ACCESS
  - CONTROL (enabl/disabl profibus)

Level Sensor mode

CALIBRATION
- CALIBRATE with LIQUID >100mm
  - Cal Sensor 1 & 2 (Lev & Vel)
  - Cal Sensor 3 & 4 (Lev& Vel)
- CALIBRATE with AIR
  - Cal Sensor 2 (Vel)
  - Cal Sensor 4 (Vel)

SHOW DATA
- Sensor 1 & 2
  - Measured Level Sensor 1
  - Calibrated Level Sensor 1
  - Measured Velo Sensor 2
  - Calibrated Velo Sensor 2
- Sensor 3 & 4
  - *same as above*

SETTINGS
- SET parameters Sensor 1 & 2
  - SET Range
  - SET Offset
  - SET WR threshold
  - SET Liquid SoundVELOCITY
  - SET Sensor 2 InnerDISTANCE
  - SET Sensor 2 Sensor HEIGHT
  - SET Sensor 2 Sensor Control
  - SET Sensor 1 Bottom THICKNESS
  - SET Sensor 2 Wall THICKNESS
  - SET Sensor 1 FREQUENCY
  - SET Sensor 2 FREQUENCY
- SET parameters Sensor 3 & 4
  - *same as above*
- SET RELAY 1
- SET RELAY 2
- SET RELAY 3
- SET RELAY 4
- SET mA output A
- SET mA output B

HELP
- CONNECTOR Terminals 1-7
- CONNECTOR Terminals 8-17
- Information
- Software version

ADVANCED SETTINGS
- set sensor MODE
- RESTORE settings and calibrations
- PROFIBUS SETTING
  - BITRATE
  - ADDRESS
  - PARAMETER ACCESS
  - CONTROL (enabl/disabl profibus)

Gel Sensor mode

CALIBRATION
- 1-4 together
- GelSensor 1
- GelSensor 2
- GelSensor 3
- GelSensor 4

SHOW DATA
- Gel Sensor Measured data
  - Gelconcentration %
  - Relativ Signal %
  - Relativ Attenuation dB/m
  - Signal dB
  - Liq WR sensor
- Gel Sensor Cal Data
  - Cal Liquid dB
  - Freq
  - Test Sensor dB

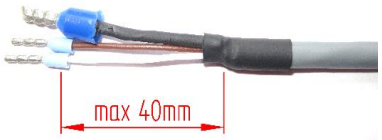
SETTINGS
- SET parameters Sensor 1
  - SET TYPE
  - SET ECHO DISTANCE
  - SET GEL-TYPE
  - SET GEL-THRESHOLD
  - SET FREQUENCY
  - SET WR THRESHOLD
  - SET RELAY1,2
  - SET RELAY3,4
  - SET mA output A
  - SET mA output B

HELP
- CONNECTOR Terminals 1-7
- CONNECTOR Terminals 8-17
- Information
- Software version

ADVANCED SETTINGS
- set sensor MODE
- RESTORE settings and calibrations
- PROFIBUS SETTING
  - BITRATE
  - ADDRESS
  - PARAMETER ACCESS
  - CONTROL (enabl/disabl profibus)

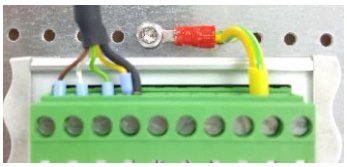
4. Electric Noise

Ground Connection and Sensor Cable



All sensor cables must be shielded. The unshielded part of the sensor cable should be maximum 40mm. The sensor cable may not be extended.

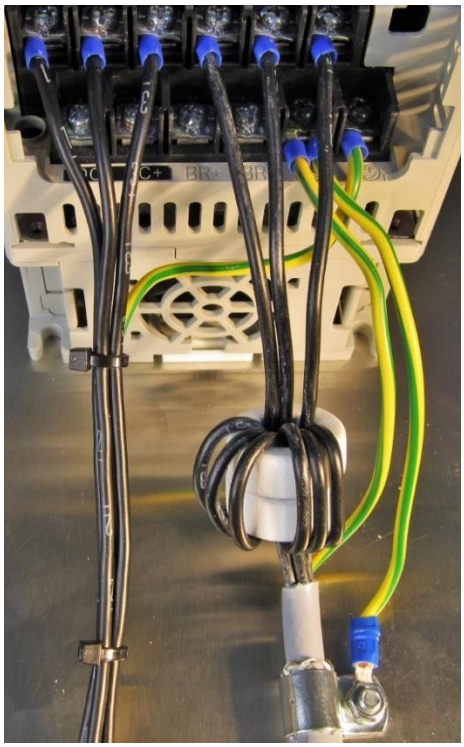
Best connection to ground is achieved by using grounded cable glands on the sensor cables. Only if the sensor cable is not grounded via the cable gland, is it recommended to connect terminal 16 on the D72, DP72, G72, GP72, GS72 or terminal 19 on D128, G128 to ground, near the transmitter as shown in the picture.



Electric noise, with frequency around 2 MHz, entering the sensor cable can cause measurement problems and is better to be minimized by using shielded cables and by not routing the sensor cables along high voltage cables connected to a variable frequency drive.

Noise from Variable Frequency Drives

Variable frequency drives produces noise which exist mainly in the cable connecting the variable frequency drive to the motor. It is good if this cable is shielded and not routed along the sensor cables. The variable frequency drive also produces ground current noise, caused by noise travelling capacitively to ground inside the motor. To reduce such ground current, a common mode filter can be used. The most simple common mode filter is a ferrite clamp, clamped on the three wires coming out of the variable frequency drive. An even more efficient filter is a toroid. It consist of a ferrite toroid with the three wires, connected to the 3-phase output of the variable frequency drive, threaded through the toroid as shown in the picture.

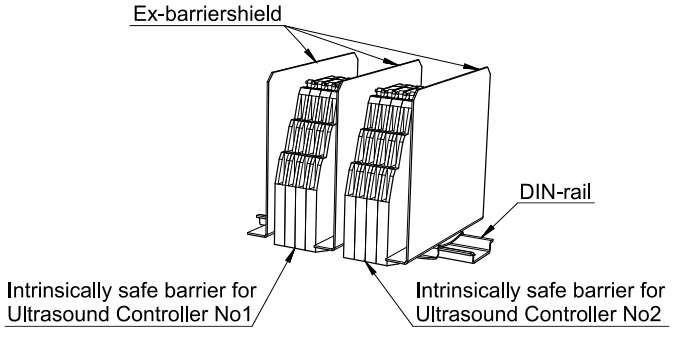


The filter in the picture is very good and is made of two ferrite toroids. The three wires are wound three times through the toroid. The ground wire do not go through the toroid.

Ferroxcube toroid TN25/15/10-3F3 is suitable for wires up to 2,5mm^2 and it is shown in the picture. Alternatively, EPCOS toroid B64290L616X830 can be used. If the wires do not fit, a larger toroid can be used. Ferroxcube toroid of material 3F3 or EPCOS toroid of material N30 or Amidon toroid of material 77 are suitable for filtering frequencies around 2MHz.

5. Ex-installation with ex-barriers

Ex-barriers are not shielded so if ex-barriers are used, Ex-barrier shields must be inserted on each side of the group of EX-barriers connected to each Ultrasound Controller (see picture). The ex-barrier connects the sensor cable shield to ground which makes it possible for ground currents to enter. Because of this, minimizing ground currents is very important especially when EX-barriers are used.



6. Air Sensor Mode

In Air Sensor mode the Air Sensor is used to measure the presence of bubbles in flowing liquid. To one Ultrasound Controller there can be connected two Air Sensors model SAC, APS, DAP, DAT, CCS, PAC, FCS or FCP. For Air Sensor model CQS only one can be connected.

Quick start guide

- Install Air Sensors according to instructions in the Air Sensor Manual.
- Connect cables, see page 7 or 8 and 12.
- Switch on external power supply.
- Read about navigating the menu system, page 9.
- If display show: ***SET sensor MODE***. Choose ***Press SELECT for Air Sensor mode*** by scrolling with MENU button and selecting with SELECT button.
- Go to ***SETTINGS*** see page 14 and set all parameter that need to be set.
- Fill Air Sensor 1 (AS1) with liquid. Select ***Calibrate LIQUID AS1*** and Press SELECT button one second.
- Empty Air Sensor 1 (AS1) of liquid. Select ***Calibrate AIR AS1*** and press SELECT button one second.
- Do the calibration in the same way for Air sensor 2 (AS2). The calibration can be done in any order as long as both air and liquid will be calibrated.
- A simple validation: AIR should be indicated when the Air Sensor is empty and LIQUID when it is filled with liquid.
- Go to ***SHOW DATA*** for a more thorough validation of the calibrated values, see page 16.
- Ready.

Functional Description

Bubbles in the liquid flowing through the Air Sensor are monitored using ultrasound. Inside the Air Sensor two low intensity beams of ultrasound are transmitted across the liquid-path. When a bubble moves through an ultrasound-beam the sound will be partially deflected and the intensity of the ultrasound beam changes. The controller constantly measures ultrasound intensity and in this way detects bubbles. Dense particles in the liquid can also deflect ultrasound and therefore can cause bubble detection. Normally there are two ultrasound beams or four beams for Air Sensor CQS. Using muliple beams allowes higher sensitivity and more reliable bubble detection.

The measurement when very low sensitivity is selected, uses a different measurement technique. It measures ultrasound echoes in the air sensor walls being dampened by liquid. The sensitivity for bubbles is very low. However there is a temperature dependency so it is good if temperature during calibration and operation do not vary more than +-5ºC in this case.

The measurement accuracy depend on how well the Air Sensor is calibrated, the flow-rate, the type of liquid, how the Air Sensor is mounted and weather there is a single bubble or many bubbles and the Air Sensor size.

Orientation of the Air Sensor

If the Air Sensor is mounted horizontally orientation is important. Liquid flowing through the Air Sensor tends to pull bubbles towards the center of the tube but when flow rate is low, bubbles can rise to the top. The Air Sensor is slightly more sensitive to bubbles if it is rotated so that the cable/connector is facing up.

Connecting the Air Sensor

Maximum cable length depends on the Air Sensor, see Air Sensor manual. The Air Sensor cable can be ordered in different length and should not be extended. The unshielded part of the cable should be no longer than 40mm.

SAC, PAC, DAP, APS and DAT uses M8 connectors. Screened cable with 4pin M8 connector can also be used. Then instead of green, black is connected and instead of yellow, blue.

If D72 is mounted inside a metal cabinet it is good to connect D72 to the cabinet (ground) and this is best done using shielded cable glands for the Air Sensor cables. If shielded cable glands are not used then terminal 11 or 16 on the D72, DP72 or terminal 14 or 19 on D128 can be connected to the cabinet instead. Note that Air Sensor PAC needs a short jumper cable. To minimize the risk of electric interference and noise, see Electric Noise page 10.

Terminal number			Cable Color						
D72 DP72	D128		SAC	PAC	FCP	FCS	CCS	DAP APS DAT	CQS
8	11	Air Sensor 1	Brown	Brown	Brown	Brown	Brown	Brown	Brown
9	12		White	White & Jumper A	Shield of Brown & Shield of Green	Shield of Brown & Shield of Green	White	White	White
10	13		Green	Green (Black)	Green	Green	Black	Green (Black)	Green
11	14		Yellow & Shield	Shield & Jumper A	Shield of White (Yellow not used)	Shield of White & Shield of Yellow	Blue & Shield	Shield	Shield
12	15			Yellow (Blue)	White	Yellow & (White not used)		Yellow (Blue)	Yellow
13	16	Air Sensor 2	Brown	Brown	Brown	Brown	Brown	Brown	Pink
14	17		White	White & Jumper B	Shield of Brown & Shield of Green	Shield of Brown & Shield of Green	White	White	Grey
15	18		Green	Green (Black)	Green	Green	Black	Green (Black)	Blue
16	19		Yellow & Shield	Shield & Jumper B	Shield of White & (Yellow not used)	Shield of White & Shield of Yellow	Blue & Shield	Shield	(Shield)
17	20			Yellow (Blue)	White	Yellow & (White not used)		Yellow (Blue)	Red

Connecting the Air Sensor Ex via Ex-barrier

In hazardous area, intrinsically safe barriers must be used to connect SAC Ex, CCS Ex or FCS Ex to the Ultrasound Controller. In this table connection is shown for a dual channel zener ex-barrier

(channel A and B). Read Air Sensor Ex Manual about how to select the barrier and how to connect the Air Sensor Ex to the barrier. To minimize the risk of electric interference and noise, see Electric Noise page 10.

Terminal number			Cable Color			
D72 DP72	D128		Dual channel zener Ex-Barriers	SAC Ex or CCS Ex	Dual channel zener Ex-Barriers	FCS Ex
8	11	Air Sensor 1	Channel A	Brown	Channel A	White
9	12		Ground	White	Ground	Shield of White & Shield of Yellow
10	13		Channel B	Green (Black)	Channel B	Yellow
11	14		Ground	Yellow (Blue) & Shield	Ground	Brown & Green and Shield of Brown & Shield of Green
12	15					
13	16	Air Sensor 2	Channel A	Brown	Channel A	White
14	17		Ground	White	Ground	Shield of White & Shield of Yellow
15	18		Channel B	Green (Black)	Channel B	Yellow
16	19		Ground	Yellow (Blue) & Shield	Ground	Brown & Green and Shield of Brown & Shield of Green
17	20					

Setting lowest possible sensitivity for bubbles

If mounted horizontally rotate the Air Sensor so that the cable connector is facing down.

The ***FILTER*** setting determines the delay (response time) for detecting air. Set ***FILTER*** to ***delay 0,3s*** or longer depending on maximum acceptable delay (do not set it to integrate). Bubbles that quickly come and go will then pass undetected.

