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FACTORY AUTOMATION

Instruction Manual

Service Program Ultra 2001

Parameterizing Software for Ultrasonic Sensors with RS 232 Interface

CE

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Ultra 2001 Service Program

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1 Introduction

1.1 General description

The ULTRA 2001 software is a program for servicing and setting parameters for Pepperl+Fuchs ultrasonic sensors via an RS 232 serial interface.

ULTRA 2001 is designed for communication with the following sensors:

UC300 UC500 UC1000 UCC1000 UC2000 UC4000 UC6000	**-**	**30GM**	**-**	**E6R2 E7R2 IUR2**	**-**	**K-V15 V15**
and						
UC500 UC3000	**+ -**	**U9 FP**	**+ -**	**E6 E7 IUE0 IUE2**	**+**	**R2**
and						
UJ3000 UJ6000	**+ -**	**U1 FP**	**+ -**	**8B E22 IU**	**+**	**RS**
and						
UC300 UC2000	**-**	**F43**	**-**	**2KIR2**	**-**	**V17**

Attention

The use of other sensors than those listed above is not permissible. Pepperl+Fuchs will not accept liability for any damages, either direct or indirect, arising from such use.

1.2 Why use PC software to set parameters?

If a sensor is equipped with an RS 232 interface, then the transfer of commands and parameters to the sensor is performed via that interface. These commands can be used to output measured values, to configure the evaluation procedure, the switching outputs and/or the analog output, to set and interrogate parameters and to initiate general device functions. This provides the user with a tool for adjusting a sensor for optimum performance under current application conditions and for displaying parameters or measurement results.

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1.3 Brief description

This program is a multi-lingual, menu-driven user interface with a comprehensive help system.

It supports up to 5 separate windows. The windows can be hidden or shown, repositioned on the screen and resized. The program notes the position and size of the windows:

Show It: Graphical representation of the measured distance. The switching points that have been set are marked. Imitation LEDs simulate the switching states of the outputs and the interface.

Parameter: All parameters can be modified here. Display or input fields allow commands or parameters to be modified rapidly with a mouse click without users being required to involve themselves intensively with the commands and their syntax.

Send command: As with a terminal program, commands are used here to set and interrogate the sensor parameters (as an alternative to the parameters window).

Port Monitor: Displays the commands sent to and received by the sensor.

Distance: Displays the most recently measured distance.

The program parameters being used and the sensor parameters retrieved can be stored either on the hard disk or a floppy disk. Series of measurements can be started, their measurement data periodically queried and output on a printer or to the hard disk/floppy disk in the form of a log.

1.4 Safety instructions

Symbols used

Attention

Attention warns of a possible fault. Failure to observe the commands given in this warning may result in the device and any facilities or systems connected to it developing a fault or even failing completely.

Note

Note about important information that will make working with the ULTRA 2001 Service Program easier.

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2 Installation

2.1 Preparation

Check that the scope of supply is correct and complete and that your PC satisfies the system requirements.

System requirements:

ULTRA 2001 will run on any personal computer or laptop. It requires Windows 95 or higher, a VGA graphics card or higher and a free RS 232 interface.

Download and interface cable:

The latest version of the ULTRA 2001 service program can be downloaded free of charge from our Internet portal. This also contains the latest operating commands as a PDF file.

To connect your Ultrasonic Sensors to the RS 232 interface of your PC you require a special interface cable that is available from us as an accessory. The correct interface cable is shown in the list on Page 7.

2.2 Connecting the sensors

2.2.1 Safety commands on the sensors

Attention

When connecting the sensors, attention should be paid to the details on the data sheet, in particular the layout of the connections and the operating voltage range.

Attention

For sensors with coding switches (in the terminal housing), DIP switch 10 should be set to OFF (RS 232 mode) before the interface cable is connected. Failure to set this switch correctly can result in irreparable damage to the interface.

The connection diagram in the data sheet shows how the interface cable provided should be connected. For sensors with a terminal compartment the connections should usually be made as follows:

Cable colour	brown (TD)	→	terminal 4 (RD)
	black (RD)	→	terminal 2 (TD)
	blue (GND)	→	terminal 3 (-UB)

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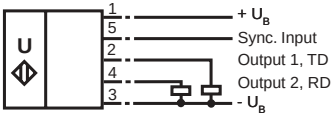
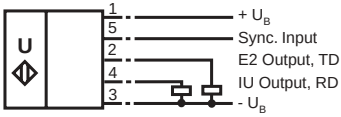
2.2.2 Connection diagram:

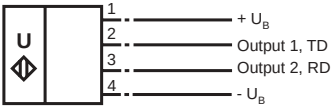
Version UC... E6/E7



Version UC... IUE0/E2

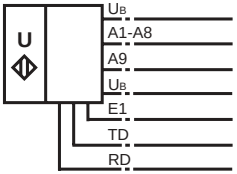


Version UJ... E22



Version UJ... IU

Version UJ... 8B



Cable colour:	
brown	
see table	
red/blue	
blue	
grey/pink	
(TD) brown/green	
(RD) violet	

8 bit switch output:

A1 = white
A2 = yellow
A3 = pink
A4 = red
A5 = green
A6 = grey
A7 = black
A8 = violet

Note

Connection via the interface cable is only required when setting parameters. Following this stage, the cable may be disconnected. The sensors operate independently. Remember to set DIP switch 10 back to ON.

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2.2.3 The correct interface cable for the respective series

Sensors of the F43 series are connected using the RS 232 interface UC-F43-R2. This is simply looped into the sensor connection line.

UC-F43-R2

The UC-30GM-R2 interface cable is available for the parameter setting of the 30GM sensors. This interface cable enables types UC...-30GM-..R2-...-V15 ultrasonic sensors to be programmed. The cable provides the connection between the RS 232 interface inside the PC and the plug connection of the temperature/programming plug on the sensor.

UC-30GM-R2

The UCFP/U9-R2interface cable is provided for the parameter setting of sensors of the -FP- and +U9+ or +U1+ (*VariKont*) series. This interface cable enables the programming of type UC...-FP-...R2, UC...+U9+...R2, UJ...-FP...RS and UJ...+U1...RS ultrasonic sensors.
The cable provides a connection between the RS 232 interface inside the PC and the terminal compartment of the sensor.

UC-FP/U9-R2

2.3 Transmission protocol

You can communicate with the sensors using any terminal program such as Windows Terminal (under “Accessories”) if the following parameters are set under “Settings” and “Data Transmission”:

Bit rate	9600 bit/s
Parity	none
Data bits	8
Stop bit	1

COM1 or COM2, according to the interface being used.

A detailed knowledge of the command syntax to set these parameters is required. This is explained under “Command set for ultrasonic sensors”.

The ULTRA 2001 service program allows you to exploit the manifold capabilities of the sensor much more conveniently and through a more standard interface.

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2.4 Program installation

To install the software, download it from our Internet portal and run the file SET-UP.EXE from within Windows.

Now follow the commands in the setup program.

The Setup program suggests C:\Ultra 2001 as an installation path, but a different path may be specified if required.

2.5 Run the ULTRA 2001 service program

After the installation has been completed successfully, ULTRA 2001 can be launched from within Windows like any other software. The program displays a title page, and a field is then overlaid on it in which the loading of data from the sensor into the software is indicated. Ensure that a suitable sensor is connected via the interface of your PC and that it is being supplied with power.

After all sensor data has been read, the user interface will appear as a full screen window with a menu bar and toolbar.

Messages on first use:

When using the software for the first time to access the connected ultrasonic sensor, the error message “Error on initialising serial port” may occur. Acknowledge this message by choosing Cancel and then select “Options” from the menu bar. A dialog box should now appear; select the serial port to which the sensor is connected.

