1 Ultrasonic Sensors

Ultrasonic sensors precisely detect objects made from various materials regardless of their shape, color, or surface contour.

1 Physical Principles

Sound waves with a frequency above approximately 16 kHz are referred to as ultrasonic. These sound waves can travel through a wide variety of media and effectively detect or monitor objects with a relatively high density. Common ultrasonic targets include solids, liquids, and granular materials.

Because the transmission properties and speed of sound change in different media, sensors must be adapted specifically to each medium. Pepperl+Fuchs' ultrasonic sensors are optimized for the propagation of sound waves in the air. At room temperature, the speed of sound in air is about 344 m/s.

The sensor emits ultrasonic pulses that are then reflected by an object. The generated echo is received again by the sensor and converted into an electric signal via the piezoelectric transducer. This is known as the propagation time of sound.

$$s = \frac{t \cdot c}{2}, \tag{1}$$

where c is a speed of the pulse and t - time difference.

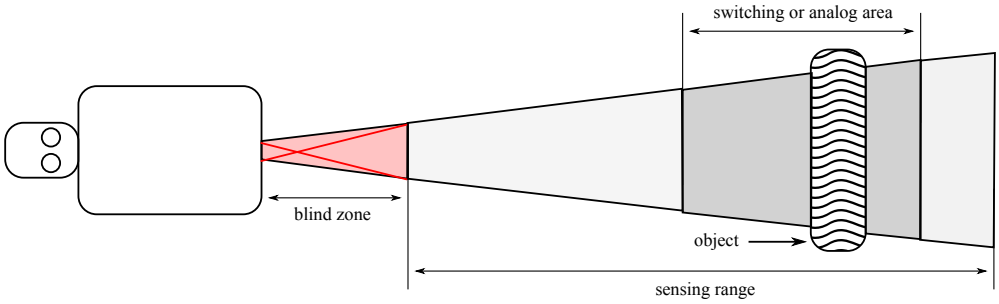


Figure 1: Sensing Range

Within the sensing range, it is possible to determine distance limits or windows using a Teach-In function.

Work flow

Getting to know different types of sensors and programming thereof.

2 Binary Sensor UB500-18GM75-E5-V15

Programming the sensor.

Task

✓ Program the sensor such way that

- Within sensing range object detection area begins at (see Fig. \1)
  - Take $k :=$ "the last number of you studentID" (sum it up if you do work together);
  - Beginning of switching zone $b = k + 3$ [cm], where 3 cm is a dead zone;
  - $b =$ _____[cm].
- Within sensing range object detection area ends at (see Fig. 1)
  - Take $l :=$ "the last number of you studentID" (take absolute value of the difference of two studentIDs);
  - End of the switching zone $z = b + l + 5$ [cm], but not greater than 27 cm;
  - $z =$ _____[cm].

✓ Put plane white paper sheet on the glass under the sensor.

✓ Provide levels A_1 and A_2 at what you see reaction of the sensor (LED Displays).

Five different output functions can be set:

1. Window mode, normally-open function,
2. Window mode, normally-closed function,
3. One switch point, normally-open function,
4. One switch point, normally-closed function,
5. Detection of object presence.

2.1 Adjustment within the Sensing Range

The ultrasonic sensor features a switch output with two teachable switching points. These are set by applying the supply voltage $-U_B$ or $+U_B$ to the TEACH-IN input. The supply voltage must be applied to the TEACH-IN input for at least 1 s. LEDs indicate whether the sensor has recognized the target during the TEACH-IN procedure. Switching point A_1 is taught with $-U_B$, A_2 with $+U_B$.

NB! Switching points may only be specified directly after Power on. A time lock secures the adjusted switching points against unintended modification 5 minutes after Power on.

2.2 TEACH-IN Window Mode, Normally-Open Function

1. Set target to near switching point.
2. TEACH-IN switching point A_1 with $-U_B$.
3. Set target to far switching point.
4. TEACH-IN switching point A_2 with $+U_B$.