Set the ***SENSITIVITY*** to ***low***. ***SENSITIVITY*** can also be set to ***very low*** or ***very very low***, but these settings uses a different measurement technique where the presence of liquid is detected regardless of bubbles. This technique is sensitive to temperature changes and works only on diameters > 16mm. Don't use it if there is more than +- 5°C temperature variation during measurement and calibration. Try first set ***SENSITIVITY*** to ***low*** and ***FILTER*** to ***delay 0,3s*** or longer. If there are still unwanted detections of bubbles, then change the setting of ***SENSITIVITY*** to ***very low*** or ***very very low***.

SETTINGS

Through the ***SETTINGS***-menu the parameters of the Air Sensor can be set.

Select ***SET TYPE*** to set the type of Air Sensor connected. This tells the Ultrasound Controller to make the correct adjustments for this Air Sensor type.

Select ***SET DIAMETER*** to set it to the diameter of the connected Air Sensor or as close as possible. This tells the Ultrasound Controller to make the correct adjustments for this Air Sensor diameter.

Select ***SET SENSITIVITY*** to set the sensitivity. This determines how sensitive the Air Sensor is for bubbles.

SENSITIVITY can be set to ***high***, ***medium***, ***low***, ***very low*** and ***very very low***. Detectable bubble size is somewhat dependent on Air Sensor inner diameter:

At ***high*** sensitivity, a single bubble of approximately 1-60µl can be detected depending on Air Sensor diameter: SAC10,FCS10: 1µl, SAC22,FCS22: 6µl, SAC35,FCS35: 8µl, SAC46,FCS46: 80ul, DAP6,APS6: 3µl, DAP10,APS10: 20µl, DAP22,APS22: 60µl

At ***medium*** sensitivity, a single bubble of approximately 10-150µl can be detected depending on Air Sensor diameter: SAC10,FCS10: 10µl, SAC22,FCS22: 30µl, SAC35,FCS35: 40µl, SAC46,FCS46: 170ul, DAP6,APS6: 30µl, DAP10,APS10: 60µl, DAP22,APS22: 150µl

At ***low*** sensitivity, a single bubble of approximately 500-1200µl can be detected depending on Air Sensor diameter: SAC10,FCS10: 500µl, SAC22,FCS22: 900µl, SAC35,FCS35: 1000µl, SAC46,FCS46: 5000ul, DAP6,APS6: 200µl, DAP10,APS10: 500µl, DAP22,APS22: 1200µl

Sensitivity is also affected by liquid flow rate. At a flow rates above 4m/s sensitivity starts decreasing. Many small bubbles together may also detect as if they were a big bubble. Even tiny, microscopic bubbles may cause detection if there are very many of them.

High, ***medium*** and ***low*** sensitivity are the normal measurements.

At ***very low*** and ***very very low*** sensitivity, a different measuring technique is used (WR-technique). This technique measures the presence of liquid or no liquid, making the Air Sensor very insensitive for bubbles. It can be used for Air Sensors DAP and APS with diameter ≥ 6mm and Air Sensor SAC with diameter ≥ 22mm. There is temperature dependence and this setting should not be used if temperature variation between calibration and operation is more than ±5ºC.

Select ***SET FILTER*** to set the filter-time. It determines how the detection-data is filtered. ***FILTER*** can be set to either ***integrate 1ms*** - ***3s*** or ***delay 300ms*** - ***10s***.

Integrate means integrating (adding) the duration of each bubble in the measuring zone. When the sum becomes higher than the integrate time, air will be indicated. Whenever liquid is next time indicated, the integration-process will start over.

Delay means that air will only be indicated when air has been continuously detected for a time longer than the delay time.

Long ***FILTER delay*** and low ***SENSITIVITY*** is useful if some quantity of bubbles are acceptable.

Short ***FILTER integrate*** and high ***SENSITIVITY*** is useful when almost every bubble must be detected.

Select ***SET FREQUENCY*** to set the ultrasound frequecy that is used to detect bubbles. Normally it should be set to ***Auto***, then the frequency that works best is automatically selected. However for some liquids it works better to set it manually. (For example acetic acid is better to set to 2,0MHz)

Select ***SET RELAY*** to set how the relays should act. There are four relays each with one normally open contact (at power off and when sensor is not connected the relay is open). Each relay can be set independently. Choose between Closed with air or closed with liquid and choose between Air Sensor 1 and Air Sensor 2. The duration of air being indicated is minimum 0,5 second even if the bubble is detected much shorter time (to make sure the indication of air is registered).

Select ***SET mA output*** to set the assignment of the mA-outputs. There are two mA-outputs: A and B. They can be assigned to output ***Normal Measurement Data*** or ***All Sensitivities*** for air sensor 1 or 2.

Normal Measurement Data This is a combination of the analog ***Ndata*** (during the time liquid is indicated) and 6mA whenever air is indicated. Note that ***Ndata*** is filtered with very long (1s) time constant and is too slow to be used for detecting bubbles. The reaction time for the air indication is 40ms and detection is always minimum 500ms.

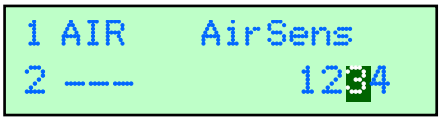
8mA – 20mA = ***Ndata*** = 0% – 150% (but only during the time Liquid is indicated)
6mA = when Air is indicated
4mA = error

All Sensitivities This is a combination of all sensitivities so that different bubble sizes can be output to the mA output. The reaction time is 40ms but the bubble indication time is always minimum 500ms regardless of how long the bubble is being detected.

16mA = Liquid (no bubble)
12mA = medium bubble
8mA = very big bubble
4mA = error.

14mA = small bubble
10mA = big bubble
6mA = very very big bubble

Air Sensor start-screen



When power is applied, the Air Sensor start-screen is displayed showing something like this. On the first line to the right is written AirSens meaning this is Air Sensor-mode. The first digit to the left indicates Air Sensor 1 and Air Sensor 2. Following the digit is diagnostic information about each Air Sensor:

---	No Air Sensor is connected and ***Air Sensor TYPE*** or ***DIAMETER*** is set to ***no Air Sensor***
set	Settings are missing
cal	Waiting for calibration to be done
CalAir	Calibration of air is perhaps good to do (after calibration of liquid)
CalLiq	Calibration of liquid is perhaps good to do (after calibration of air)
err 1	Error, no Air Sensor is detected
err 2	Error, ***NAir*** too high, see troubleshooting
err 3	Error, ***VLthld*** too low, see troubleshooting
err 4	Error, ***NLiq*** too low, see troubleshooting
SetErr	Error, wrong settings, see troubleshooting
AIR	Air or bubble is detected
LIQUID	Liquid without bubble is detected.

(LIQUID is blinking if measurement data is higher than 200% suggesting a new calibration may be advisable). On the second line to the right is written 1234 which shows the state of each of the four relays. A light digit on dark signifies a closed relay.

ADVANCED SETTINGS

Select ***Set sensor MODE*** to set either ***Air Sensor mode***, ***Level Switch mode***, ***Level Sensor mode*** or ***Gel Sensor mode mode***. It determines which sensor can be connected.

Select ***SIMULATE*** to simulate detection of air or liquid. Press SELECT button to toggle between simulation of AIR and LIQ. Press MENU button to change between Air Sensor 1 and 2.

Select ***RESTORE settings and calibrations*** to restore all settings and calibrations to factory-settings.

Select ***PROFIBUS SETTINGS*** see page 42 (for DP72).

CALIBRATION

Calibration must be done both with air (with empty Air Sensor) and liquid (with full Air Sensor) and it can be done in any order. To calibrate liquid, make sure there is liquid inside the Air Sensor and select ***calibrate LIQUID*** (and press SELECT button one second). To calibrate air make sure the Air Sensor is empty and select ***calibrate AIR*** (and press SELECT button one second). During calibration of liquid, Ultrasound Controller adjusts the intensity of the ultrasound to become 100%. Each Air Sensor should be calibrated after installation. After the calibration it is advisable also to check the values in ***SHOW DATA*** (see below).

A new calibration of liquid may be required if the liquid properties has changed significantly since the last calibration. For the Air Sensor PAC or FCP a temperature change over 20ºC requires a new calibration of liquid. When very very low sensitivity is used a temperature change of more than 4ºC requires a new calibration of both air and liquid.

SHOW DATA

There are two measurement techniques, normal measurement and very low sensitivity measurement. These are then doubled into two perpendicular measurements for increased reliability and sensitivity.

During normal measurement a beam of ultrasound is transmitted and the echo is amplified. A bubble scatters the sound causing reduced intensity. This is how a bubble is being detected.

During very low sensitivity measurements the Air Sensor transmits ultrasound and listens to how quickly vibrations inside the walls of the Air Sensor disappear into the liquid.

Calibration Data

The Calibration Data page shows calibration data from normal measurement. Calibration data is measured and stored during calibration. The two data on each line correspond to the two perpendicular measurements.

On the first line is ***NLiq*** which is the ultrasound strength measured in dB with liquid in the Air Sensor. ***NLiq*** is usually around 40dB, depending on type of Air Sensor. A high value means strong sound which is better than a low value. Check that ***NLiq*** is higher than 30dB for SAC and FCS, higher than 18dB for SAC Ex, CCS Ex or FCS Ex, higher than 19dB for PAC and FCP.

On the second line is ***NAir*** which is the relative sound strength, relative to ***NLiq***, with air in the Air Sensor. Ideally ***NAir*** should be 0% but as sound travels around the walls it will not be 0%. Check that ***NAir*** is less than 15%.

Normal Measurement Data

This page shows the current normal measurement data, ***Ndata*** (The two data correspond to the two perpendicular measurements). It is the relative ultrasound strength (relative to ***NLiq***). With liquid in the Air Sensor, it should be near 100%, depending on the liquid. All liquids do not conduct sound equally well. If ***Ndata*** with liquid is > 130% or if it is < 80% it is advisable to calibrate the Air Sensor with liquid again.

With air in the Air Sensor, ***Ndata*** should be less than 15%. The threshold at which air bubble is detected depend on sensitivity setting and type and size of Air Sensor (approximately at high sensitivity threshold is 44% and at low sensitivity threshold is 27%).

Very Low Sensitivity Data

This page shows data from the very low sensitivity measurement. This measurement technique is different from the normal measurement technique and is used only for ***very low*** and ***very very low sensitivity*** settings. The two data on each line correspond to the two perpendicular measurements.

On the first line is ***VLdata*** showing the current measured ultrasound strength.

On the second line is ***VLthld*** showing the threshold. ***VLthld*** is measured and stored during calibration. Liquid is detected when ***VLdata*** is > ***VLthld***. For reliable operation ***VLthld*** should be > 5.

AUXILIARY DATA

This page shows unprocessed data from the Air Sensor. It can be used for troubleshooting when contacting AQ M-Tech AB.

HELP

Select ***HELP*** to show information about how to connect the Ultrasound Controller.

Sound velocity in the Air Sensor

With sensitivity set to ***low***, ***medium*** or ***high*** and with two liquids having different sound velocities in the Air Sensor and with these liquids not well mixed, there can be false indication of air. The sound is refracted due to velocity change, as it travels from one liquid to another. Setting longer filter times and lower sensitivity can reduce such false indications of air.

Air Sensor CQS

Air Sensor CQS has a relatively large diameter and therefore it uses four measurement zones instead of two. This improves bubble detection. However only one Air Sensor CQS can be connected to one D72. Settings should be set for air sensor 1 (setttings for air sensor 2 is disabled when air sensor 1 is set to CQS).

Air Sensor TROUBLESHOOTING

Air or Liquid is indicated on the display but the relay does not change = ***RELAY*** setting is wrong.

Display shows:

Cal Calibration should be done.

CalAir Calibration Air should be done.

CalLiq Calibration Liquid should be done.

Set Settings of TYPE or DIAMETER is missing

err 1 No Air Sensor is detected. The reason for this can be wrongly connected Air Sensor, or faulty Air Sensor.

err 2 The relative signal with Air is too strong (at ***low***, ***medium*** or ***high*** sensitivity). ***err 2*** is shown if ***NAir*** is higher than 21-25%.
The reason for high ***NAir*** can be:
Calibration of AIR has been done with liquid in the Air Sensor. Or Wrong settings of Air Sensor Type or Diameter. Or electric interference. Or a faulty Air Sensor. Or calibration of LIQUID has been done with liquid having lots of bubbles or particles attenuating the sound.

Electric interference will show itself as ***Ndata*** being unstable with Air in the Air Sensor. To minimize the risk of interference it is important that sources of interference like frequency inverters should use shielded cables between inverter and motor. Also any unshielded part of the cable between the Air Sensor and Ultrasound Controller should be short. If ex-barriers are used, Ex-barriershields must be used especially if there is more than one Ultrasound Controller.

err 3 There is not enough signal difference between air and liquid (at ***very low*** or ***very very low sensitivity***). ***err 3*** is shown if ***Very Low*** sensitivity threshold is not high enough for reliable measurement (***VLthld***<6). Air Sensor with diameter less than 22mm may have difficulty measuring at very low sensitivity. Change ***SENSITIVITY*** to ***low***, ***medium*** or ***high*** instead.

err 4 The absolute signal with Liquid is too weak (at ***low***, ***medium*** or ***high*** sensitivity). err 4 is shown if the calibrated data with Liquid, ***NLiq*** is lower than 31dB for SAC and FCS or 19dB for SAC Ex, CCS Ex and FCS Ex or lower than 18dB for PAC and FCP.
The reason for this can be: Calibration of LIQUID has been done with air or liquid having lots of bubbles or particles attenuating the sound. Or wrong settings of Air Sensor Type or Diameter. Or Air Sensor is wrongly connected. Or Air Sensor is faulty

SetErr Air Sensor DAP, DAT and APS can not be used together with another type of Air Sensor (this is due to an internal configuration common to both air sensors). When ***TYPE*** is set to ***DAP, DAT*** or ***APS*** on one air sensor, the other air sensor must also be set to ***DAP, DAT*** or ***APS*** or ***No Air Sensor***.