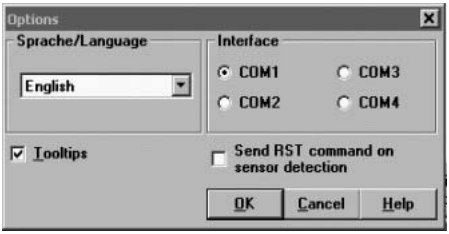

Figure 2.1: Options dialog box

Note

Use this opportunity to select the required language in the dialog box. As a relatively new user you should certainly also check the box to enable the help system, and you should work with the assistance of on-line help and help texts.

Exit the dialog box by clicking OK. The serial port you selected will now be stored and will be indicated on the bottom of the screen on the left in the footer/events bar.

Checking the connection to the sensor:

Choose the “Show It” option under “Window” on the menu bar. If the sensor is connected correctly, then the sensor imitation LED will be displayed in green. Sensor, measurement length and target can all be seen at the same time. The green bar indicates that the sensor is sending and receiving sound signals and that the interface communication is working correctly and error-free.

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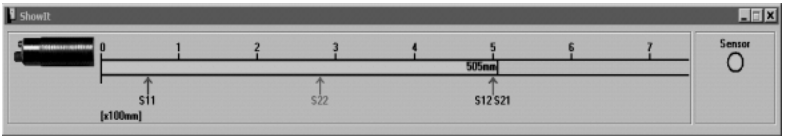

To close the ShowIt window, click the “Window” menu again or click the “ ” button (as normal) in the top right corner of the window.

3 Software display and configuring tools

When the program is first started, a menu bar with a toolbar below it is displayed on the screen. Most of the screen remains blank providing none of the 5 possible windows are opened.

The most important program functions from the menu bar are included again in the toolbar to make them more readily accessible. The underlined characters indicate that the menu item can also be invoked using the key combination ALT + character. From the menu, a selection can be made using just the underlined character.

Click on the pull-down menus from the menu bar to see which functions are available:

File	Sensor	Options	Window	Help
Open **Save** **Print** **Export** **Exit**	**Read Sensor** **Write Sensor** **Reset Sensor** **Master Mode** **Save Configuration** **Read Configuration** **Log File** **Start Recording** **Sensor Info**	**see Figure 2.1 on Page 8**	**Show It** **Distance** **Parameter** **Command Input** **Port Monitor** **Default Position**	**Contents** **About**

As mentioned above, some of the button and menu functions are identical.

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File Menu

Open	The parameters saved to hard disk or floppy disk using Save or Export update the parameters in the sensor and the software.
Save	The current sensor parameter values are saved in a file of your choice on hard disk or floppy disk.
Print	Important data, such as type designation, year of manufacture, version number and the parameters, are printed with the date. Comments can be added before the data is printed. The button can be used to start the default printer; the menu can be used to select and set up the printer.
Export	Same as “Save”, although the data can be exported in TXT or CSV format. Exporting in CSV format is useful, for example, when inserting text in an MS Excel worksheet.
Exit	Exit the program

Sensor Menu

Read Sensor	Read the sensor parameters into the program via the interface, update the parameter window and display.
Write Sensor	Transfer data from the software to the sensor.
Reset Sensor	The sensor parameters are reset to the factory setting stored in the sensor and the parameter values in the program updated accordingly.
Master Mode	Puts the sensor into Master Mode. The sensor will now send data continuously to the program.
Configuration Save	All current parameter values are saved to a separate location in the sensor. This function is not available for all sensors.
Read Configuration	The data saved in the sensor using the “Save Configuration” option is retrieved and the sensor parameters set up accordingly.
Log File	All the settings necessary for creating a log file can be entered using a comprehensive input dialog. (see chapter 5)

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Recording Start/Stop	**Start or Stop recording using the parameters specified under “Log File”.**
Sensor Info	**Display the sensor type and the version number of the software installed in the sensor.**

Options Menu

Calls up a dialog box in which the serial interface, the language options and options regarding the help system are defined: (see Figure 2.1 on Page 8):

- The selected interface is displayed in the left of the footer. If the display is greyed, the interface cannot be initialised.
- Help texts relating to the toolbar buttons and the parameter window are displayed when the help option is checked.
- Help texts regarding the button, options, functions or menus selected with the mouse cursor are called up using function key F1.

Quitting the dialog by clicking on OK saves the options permanently; the Cancel button discards any changes that were made.

Window Menu

Show It	**Visualisation of the current measuring geometry showing sensor, signal link, specified switching points and identified target. Replica LEDs indicate the communication and switching status or analog values of the outputs: LED sensor: green - sensor interface/program communications working OK LED S1/S2 : yellow - output switched**
Distance	**Displays the current measured distance in mm. The size (incl. full screen display) and position of the display field on the screen can be selected as required.**
Parameter	**Header: Sensor type Window: numerous parameter fields that are used to select the basic framework for the evaluation method, set the switching point, switching mode, hysteresis or measuring range limits or determine the status of the DIP switches. The input fields are clearly arranged. They will vary depending on the type of sensor that is connected. Editing is a very straightforward matter and no knowledge of the command syntax is required. It is useful to check everything in conjunction with the “Show It” function, which can be opened at the same time.**

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Command Input	**The dialog field that opens enables commands to be entered directly. An interpreter analyses the inputs and updates the parameter window as necessary. The last 10 commands are stored and can be called up.** **The response from the sensor is displayed.** **See "Command set for Ultrasonic sensors" for details of command syntax and their function.**
Port Monitor	**Displays all the data that is being exchanged with the sensor:** **W: (Write) - Data to sensor/R: (Read) - Data from sensor** **Static, dynamic or both types of data can be displayed on the monitor:** x **static** - user inputs, i.e. entries in the parameter window or using "Send Command" with command input x **dynamic** - The commands sent from time to time to the sensor from the opened "ShowIt" or "Distance" window are displayed. **The Clear button clears the displays.** **The Port Monitor stores the last 100 communication actions.**
Default Position	**Restores the display to its default settings.** **In situations where all the windows are open and perhaps overlap, they can be tidied up using this option. (see chapter 4.1).**

Help Menu

Contents	**Contents of the online help**
About	**Information about the software**

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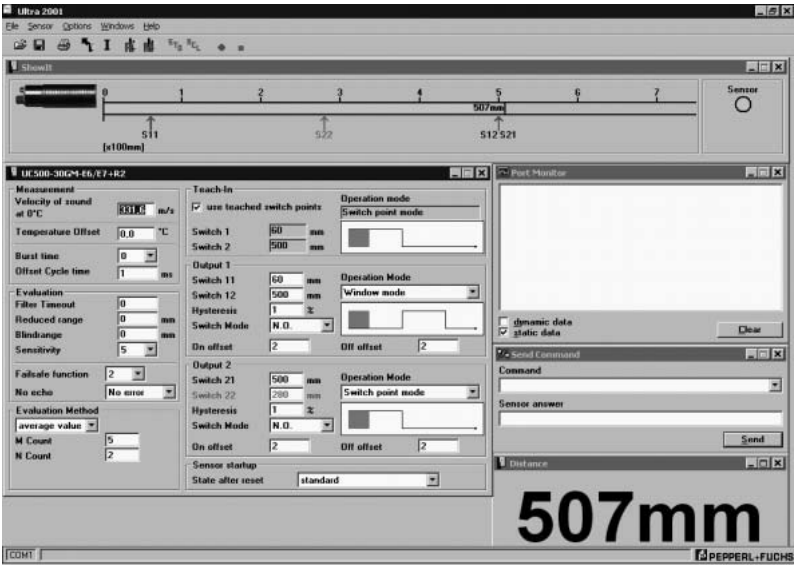

Figure 3.1: Screenshot with all activated windows

4 Using the display and parameter setting options

4.1 Arrangement on the screen

The multitude of possible displays makes it tempting to open all the windows simultaneously. This, however, would at first be unintelligible. Only those windows that are definitely required should be used.