2.3 Adjusting the Sound Cone Characteristics

The ultrasonic sensor enables two different shapes of the sound cone (see Fig. 2), a wide angle sound cone and a small angle sound cone.

Figure 2: Sound beam

TASK

✓ Program sensor to Small angle sound cone. Provide edges of the switching area on paper for the current case. NB! In this mode Object should be perpendicular to the sensor.

✓ Program sensor to Wide angle sound cone. Provide edges of switching area on paper for the current case.

Calculations

1. How many times one area is larger that another?
2. Answer the question: In what case each of them is used?

2.4 Small Angle Sound Cone

1. Switch off the power supply,
2. Connect the Teach-input wire to $-U_B$ (Press A_1),
3. Switch on the power supply,
4. The red LED flashes once with a pause before the next.

Figure 3: Narrow Cone

5. The yellow LED: permanently on: indicates the presence of an object or disturbing object within the sensing range.
6. Disconnect the Teach-input wire from $-U_B$ and the changing is saved.

2.5 WideAngle Sound Cone

1. Switch off the power supply,
2. Connect the Teach-input wire to $+U_B$ (Press A_2),
3. Switch on the power supply,
4. The red LED flashes once with a pause before the next.

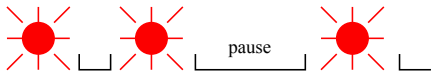


Figure 4: Wide Cone

5. The yellow LED: permanently on: indicates the presence of an object or disturbing object within the sensing range.
6. Disconnect the Teach-input wire from $+U_B$ and the changing is saved.

3 Analog Sensor UB500-18GM75-I-V15

Measurement of the data, displaying information.

3.1 Adjustment within the Sensing Range

Two different output functions can be set:

1. Analog value increases with rising distance to object (rising ramp).
2. Analog value decreases with rising distance to object (falling ramp).

3.2 TEACH-IN Rising Ramp ($A_2 > A_1$)

1. Place object at lower evaluation limit.
2. TEACH-IN lower limit A_1 with $-U_B$.
3. Place object at upper evaluation limit.
4. TEACH-IN upper limit A_2 with $+U_B$.

TASK

✓ Make sure that sensor is configured to Wide angle sound cone.

✓ Check the ultrasonic sensor specifications (see Appendix 1).

1. Find out the type of output signal _____ [mA] or [V].
2. Find out the sensing range _____ [mm] or [cm].

✓ Programm display (see Appendix 2) the following way

1. Maximal and Minimal values should be displayed.
2. Maximal and Minimal values cannot be reset.
3. Provide measuring with the next accuracy
   - if k in Sec. 2 is odd, then readings units aremm with one decimal place;
   - if k in Sec. 2 is even, then readings units are cm with two decimal places.

✓ Measure distance to the object, which is provided to you (Object No. ____).

Calculations

1. What is the sensor output value ([mA] or [V]) with the provided measurement?

2 Laser Sensor

The VDM18 is an optical sensor and measures distances without contact. When combined with another VDM18 sensor, the thickness of objects can also be measured.

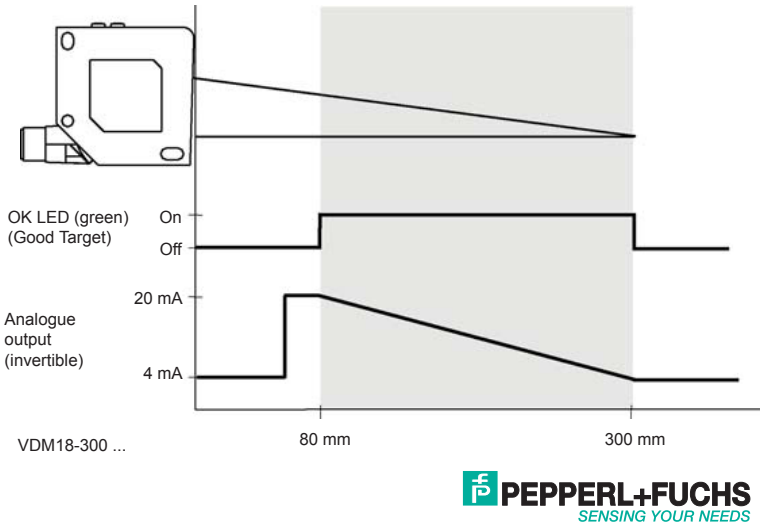


Figure 5: Operating range (Factory setting)