7. Level Switch Mode

In Level Switch Mode the Level Switch measures a single level from the side of the container. It measures the presence or no presence of liquid behind the container (or pipe) wall. The Level Switch senses through the wall AND no hole is needed. Four Level Switches can be connected to one Ultrasound Controller.

Quick start guide

- Install Level Switches according to instructions in the Level Switch Manual.
- Attach the included tape, see page 21
- Connect cables, see page 7 or 8 and 19.
- Switch on external power supply. You may have to press POWER to exit standby on D128.
- Read about navigating the menu system, page 9
- If display show: ***SET sensor MODE***. Choose ***Press SELECT for Air LevelSwitchmode*** by scrolling with MENU button and selecting with SELECT button.
- Go to ***SETTINGS*** see page 23 and set all parameter that need to be set.
- Now calibrate Level Switch 1. Make sure liquid level is below the Level Switch. Select ***CALIBRATE with AIR (empty)*** then select ***Calibrate AIR Level Switch1*** and press SELECT button one second.
- Make sure liquid level is above the Level Switch. Select ***CALIBRATE with LIQUID (full)*** then select ***Calibrate LIQUID Level Switch1*** and press SELECT button one second.
- Do the calibration for all connected Level Switches. The calibration order air/liquid and Level Switch number can be mixed.
- Go to ***SHOW DATA*** to check calibrated values, page16
- Ready.

Connecting the Level Switch

The Level Switch cable is better not be extended. Maximum cable length, see Level Switch manual. The unshielded part of the cable should be no longer than 40mm. Yellow and green wire are not used except for Level Switch DL which is a Level Switch with two sensors.

If D72 is mounted inside a metal cabinet it is good to connect D72 to the cabinet (ground) and this is best done using grounded cable glands for the Level Switch cables. If grounded cable glands are not used then terminal 16 on the D72, DP72 or terminal 19 on D128 can be connected to the cabinet instead.

To minimize the risk of electric interference and noise, especially in ex-installation, see Electric Noise page 10.

Ultrasound Controller Terminal		Level Switch Cable	Level Switch DL (two sensors with a single cable)
D72 DP72	**D128**	**Cable Color**	**Cable Color**
8	11	Sensor **1** Brown	Sensor 1 Brown
9	12	Sensor **1** White	Sensor 1 White
10	13	Sensor **2** Brown	Sensor 2 Green (or black)
11	14	Sensor **1** Shield & Sensor **2** Shield	Shield
12	15	Sensor **2** White	Sensor 2 Yellow (or blue)
13	16	Sensor **3** Brown	Sensor 3 Brown
14	17	Sensor **3** White	Sensor 3 White
15	18	Sensor **4** Brown	Sensor 4 Green (or black)
16	19	Sensor **3** Shield & Sensor **4** Shield	Shield
17	20	Sensor **4** White	Sensor 4 Yellow (or blue)

Level Switch Type and Technique

There are two different measuring techniques: Echo and WR (Wall Reverberate). The different Level Switches are optimized for each technique. Level Switch RS works well with the WR-technique and do not work well with Echo-technique. Level Switch MK has a soft silicone surface adapting to the container surface and works well with Echo-technique and does not work well with the WR-technique. Two Level Switch MK also works well with the dual-technique for improved detection when the container is small. Level Switch KS and LS works well with the Echo-technique and on plastic containers they also works well with the WR-technique.

Echo Technique

The echo-technique uses echo from a reflecting surface inside the container (usually the opposite container wall) to determine if there is liquid or not inside. All types of Level Switch except Level Switch RS can be used.

The echo-technique transmits short sounds and then measures the echo bouncing on the opposite reflecting surface. With liquid inside, there is an echo and with no liquid there is no echo. If the liquid attenuates the sound too much the echo may disappear. Small bubbles and particles in the liquid can cause attenuation and unmixed liquids having different sound velocities can cause refraction of the sound and thereby the echo disappear resulting in wrong indication of low level. It is important that the sound-beam from the sensor is reflected, back to the sensor and not diverted in the wrong direction.

It is desirable that the ultrasound passes as easy as possible through the container wall. How well it passes depend on the wall material and thickness. Steel or glass wall should be in the range 1,2mm - 15 mm and plastic wall <15mm (PP<10mm). Plastic with fiberglass can be troublesome. Testing on the actual container is recommended. Any welding or other unevenness in the wall should be avoided as it can refract (bend) the sound-beam in an unwanted direction.

The ultrasound beam behaves similar to a light-beam, the direction of the echo depend on from what angle it hits the reflecting surface. Obstructing object in the path between sensor and the reflecting surface should be avoided. The sound beam is approximately 1cm in diameter. A tube in the center of the container can give an echo but it is weak. In case there are obstructing objects inside the container, perhaps the Level Switch RS with the WR-technique is a better choice.

On small containers, disturbing background echoes becomes stronger in relation to the echo. Level Switch LS and KS should therefore not be used on metal and glass containers smaller than 44mm diameter.

WR Technique

The WR technique measures vibrations in the container wall to determine if there is liquid or not behind the wall. Level Switch RS should be used. However, on plastic walls Level Switch KS or LS can also be used.

The WR-technique transmits sound and then measures the remaining vibrations in the container wall. Vibrations decay more quickly with liquid inside due to the dampening effect of the liquid. The WR-technique works with most liquids since the sound does not have to travel through the liquid. But the WR-technique is dependent on the material and thickness of the wall. Steel or glass wall 1,2mm - 15 mm or plastic wall < 15mm (PP<10mm) should be ok. Fiberglass-plastic would be troublesome and testing on a container is recommended. WR technique can have quite high temperature dependence, depending on wall material, and should not be used if temperature differ more than 15ºC between temperatures during operation and calibration.

When using the WR-technique on plastic walls Level Switch KS can be used instead of Level Switch RS.

The WR-technique measures small signal changes and is therefore sensitive to small displacements of the Level Switch. So the Level Switch must be steadily attached. Ideally the Level Switch RS is glued with silicone sealant. Level Switch MK is not recommended for use with the WR-technique since it is not easy to mount steadily. The WR-technique may also detect drops of liquids lingering on the inside of the wall and falsely indicate them as liquid. There is also sensitivity to temperature changes. The advantages of the WR-technique is independecy of liquid sound-properties and independency of bubbles and no need for a reflecting surface.

Dual Technique

The dual technique is intended for Level Switch MK. It uses two level switches MK to measure a single level. The two Level Switches are placed on each side of the container opposite to each other. Ultrasound is transmitted from the one Level Switch to the other. Ultrasound will only travel once through the liquid so the received ultrasound will be stronger than when the echo technique is used. The large amount of silicone inside a Level Switch MK creates troublesome internal echoes, which on a container with diameter 40mm or less may interfere with the measured echo. Using two Level Switch MK avoids this problem and therefore achieves more reliable result. So especially on small diameter containers it is a more reliable technique. The two Level Switches that are to be used with dual technique should be connected as level switch 1 and level switch 2 and level switch 1 should be set to Type:MK Technique:Dual and Level Switch 2 set to No Level Switch. Two other Level Switches can also be connected as level switch 3 and level switch 4. Level Switch 3 should then be set to Type:MK Technique:Dual and Level Switch 4 set to No Level Switch.

Mounting the Level Switch

Between the Level Switch and the container there must be a tight ultrasound-connection. For Level Switch MK, this is achieved with its soft silicone surface. For the other Level Switches, it is achieved by using silicone sealant or HTC-compound.

Mounting Level Switch MK

For attaching the Level Switch MK no glue or compound is needed. The Level Switch MK has a flexible surface which acieves a good ultrasound-connection when it is pressed against the container. The pressure needs to be around 15N (minimum 5N and maximum 50N), depending also on the shape of the container. The pressure makes the flexible surface adapt to the container. It is important the Level Switch MK is held in place with a fixture. The fixture should provide the means for applying the pressure on the Level Switch so it will be pressed against the container. Since the Level Switch MK has a rounded surface, the fixture need also to hold the Level Switch MK straight in place. A possible fixture is a plastic block adapted to the shape of the container, with a 25,1mm hole for the Level Switch. More information about how the Level Switch MK can be used for measuring is available in Level Switch manual.

Mounting Level Switch KS / KSF / RS / RSF / CF / LS / LSF

Gluing the Level Switch is the best attachment technique. Transparent silicone sealant is highly heat-resistant and is a very good glue. A Level Switch glued with silicone sealant is easy to remove. The silicone sealant can for instance be Loctite 5366 or similar. Searching for silicone sealant on google usually gives a lot of search results. Sanitary silicone sealant is however best to avoid due to its content of fungicides which may be poisonous. Silicone takes a few days to cure but the Level Switch can be used while the silicone is curing. Put some silicone sealant on the container-facing side of the Level Switch and press it on to the container. The silicone should completely cover the gap between the Level Switch and the container. During the first hours, the Level Switch must be held securely in place with some tape or a clamp.

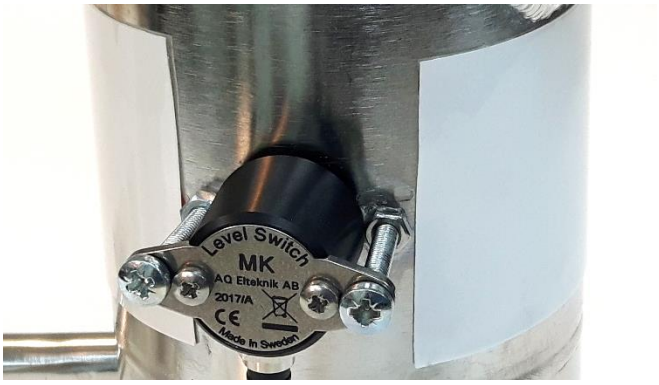
Transparent MS-polymer (modified silane polymers, also called SMP or STP or STPE) can also be used instead of silicone sealant. Searching on google gives many results like MSPT.K290. It is environment friendly but does not endure as high temperature as silicone sealant. Like silicone sealant it takes some days to cure.

Hard glues should be avoided since they can come loose by temperature variations.

If the Level Switch is not glued, Electrolube Heat Transfer Compound can be used. It does not cure so the Level Switch must be held in place by other means. If the Level Switch is removed, the old compound should be wiped off and new used next time. These compounds are not recommended at temperatures above 60°C.

Level Switch RS can only be used with the technique WR and gluing the Level Switch RS with silicone sealant or MS-polymer is essential.

Stainless Steel and Glass Containers



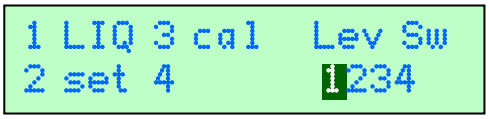
When the Level Switch is mounted on a stainless steel or glass container and the echo-technique is used, it is advisable to also attach a sound absorbing tape on the container. The tape will supress unwanted sound travelling along the container and thereby improve the measurements (the ***Edata*** will be lower with air, making threshold ***Ethd*** also lower, which is good). The 3M tape SGH12 or 8671 is suitable for this purpose. It withstands high temperature 135°C. The tape is transparent and can be removed without leaving any trace. The picture shows the tape with the protective paper still attached. It should be placed centered over the Level Switch and go around the container, starting and ending near the Level Switch. The important area to cover is about 100mm on each side, close to the Level Switch. On a big container, if the tape is too short, it can be cut in two pieces and placed on each side of the Level Switch. The tape is 51mm wide and one tape should be used for each Level Switch. Attaching tape above or below the Level Switch does not help. The tape is supplied with the Level Switch in 500mm length and can also be ordered separately from AQ M-Tech, order number 101310. The material is polyurethane. Acetone should not be used for cleaning the tape.

Level Switch start-screen

When power is applied, the Level Switch start-screen is displayed showing `Lev Sw` on first line to the right signifying this is Level Switch start-screen. . On the second line to the right is written `1234` which shows the state of each of the four relays. A dark background signifies a closed relay.

To the left are four small digits signifying Level Switch 1 2 3 and 4 with three-letter-text following each digit showing information about each Level Switch:

`AIR`	air is detected
`LIQ`	liquid is detected
`cal`	Waiting for calibration of Air and/or Liquid
`set`	parameters need to be set
`--`	Level Switch disconnected
`err`	error – see troubleshooting
	Level Switch is not existing



Example: Level Switch 1 detecting liquid, Level Switch 2 connected but not set, Level Switch 3 need to be calibrated, Level Switch 4 not existing, Relay1 closed.

SETTINGS

Through the SETTINGS-menu the parameters of the Level Switch can be set.

Select *SET Type AND Technique* to set it to either *Type: KS,MK,MS,LS, Technique: ECHO* or *Type: RS, Technique: WR* or *Type KS,MK,LS Technique WR* or *Type: MK Technique: Dual* or *No Level Switch*.

Select *SET DISTANCE to reflecting wall* to set it between *46mm* (minimum) and *600mm* (maximum). This parameter is needed if the "ECHO" technique is chosen and should be set to actual distance. It does not have to be exact, just use the nearest value. If Technique is set to WR this setting is not needed.

Select *SET FILTER* to set the filter-time between *0,5s 1s 2s* or *4s*. It determines how fast the Level Switch detects air or liquid.

Select *SET Jacket* to set the distance in mm between jacket and container. Set it only if the container has a jacket.

Select *SET FREQUENCY* to set the measurement frequency. This setting is dependent of the container wall material and thickness. Usually it can be set to Auto unless a particular frequency is known to be the best. *1*=1,3MHz, *2*=1,5MHz, *3*=1,7MHz, *4*=2,0MHz or *5*=2,2MHz). Changing the *FREQUENCY* does not change the calibration.