If all the windows are important, an arrangement is possible as shown on our template. If everything starts overlapping when the fields are moved, don't panic! By clicking on the option "Default Position" in the "Window" the windows will be rearranged in a clear and logical manner.

Note

In the case of a small screen, the option exists after opening all the windows of superimposing a full-screen parameter setting window over the combined "Show It", "Port Monitor", "Send Command" and "Distance" menus. The latter windows are only visible when the parameter setting window is closed or moved.

Note

All windows can only be minimised to a minimum size.

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4.2 Parameter setting window

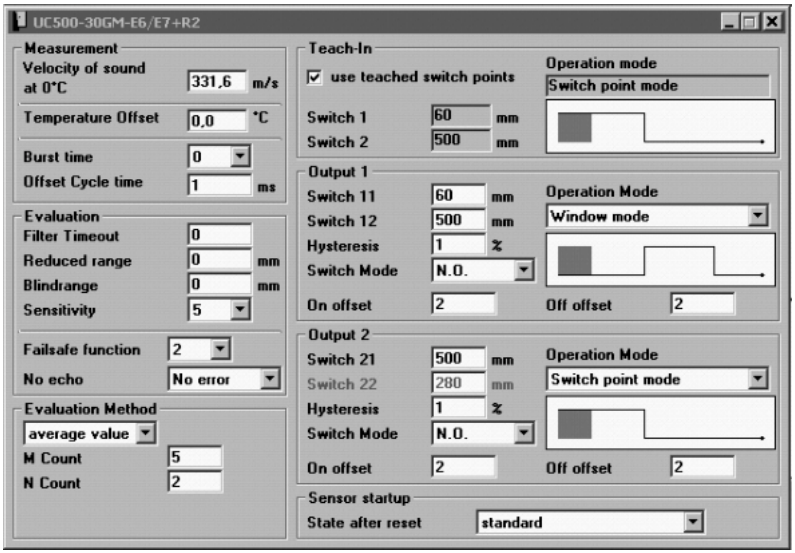

Figure 4.1: Parameter setting window for example UC...-30GM-E6R2/E7R2...

The choice of displays and associated parameter setting options varies according to the sensor type connected. The type key for the connected ultrasonic sensor is displayed in the header of the parameter setting window.

Attention

If the connected sensor and the type key displayed do not agree (e.g. after replacing a sensor), the sensor data must be re-entered:
Button or from menus "Sensor" Option "Read Sensor".

Online help

The comprehensive nature of the extensive parameter setting options sometimes requires a special knowledge of the commands and the effect they have on the sensor. The commands are described in the "Command set for ultrasonic sensors".

For newcomers to the system, the online help offers valuable explanations of the options, parameters and their application. The sometimes specific details always refer to the connected sensor, and are therefore also indispensable for the expert.

The online help supplies important information in various ways:

Note

1. The online help is activated when the cursor is located in a field and the F1 key is pressed at the same time.
The text field that appears provides clear explanations of the option, method, parameter, etc., selected with the cursor.

This applies to all windows.

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Note

2. When the cursor is located on a field, an explanation of it is displayed below in the event bar. In the case of parameter values, the relevant value range of that parameter for the connected sensor is also displayed.

If the information stated in section 2. does not appear, the online help is not activated (see chapter 2.4).

Open the “Option” menu and highlight the “Help Settings” prompt in the dialog box that appears. Select OK to close the dialog box.

Modifying parameter values

Note

The parameter values are modified directly in the corresponding field. Press the “Enter” key or click on a different input field to confirm the value.
The software will reject invalid parameters.
If the operation of a sensor has become unreliable, perhaps as the result of an incorrect parameter setting, all basic functions can be restored by resetting the default values.
Button *or “Reset Sensor” option in the “Sensor” menu.*

4.3 “Send Command” and “Port Monitor” windows

Opening both these windows simultaneously is the ideal way of sending command parameters to the sensors.

To see the effect of the command straight away, open the parameter setting window as well.

An interpreter supports the **“Send Command”** window, converts all text inputs into upper case and transmits the commands to the sensor. The last 10 commands are stored in the input, from where they can be retrieved as required and re-used using the “Send” key.

The response to the command appears in the “Sensor Response” field. This may be an error message, the interrogated evaluation mode, parameter values or coded information concerning the status of the sensors, outputs, etc.

Modifications to the parameters are displayed in the parameter window after the transfer has taken place.

All data that is exchanged with the sensor is displayed in the **“Port Monitor”** window. Data transmitted to the sensor begins with W: (Write).

Data received from the sensor begins with R: (Read).

Note

Commands to the sensor end with <CR>, carriage return; outputs from the sensor end with <CR> and <LF>, line feed. This means that commands and responses can be easily distinguished from each other.

The Port Monitor stores the last 100 communication actions. It is useful, therefore, to increase the window height slightly.

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The operator can influence the visible output via the two selection fields “Dynamic Data” and “Static Data” fields:

Dynamic Data All data concerning the processes running in the background is displayed.

The “Show It” and “Distance” windows transmit commands to the sensor at periodic intervals. These commands can be visualised via this option.

Static Data This filter controls the logging of operator inputs. All inputs which are made in the “Send Command” or parameter setting window are displayed using this option.

Note

The effects of individual commands on the sensor and its responses can be checked easily if you only enable the display “Static Data” in the “Port Monitor” and clear its display field beforehand.

5 Logging measurement series

One important feature of this software is its ability to configure measurement series and record the results. The corresponding “Log File” option, which is used for defining typical values for the measurement series and the log, can be found in the “Sensor” menu.

It does not make sense to start logging until the measurement task and recording method have been defined via the extensive “Log File ” dialog box. Logging can be started as follows:

- with the “Start Recording” option in the “Sensor” menu,
- with the “Start” button in the dialog box or
- with the button containing the red diamond, which is then greyed out.

Recording can only be terminated using the adjacent button with the black square.

Format of the log file:

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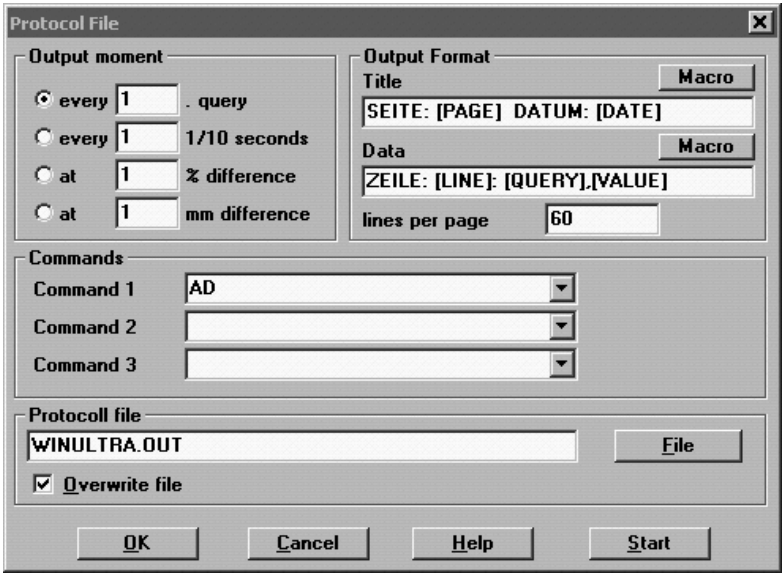

Figure 5.1: Input mask for defining and formatting the log file

Output time:

The criteria for deciding what data is to be logged are selected in this field. The first two options specify a point in time, options 3 and 4 deviation from a comparison value.