1 Mode of Function

The VDM18 sensor measures according to the principle of triangulation. The distance between the object and sensor is determined on the basis of the position of the light spot on the detector.

TASK

Display how many books in the stack.

✓ First of all set limits for the sensor

1. Check operating range of the sensor (see Fig. 5). Make sure that lower position of the books stack (0 books) is inside the range. Use stand if necessary.
2. Use Mode 22 or Reset mode (see Appendix 3) in order to reset factory settings.
3. Use Mode 16 to set value corresponding to 4 mA (0 books).
4. Use Mode 17 to set value corresponding to 20 mA (10 books).

✓ Programm display (see Appendix 2) the following way

1. Check the right range of input signal.
2. Set 0 decimal places for dP parameter.
3. Set 0 value, which corresponds to level with 0 books in the stack.
4. Set 10 value, corresponding to level with 10 books in the stack.

✓ Programm display (see Appendix 2) the following way. Take as many books as "the last number of your studentID or b". Does value of the display corresponds to it?

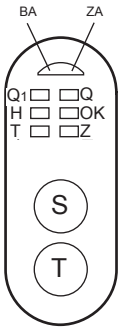
- If value switching all the time, provide measurement with one decimal point in display.

✓ What is the sensor output value _____ [mA] with the provided measurement.?

2 Instruction of Use

Table 1: IR Sensor panel signals

LED	Color	Use/Description
BA	Green	Power supply indicator. On: ready. Flashing: setting mode is active
ZA	Red	Status indicator. Function (not) activated, or conformation signal
Q_1	Yellow	Q_1input/output
Q_2	Yellow	Q_2input/output
H	Green	Q_1trigger input or Q_1 enable input function active
OK	Green	Good target
T	Green	Pulse stretching function is active
Z	Green	Q_1automatic center or Q_1 automatic zero function is active



Appendix 3 explains the further significance of the LEDs: Q_1, Q_2, H, OK, T and Z.

The following four steps are used to configure the VDM18 sensor:

1. Activate setting mode

   ✓ Press the S and T buttons together for 3 seconds

   After this period, the power supply indicator BA flashes

   ✓ set VDM18. The LEDs show the status of function no. 1 (see Appendix 3)

   When all the LEDs start immediately flashing

   ✓ Unlock VDM18, see paragraph "Unlocking keys" (see end of Appendix 3)

2. Select functions

   Press the T button to select the next function in the function table. The function number is indicated by a clear LED pattern and the function status is indicated by the status indicator ZA (LED on = active, LED off = not active).

   NB! The sensor only switches to the next function when the T button is released.

   If no change occurs:

   ✓ Press T button for longer.

   ✓ Press the T button several times until the required function reappears.

   ✓ Or deactivate setting mode (see point 4) and repeat procedure from step 1.

3. Setting the function status

   ✓ Press the S button to alter the status of a particular function. The status indicator alters according to the table of functions. Settings are immediately effective but must still be saved as described in point 4.

   ✓ To reset the setting, press the S button once again (is not valid when transferring measured value as switching point!)

4. Deactivate setting mode

   First press the T button and then simultaneously press the S button. All settings are then saved. Once the S button is released, the sensor is in run mode. The BA power supply indicator is permanently alight.