Select *SET RELAY* to set how the relays should act. Each relay have one normally open contact (at power off and when sensor is not connected the relay is open).). There are four relays and each relay can be controlled independently by any Level Switch. Choose between Closed with air or closed with liquid. It is also possible to set one relay to be controlled by two Level Switches. **Example (pump filling a container):** LS1 is placed high and LS2 is placed low on a container. The relay is set to: *Open LS1 Liq, Closed LS2 Air*. When liquid level drops below LS2, the relay closes (starting the pump to fill the container). When liquid level rises to LS1, the relay opens (stopping the pump).

Example (pump emptying container): LS1 is placed high and LS2 is placed low on a container. The relay is set to: *Open LS2 Air, Closed LS1 Liq*. When liquid level rises to LS1, the relay closes (starting the pump to empty the container). When liquid level drops to LS2, the relay opens (stopping the pump).

Container with jacket

In a container with a jacket the small space between the container and the jacket is filled with liquid to regulate the temperature of the inner container. This is a special case when a Level Switch KS can use the Technique set to *WR* and *Jacket* set to the distance between the jacket and container walls. Measurements will then be made on the inner container using the WR technique. The space between the jacket and container must be filled with liquid.

CALIBRATION

Select *CALIBRATION* to calibrate the Level Switch. Each Level Switch must be calibrated after installation. Calibration must be done both for liquid and for air. The order or the time between the calibration of air and liquid is of no importance.

A new calibration has to be done if the Level Switch is moved and should be done if the temperature or the liquid properties has changed significantly since the last calibration. To see how well the Level Switch behaves at different temperatures or with a different liquid the measurement data can be checked.

SHOW DATA

Select *Echo DATA* to show *Edata*: echo measurement data (echo strength) relative to *ELiq*. During calibration it is set to be 100% with liquid. *Efrq*: shows the frequency (1, 2, 3 or 4). On the second line threshold *Ethd*: is displayed. If *Edata* is higher than *Ethd* then liquid is detected. *ELiq* shows calibrated echo strength with liquid (0,7dB units). Maximum is 100 and a value of 40 is a weak echo. *Eliq* depends on the sensor and the container. *Ethd* is best if it is less than 40%. If higher than 60% the difference between echo strength with liquid and air is too low.

Select *WR DATA* to show measurement data of the WR-technique. This screen shows first *Wdata*: WR measurement data. *Wdata* is approximately zero when there is air. With Liquid it becomes approximately twice *Wthld*. *Wfrq*: shows the frequency that has been chosen either manually or automatically (1, 2, 3 or 4). The best frequency depends on the container wall thickness. On the second line is *Wthd*: WR threshold which is the value of *Wdata* at which indication changes between Air and Liquid. If *Wdata* is higher than *Wthd* then liquid is indicated. *Wthd* is set during calibration to half the value of *Wdata* with Liquid. *Wss*: approximate signal (set at calibration) in 0,3dB units.

Select *Auxiliary data* to show raw data from the Level Switch. There are two pages A and B (press MENU button to switch between them).

Select *Test Level Switch* to show test-data for the Level Switch when it is not attached to a container. A value is shown for each Level Switch. If the Level Switch is correctly connected a value between 0 and 70 should be shown. Then by pressing on the inner side of the Level Switch with a finger this value should increase if the Level Switch is ok. A Level Switch wrongly connected or unconnected shows a value higher than 100.

ADVANCED SETTINGS

Select *Set sensor MODE* to set either *Air Sensor mode*, *Level Switch mode*, *Level Sensor mode* or *Gel Sensor mode mode*. It determines which sensor can be connected.

Select *SIMULATE* to simulate detection of air or liquid. Press SELECT button to toggle between simulation of Air and Liq. Press MODE button to change between Level Switch 1, 2, 3 and 4.

Select *RESTORE settings and calibrations* to restore all settings and calibrations to factory-settings.

Select *PROFIBUS SETTINGS* see page 42 (for DP72).

HELP

Select *HELP* to show information about connecting the Ultrasound Controller.

Sound velocity and the Level Switch

When *ECHO Technique* is used and there are two liquids with significant different sound velocity in the container and these liquids are not well mixed, then there can be a false indication of air because the sound is refracted at the surface between the two liquids. Sound velocity of liquids lies usually within 900-2000m/s. A sound velocity outside this range may be compensated by increasing or decreasing *DISTANCE to reflecting wall*.

Measurement Reliability

Many factors determine the reliability (wall material, wall thickness, liquid properties, temperature and glue). Therefore it is always advisable to make tests on the actual container under varying conditions and temperatures.

Level Switch TROUBLESHOOTING

Display shows:

-- - The Level Switch is not connected or there is a short circuit.

cal - Calibration has not been done. It must be calibrated both for Air and Liquid before cal disappears.

set - ***Echo technique*** is chosen but the ***DISTANCE to reflecting wall*** is not set.

The relay does not change but the display changes between Air and Liquid. — Wrong setting of ***RELAY***.

err - Measurement cannot be done. During calibration there was not enough difference between the signal with air and with liquid: For ***ECHO technique***, echo threshold ***Ethd*** must be < 50% and for ***WR technique***, WR threshold ***Wthd*** must be > 5. The reason for ***err*** can be:
Calibration was made for Air but there was Liquid in the container or calibration was made for Liquid but there was Air in the container.
The Level Switch is not attached correctly to the container. There is a tiny air-gap between the Level Switch and the container.
If ***ECHO technique*** is chosen and the ***DISTANCE to reflecting wall*** is wrong.
If ***ECHO technique*** is chosen and the echo is reflected in a direction so it does not bounce back to the Level Switch.
If ***ECHO technique*** is chosen and the something is obstruckting the sound beam.
The liquid does not let through enough sound. Try using a Level Switch RS instead of a Level Switch LS.
The container wall does not let through enough sound. Try a different ***FREQUENCY*** or set it to Auto.
Wrong connection or faulty Level Switch. Select ***Test Level Switch*****:** to test the level switch and its connection.

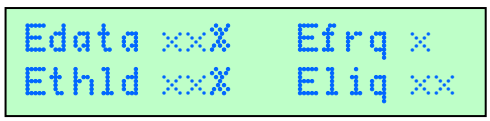
Electric interference can show itself as ***Edata*** being unstable with Air or ***Wdata*** being unstable with liquid. To minimize the risk of interference, see Electric Noise page 10.

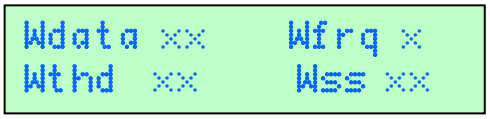
Requesting support from AQ M-Tech AB

If the Level Switch is not working properly, support can be requested from AQ M-Tech AB by sending an email requesting support. In this case it is necessary to provide settings and data since this information is needed for AQ M-Tech AB to find a solution for the problem. It can be written down or pictures of the display can be taken. If you don't know how to navigate the menu system, read "Navigating the Menu System" page 9.

Even if settings are supposed to be correct, they may have been changed so it is a good also to check SETTINGS and write them down. Se SETTINGS page 23. In menu ***SETTINGS***, go to each menu page and write down the settings and do this for each Level Switch.

In the menu ***SHOW DATA*** go to menu ***Echo DATA*** and write down all the data shown there and go to menu ***WR DATA*** to write down the data there (WR DATA can be useful to know even if WR-technique is not used). Do this for each Level Switch. Also specify if actual level is high or low if it is known, or even better, write down data for both high and low level. Data from menu ***Auxiliary data*** is not needed.





Please also add information about which model of Level Switch that is being used, the serial number and software version of the D72/DP72, (see Introduction page 2) and the wall thickness and diameter of the container and the type of material the container is made of. Describe also how the Level Switch is attached to the container (Heat Transfer Compound or glue or ….) and

describe if sound absorbing tape is used on the container, see Stainless Steel and Glass Containers page 22. If the Level Switch is installed with ex-barriers, also include information about the ex-barrier type and how it is connected to the Level Switch and D72/DP72.

8. Level Sensor Mode

In Level Sensor mode a sensor is attached at the bottom of the container and measures the continuous liquid level. The sensor is attached outside the container and senses through the bottom (no hole is needed). A second velocity sensor measuring sound velocity can also be attached.

Four sensors can be attached to one Ultrasound Controller, measuring the level in two containers.

Quick start guide

- Install sensors according to instructions on page 28 and instructions in Level Switch Manual.
- Connect cables, see page 7 or 8 and 28
- Switch on external power supply.
- Read about navigating the menu system, page 9
- If display show: ***SET sensor MODE***. See page 9 how to select Level Sensor mode.
- Go to ***SETTINGS*** see page 29 and set all parameter that need to be set.
- Calibrate with liquid sensor 1 & 2: Fill container above Sensor 2 and at least 100mm. Select ***Calibrate with LIQUID***, Select ***Cal Sensor 1 & 2 (Lev & Vel)*** and Press SELECT button one second.
- Empty container (level below Sensor 2). Select ***Calibrate with AIR***, Select ***Cal Sensor 2 (Vel)*** and Press SELECT button one second.
- If sensor 3 and 4 exist, do the calibration for them also in similar way.
- Go to ***SHOW DATA*** to check calibrated values, page 31.
- Ready.

Functional Description

A Level Switch-type of sensor is attached under the container bottom. It sends ultrasound through the bottom and through the liquid, and then receives the echo bouncing off the liquid surface. The Ultrasound Controller then calculates the liquid level.

This measurement technique is dependent on sound velocity which vary to some degree with type of liquid and temperature. By using a second velocity sensor attached on the vertical wall of the container the velocity can be measured and compensate for it. It measures the velocity by measuring the echo from the opposite container wall. In addition, it also makes level switch measurements telling if there is liquid or not behind the wall. This can be used for setting limits for the level measurement, improving reliability see ***SETTINGS***.

It is important the echo is as strong as possible. Sound is attenuated by travelling through the bottom and through the liquid. Small bubbles and particles in the liquid also causes attenuation. The sensor need to be fairly horizontal (parallell to the liquid surface) in order for the echo to bounce back in the correct direction. If the liquid surface is disturbed by waves or vortex then the echo may not bounce back correctly. Unmixed liquids having different sound velocities can cause refraction of the sound so it bends and do not bounce back to the sensor. The strength of the echo can be seen in ***SHOW DATA***.

In an empty container it is difficult to measure the level since there is no echo from a liquid surface. Also levels below 20mm are difficult to measure since the echo is close to echoes within the bottom. A special measurement technique (Wall-Reverberation measurement-technique, WR) can give more reliable measurement when the level is below 20mm. It measures the strength of echoes bouncing within the bottom. Liquid dampens those echoes.

Level Switch KSF should be used as sensor for level and Level Switch KS for velocity. Level Switch RS cannot be used and Level Switch LS is not recommended.

Connecting the level sensor

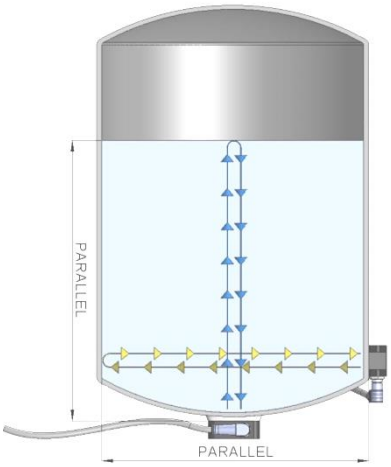
The Level Sensor cable may not be extended. Maximum cable length, see Level Switch manual. The unshielded part of the cable should be no longer than 40mm. The shield shall if possible be connected to ground via shielded cable glands. To minimize the risk of electric interference and noise, especially in ex-installation, see Electric Noise page 10.

If D72 is mounted inside a metal cabinet it is good to connect D72 to the cabinet (ground) using grounded cable glands for the Level Switch cables. If grounded cable glands are not used then terminal 16 on the D72, DP72, GS72 or terminal 19 on D128 can be connected to the cabinet instead.

Ultrasound Controller Terminal		Cable	GF90
D72 / DP72	D128		
8	11	Sensor 1 (level) Brown	1 Brown
9	12	Sensor 1 White	1 White
10	13	Sensor 2 (velocity) Brown	1 Green
11	14	Sensor 1 Shield and Sensor 2 Shield	Shield
12	15	Sensor 2 White	1 Yellow
13	16	Sensor 3 (level) Brown	2 Brown
14	17	Sensor 3 White	2 White
15	18	Sensor 4 (velocity) Brown	2 Green
16	19	Sensor 3 Shield and Sensor 4 Shield and	Shield
17	20	Sensor 4 White	2 Yellow

Mounting the Sensor for level and the velocity sensor

Level Sensor 1 or Level Sensor 3 measures the level and it is a Level Switch type of sensor which is mounted under the bottom of the container. The ultrasound travels through the bottom and it is important the sound can pass easily through the bottom into the liquid. It depends on the wall material and thickness. Steel or glass bottom 1,2mm - 7 mm are ok. Most plastics let sound trough well except polypropylene and fiber reinforced plastics. For stainless steel, best result is achieved with bottom thickness being a multiple of 1,42mm (resonance at 2MHz half wavelength). Stainless steel bottom thickness 7mm 5,7mm 4,3mm 2,8mm or 1,4mm is ok at 2MHz which is the best frequency for the Level Switch. For other thicknesses other less ideal frequencies will be chosen by the Ultrasound Controller. The thickness of the bottom also determines how well low levels can be measured. When the bottom is thick, vibrations within the wall decays slowly and measurements of low levels becomes more difficult. Minimum level that can be measured depends on the bottom thickness and material. The ultrasound beam is narrow (beam angle is about 10˚) so the level sensor must be aimed in such a way that the echo from the surface is properly returned back to the level sensor. If the bottom is not horizontal, silicone sealant can be used to glue the Level Switch at an angle, see below. See Level Switch manual how to glue the sensor. The GF90 contain both level and velocity sensors. Sound velocity varies with liquid and temperatures. The Level Switch used as a sensor for velocity is placed low on the container wall. It measures and compensates for sound velocity changes. It also makes level switch measurement which can be used to limit the measured level for extra reliability.