The time specified is regarded as the minimum required. The period of time between two measurements may be greater because MS Windows is not a real-time operating system.

The % and mm information in the “Difference” input fields refer to the command in the first line of the command field. The commands in the subsequent lines will only be evaluated if the condition for this command is fulfilled in the first command field.

Commands:

In the “Commands” field you specify which values are to be checked.

All three command lines contain a command set whose commands can be overwritten by others as necessary. The command syntax must be appropriate for the connected sensor.

The three lines enable three different commands to be logged. The point in time of the output always refers to command 1.

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Output format:

The "Output Format" field at the top right defines the format and style of the log file.

The "Title Bar" input field specifies which text is to appear at the start of the log and on each new page. The "Data Lines" input field refers to each line. These two input fields determine the layout of the log on the page.

Six text macros are available:

[PAGE]	Insert the current page number.
[LINE]	Insert the current line number. The line number is reset at the start of a new page.
[DATE]	Insert the date
[TIME]	Insert the time
[QUERY]	Insert the command. The processed command from the three command fields is inserted here:
[VALUE]	Insert the result of the last command executed, which is the purpose of logging.

The text macros can be entered directly into the two text input fields or by using the two macro buttons at the top right. Use upper case letters when entering text macros.

Additional text strings, which improve the appearance of the logs, may also be entered. In the simple example shown here (see screenshot and extracts from log), the string "Test log on ....." has been added to the page header and the word "Value:" to each line.

The fields have been deliberately separated with spaces.

In the example, the distance from an object and the switching state of both outputs is logged every 3 seconds.

The "Lines per Page" input field specifies the number of lines on each page. Depending on the number entered a <FormFeed> character (page break) is inserted. 60 lines per page is a good number.

The lower third of the dialog box enables the names and memory location of the data file to be specified.

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Log file:

The name of the log file is specified in this input field. If no absolute path is entered, the current ULTRA 2001 program working directory is used.

In order to maintain strict separation of the service program and the log file, you can create a special file for logging purposes using File Manager or Explorer prior to creating the log. This is facilitated by using the “File” button in the dialog box.

The “File” button initiates a further file selection dialog in which the path, file name, file type and drive can be selected.

Whether to overwrite the existing log file each time a new log is created or append the new data to the end of the previous log file is determined using the “Overwrite File” option.

Sample log: (As per log definition on Page 17)

1 Test log on 05.03.98 for sensor UC3000+U1+E6+R2

1	14:08:13	AD	value: 1842
2	14:08:13	SS1	value: 0
3	14:08:13	SS2	value: 1
4	14:08:16	AD	value: 754
5	14:08:16	SS1	value: 0
6	14:08:16	SS2	value: 1
7	14:08:19	AD	value: 646
8	14:08:19	SS1	value: 0
9	14:08:19	SS2	value: 1

2 Test log on 05.03.98 for sensor UC3000+U1+E6+R2

1	14:08:22	AD	value: 944
2	14:08:22	SS1	value: 0
3	14:08:22	SS2	value: 1
4	14:08:25	AD	value: 325
5	14:08:25	SS1	value: 1
6	14:08:25	SS2	value: 1
7	14:08:28	AD	value: 754

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Description and command set of UC sensors

UC300	-30GM-E6R2	-K	-V15
UC300	-30GM-IUR2	-K	-V15
UC500	-30GM-E6R2/E7R2		-V15
UC500	-30GM-IUR2		-V15
UCC1000	-30GM-E6R2		-V15
UC1000	-30GM-E6R2/E7R2-K		-V15
UC1000	-30GM-IUR2	-K	-V15
UC2000	-30GM-E6R2/E7R2		-V15
UC2000	-30GM-IUR2		-V15
UC4000	-30GM-E6R2/E7R2		-V15
UC4000	-30GM-IUR2		-V15
UC6000	-30GM-E6R2/E7R2		-V15
UC6000	-30GM-IUR2		-V15

UC500	+U9+E6/E7	+R2
UC500	+U9+IUE0/E2	+R2
UC3000	+U9+E6/E7	+R2
UC3000	+U9+IUE0/E2	+R2

UC6000	-FP-E6/E7	+R2
UC6000	-FP-IUE0/E2	+R2

UC300	-F43-2KIR2	-V17
UC2000	-F43-2KIR2	-V17

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9 Command set 45

AD [**A**bsolute **D**istance] 46
ADB [**A**bsolute **D**istance **B**inary] 46
BR [**B**lind **R**ange] 46
CBT [**C**onstant **B**urst **T**ime] 47
CCT [**C**onstant **C**ycle **T**ime] 49
CON [**CON**servative Filter] 49
DAT [software **DAT**e] 50
DEF [**DEF**ault settings] see command **SUC** **51**
DIP [read DIP switches] 51
EM [**E**valuation **M**ethod] 51
ER [**E**cho **R**eceived] 54
FDE [**F**ar **D**istance of **E**valuation] see command **NDE** **55**
FSF [**F**ail **S**afe **F**unction] 55
FTO [**F**ilter **T**ime **O**ut] 57
ID [sensor **ID**entification and version] 58
MA [**M**ain **A**pplication] 58
MD [**M**aster **D**evice] 59
NDE [**N**ear **D**istance of **E**valuation]
FDE [**F**ar **D**istance of **E**valuation 60
NEF [**No** Echo is **F**ailure 61
OPM [**Op**eration **M**ode] 62
OM [**O**utput **M**ode] 63
RD [**R**elative **D**istance] 64
RDB [**R**elative **D**istance **B**inary] 65
REF [**REF**erence Distance] 65
RR [Reduced Range] 66
RUC [**R**ecall **U**ser **C**onfiguration] see command **SUC** **66**
RST [sensor software **R**e**S**e**T**] 66
RT [**R**un **T**ime] 66
RTB [**R**un**T**ime **B**inary] 67
SD1[1] [**S**witching **D**istance **1.1**]
SD1[2] [**S**witching **D**istance **1.2**]
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SUC [**S**tore **U**ser **C**onfiguration]
RUC [**R**ecall **U**ser **C**onfiguration]
DEF [**DEF**ault settings] 71
SSY [**S**tartup **Sy**nchronized] 72
TEM [**TEM**perature] 72
TO [**T**emperature **O**ffset] 73
UDS [**U**se **D**ip **S**witches] 73
VER [sensor **VER**sion] 74
VS [**V**elocity of **S**ound] 75
VS0 [**V**elocity of **S**ound at **0** °C] 75

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1 Introduction

Connection via RS 232 Interface

For ultrasonic sensors with an RS 232 interface, parameters can easily be assigned via that interface. Transmission is performed using the following **transmission protocol:**

Bit rate	9600 bit/s
Parity	none
Data bits	8
Stop bit	1

COM x, according to the interface being used.

This, however, demands a detailed knowledge of the commands and the effect they have on sensor response. Older sensors with an RS 232 interface have a command format with an analog structure and a partially matching command set. However, individual commands have either changed in terms ofmeaning, functionality or syntax, while others no longer exist. The most important features of the new sensors are explained further below.

Command format:

Commands consist of	two letters, three letters four letters or two letters and one number.

If appropriate, one or more parameters separated by commas can be appended to this command.