1 Appendix

Ultrasonic sensor UB500-18GM75-I-V15

Model Number

UB500-18GM75-I-V15

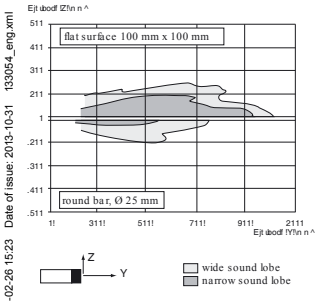
Single head system

Features

- Analog output 4 mA ... 20 mA
- Measuring window adjustable
- Selectable sound lobe width
- Program input
- Synchronization options
- Deactivation option
- Temperature compensation
- Very small unusable area

Diagrams

Characteristic response curve



Technical data

General specifications	
Sensing range	30 ... 500 mm
Adjustment range	50 ... 500 mm
Unusable area	0 ... 30 mm
Standard target plate	100 mm x 100 mm
Transducer frequency	approx. 380 kHz
Response delay	approx. 50 ms
Indicators/operating means	
LED yellow	solid yellow: object in the evaluation range yellow, flashing: program function, object detected
LED red	solid red: Error red, flashing: program function, object not detected
Electrical specifications	
Operating voltage U_B	10 ... 30 V DC , ripple 10 $\%_{SS}$
No-load supply current I_0	≤ 45 mA
Input/Output	
Synchronization	1 synchronous connection, bi-directional 0-level: -U_B...+1 V 1-level: +4 V...+U_B input impedance: > 12 kΩ synchronization pulse: ≥ 100 µs, synchronization interpulse period: ≥ 2 ms
Synchronization frequency	
Common mode operation	≤ 95 Hz
Multiplex operation	≤ 95 Hz /n, n = number of sensors
Input	
Input type	1 program input lower evaluation limit A1: -U_B ... +1 V, upper evaluation limit A2: +4 V ... +U_B input impedance: > 4.7 kΩ, pulse duration: ≥ 1 s
Output	
Output type	1 analog output 4 ... 20 mA
Resolution	0.13 mm for max. detection range
Deviation of the characteristic curve	± 1 % of full-scale value
Repeat accuracy	± 0.1 % of full-scale value
Load impedance	0 ... 300 Ohm
Temperature influence	± 1.5 % of full-scale value
Ambient conditions	
Ambient temperature	-25 ... 70 °C (-13 ... 158 °F)
Storage temperature	-40 ... 85 °C (-40 ... 185 °F)
Mechanical specifications	
Connection type	Connector M12 x 1 , 5-pin
Protection degree	IP65
Material	
Housing	brass, nickel-plated
Transducer	epoxy resin/hollow glass sphere mixture; foam polyurethane, cover PBT
Mass	60 g
Compliance with standards and directives	
Standard conformity	
Standards	EN 60947-5-2:2007 IEC 60947-5-2:2007 EN 60947-5-7:2003 IEC 60947-5-7:2003
Approvals and certificates	
UL approval	cULus Listed, General Purpose
CSA approval	cCSAus Listed, General Purpose
CCC approval	CCC approval / marking not required for products rated ≤36 V

Release date: 2013-02-26 15:23 Date of issue: 2013-10-31 133054_eng.xml

2 Appendix

DA5-IU-C

ANLOGUE GND
(Terminal 6)
If no isolation between measuring circuit and supply voltage is necessary, connect terminal 2 or 3 to this input.

3. Setting of the operating parameters

3.1 Selecting the displayed value and resetting the maximum or minimum value

Pressing the right key allows switching the display can be switched between the current, min., or max. measured value.

Pressing the right key once displays the current function („Act“, „Min“ or „Max“) for 2 seconds. If within this period the right key is pressed again, the current function is changed. The display shows the new current function for two seconds. Afterwards the corresponding value is displayed. If „Min“ or „Max“ is the current function, the value can be reset by pressing the left key. If neither storing of min. nor max. value is activated in set up, both keys are out of function.