Mounting the velocity sensor

Velocity Sensor 2 and Velocity Sensor 4 is a Level Switch-type of sensor which is used to measure the sound velocity of the liquid. It should be mounted on the container wall to measure the echo from the opposite container wall. If possible near the bottom

but nothing should obstruct the echo. How well the sound passes through the wall depend on the material and thickness, see above. This sensor also detects if there is liquid or air at its level. The GF90 has the velocity sensor built in.

Installing the sensor on a non-horizontal bottom

If the bottom is not horizontal or has uneven thickness, a thick layer of silicone sealant can be used to glue the sensor in a more horizontal position. In this case the sensor should be connected to Ultrasound Controller and be active measuring before it is being glued so that the position can be adjusted for the strongest echo. Fill the container half or more and attach the sensor with silicone between sensor and bottom. Calibrate with liquid and go to ***Measured Level Sensor***. The echo strength is shown in ***dB***. Small adjustments can be made of the angle of the sensor and the thickness of the silicone in order to achieve maximum echo strength. Find the best position and calibrate with liquid again and check position again for maximum echo strength. Then keep the level sensor fixed there until the silicone cures.

Container top

When the container is full of liquid all the way up to the top, the ultrasound will bounce off the top instead of off the liquid surface. Ideally the top should be parallell with the sensor and rather not very much conical. If it must be conical, a small conical angle is prefferred, or a small non-conical part of the radius above the sensor in order to make the echo stronger.

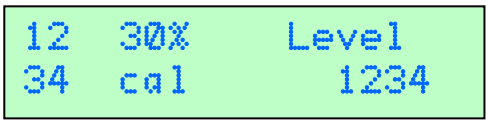
Level Sensor start-screen

When power is applied, the Level Sensor start-screen is displayed showing `LevlSens` on first line to the right signifying this is Level Sensor start-screen. On the second line to the right is written `1234` which shows the state of each of the four relays. A light digit on dark background signifies a closed relay.

To the left, the digit 12 signifies sensor 1 (level) + sensor 2 (velocity), followed by the measured level in %. If no measurement can be done there is text with error information instead. On the second line, the digit 34 signifies sensor 3 (level) + sensor 4 (velocity). The digit background changes to dark when liquid is sensed by the velocity sensor.

`cal`	calibration needs to be done of air or liquid
`set`	parameters remain to be set
`---`	not active
`> 100%`	level is over 100%
`err1`	error1 – see troubleshooting
`err2`	error2 – see troubleshooting
`err3`	error3 – see troubleshooting

Example: Sensor 1 + 2 show 30% level
Sensor 3 + 4 need to be calibrated



SETTINGS

Through the ***SETTINGS***-menu the parameters can be set.

Select ***SET Range*** to set the level change in mm which correspond to 100% level change. (Measurement is done up to 170% of this level)

Select ***SET Offset*** to set an offset which is added to the measured level before it is converted to percent and sent to mA outputs. Offset is not added to the measured level in mm.

Select ***SET Sensor WR threshold*** to set the threshold (in dB) for very low level echo to be detected using WR-technique. Higher value makes it less sensitive. A smaller value makes it more sensitive but with higher risk of wrongly detecting low level when there is high level.

Select ***SET Liquid Sound Velocity*** This parameter is used if there is no velocity sensor. It should be set to the correct velocity for the liquid.

Select ***SET Sensor InnerDISTANCE*** to set the inner diameter (in mm). If no velocity sensor exist this parameter should be set to ***[not set]***.

Select ***SET Sensor HEIGHT*** to set the height (in mm) above the bottom where the sensor for velocity is attached. If this value is set, the level measurements of the velocity sensor can be used to set limits for the level measurement.

Select ***SET Sensor Control*** to set how the air/liquid measurements of the velocity sensor is used. Set it to ***Level unaffected*** if it should not be used. Set it to ***Limit level*** if it should limit the level measurements. This can improve reliability. When level is above the velocity sensor the measured level will be limited to be above there and for levels below the velocity sensor the measured level will be limited to be below there.

Select ***SET Sensor Bottom-Thickness*** This is used to compensate for sound travelling time through the bottom of the container.

Select ***SET Sensor Wall-Thickness*** This is used to compensate for sound travelling time through the wall.

Select ***SET Sensor1/3 FREQUENCY*** This is the frequency used for the level sensor. Usually Auto is good choice or manually try different frequency depending on container bottom thickness.

Select ***SET Sensor2/4 FREQUENCY*** This is the frequency used for the velocity sensor. Usually Auto is good choice or manually try different frequency depending on container wall thickness.

Select ***SET RELAY*** to set how the relays should act. Each relay have one normally open contact (at power off the relay is open).

Settings for GF90: ***Sensor WR threshold:*** *disabled*, ***InnerDISTANCE:*** *90mm*, ***Sensor HEIGHT:*** *not set*, ***Sensor Control:*** *level unaffected*, ***Sensor Bottom-Thickness:*** *GF90*, ***Sensor Wall-Thickness:*** *GF90*, ***Sensor1/3 FREQUENCY:*** *2,0MHz*, ***Sensor2/4 FREQUENCY:*** *2,2MHz*

CALIBRATION

Select ***CALIBRATION*** to calibrate. Calibration must be done after installation. Calibration should be done for liquid with minimum 100mm liquid level and the level must also be above the velocity sensor. Do not fill completely if the container top is conical which do not reflect the echo so well. During calibration the Ultrasound Controller tries different frequencies and selects the one with the strongest echo. Calibration should also be done for Air if the velocity sensor exist (then liquid level must be below the velocity sensor). Air calibration is only necessary if a velocity sensor is used. If possible calibrate with a similar type of liquid as the one to be used later.

If there is a velocity sensor the calibration measures the sound velocity and this measurement will be used when the liquid level is below the velocity sensor. If the measured level is higher or lower than it should be, it can be because the measured velocity is too high or too low. Adjusting the ***Sensor InnerDISTANCE*** can be done to correct that. If the measured level is too low, increasing ***Sensor InnerDISTANCE*** will make the level higher and vice versa. New calibration with liquid must be done if ***Sensor InnerDISTANCE*** is changed.

It is important to check (in ***SHOW DATA***) that the calibration value of the echo is higher than 20dB.

A new calibration must be done if a sensor is moved or removed.

It is recommended to perform a new calibration every year to compensate for possible slow changes.

SHOW DATA

Select *Measured Level Sensor*: to show measured *level mm*, echo strength *dB*, the amount of background noise *dBnoise*, *dBWR* which is the strength of very low level echo. Check that the value of echo strength *dB* is high and *dB noise* is low.

Select *Calibrated Level Sensor*: to show calibrated echo strength *dB* and calibrated selected frequency *MHz*.

Select *Measured velo Sensor* to show echo strength *%* of calibrated strength with liquid and *dB* and used velocity *m/s* and whether there is *AIR* or *LIQ* behind sensor 2.

Select *Calibrated Velo Sensor* to show calibrated velocity *m/s*, calibrated echo strength *dB*, calibrated frequency *MHz* and calibrated threshold for detecting liquid *%*.

Select *Low level WR-measurements* to show data from low level measurements (for troubleshooting only)

ADVANCED SETTINGS

Select *Set sensor MODE* to set either *Air Sensor mode*, *Level Switch mode*, *Level Sensor mode* or *Gel Sensor mode mode*. It determines which sensor can be connected.

Select *RESTORE settings and calibrations* to restore all settings and calibrations to factory-settings.

Select *PROFIBUS SETTINGS* see page 42 (for DP72).

HELP

Select *HELP* to show information about connecting the Ultrasound Controller.

Level Sensor TROUBLESHOOTING

Display shows:

set	Some setting is missing
cal	Calibration of air and/or liquid must to be done.
>100%	Measured level is >100%. Consider changing *Range.*
err1	During calibration with liquid, the echo from the level sensor is missing or very weak.
err2	During calibration, the difference in strength between echo with liquid and with air is too small.
err3	During calibration, the echo with liquid from the velocity sensor is too weak.

Container is full and the inside surface of the top of the container is shaped in such a way that echoes are reflected in wrong direction. – Make a small portion of the inside surface flat just above the level sensor.

Level sensor is aimed in wrong direction. – Aim the level sensor in the right direction.

The container is inclined and thereby the echo is bounced off in wrong direction. – Unincline the container or aim the level sensor to correct it.

The echo strength *dB*, *dBnoise* and *dBWR* should be checked. In order for Ultrasound Controller to measure the level it needs echoes from the surface. Due to various reasons however the echoes can become too weak to be detected. Echo strength *dB* indicates how strong the echo is and should be compared to *dB noise* which is the background noise. In an empty container there is no echo. If the echo strength *dB* is not higher than 10dB above *dBnoise* there can be difficulties

measuring the level. Make sure the echo is reflected properly back to the level sensor and that the Level Switch is horizontal. The bottom thickness and material also influences the echo strength, see Mounting the Level Sensor. If bottom thickness is such that resonance is not at 2MHz the echo is weaker. Bubbles or particles scatter the echo.

dBWR shows the strength of low level echoes (0-20mm) using the WR-technique. Low level echoes ***dBWR*** are compared with the ***WR threshold*** and if ***dBWR*** is above this threshold, and the velocity sensor detects low level, then the WR-technique measurement takes over and forces the level to be whatever it measures. If ***WR threshold*** is lower it becomes more sensitive but risk increases of wrong detection due to temperature changes. Empty container gives rather weak low level ***dBWR*** indication. In an empty container there is no echo from a surface and the WR-technique is then comparing the echoes within the bottom with calibrated echoes within the bottom as measured with liquid. With higher ***WR threshold*** the WR-technique becomes less sensitive and may miss detecting empty container. Set to disabled, WR-technique is disabled.

9. Gel Distance Mode

In Gel Distance mode, a Gel Distance Sensor measures the distance to the gelbed.

Ultrasound Controller GS72 must be used for this mode. One sensor can be attached.

Quick start guide

- Connect the gel distance sensor cable to GS72 terminal: Red to 8 white to 9 and shield to 11. Connect power supply to GS72 terminal: Plus 24V to 1 and minus to 2.
- Switch on external power supply.
- Read about navigating the menu system, page 9
- If display show: ***SET sensor MODE***. Choose ***Press SELECT for GelDistance mode*** by scrolling with MENU button and selecting with SELECT button.
- Go to ***SETTINGS*** see page 34 and set the parameter that need to be set.
- Calibrate with liquid: Fill container and make sure the distance to the gelbed is > 40mm and there are no bubbles under the sensor. Select ***CALIBRATION with Liquid***, and Press SELECT button one second.

Functional Description

A Gel Distance Sensor sends ultrasound through the liquid, which then bounces back at the gelbed surface. GS72 measures the echo and calculates the distance. The distance and echo strength is shown on the display.

When gelbed is expanded the gelbed surface becomes diffuse and the measured distance will be approximate. Also, the echo becomes weaker. When echo is weaker than 15dB the measurement can be unreliable. Small bubbles and particles in the liquid also causes echoes. The sensor need to be fairly horizontal (parallel to the gelbed surface) in order for the echo to bounce back properly. Unmixed liquids having different sound velocities can cause refraction of the sound so it does not bounce back to the sensor.

Measuring short distance (<20mm) can be difficult due to remaining vibrations inside the sensor. The measurement technique is dependent on sound velocity which can vary with liquid and temperature.

The mA output can be set to output distance (0% Level = 4mA, 100% Level = 20mA) or Signal strength (0dB = 4mA, 85dB = 20mA). It is adviseable to check the signal strength also during testing.

Connecting the gel distance sensor

The Gel Distance cable may not be extended. The unshielded part of the cable should be no longer than 40mm. The shield shall if possible be connected to ground via shielded cable glands. To minimize the risk of electric interference and noise, see Electric Noise
page 10.

If GS72 is mounted inside a metal cabinet it is good to connect GS72 to the cabinet (ground) and this is best done using shielded cable glands for the Gel Distance Sensor cables. If shielded cable glands are not used then terminal 16 on the GS72 can be connected to the cabinet instead.

GS72 Terminal	Cable
8	Red
9	Blue or White
10	
11	Shield
12	
13	
14	
15	
16	Ground
17	

Gel Distance start-screen

When power is applied, the Gel Distance start-screen is displayed showing GelDist on first line to the right signifying this is Gel Distance start-screen. On the second line to the right is written 1234 which shows the state of each of the four relays. A light digit on dark background signifies a closed relay.

To the left on first line, distance is displayed in mm and on second line, echo strength in dB. If no measurement can be done there will be text with information instead.

cal	calibration needs to be done of air and/or liquid
set	parameters need to be set
---	not active
err	error – see troubleshooting

SETTINGS

Through the ***SETTINGS***-menu the parameters can be set.

Select ***SET Sensor 100% Distance*** to set the distance which correspond to 100% distance. A distance over 170% will not be measured at all.

Select ***SET Sensor 0% Distance*** to set the distance in mm under which the distance will show 0%. This is to show zero instead of an unreliable value at low levels.

Select ***SET Liquid Sound Velocity*** This should be set to the sound velocity for the liquid used.

Select ***SET RELAY*** to set how the relays should act. Each relay has one normally open contact (at power off the relay is open).

CALIBRATION

Select *CALIBRATION* to calibrate with liquid. Calibration must be done after installation. Fill container and make sure the distance to the gelbed is > 40mm and there are no bubbles under the sensor. Select *CALIBRATION with Liquid*, and Press SELECT button one second.

SHOW DATA

Select *Measured Distance*: to show measured distance *mm*, echo strength *dB* and noise strength *dB noise*. Check that the value of echo strength *dB* is high and *dB noise* is lower.

Select *Calibrated Distance*: to show calibrated echo strength *dB* and calibrated selected frequency *MHz*.