There are pure **Query** commands for querying measurement results or non-variable sensor data, commands for **defining parameters** (which can be used without parameters for querying) and commands for **trimming/adjusting**.

(see “Overview of all sensor commands Overview”, table from page 38.

All characters are sent in ASCII code (example: the number 1 as 31h or the letter A as 41h), while on the other hand the numeric parameters are sent as decimal numbers.

Note

For commands requiring binary data transmission, e.g. ADB, RDB, RTB, the data display in the terminal program can generally not be evaluated.

By default the sensor will accept commands irrespective case.

The sensor may respond with an error message rather than requested sensor parameter or measured value.

The following **error signal** are possible:

80h (ç) No error
81h (ü) Invalid parameter
82h (é) Invalid command
83h (â) Overflow

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Possible error signals of older software versions:

30h	No error
31h	Invalid parameter
80h	Overflow
84h	Hardware error
FFh	Invalid command

The parameters sent to the sensor are stored there in the EEPROM and remain available even after an interruption to the supply voltage. The condition for this is that communication with the sensor must run without any problems for the duration of the transmission + approx. 100 ms.

The response of the sensor must be received with a delay of no longer than 1 measurement cycle (approx. 10 ms). The sensor ensures data consistency while parameters are being defined by finishing a measurement before interpreting and executing a new command.

Important features of the sensors

The sensors feature, for example,

- a **temperature sensor:**

The propagation rate of ultrasonic varies with, amongst other factors, the temperature of the carrier medium. By measuring the ambient temperature, this influence is taken into account when measuring the distance from the echo propagation time.

- an **independent switching hysteresis:**

The hysteresis of switch outputs is in limits that can be specified independently of one another.

- a **selectable blind range:**

An extended blind range can be defined, in which any echos that may be received will be ignored.

- the facility to **store** a whole set of user settings for security, and retrieve them as and when required.

- certain **changes to the evaluation methods** in relation to earlier versions of the software.

- **Default setting**

The factory settings stored in the sensor can be fetched at any time.

The commands AD, RD and RT are supplemented by new versions **ADB, RDB, RTB, RRTB** which return the required data in binary form.

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Special features of the UC... -30GM/+U9/-FP sensors

- a **synchronisation input**:

The sensors can be synchronized externally, or they may be synchronized with one another.

- independent **modes of operation** of the switch outputs:

The response of the individual sensor outputs can be modified to suit the application: switching point mode, window mode, reflex photoelectric barrier mode, double switching point mode or range monitoring.

- **additional switching points**:

Additional switching points can be configured for window mode, double switching point mode or range monitoring.

Special features of UC... -F43 sensors

- selectable **switching behavior** of the relay outputs:

Each relay can be set separately: N/C, N/O contact behavior or output inactive (de-energized operating coil).

- selectable switching points:

The switching point can be selected as required between the blind range and double the nominal switching distance for each relay.

- Options, for **interrogating distance**

The absolute distance in [mm], the relative distance in digits as a 12-bit value (up to 4095) or the echo propagation time in machine cycles. In addition to these options, it is also possible to output the required data in binary format.

2 Description of the sensors

2.1 Propagation time measurement

Ultrasonic sensors determine the distance to an object by measuring the time delay that elapses between the sending out of an ultrasonic package (burst) and the arrival of the echo reflected by the object.

If an ultrasonic sensor operates as a **single head system** with only one sound converter (as transmitter and receiver in succession), the time required by the converter for the vibration to die down creates a blind range. Echos from a defined range directly in front of the sensor are ignored. For example, with a detection range of 2000 mm, the blind range is 100 mm.

If the sensor, however, is a **two-head system** with two sound converters (one converter for sending the sound pulse and a second for registering the echo), a blind zone can be very small. If both converters are inserted in a suitable housing cavity, the detection range will start to be flush with the surface of the sensor housing.

The detection range of the sensor depends directly on the sound reflection properties of the object. Good reflectors can be detected from up to double the nominal detection range. On the other hand, an object situated close to the sensor can produce several echo signals (as the ultrasonic package passes backwards and forwards several times between the target and the sensor housing). This can lead to incorrect evalua-

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tion, for example, if the first echo falls in the blind range and only the second echo is recognized as an echo signal.

Blind range and range are functions of the energy contained in the burst: The longer the burst, the greater the range, but by the same token the time for the vibration to die down and thus the blind range of the ultrasonic transformer also increase.

2.1.1 Variable burst and measuring cycle times, parameter assignment options (CBT,CCT)

The default setting is for the sensors to work with variable burst length (CBT, 0). The evaluation adapts the burst length to match the measured echo propagation time. If the propagation time measured is short, then the sensor will shorten the burst down to its minimum length, and the burst will be set to the maximum length if the sensor receives a distant echo. If the sensor is unable to detect any echo, it toggles the burst length between maximum and minimum.

The command **CBT** (CBT,xxx [µs]) fixes the burst length to a constant value. The burst sent out always has the same length irrespective of the echo propagation time measured.

The parameter for CBT can be set with the ULTRA 2001 service program in the Parameters window via the Cycle time entry field.

The command **CCT** influences the measuring cycle time. After CCT,0, the evaluation adapts the measurement cycle to the echo propagation time determined: the measurement is terminated if no further echo occurs within 2.5 times the time following the last echo.

The sensor determines the result and starts the next measurement. Shorter response times thus occur, but also the danger of incorrect measurements in the case of very distant objects. If echos are picked up from them after the new burst, these may be mistaken for echos from very close objects.

The CCT,xxx [ms] command sets a constant cycle length. However, pauses of variable length (1...1000 ms) are inserted between the cycles. This means that echos from distances greater than 6.5 m can be reliably evaluated as well, although the response time of the sensor increases.

The parameter for CCT can be set with the ULTRA 2001 service program in the parameter window via the Offset Cycle Time entry field.

2.1.2 Blind range, parameter setting options (BR)

Ultrasonic **two-head systems** send sound impulses via one ultrasonic transducer and receive the echo via a second. With this type of evaluation, the blind range is negligible. The sensor normally uses the first echo received to determine the echo propagation time. In this way, an object near the sensor is always detected.

If this object is to be disregarded, however, because the region to be monitored begins behind it, the sensor can be allocated a configured blind range using the **BR** command.

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With ultrasonic **single-head systems** the blind range is determined by the decay time of the ultrasonic converter. The decay behavior of the ultrasonic converter changes depending on the temperature. For this reason, the default setting of the ultrasonic sensors will ignore all echo signals for up to 75 % of the blind range quoted in the data sheet.

If a larger blind range is required (for example, to eliminate an unwanted nearby object in the detection range), this range can be selected via the **BR** command.

The sensor ignores all echo signals received up to the distance specified by BR,xxx [mm]. An object may however generate a second or third echo which lies beyond the blind range, and thus produces an incorrect measurement. The evaluation can no longer recognize and suppress duplicate echos.

2.1.3 Reduced range (RR)

This command can be used to reduce the upper limit of the detection range (background suppression).

The command is useful with the setting NEF=1 (No echo Failure). In this setting the sensor interprets an echo coming from a greater distance or a missing echo as an error and switches to a state defined by FSF (Fail Safe Function).

The maximum required distance in units of mm is entered as the parameter.

2.1.4 Sensitivity (SEN) (UC...-30GM)

This parameter can be used to set the sensitivity of the sensors.

In applications in which may protrude into the detection range, the reliability of the system can be increased by reducing the sensitivity of the sensor to a level at which these “disturbance targets” are suppressed. In this way not only the “forward” range of the sensor is reduced, but also the sonic beam divergence angle is smaller.