3.2 Setting the device parameters

a. Hold down both keys on front panel and switch on the supply voltage.
b. The display shows
   `ProG`
c. After releasing the keys the display alternates between menu title and corresponding menu setting at a frequency of 1 Hz. After any key is pressed, only the menu setting is displayed.
d. Pressing the right key will switch the menu setting to the following value.
   If numerical values are to be set (e.g. factor setting), the left key allows selecting the decade and the right key sets the value.
e. Hold down the left key and press the right key to switch to the next menu item.
f. The last menu item, “EndPro”, allows exiting the programming routine by selecting “Yes”; the new values will be stored. If „No“ is selected, the programming routine will be passed through once again. The last set values remain maintained, allowing to check or modify them once more.

4. Programming routine

The programmable device parameters are shown in succession. After one pass, the device is fully programmed.
In each case the first item shown is the factory preset.

4.1 Input signal range

`rAnGE`

- `0.20mA` 0..20 mA
- `4.20mA` 4..20 mA
- `0..10U` 0..10 V
- `2..10U` 2..10 V

4.2 Max. value display

`MAX`

- `YES` Max. value can be displayed
- `no` Max. value will not be displayed, next menu item is skipped

4.3 Max. value reset

`rMAX`

- `YES` Max. value can be reset by pressing the red button. (Current value becomes new max. value)
- `no` Max. value cannot be reset.

4.4 Min. value display

`Min`

- `YES` Min. value can be displayed
- `no` Min. value will not be displayed, next menu item is skipped

4.5 Min. value reset

`rMin`

- `YES` Min. value can be reset by pressing the red button. (Current value becomes new min. value)
- `no` Min. value cannot be reset.

DA5-IU-C

4.6 Decimal point

dP

0 — The decimal point indicates the number of decimal places.

0.0000

0	no decimal place
0.0	one decimal place
0.00	two decimal places
0.000	three decimal places
0.0000	four decimal places

4.7 Min. input signal (only if input signal range is 4..20 mA or 2..10 V)

This menu item allows a limitation of the display range (refer to 4.9 and 9.4)

Lo S — a) or b) is selected depending on the chosen input range

a) 04.000 / 20.000 — If, with the input range 4..20 mA, the input signal level becomes smaller than this value, the display shows „lo“.

b) 2.000 / 10.000 — If, with the input range 2..10 V, the input signal level becomes smaller than this value, the display shows „lo“.

4.8 Displayed value at min. input signal

LodiS

-19999 / 99999 — A corresponding display value between -19999 and 99999 can be assigned to the lowest input signal. The decimal point position is considered.

4.9 Max. input signal (only if input signal range is 4..20 mA or 2..10 V)

This menu title allows a limitation of the display [illegible] to 4.7 and 9.4).

hiGh — a) or b) is selected depending on the chosen input range

a) 04.000 / 20.000 — If, with the input range 4..20 mA, the input signal level exceeds this value, the display shows „hi“.

b) 2.000 / 10.000 — If, with the input range 2..10 V, the input signal level exceeds this value, the display shows „hi“.

4.10 Displayed value at max. input signal

hiSdiS

-19999 / 99999 — A corresponding display value between -19999 and 99999 can be assigned to the highest input signal. The decimal point position is considered.

4.11 End of programming

EndPro

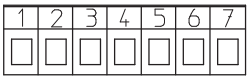
no — Programming routine will be passed through once again. All parameters can be checked.

YES — Programming routine will be left and the new parameters will be stored. Afterwards the device is ready to use.

english

5. Connections

1 10 – 30 VDC
2 GND
3 GND
4 LATCH
5 0 (4) – 20 mA
6 Analogue GND
7 0 (2) –10 V DC



6. Technical data

Display: 5-digit 7-segment red LED-Display, 8 mm high characters

Range of input signals
0 .. 10 V DC
2 .. 10 V DC
0 .. 20 mA DC
4 .. 20 mA DC

Resolution: 14 bits

Linearity: < 0.1% ± 1 digit at an ambient temperature of 20 °C

Zero adjustment: automatic

Temperature drift:
<70ppm/K

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3 Appendix

Settings

The VDM18 sensor can be configured as follows with functions 1 to 26 in setting mode (teach-in).