ADVANCED SETTINGS

Select *Set sensor MODE* to set either *Air Sensor mode*, *Level Switch mode*, *Level Sensor mode*, *Gel Sensor mode mode*, or *Gel Distance mode*. It determines which sensor can be connected.

Select *RESTORE settings and calibrations* to restore all settings and calibrations to factory-settings.

HELP

Select *HELP* to show information about connecting the Ultrasound Controller.

Gel Distance TROUBLESHOOTING

Display shows:

set	Setting is missing
cal	Calibration of liquid must to be done.
err	During calibration with liquid, the echo from the level sensor is missing or very weak.

For Ultrasound Controller to measure the level well it needs detectable echoes from the gel surface. Due to various reasons, the echoes can become too weak to be able to be detected. Echo strength *dB* shows how strong the echo is and and *dB noise* shows how strong the noise is. In air, there is no echo.

10. Gel Sensor Mode

Gel Sensor Mode measures the presence and concentration of gel media. The Gel Sensor GF90 or Level Switch KS can be used as sensors. Up to four sensors can be connected to one Ultrasound Controller.

Quick start guide

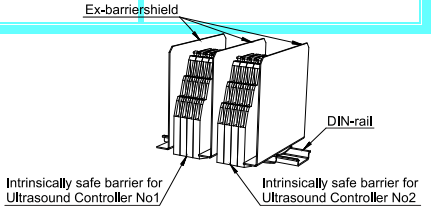
- Install sel sensors (Level Switches) according to instructions in the Level Switch Manual.
- Connect cables, see Connecting the Gel Sensor.
- Switch on external power supply. You may have to press POWER to activate D128.
- You may read about navigating the menu system, page 9
- If display show: ***SET sensor MODE***. You must choose gel sensor mode by scrolling with MENU until display show ***Press SELECT for Gel Sensor mode*** then press SELECT.
- Go to ***SETTINGS*** see page 39 and set all parameter that need to be set.
- Calibrate gel sensors with liquid. Make sure there is liquid and not gel at the gel sensors. Select ***Calibrate Liquid 1- 4 together*** and press SELECT button one second.
- Go to ***SHOW DATA*** to check values, page 40
- Ready to use.

Connecting the Gel Sensor

GF90 can be connected only to G72, GP72 or G128. Level Switch KS or Level Switch QS can be used as gel sensor and can be connected to D72, DP72 or D128.

The Level Switch cable is better not to be extended. Maximum cable length, see Level Switch manual. The unshielded part of the cable should be no longer than 40mm. The shield shall if possible also be connected to ground via shielded cable glands. To minimize the risk of electric interference and noise, especially in ex-installation, see Electric Noise page 10.

Ultrasound Controller		**Cable color**	**Cable color**
D72 DP72	**D128**	**Level Switch KS**	**Level Switch QS**
8	11	Sensor **1** Brown	Black (Brown)
9	12	Sensor **1** White	Grey
10	13	Sensor **2** Brown	Blue (White)
11	14	Cable shield	Cable shield
12	15	Sensor **2** White	
13	16	Sensor **3** Brown	White (Blue)
14	17	Sensor **3** White	Grey (jumper)
15	18	Sensor **4** Brown	Brown (Black)
16	19	Cable shield and Ground	Cable shield & Ground
17	20	Sensor **4** White	



If D72 or G72 is mounted inside a metal cabinet it can be good to connect D72, DP72, G72, GP72 to the cabinet (ground) and this is best done using shielded cable glands for the sensor cables. If shielded cable glands are not used then terminal 16 on the D72, DP72, G72, GP72 or terminal 19 on D128, G128 can be connected to the cabinet ground instead.

The cable from the Gel Sensor is better connected directly to the Ultrasound Controller rather than being extended. The unshielded part of the cable should be rather short, something like 40mm. To

minimize the risk of electric interference it is important that sources of interference like frequency inverters should use shielded cables especially between inverter and motor.

Measuring Gel

Gel media used in chromatography systems consists of small particles. These particles scatters ultrasound and this causes attenuation of the ultrasound echo. Measuring ultrasound attenuation is a reliable method to measure the gel concentration. Ultrasound attenuation is proportional to gel concentration as long as gel concentration is fairly low. The amount of attenuation also depends on the ultrasound frequency and gel type.

In the calibration process the internal amplifiers are adjusted so that the relative echo strength (***Relativ Signal***) becomes 100% and relative attenuation (***RelativAtt***) then becomes 0dB/m, and gelconcentration (***Gelconc***) becomes 0%. Calibration should be done with liquid without gel. Then with increasing gel concentration, the relative echo strength (***Relativ Signal***) drops and attenuation (***RelativAtt***) increases and (***Gelconc***) increases.

Ultrasound Controller		Cable color
G72 GP72	**G128**	**GF90**
8	11	Sensor **1** Yellow
9	12	Sensor **1** Green
10	13	Sensor **2** Yellow
11	14	Cable shield & Brown & White
12	15	Sensor **2** Green
13	16	Sensor **3** Yellow
14	17	Sensor **3** Green
15	18	Sensor **4** Yellow
16	19	Cable shield & Brown & White & Ground
17	20	Sensor **4** Green

The gel concentration is available on the relay outputs as an indication that gel concentration is above or below a threshold (***GEL-THRESHOLD***). But gel concentration is also available as an analogue value either via 4-20mA outputs or via Profibus.

Just as gel causes ultrasound-attenuation, unsolved dense matter and also tiny bubbles causes attenuation. ***GEL-THRESHOLD*** should be set high enough so that wrong detection of gel is avoided but not so high that the desired detection of gel is missed. You can look at ***Gelconc %*** or ***RelativAtt*** or ***Relativ Signal*** with your different liquids in the container to check how much the liquid affect attenuation. ***Relativ Signal*** can become over 100% but ***Gelconc %*** and ***RelativAtt*** can not become negative.

Two not so well mixed iquids with different sound velocities can cause refraction of the ultrasound and thereby attenuation. This happens for example if a liquid is suddenly switched from one type of liquid to another.

Air (low liquid level) will cause very high attenuation and cannot be distinguished from high gel concentration. However by measuring the presence of air with the WR-technique detection of gel can be prevented when there is air.

In ***SHOW DATA*** all measurement data can be viewed.

Measurement technique

Gel concentration is determined by measuring ultrasound echo attenuation using echo-technique. Air or liquid can also be measured by the same sensor using the WR technique and this is enabled by setting ***Liquid Sensor SET WR THRESHOLD*** to other than “disabled”.

The echo is bouncing off the reflecting surface, either the opposite container wall or the pin on GF90. Sound pulses are constantly being transmitted and the returning echo is constantly being measured.

The echo strength is measured and relative attenuation is calculated by comparing to the calibrated echo strength. The relative attenuation is calculated by taking into account the ultrasound travel distance. The result is relative attenuation measured in dB/m and it is fairly proportionat to gel concentration. It can be converted into gel concentration. The setting of ***GEL-TYPE*** sets the amount of gel-attenuation in dB/m at a 1% gel concentration. This value is dependent on type of gel and the measuring frequency.
To find out the amount of gel-attenuation for your gel, you can measure it by making a 1% concentration of the gel in a small container and using GF90 measure the relative attenuation while intensively stirring so the gel doesn't just fall to the bottom. (If you make another gel concentration, for instance 3% then divide the measured gel-attenuation by 3) Then adjust ***GEL-TYPE*** according to the gel-attenuation you have for your gel.

If you are not using GF90, it is important the ultrasound can pass as easy as possible through the container wall. How well it passes depend on the wall material and thickness and how the Level Switch is attached. Steel or glass wall should be in the range 1,3mm - 15 mm and plastic wall <30mm. Testing on the actual container is recommended. Any welding-joint in the wall should be avoided as it can refract the sound-beam.

The ultrasound beam behaves similar to a light-beam, the direction of the echo depend on from what angle the beam hits the reflecting surface. The sound beam is approximately 1cm in diameter. Obstructing objects in the path between sensor and the reflecting surface may cause the beam to divert. It is possible to use objects other than the opposite container wall as a reflecting surface. Sound also travels inside the wall along the container and this can cause problems as it may interfer with the proper echo, especially if the echo is weak. This will be a problem in stainless steel containers and also to a less degree in glass containers. Attaching sound absorbing polyurethane tape outside the container near the Level Switch helps reducing the amount of sound travelling along the containewr wall, see Level Switch Manual for more information. This does not apply to GF90.

The Liq WR sensor measurement is done with the same sensor as the gel-measurement but is independent of the gel-measurement. It can detect the presence of air which would otherwise give a false indication of gel. The Liq WR sensor measures vibrations in the container wall or sensor wall in GF90, to determine if there is air or not. The Liq WR sensor transmits sound and then measures how vibrations in the container wall disappear. Vibrations in the wall disappear more slowly with air. The Liq WR sensor is dependent on the material and thickness of the wall. Only plastic wall < 30mm works well. Liq WR sensor may have some temperature dependence. The Liq WR sensor measures small signal changes and is sensitive to small movements of the Level Switch, therefore unless GF90 is used, gluing is preferred when using Liq WR measurement.

Mounting the Level Switch

How to mount the Level Switch on the container is described in Level Switch manual.

Gel Sensor start-screen

When power is applied, the Gel Sensor start-screen is displayed showing GelSen on first line to the right signifying this is Gel Sensor start-screen. On the second line to the right is written 1234 which shows the state of each of the four relays. A light digit on dark signifies a closed relay.

To the left are four small digits signifying Gel Sensor 1 2 3 and 4 with three-letter-text following each digit showing information about each Gel Sensor:

GEL gel is detected

LIQ liquid is detected

AIR air is detected

OUT measurement is near out of range (actual gel concentration can be higher than measured)

gel sensor is not existing

cal calibration (of liquid) needs to be done

set some parameter settings are missing

err gel sensor is disconnected

Example: Gel Sensor 1 is detecting GEL, Gel Sensor 2 is detecting AIR, Gel Sensor is out of range or close to be out of range, Gel Sensor 4 is disconnected, Relay1 is closed.

SETTINGS

Through the ***SETTINGS***-menu the parameters of the Gel Sensor can be set.

Select ***SET Type*** to set it according to how many sensors are connected, or set to ***Level Switch QS***. For GF90 set it to ***GS1*** if one is connected and ***GS1,GS2*** if two are connected and so on.

Select ***SET ECHO-DISTANCE*** to set the distance between the Level Switch and opposite reflecting surface inside the container. For GF90 set it to *90mm*.

Select ***SET GEL-TYPE*** to set the the amount of attenuation of the gel. It depend on gel type and frequency. (Streamline SP: *7dB/m at 2MHz,14dB/m at 4MHz*) (tungsten gel: *40dB/m at 2MHz,80dB/m at 4MHz,* note that high attenuation of tungsten gel makes it difficult to measure high gel concentrations).

Select ***SET GEL-THRESHOLD*** to set the gel concentration for detection. (note that depending on measuring distance and gel type, high concentrations of gel can be difficult to measure)

Select ***SET FREQUENCY*** to set the measurement frequency. For GF90 it must be set to *4MHz*. For sensors placed on the container wall frequency should be tested to suit the container wall thickness resonance. Try 2,0MHz 2,2MHz 1,3MHz 1,5MHz and 1,7MHz and check ***Signal dB*** for each to find which frequency gives the strongest echo and choose that frequency.

Select ***Liquid Sensor SET WR THRESHOLD*** to set threshold of the Liq WR sensor. This is used to measure the presence of air. For GF90 a suitable value is *7dB*. A good setting is half the value of ***Liq WR sensor dB*** with air (see SHOW DATA). For sensors placed on the container wall it works only if the wall is plastic.

Select ***SET RELAY*** to set how the relays act. Each of the four relays has one contact connection and they share a common connection (at power off the relays are open).
Relay can be closed or open with detection of gel in a sensor. (If ***WR THRESHOLD*** is set then air can also be detected and whenever air is detected it prevents any relay-indication of gel)
Relay can be closed when air is detected. (***WR THRESHOLD*** must then be set for this sensor)
Relay can be closed when the sensor is disconnected.
Relay can be closed when the sensor is out of range. Out of range means the echo is rather weak and measurements is a bit unreliable. This can happen either when gel concentration is high or when there is air.

Select ***SET mA output A*** or ***SET mA output B*** to set the 4-20mA outputs.
1,5mA/GelDetectn means each gel sensor of the level switch type that detects gel adds 1,5mA to the combined output so 4 gel sensors indicating gel will output 10mA.
Relative attenu. 1mA=-4dB/m means the output increases 1mA for each additional 4dB/m of attenuation.
Gelconcentration 1mA=1% means the output is proportional to gelconcentration: 0% = 4mA, 16% = 20mA. Gelconcentration will not be affected by any WR-measurements of air and therefore since air gives high attenuation of the echo it will show as high concentration of gel.

Settings for GF90: Note that GF90, when used as gel sensor, can only be connected to G72, GP72 or G128, this is because GF90 in this case uses frequency 4MHz. Set ***Type*** to as many GF90 as are connected. ***ECHO-DISTANCE :*** *90mm*, ***FREQUENCY***: must be 4MHz If ***GEL-TYPE*** is "tungsten gel 80dB/m" then the ***GEL-THRESHOLD*** should not be set higher than perhaps 3% (due to risk of out of range at high tungsten gel concentrations).

CALIBRATION

Make sure there is liquid and not any gel at GF90 or behind the Level Switches. Select ***CALIBRATION*** and select ***1-4 together*** (or select a single sensor) then press SELECT-button one second to calibrate the Gel Sensors.

The sensors must be calibrated after installation. If the KS or QS sensors have been moved it is recommended to calibrate them again. Changing the ***ECHO-DISTANCE*** also require new calibration.