In level control applications, disturbance targets may be droplets or other adhesions inside standpipes or side obstructions such as columns along the section of an electric monorail overhead conveyor.

Whether disturbance targets protrude into the detection range of an ultrasonic sensor can be assessed from the local installation conditions and the response characteristics specified in the data sheet.

If the sensor sensitivity needs to be adapted, this will result in a change of the sensor's detection range. Values between 3 and 31 can be set.

3 corresponds to a high sensitivity (high range)
31 corresponds to low sensitivity (low detection range)

6 is the default value. The detection range specified in the data sheet is ensured with this setting. Smaller values increase sensitivity, for example for the detection of very small or poorly reflecting objects, at this same time, however, with a reduction in interference immunity.

The sensitivity setting is nonlinear. The graduations increase in fineness the smaller the SEN parameter selected.

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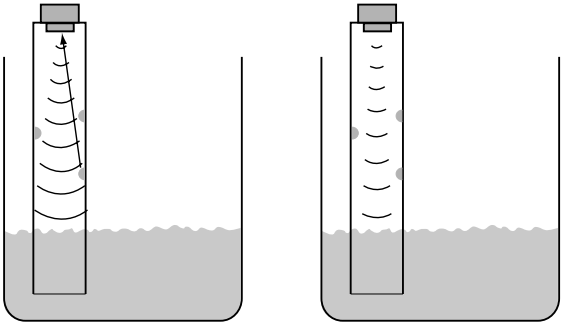

Reflection at disturbance targets Disturbance target suppressed

3 Temperature effect and compensation, parameter setting options (TO, VS0, TEM, REF)

The propagation rate of sound depends on the physical properties of the carrier medium. In the case of a gas-air mixture, temperature changes greatly affect the velocity of sound. Air pressure and humidity are lesser factors. Incorrect temperature induced measurements of the sensor are compensated by determining the temperature.

The temperature measurement is generally carried out inside the sensor and thus does not directly include the temperatures in the measurement range. The offset value **TO** takes into account the difference between the temperatures in the sensor and in the sound measurement range.

If the sensor is to operate in a gas other than air, the corresponding sound velocity in this gas at 0 °C must be set using **VS0**.

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The temperature (in Kelvin) measured at the temperature probe can be interrogated by the **TEM** command. The TEM command with a parameter (TEM,xxx), on the other hand, provides a temperature from which the resulting temperature offset TO can be calculated using the measured temperature.

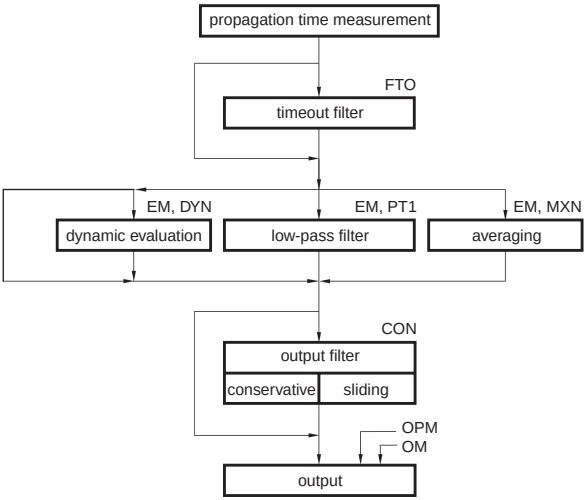
Another possibility is to allocate a reference distance to the sensor via the **REF** command. A target must then be located at the specified distance in the detection range. Using this distance and the measured echo propagation time, the sensor calculates the VS0 value, taking into consideration the previously defined offset TO. The sound velocity VS0 of a gas mixture can thereby be determined.

4 Evaluating the measured echo propagation times, parameter setting options (EM, ...)

Propagation time measurement produces an echo propagation time corresponding to the distance of the object. Disturbances can occur, caused for example by electromagnetic effects, interference noise, multiple echos or echos from other (unsynchronized) ultrasonic sensors. Different evaluation methods provide greater protection from disturbance. Of these only one can be activated:

- No evaluation
- Dynamic evaluation
- Low-pass filter (PT1-)
- Averaging (with extreme value suppression)

For special applications, an additional **FTO** filter ensures that measurements without a recognized echo are ignored.



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4.1 Masking out measurements without echo, timeout filter (FTO)

This additional filter checks before the evaluation whether or not an echo has been received. If not, the measured value is rejected and the evaluation is aborted. The filter is active when the **FTO** command has been issued with a parameter. The parameter determines the number of measurements without echo that are to be discarded.

4.2 Dynamic evaluation (EM,DYN[,N])

The evaluation algorithm compares the echo propagation time already measured against an expected value, which is calculated from the last measured value and the difference from the last measured value but one. If the present measurement value does not correspond to the expected value, it is replaced once by the expected value. The measurement must deviate for a second time before it will be accepted.

The parameter **N** specifies the permitted deviation of the final measured propagation time from the expected value as a percentage (1 % ... 15 %). If no parameter or zero is passed, then the default value N = 1 [%] is used.

4.3 Low-pass filter (PT1-) (EM,PT1[,N[,P[,C]]])

Sudden, wild fluctuations in the measured echo propagation times act on the measurement result as though filtered through a low-pass filter.

The PT1 evaluation adds the actual measured value to the weighted final measurement result and from this calculates the nearest measurement result.

The parameter **N** (0 ... 999) determines the weighting factor. If no parameter N is specified, N takes the default value of 200.

Weighting algorithm: see command EM,PT1... in the command set.

Acceptance window (PT1)

An extra level of immunity to interference is provided when an acceptance window is activated (P not equal to 0). Up to a certain threshold (C), any measured values that exhibit more than a permitted percentage deviation (P in %) from the previous result will be discarded. Any spontaneous disturbances are therefore not even included in the PT1 evaluation.

Only if a specific number of measured values in succession fall outside the acceptance window will the subsequent values again be included in the PT1 evaluation.

4.4 Calculation of average with suppression of extreme values (EM,MXN,M,N)

This evaluation uses the parameters M (1 ... 8) and N (0 ... 3) to determine how many echo propagation times are included (M) and how many are excluded (N) from the evaluation. The algorithm removes the N worst measured values from the M most recent ones. The average is calculated from the remaining (M minus N) values.

Requirement: N < M/2.

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4.5 Conservative or sliding output filter (CON)

To switch an output, the calculated result must remain above or below the switching point for a certain number of measuring cycles. Depending on the value of CON, this filter operates either conservatively (CON < 10) or sliding (CON ≥ 10).

The value of the parameter in the CON command acts at the same time as a counter for the depth of the filter.

Conservative (CON < 10): The output will be switched if CON is (always) nearer the test result than the switching point. The counter will be reset to zero even if just one measured value exceeds the switching point. The filter will then expect a succession of CON measurements nearer the switching point.

Sliding (CON ≥ 10): An up-down counter increments when the measured values are nearer than the switching point and decrements in cases where the results are greater than the specified switching point. The output switches when the counter reaches the value of CON and switches back when the counter has a value of zero.

5 Modes of operation of the switch outputs, configuring options (OPM)

The switch outputs of the ultrasonic sensors can switch according to the mode of operation:

- Switching mode (default),
- Window mode,
- Reflex photoelectric barrier mode,
- Double switching point mode,
- Range monitoring

The switch outputs can also be configured as N/C contacts or N/O contracts, irrespective of the mode of operation.