Button

S Set button: Change / confirm a setting or set a switching point

T Toggle button: Select a function (proceed to the next function)

Functions

No.	LED Muster	Description	"ZA" status indicator	Factory setting
1	Q_1 ■ Q_2 H □ OK T □ Z	Select Q_1 output mode.	On = Q_1 is a signal output Off = Q_1 is not a signal output	On
2	Q_1 □ Q_2 H ■ OK T □ Z	Transfer of current meas. value as 1st switching point of Q_1. signal output.	On* = Measured value valid Off* = Measured value invalid	Half measuring range
3	Q_1 ■ Q_2 H ■ OK T □ Z	Scanning zone: Transfer of current meas. value as 2nd switching point of Q_1 signal output. Q_1 must be signal output (see function no 1).	On = Measured value valid Off = Measured value invalid	Off
4	Q_1 □ Q_2 H □ OK T ■ Z	N.C./N.O. change-over of switching functions for Q_1.	On = N.C. Off = N.O.	N.O.
5	Q_1 ■ Q_2 H □ OK T ■ Z	Q_2 output mode.	On = Q_2 is a signal output Off = Q_2 displays good target	Off
6	Q_1 □ Q_2 H ■ OK T ■ Z	Transfer of current meas. value as 1st switching point of Q_2 signal output. Q_2 must be signal output (see function no 5)	On* = Measured value valid Off *= Measured value invalid	Good Target
7	Q_1 ■ Q_2 H ■ OK T ■ Z	Scanning zone: Transfer of current meas. value as 2nd switching point of Q_2 signal output. Q_2 must be signal output (see function no 5).	On = Measured value valid Off = Measured value invalid	Off
8	Q_1 □ Q_2 H □ OK T □ Z	N.C./N.O. change-over of switching functions for Q_2.	On = N.C. Off = N.O.	N.O.
9	Q_1 ■ Q_2 H □ OK T □ Z	Pulse stretching of Q_1 and Q_2 by 50 ms.	On = Pulse stretching on Off = Pulse stretching off	Off
10	Q_1 □ Q_2 H ■ OK T □ Z	Q_2 signal output shows status "good target". Switching signal can be inverted with function no 8.	On = Object within... Off = Object outside... ...measuring range	On

* as long as the S button is pressed

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No.	LED Muster	Description	"ZA" status indicator	Factory setting
11	Q_1 ■ ■ Q_2 H ■ □ OK T □ □ Z	Q_1 trigger input mode: With rising edge on Q_1, measured value is held until the next trigger occurs.	On = Q_1 is a trigger input Off = Q_1 is not a trigger input	Off
12	Q_1 □ ■ Q_2 H □ □ OK T ■ □ Z	Q_1 enable input mode: Used to switch laser beam on and off. Laser beam is on when $Q_1 = +U_B$. If $Q_1 = -U_B$, the laser beam is switched off. Last measured value remains. When re-activated, the response time is prolonged according to the set mean value.	On = active Off = not active	Off
13	Q_1 ■ ■ Q_2 H □ □ OK T ■ □ Z	Switches off averaging: The first measured value is taken into account (page 35).	On = Averaging off	On
14	Q_1 □ ■ Q_2 H ■ □ OK T ■ □ Z	Switches on 4 ms averaging: the first 10 meas. values are taken into account (page 35).	On = active Off = not active	Off
15	Q_1 ■ ■ Q_2 H ■ □ OK T ■ □ Z	Switches on 40 ms averaging: all (max. 100) meas. values are taken into account (page 35).	On = active Off = not active	Off
16	Q_1 □ □ Q_2 H □ ■ OK T □ □ Z	Set analogue output 0% (4 mA): When S button is activated, the current meas. value corresponds with 0% value of the analogue output.	On* = Object within… Off* = Object outside... ...measuring range	0% = 4 mA = end of meas. range
17	Q_1 ■ □ Q_2 H □ ■ OK T □ □ Z	Set analogue output 100% (20 mA): When S button is activated, the current meas. value corresponds with 100% value of the analogue output.	On* = Object within… Off* = Object outside... ...measuring range	100% = 20 mA = start of meas. range
18	Q_1 □ □ Q_2 H ■ ■ OK T □ □ Z	Q_1 automatic zero mode: For characteristic curve displacement. If $Q_1 = +U_B$, the current measuring signal is set to the analogue value 0 % = 4 mA. The incline of the characteristic curve is maintained. If exceeded, the characteristic curve ends at the start or end of the measuring range.	On = Automatic zero active Off = Autommatic zero not active	Not active
19	Q_1 ■ □ Q_2 H ■ ■ OK T □ □ Z	Q1 automatic centre mode: displacement of centre of characteristic curve. If $Q_1 = +U_B$, the current measuring signal is set to the analogue value 50 % = 12 mA. The incline of the characteristic curve is maintained. If exceeded, the characteristic curve ends at the start or end of the measuring range.	On = Automatic centre active Off = Automatic centre not active	Not active