To see how well the Gel Sensor behaves with different liquids the relative echo signal can be checked in ***SHOW DATA***. Look at the values in ***Relativ Signal %*** and ***Gelconc.*** Check how different liquids affect the echo signal.

If Liquid Sensor WR is enabled, check also ***Liq WR sensor dB.*** This is the signal from the Liquid Sensor WR which becomes zero during calibration. With air in the container check the value of ***Liq WR sensor dB***. The ***Liquid Sensor WR THRESHOLD*** should be set to about half of this value.

Check ***Signal Strength***. With liquid and no gel, it should be absolutely minimum 35dB. The reason for a low signal strength can be a tiny air-gap between the Level Switch and the container, wrong angled Level Switch, wrong settings, liquid that attenuates the sound, glass or steel wall with thickness that do not let through the selected frequency very well (try a different frequency).

SHOW DATA

Select ***Measured data*** to show measured data. All four Gel Sensors are shown together. Pressing MENU button scrolls through several pages with data: ***Gelconc. %*****,** ***Relativ Signal %*****,** ***RelativAtt. dB/m*****,** ***Signal dB*** and ***Liq WR sensor dB*****.**

Gelconc. %**,** is the measured gel concentration.

Reltiv Signal %**,** is measured echo signal strength in percent of calibrated echo signal strength.

RelativAtt. dB/m**,** is the measured sound attenuation per meter. It is set to zero at calibration and it is independent of echo-distance.

Signal dB is the measured echo signal strength (dB) where 95dB is maximum and 10dB is minimum. Signal less than 30dB is so weak it starts being difficult to measure and is therefore considered out of range.

Liq WR sensor dB is the signal from the WR-measurement (determining if there is air or not) and it is shown relative to signal strength at calibration (dB). It is adjusted to show 0dB with liquid during calibration and becomes higher with air. Check this with liquid and with air to determine the value for ***WR THRESHOLD*****.**

Select ***Calibrated Data*** to show calibrated data. All four Gel Sensors are shown together. Pressing MENU button scrolls through: ***Cal Liq dB*****,** ***Freq*** and ***Test Sensor dB***

Cal Liq dB is the measured echo signal strength during calibration with liquid (dB). The higher the better. Lower than 30dB is considered to be too weak signal.

Freq is the chosen frequency: 1=1,3MHz, 2=1,5MHz, 3=1,7MHz, 4=2MHz, 5=2,2MHz or 6=4MHz. Use as high as possible (but only GF90 and G72, GP72 or G128 uses 4MHz). Steel or glass wall thickness may make it necessary to change to a different frequency in order to get high echo strength.

Test Sensor dB shows Liquid Sensor WR signal. It can be used to test a Gel Sensor not attached to a container. If the Gel Sensor is correctly connected a value between 0 and 30 should be shown. Pressing on the inner side of the Gel Sensor with a thumb the value increases showing the Level Switch is working. A bad Level Switch, wrong or not connected will show a value 60 or more.

ADVANCED SETTINGS

Select *Set sensor MODE* to set either *Air Sensor mode*, *Level Switch mode*, *Level Sensor mode* or *Gel Sensor mode mode*. It determines which type of sensor can be connected.

Select *RESTORE settings and calibrations* to restore all settings and calibrations to factory-settings.

Select *PROFIBUS SETTINGS* see page 42 (for DP72 and GP72).

HELP

Select *HELP* to show information about the Ultrasound Controller.

Measurement Reliability

Many factors determine the reliability (wall material, wall thickness, liquid properties, temperature and glue). Therefore, it is always advisable to make tests under varying conditions and temperatures.

The reliability of Liquid Sensor WR depend on the container wall. On a plastic wall 10-30mm it works well and on GF90 it works well. On glass and steel wall it does not work well.

Gel Sensor TROUBLESHOOTING

Display shows:

-- The Gel Sensor is not connected or there is a short circuit.

cal Calibration has never been done.

set Some settings are missing.

err During calibration the echo signal was too weak: The reason can be: Calibration was done without liquid or with gel. Or the Level Switch is not attached correctly to the container which means a tiny air-gap between the Level Switch and the container. Or *DISTANCE to reflecting wall* is set wrong. Or the echo is reflected in a direction where it does not reach the Level Switch. Or something obstructing lies between the Level Switch and the reflecting wall. Or the container wall does not let through enough sound using the selected *FREQUENCY*. Or wrong connection or faulty Level Switch. Select *Test Gel Sensor* can be used to test the Level Switch and its connection.

Electric interference can show itself in that attenuation and gel concentration are not able to become high enough with gel. To minimize the risk of interference it is important that sources of interference (like frequency inverters) should use shielded cables between inverter and motor. Also any unshielded part of the cable between the Level Switch and Ultrasound Controller should be short. If ex-barriers are used, Ex-barriershields should be used.

11. Profibus DP

Connecting Profibus

The Ultrasound Controller DP72, GP72 supports Profibus DP-V0 with communication speeds up to 1,5Mbit/s. The Profibus cable connects to DP72, GP72 via a 9-pin D-sub connector see table.

To terminate the Profibus cable, put 390Ω between pin6 and pin8 and 220Ω between pin6 and pin5 and 390Ω between pin3 and pin5.

The Profibus-interface in DP72, GP72 is not isolated from power supply.

The gsd-file: DP720B0E.gsd is needed for configuration of the Profibus master. It can be downloaded at www.agmtech.se The version of the gsd-file is written in the beginning of the gsd-file (the gsd-file can be viewed with a text editor). It must be the correct version. See page 3 for correct version.

PROFIBUS Parameters

The ***PROFIBUS SETTING*** menu: (accessible through ***ADVANCED SETTINGS*** menu)

Select ***BITRATE***: to set the bitrate. Auto automatically selects bitrate. (Maximum bitrate is 1,5Mbit/s).

Select ***ADDRESS***: to set the address (0-125). Every unit must have different address.

Select ***PARAMETER ACCESS***. If set to ***Profibus only*** then all parameters, (except PROFIBUS Parameters) will be set by the Profibus master only. If set to ***Menu only***, then all parameters can be set via the menu and not via Profibus master.

Select ***CONTROL***: to ***Enabled*** or ***Disabled*** Profibus communication.

Profibus Status-symbol

The status of the Profibus communication is shown as a Profibus status-symbol on the start screen at the bottom right corner of the display:

- □ Profibus enabled but no communication is detected.
- (nothing) Profibus is not enabled.
- ■ Communication is detected.
- T Correct profibus telegrams detected.
- P Parameter or configuration telegram received.
- > < (alternating) Data exchange. (Data is received and responded)
- X Ready for data exchange but no data telegram is being received.

Request Data

In data exchange state the master regularly sends one byte request data and DP72 responds with 16 bytes response data (1-16).

Request data should be normally zero. The master can start calibration of one or more sensors by sending request data with calibration command (the request data bits 1-4 are set according to which sensors are to be calibrated and bit0 is set if liquid is to be calibrated, see the Profibus data exchange table below). After the master has sent this request data with calibration command, request data should be cleared to zero again. DP72 starts the calibration exactly when request data bit 1-4 changes from being all zero to being non-zero. Calibration can also be done through

the menu system of DP72. Calibration takes about 1-5 seconds and during this time DP72 will not accept any new calibration commands (calibration in progress is shown in response data 1 bit7).

Response Data

Most of the Response data is the same data as shown in SHOW DATA menu and the start screen. The format is 8 bit unsigned and in some cases 16 bit unsigned. Chapter SHOW DATA gives more information about the data.

Air Sensor: Response data 1 and 2 bit 0 shows the Filtered Air/Liquid-data for the selected sensitivity. Filtered Air/Liquid-data for all sensitivities are available in Response data 3 and 4 and can be used to show different bubble sizes or change sensitivity without changing any settings**.** The indication of Air is always minimum 0,5s even if a bubble passes quickly through the Air Sensor.

Level Sensor: For ***Measured Level*** %, the value 255 corresponds to 100%. For ***Measured Level*** mm the format is 16 bit unsigned data: high byte and low byte

Request Data table

Request Data	Air Sensor Mode	Level Switch Mode	Level Sensor Mode	Gel Sensor Mode
1	bit0: 0= Air 1=Liquid bit1: 1= calibr AS1 bit2: 1= calibr AS2 bit3: 0 bit4: 0 bit5: 0 bit6: 0 bit7: 0	bit0: 0= Air 1=Liquid bit1: 1= calibr LS1 bit2: 1= calibr LS2 bit3: 1= calibr LS3 bit4: 1= calibr LS4 bit5: 0 bit6: 0 bit7: 0	bit0: 0= Air 1= Liquid bit1: 1= calibr Level1 bit2: 1= calibr Level2 bit3: 0 bit4: 0 bit5: 0 bit6: 0 bit7: 0	bit0: 0 bit1: 1= calibr Liquid GS1 bit2: 1= calibr Liquid GS2 bit3: 1= calibr Liquid GS3 bit4: 1= calibr Liquid GS4 bit5: 0 bit6: 0 bit7: 0

TROUBLESHOOTING

The Profibus status-symbol on the start screen at the bottom right corner of the display gives information for troubleshooting.

When Profibus is working correctly, Profibus status-symbol should show alternating › ‹ indicating data communication.

If the Profibus status-symbol shows □ it means DP72 do not detect any communication. The reason can be Profibus-cable is not connected or Profibus Master is inactive.

If the Profibus status-symbol shows ▮ it means DP72 detects communication but it is not correct Profibus telegrams. Bitrate or cable polarity could be wrong.

If the Profibus status-symbol shows T it means DP72 detects correct Profibus-telegram but nothing is addressed to DP72. The reason can be wrong address or wrong master settings.

If the Profibus status-symbol shows P it means the Profibus master is sending parameter telegrams. If P is shown repeatedly it means Profibus master is repeatedly sending parameter telegrams but DP72 do not accept them. Something is wrong with the parameter telegrams. The reason can be the master in configured with wrong gsd-file or old gsd-file version.

If no Profibus status-symbol is shown at all it means Profibus is not enabled.

Response Data byte	Air Sensor Mode	Level Switch Mode	
1	**Air Sensor 1** bit0: 0= Air 1= Liquid bit1: not used bit2: 1= settings error bit3: 1= no sensor bit4: 1= calibration not been done bit5: 1= error bit6: 1= error very low sensitivity bit7: 1= calibration in progress	**Level Switch 1** bit0: 0= Air 1= Liquid bit1: ***Efrq*** or ***Wfrq*** bit0[2] bit2: ***Efrq*** or ***Wfrq*** bit1[2] bit3: ***Efrq*** or ***Wfrq*** bit2[2] bit4: 1= no sensor bit5: 1= error bit6: not used bit7: 1= calibration in progress	
2	**Air Sensor 2** (same as above)	**Level Switch 2** (same as above)	
3	**Air Sensor 1** 0=Air 1=Liquid bit0: Very Very low bit1: Very low sensitivity bit2: Low sensitivity bit3: Medium sensitivity bit4: High sensitivity bit5-7 not used	**Level Switch 3** (same as above)	
4	**Air Sensor 2** (same as above)	**Level Switch 4** (same as above)	
5	Air Sensor 1a ***Ndata*** % or ***VLdata***[1]	**Level Switch 1** ***Edata*** % or ***Wdata***[2]	
6	Air Sensor 1b ***Ndata*** % or ***VLdata***[1]	**Level Switch 2** ***Edata*** % or ***Wdata***[2]	
7	Air Sensor 2a ***Ndata*** % or ***VLdata***[1]	**Level Switch 3** ***Edata*** % or ***Wdata***[2]	
8	Air Sensor 2b ***Ndata*** % or ***VLdata***[1]	**Level Switch 4** ***Edata*** % or ***Wdata***[2]	
9	Air Sensor 1a ***NLiq***	**Level Switch 1** ***ELiq*** or ***Wss***[2]	
10	Air Sensor 1b ***NLiq***	**Level Switch 2** ***ELiq*** or ***Wss***[2]	
11	Air Sensor 2a ***NLiq***	**Level Switch 3** ***ELiq*** or ***Wss***[2]	
12	Air Sensor 2b ***NLiq***	**Level Switch 4** ***ELiq*** or ***Wss***[2]	
13	Air Sensor 1a ***NAir*** % or ***VLthld***[1]	**Level Switch 1** ***Ethd*** % or ***Wthd***[2]	
14	Air Sensor 1b ***NAir*** % or ***VLthld***[1]	**Level Switch 2** ***Ethd*** % or ***Wthd***[2]	
15	Air Sensor 2a ***NAir*** % or ***VLthld***[1]	**Level Switch 3** ***Ethd*** % or ***Wthd***[2]	
16	Air Sensor 2b ***NAir*** % or ***VLthld***[1]	**Level Switch 4** ***Ethd*** % or ***Wthd***[2]	

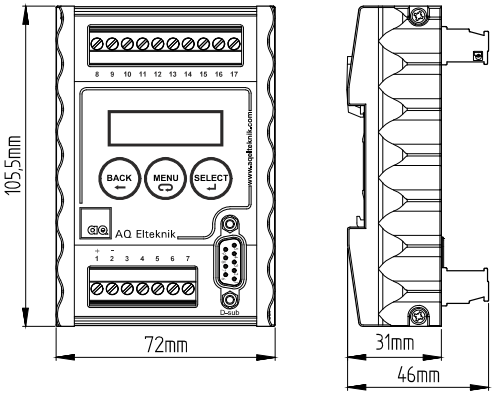
[1] depend on sensitivity (Normal or Very Low)
Ndata = Normal measurement data
Efrq = Echo frequency
VLdata = Very Low sensitivity measurement data
NLiq = Normal sensitivity calibrated liquid data dB
NAir = Normal sensitivity calibrated air data
VLthld = Very Low sensitivity calibrated threshold
Ethd = Echo threshold

[2] depend on Technique (Echo or WR)
Wthd = WR threshold
Wfrq = WR frequency
Edata = Echo measurement data
Wdata = WR measurement data
ELiq = Echo calibrated liquid data * 0,3dB
Wss = WR signal * 0,7dB