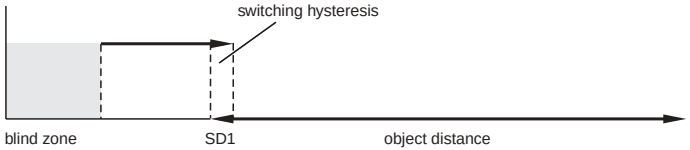
E6/E7 sensors: both switch outputs can be set independently of each other.

IUE0/E2 sensors: the IU output only works in standard mode or range monitoring. Operation with zero point line is a special case of standard mode in which NDE corresponds to a distance of 0 mm.

UC...-F43-... sensors always work in **switch mode**.

5.1 Switching point mode (S)

The switch output switches when an object is detected that is nearer than the selected switching point. If the object disappears, the output switches back again using the delay inherent in the hysteresis value. Sensors with differing detection ranges have blind ranges that are also of different sizes. Details can be found in the data sheets.



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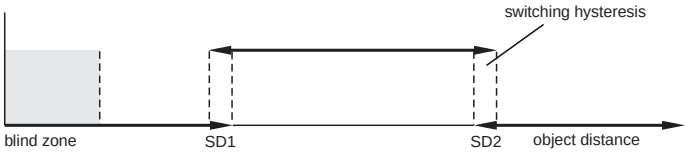
5.2 Window mode (W)

The switch output only switches if the sensor detects the first echo within the evaluation window. The window sizes are configurable (DIP switches or parameter inputs).

If a number of echos arrive at the sensor at different times, one of which is **before** SD1, the output will not switch even if there is an echo in the measuring window. The sensor only evaluates the first echo. It is therefore not possible to detect multiple echos in this way.



5.3 Reflex photoelectric barrier mode (R)

The switch output switches in the following circumstances:

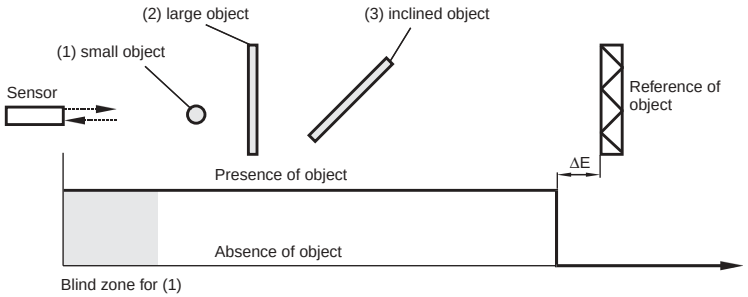
(1) the sensor picks up echos from a small object in the sound cone and from the reference reflector,

(2) the sensor detects a large object but does **not** receive an echo from the reference reflector,

(3) the sensor is not picking up any echos because, for example, an object is lying at an angle and deflecting the sound.

The position of the reference reflector must not be changed. The distance taught, for example through SD1, must be smaller than the distance to the reflector by the amount Δ E:

UC 3000 ΔE > 2 % 3000 (60 mm)
UC 6000 ΔE > 2 % 6000 (120 mm).



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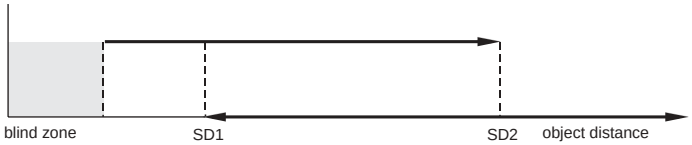
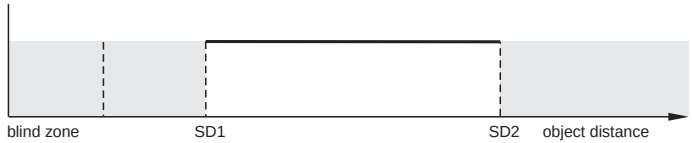
5.4 Double switching point mode (H) switch output (hysteresis mode)

The sensor retains the previous switching status in an area of the evaluation window selected using DIP switches or parameter inputs. The switching output switches when an object approaches the sensor switching point and only switches back when the object moves away beyond the switching point at a distance from the sensor. Both switching points generate a large hysteresis.



5.5 Range monitoring (L) switching output

The sensor monitors the evaluation window. The output only switches when an object is detected within the window. Echos from ranges in front of or behind the evaluation window are ignored. Multiple echos from the zone that is grayed out, including echos in front of SD1, do not affect the evaluation.



5.6 Standard mode (S) IU output

The current/voltage output provides a signal that is proportional to the distance. The range limits NDE, FDE can be selected by a command and for the *VariKont* (U1, U9) and -FP series also by setting DIP switches. For evaluation with the *VariKont* (U1, U9) and -FP series, the value of the UDS flag is therefore important. With UDS, 1 the switch setting is valid, with UDS, 0 the values of NDE and FDE are valid.

If the range limits are selected such that NDE > FDE, the current/voltage value will have a falling output ramp.

5.7 Range monitoring (L) IU output

The sensor only monitors the evaluation window that is delimited on both sides by a blind range. The IU output provides a signal that is proportional to distance. The range limits NDE, FDE can be selected by a command and for the *VariKont* (U1, U9) and -FP series also by setting DIP switches (see section 5.6).

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Echo from areas that are grayed out are ignored, but do not result in an interruption of the measurement.

5.8 Zero point line IU output (only UC...-30GM-... series)

The zero point line is a special case of standard operation in which parameter NDE = 0. This means that the analog output characteristic is set so it reaches its maximum value 10 V/20 mA when the distance corresponding to parameter FDE is reached. The minimum value 0 V/4 mA would be reached with an object distance of 0 mm. Due to the blind range present, this distance is only of theoretical importance.

6 Switching functions, configuring options (OM)

6.1 UC...-30GM/+U9/-FP: N/O and N/C switching functions

Switching outputs can work as N/C or N/O contacts. The **OM** command is used to configure both switching outputs as N/C or N/O contacts independently of each other. Which potential is switched -PNP or NPN - has no effect as both variants use the same software.

6.2 UC...-F43: switching function N/C, N/O contact and inactive

Switching outputs can work as N/C or N/O contacts. The **OM** command is used to configure both working contacts of both relays as N/C or N/O contacts independently of each other. A third option can be used to deactivate the operating coil.

6.3 Fail-safe switching function, configuring options (FSF)

The sensor can be assigned a fail-safe switching function for fault situations. The default is the type 0 fail-safe switching function, where the switching outputs or the analog outputs retain their existing states.

In the case of type 1, the sensor responds as if an object had been detected.

In the case of type 2, on the other hand, as if the sensor had not detected an object.

If a fault current of 0 mA to 4 mA (or a voltage of 0 V to 2 V) had also been specified for the analog output, this current (or voltage) value will be on the analog output in the event of a fault.

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7 Synchronization of ultrasonic sensors

The sensors are not synchronized during normal operation. An interaction can therefore occur if a minimum distance is not observed during installation.

The necessary minimum distance can be relatively large, depending on the nominal detection range, the distance to the object and the site conditions. There will therefore be an area between two sensors that will remain undetected.

If an area of shadow like this is unacceptable, in other words the ultrasonic sensors must operate within a confined area, interaction can be prevented by synchronizing the sensors. The **Sync synchronisation input and output** is provided for this purpose on selected ultrasonic sensors.

Synchronization pulses sent to the output initiate the measuring cycle in the sensor.

Sensors equipped with a synchronization input/output operate as follows:

- individual sensors asynchronized (Sync is not wired)
- adjacent sensors synchronized (Sync lines connected)
- synchronisation via an external control
- High signal deactivates the sensor (standby)

In the event of a constant low signal (or Sync remains unwired) the sensor operates in asynchronized mode.