* as long as the S button is pressed

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No.	LED Muster	Description	"ZA" status indicator	Factory setting
20	Q1 □ □ Q2 H □ ■ OK T ■ □ Z	Q1 maximum hold mode: Provided Q1 = +UB, the max. recorded measured value is stored. If Q1 = -UB, the determined value is transmitted at the analogue output. A minimum hold can be set by inverting the analogue characteristic curve (analogue 100% point < analogue 0 % point).	On = Maximum hold active Off = Maximum hold not active	Not active
21	Q1 ■ □ Q2 H □ ■ OK T ■ □ Z	Q1 difference hold mode: Provided Q1 = +UB, the difference between the measured values is saved. When Q1 = -UB, the determined value is transmitted at the analogue output.	On = Difference hold active Off = Difference hold not active	Not active
22	Q1 □ □ Q2 H ■ ■ OK T ■ □ Z	Activate factory settings: When the S button is pressed, the factory setting is activated.	ZA lights up as long as the S button is pressed	Not active
23	Q1 ■ □ Q2 H ■ ■ OK T ■ □ Z	Locking keys: If function is activated locking becomes active once the setting mode has been quit. Cancel locking with RESET or the unlocking function (see "Unlocking keys")	On = Locking is active Off = Locking is not active	Not active
24	Q1 □ □ Q2 H □ □ OK T □ ■ Z	Meas. value hold mode: If no object is in the measuring range (good target = off), the last meas. value is held at the analogue output.	On = Meas. value hold is active Off = Meas. value hold is not active	Not active
25	Q1 ■ □ Q2 H □ □ OK T □ ■ Z	Differential measurement mode master: Activate/deactivate (option /88 only) Description see differential measurement mode (page 38).	On = Differential measurement mode - master is active Off = Differential measurement mode - master is not active	Not active
26	Q1 □ □ Q2 H ■ □ OK T □ ■ Z	Differential measurement mode slave: Activate/deactivate (option /88 only) Description see differential measurement mode (page 38).	On = Differential measurement mode - slave is active Off = Differential measurement mode - slave is not active	Not active

Reset

Q1 ■ □ Q2
H ■ □ OK
T ■ □ Z

When switching on the sensor (power on), keep the S button pressed (approx. 10 seconds) until the LED lights stop flashing and are permanently on. The BA power supply indicator is green. When the S button is released, a Reset is carried out which returns the VDM18 to delivery status where factory settings are active.
(See table of functions page 32-34).

Unlocking keys

Q1 □ ■ Q2
H □ ■ OK
T □ ■ Z

When switching on the sensor (power on), keep the T button pressed (approx. 10 seconds) until the LED lights stop flashing and are permanently on. The ZA status indicator is red. When the T button is released, the setting mode is unlocked.

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SENSING YOUR NEEDS