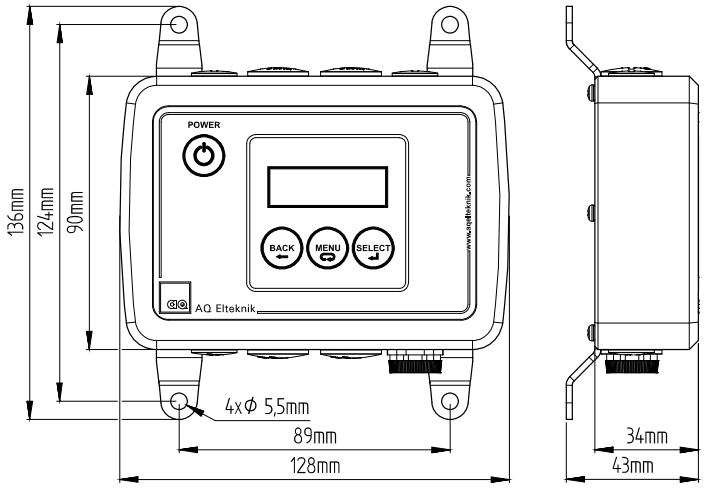
Response Data byte	Level Sensor Mode	Gel Sensor Mode
1	**Level Sensor 1** bit0: velocity sensor 2: 0=Air 1=Liq bit1: 1= no sensor 1 or 2 bit2: 1= calibration missing bit3: 1= error bit4: 1= no echo bit5: 1= OVER (>100%) bit6: -	**Level Switch 1** bit0: 0=no Gel 1=Gel bit1: bit2: bit3: bit4: 1=no sensor bit5: bit6: bit7: 1=calibration in progress
2	**Level Sensor 3** (same as above)	**Level Switch 2** (same as above)
3	**Level Sensor 1** *Measured Level* % (255=100%)	**Level Switch 3** (same as above)
4	**Level Sensor 3** *Measured Level* %	**Level Switch 4** (same as above)
5	**Level Sensor 1** *Measured Level* mm High byte	**Level Switch 1** *Gelconc* % (255=25,5%)
6	**Level Sensor 1** *Measured Level* mm Low byte	**Level Switch 2** *Gelconc* % (255=25,5%)
7	**Level Sensor 3** *Measured Level* mm High byte	**Level Switch 3** *Gelconc* % (255=25,5%)
8	**Level Sensor 3** *Measured Level* mm Low byte	**Level Switch 4** *Gelconc* % (255=25,5%)
9	**Sensor 2** *Sound velocity* m/s High byte	**Level Switch 1** *Signal dB*
10	**Sensor 2** *Sound velocity* m/s Low byte	**Level Switch 2** *Signal dB*
11	**Sensor 4** *Sound velocity* m/s High byte	**Level Switch 3** *Signal dB*
12	**Sensor 4** *Sound velocity* m/s Low byte	**Level Switch 4** *Signal dB*
13	**Level Sensor 1** *dBWR*	**Level Switch 1** *Liq WR sensor dB*
14	**Level Sensor 3** *dBWR*	**Level Switch 2** *Liq WR sensor dB*
15	**Level Sensor 1** *Echo strength* dB	**Level Switch 3** *Liq WR sensor dB*
16	**Level Sensor 3** *Echo strength* dB	**Level Switch 4** *Liq WR sensor dB*

12. Technical specifications Ultrasound Controller

Hardware version	See page 3
Software version	See page 3
Weight	210g (D72,DP72,G72), 370g (D128, G128)
Operating temperature	0°C to 50°C
Supply voltage	24V ± 3V DC
Current consumption max	200mA
Relay 1-4	potential free contacts (open when power is off) Maximum load: 30V DC/AC 500mA All four relays are connected to a single common (terminal 3)
mA output	4-20mA (active output) maximum voltage drop on connected load 10V
Protection class	IP30 (D72,DP72,G72) IP65 (D128,G128)
Ambient Humidity	0% - 90%
Material	Aluminum, PA, PC, POM
Measurement frequency	1,1 – 2,2 MHz
Average output power	10 mW
Profibus DP	In DP72 only
Gsd file for DP72	DP720B0E.gsd version see page 3
Cable glands in D128	M12: cable Ø3,5mm - Ø7mm M16: cable Ø4,1mm - Ø10mm



D72,DP72,G72



D128

Sensors	Maximum number of sensors	Mode	Ultrasound Controller	Outputs	Enclosure
Air Sensor	**2**	**Air Sensor mode**	**D72**	4-20mA and relays	Aluminum box for DIN rail IP30
			DP72	Profibus and relays	Aluminum box for DIN rail IP30
			D128	4-20mA and relays	Plastic box IP65
Level Switch	**4**	**Level Switch mode**	**D72**	4-20mA and relays	Aluminum box for DIN rail
			DP72	Profibus and relays	Aluminum box for DIN rail IP30
			D128	4-20mA and relays	Plastic box IP65
Level Switch used as level sensor or GF90	**2**	**Level Sensor mode**	**D72**	4-20mA and relays	Aluminum box for DIN rail IP30
			DP72	Profibus and relays	Aluminum box for DIN rail IP30
			D128	4-20mA and relays	Plastic box IP65
GF90	**4**	**Gel Sensor mode** (must use Frequency 4MHz)	**G72**	4-20mA and relays	Aluminum box for DIN rail IP30
			GP72	Profibus and relays	Aluminum box for DIN rail IP30
			G128	4-20mA and relays	Plastic box IP65
Gel distance sensor	**1**	**Gel Distance Sensor mode** (must use Frequency 4MHz)	**GS72**	2 4-20mA, 4 relays	Aluminum box for DIN rail IP30

13. Parameter settings

Air Sensor Mode		
TYPE	**DIAMETER**	**FILTER**
No Air Sensor	No Air Sensor	integrate 1ms
SAC or CCS	2 mm	integrate 3ms
SAC Ex or CCS Ex	3 mm	integrate 10ms
FCS	4 mm	integrate 30ms
PAC or FCP	4,5 mm	integrate 0,1s
FCS Ex	5,7 – 6,3 mm	integrate 0,3s
DAP or APS	6,4 – 7,4 mm	integrate 1s
	7,4 – 8,4 mm	integrate 3s
SENSITIVITY	8,4 – 9,5 mm	delay 0,3s
very very low	9,5 – 10,5 mm	delay 1s
very low	10,6 – 11,8 mm	delay 3s
Low	11,9 – 13,1mm	delay 10s
medium	13,2 – 14,9 mm	
High	15,0 – 16,9 mm	**FREQUENCY**
	17,0 – 18,9 mm	Auto
mA output	19,0 – 21,0 mm	2,0MHz
disabled	21,0 – 23,8 mm	2,2MHz
Normal Measurement Data	23,9 – 27,8 mm	
All Sensitivities	27,9 – 32,3 mm	**RELAY**
	32,4 – 36,5mm	Open AS1 Liq,Close AS1 Air
	36,5 – 39,8 mm	Open AS1 Air,Close AS1 Liq
	39,9 – 43,8 mm	Open AS2 Liq, Close AS2 Air
	43,9 – 48,5 mm	Open AS2 Air,Close AS2 Liq
	48,5 – 53,1 mm	
	53,2 – 57,6 mm	
	57,7 – 62 mm	
	62 – 67 mm	
	67 – 75 mm	

Level Switch Mode		
Type AND Technique	**ECHO-DISTANCE**	**Jacket**
No Level Switch	15mm	no Jacket
Type: KS,MK,MS,LS Technique: ECHO	18mm	... mm
Type: RS Technique:WR	22mm	
Type: KS,MK,LS Technique: WR	26mm	**FREQUENCY**
Type: MK Technique: Dual	30mm	1,3MHz
	34mm	1,5MHz
FILTER	38mm	1,7MHz
0,5s	42mm	2,0MHz
1s	46mm	2,2MHz
2s	49mm	Auto
4s	53mm	
8s	58mm	**Relay**
12s	65mm	Open: LS1 Air Close: LS1Liq
16s	75mm	Open: LS1 Liq Close: LS1Air
	85mm	(same as above for LS2,LS3,LS4)
	100mm	Open:LS2 Air Close:LS1Liq
	115mm	Open:LS1 Liq Close:LS2Air
	135mm	Open:LS3 Air Close:LS2Liq
	165mm	Open:LS2 Liq Close:LS3Air
	200mm	Open:LS4 Air Close:LS3Liq
	250mm	Open:LS3 Liq Close:LS4Air
	300mm	
	350mm	
	400mm	
	500mm	
	600mm	

Level Sensor mode		
Range	**Sensor Control**	**Sensor 2&4 FREQUENCY**
... mm	Level Unaffected	Auto
	Limit the level	2,2MHz
WR threshold		2,1MHz
disabled	**Bottom THICKNESS**	2,0MHz
3dB	... mm	1,8MHz
4dB		1,6MHz
5dB	**Wall THICKNESS**	1,5MHz
6dB	... mm	1,4MHz
7dB		1,3MHz
8dB	**Sensor 1&3 FREQUENCY**	1,2MHz
9dB	Auto	
10dB	2,2MHz	**RELAY ON Level**
	2,1MHz	... mm
Liquid Sound VELOCITY	2,0MHz	
... m/s	1,8MHz	**RELAY OFF Level**
	1,7MHz	... mm
Inner DISTANCE	1,6MHz	
... mm	1,5MHz	**4-20mA out**
	1,4MHz	disabled
Sensor HEIGHT	1,3MHz	Level 0-100%
... mm	1,2MHz	Velocity 1000-2000m/s

Gel Distance Sensor mode		
100% Distance	**RELAY 1 ON Distance**	**4-20mA out A**
… mm	… mm	disabled
	RELAY 1 OFF Distance	Distance 0-100%
0% Distance	… mm	Signal 0-85dB
… mm	(same as above for RELAY 2-4)	**4-20mA out B**
		disabled
Liquid Sound VELOCITY		Distance 0-100%
… m/s		Signal 0-85dB

Gel Sensor mode		
Type	**GEL-THRESHOLD**	**LiquidSensorWR THRESHOLD**
No Gel Sensors	not set	disabled
Level Switch GS1 GS2 GS3 GS4	0,6 %	3 dB
Level Switch GS1 GS2 GS3	0,8 %	4 dB
Level Switch GS1 GS2	1,0 %	5 dB
Level Switch GS1 GS2	1,2 %	6 dB
Level Switch QS	1,4 %	7 dB
	1,7 %	8 dB
ECHO-DISTANCE	2,0 %	9 dB
..... mm	2,3 %	10 dB
	2,6 %	11 dB
GEL-TYPE	3,0 %	12 dB
5dB/m at 2MHz 10dB/m at 4MHz	3,5 %	13 dB
7dB/m at 2MHz (Streamline SP)	4,0 %	
10dB/m 2MHz, 20dB/m 4MHz	5,0 %	**Relay**
15dB/m 2MHz, 30dB/m 4MHz	6,0 %	not set
20dB/m 2MHz, 40dB/m 4MHz	7,0 %	Open: Gel (1…4)
25dB/m 2MHz, 50dB/m 4MHz	8,0 %	Close: Gel (1…4)
30dB/m 2MHz, 60dB/m 4MHz	9,0 %	Close: Air (1…4)
35dB/m 2MHz, 70dB/m 4MHz	10 %	Close: out of range (1…4)
40dB/m at 2MHz (Tungsten)	**FREQUENCY**	Close: no sensor (1…4)
45dB/m 2MHz, 90dB/m 4MHz	1,3 MHz	
	1,5 MHz	**mA output (4-20mA)**
	1,7 MHz	disabled
	2,0 MHz	Gel Level 1,5mA/GelDetection
	2,2 MHz	Rel. att. 1mA = - 4dB/m (GS1…GS4)
	4,0 MHz	Gelconc. 1mA = 1% (GS1…GS4)

PROFIBUS		
BITRATE	**ADDRESS**	**PARAMETER ACCESS**
9,6 kbit/s	1...125	Profibus only
19,2 kbit/s		Menu only
45,45 kbit/s	**CONTROL** (enabl/disabl Profibus**)**	
93,75 kbit/s	DISABLED	
187,5 kbit/s	ENABLED	
500 kbit/s		
1500 kbit/s		

14. Software Version History

Version 6.31 December 2022
Air Sensor DAP6 changed internal settings.
Gelsensor relay setting changes.

Version 6.22 June 2022
Bugfix on Air Sensor DAP3
Gelsensor relay setting changed from 10-16% to “out of range”

Version 6.10 March 2022
Air Sensor CQS has been added.

Version 6.00 June 2021
A new gsd-file version 6.0 (for profibus) is updated with additional parameter values. This gsd-file version 6.0 must be used for DP72 and GP72 version 6.0 and higher.
G72 and GP72: the AD-converter has been recalibrated and WR-calculation has been corrected.
Air Sensor mode: SAC4.5 internal parameters has been adjusted.
Level sensor mode: the velocity sensor will limit the level both at high and low level (previous only at low level).

Version 5.70 February 2021
Air Sensor DAP3 gets improved internal settings. Level Switch diameter range has been increased. A new Level Switch Technique is available: Dual.

Version 5.60 November 2020
Air Sensor parameter FREQUENCY is added which is needed when the liquid is acetic acid. Air Sensor SAC2 get improved internal settings

Version 5.53 May 2019
Panel buttons get improved noise filter

Version 5.52 May 2019
Air Sensor mode get fixed the type settings bug in version 5.50 and 5.51

Version 5.51 January 2019
Air Sensor FCS4 and PAC4 get improved internal settings

Version 5.50 December 2018
Air Sensor CCS Ex has been added to settings

Version 5.41 November 2018
Level Switch MK has been added to settings

Version 5.40 November 2018
Level Switch MS has been added to settings