The sensor reports an active measuring cycle by outputting a High signal on Sync. If the synchronization lines of adjacent sensors are connected, the sensors synchronize themselves (without an external control). Only one sensor performs a measuring cycle at any one time. The response time of the sensor increases as the number of sensors increases.

In the case of external synchronization, an external control issues an synchronization pulse to each sensor in turn. The sensors operate in a multiplexed manner, i.e. one after the other. The response time also increases in this case as the number sensors increases.

If the synchronization pulse is issued to all the sensors simultaneously, they will all switch to synchronous operation.

If the signal is always High, the sensor will switch to standby mode (after 1 second).

Creating the synchronous signal

The synchronization pulses on Sync can be positive or negative; in both cases, the measuring cycle in the sensor is initiated by the falling edge. The maximum repetition rate, the time to the start of the next measuring cycle, depends on the type of sensor and the number of synchronized sensors.

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8 All sensor commands at a glance

8.1 Command set of UC... sensors

Com-mand	Meaning	Type	Parameter/Response/ Acknowledge	-30GM series	+U9/-FP series	-F43 series	Page
AD	Absolute Distance	read	Distance in [mm]	●	●	●	46
ADB	Absolute Distance Binary	read	Distance in [mm], binary		●	●	46
BR	Blind Range	read/ set	Extended blind range in [mm]	●	●	●	46
CBT	Constant Burst Time	read/ set	Burst length in [µs]	●	●	●	47
CCT	Constant Cycle Time	read/ set	Pause time in [ms]	●	●	●	49
CON	CONservative fil-ter	read/ set	Type of filter, encoded, counter threshold value		●	●	49
DAT	Software DATe and version	read	Date, time	●	●	●	50
DEF	DEFault settings	Com-mand	Set default settings	●	●	●	51
DIP	Read DIP switches	read	DIP switch position, encoded		●	●	51
EM	Evaluation Method	read/ set	Evaluation method, encoded (NONE/PT1,../MXN,.../ DYN,...)	●	●	●	51
ER	Echo Received	read	Echo detected yes/no		●	●	54
FDE	Far Distance of Evaluation	read/ set	Far limit of measuring window in [mm]	●	●	●	55
FSF	Fail Safe Function	read/ set	Fault response, fault cur-rent on output	●	●	●	55

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Command	Meaning	Type	Parameter/Response/ Acknowledge	-30GM series	+U9/-FP series	-F43 series	Page
FTO	Filter Time Out	read/ set	Filter depth, number of measurements to be filtered without echo	●	●	●	57
ID	Sensor IDentification	read	Type, EPROM, version	●	●	●	58
MA	Main Application	read/ set	Meaning of green LED		●	●	58
MD	Master Device	read/ set	Master or Slave mode of the sensor		●	●	59
NDE	Near Distance of Evaluation	read/ set	Near limit of measuring window in [mm]	●	●	●	60
NEF	No echo is Failure	read/ set	Reaction when No echo	●	●	●	61
OM	Output Mode	read/ set	Output mode (1) N/C, (0) N/O	●	●	●	63
OPM	Operation Method	read/ set	Mode of operation of the outputs: S,R,W,L,H	●	●	●	62
RD	Relative Distance	read	Relative distance, digit (0...4095)		●	●	64
RDB	Relative Distance Binary	read	Relative distance, binary		●	●	65
REF	Reference Distance	Adaptation of VS0	Reference distance in [mm]		●	●	65
RR	Reduced Range	read/ set	Setting of background suppression in [mm]	●			
RST	Sensor software ReSeT	Command	Reset acknowledge 0	●	●	●	66
RT	Run Time	read	Echo propagation time in machine cycles	●	●	●	66

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Com-mand	Meaning	Type	Parameter/Response/ Acknowledge	-30GM series	+U9/-FP series	-F43 series	Page
RTB	RunTime Binary	read	Echo propagation time in machine cycles		●	●	67
RUC	Recall User Configuartion	Com-mand		●	●	●	66
SD1[1]	Switching Distance 1.1	read/ set	Near switching point/ out-put 1 in [mm]	●	●	●	67
SD1[2]	Switching Distance 1.2	read/ set	Far switching point/out-put 1 in [mm]	●	●	●	67
SD2[1]	Switching Distance 2.1	read/ set	Near switching point/ out-put 2 in [mm]	●	●	●	67
SD2[2]	Switching Distance 2.2	read/ set	Far switching point/out-put 2 in [mm]	●	●	●	67
SEN	SENsitivity	read/ set	Setting of the sensor sen-sitivity (3 ... 31)	●			
SH1	Switching Hysteresis 1	read/ set	Switching hysteresis for output/relay 1 in [%]	●	●	●	70
SH2	Switching Hysteresis 2	read/ set	Switching hysteresis for output/relay 2 in [%]	●	●	●	70
SS1	Switching State 1	read	Switch output/relay 1 active (1)/inactive (0)		●	●	70
SS2	Switching State 2	read	Switch output/relay 2 active (1)/inactive (0)		●	●	70
SSY	Startup Synchronized	read/ set	0/1 for normal/synchro-nous operation following Reset	●	●	●	72
SUC	Store User Configuartion	Com-mand	Save parameter values		●	●	71
TEM	Temperature	read/ adapt	Temperature at sensor in [0.1 K]		●	●	72
TO	Temperature Offset	read/ set	Temperature offset in [0.1 K]	●	●	●	73

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Com-mand	Meaning	Type	Parameter/Response/ Acknowledge	-30GM series	+U9/-FP series	-F43 series	Page
UDS	Use Dip Switches	read/ set	0/1 for inactive/active DIP switches		●	●	73
VER	sensor VERsion	read	Query version code		●	●	74
VS	Velocity of Sound	read	Current sound velocity in [cm/s]		●	●	75
VS0	Velocity of Sound at 0 °C	read/ set	Velocity of sound at 0 °C in [cm/s]	●	●	●	75

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8.2 Ranges and default values of sensors UC...-F43

Com-mand	Meaning	Range	Default Values
BR	Blind Range	0 ... 800 [1] 0 ... 4000 [2]	0
CBT	Constant Burst Time	0,1,2, 3	0
CCT	Constant Cycle Time	0 ... 1000	1
CON	CONservative filter	0 ... 255	2
EM	Evaluation Method	MXN, 2 ... 8, 0 ... 3 PT1, 0 - 1000, 0 ... 15, 0 ... 15 DYN,0 ... 15	MXN,5,2
FDE	Far Distance of Evaluation	1 ... 800 [1] 1 ... 4000 [2]	300 [1] 2000 [2]
FSF	Fail Safe Function	0,1,2 ; 0 ... 40	00,39
FTO	Filter Time Out	0 ... 255	0
MA	Main Application	A,S	S
MD	Master Device	OFF,AD,RD,RT,DAD, DRD,DRT, ADB,RDB,RTB	OFF
NDE	Near Distance of Evaluation	1 ... 800 [1] 1 ... 4000 [2]	25 [1] 100 [2]
NEF	No echo is Failure	0,1	1
OM	Output Mode	0,1,I	00
SD1[1]	Switching Distance 1/1	1 ... 800 [1] 1 ... 4000 [2]	25 [1] 100 [2]
SD1[2]	Switching Distance 1/2	1 ... 800 [1] 1 ... 4000 [2]	50 [1] 1000 [2]
SH1	Switching Hysteresis 1	0 ... 15	1
SH2	Switching Hysteresis 2	0 ... 15	1
TO	Temperature Offset	-200 ... +200	80
VS0	Velocity of Sound at 0 °C	10000 ... 60000 [1] 12000 ... 60000 [2]	33160

1) UC300-F43-2KIR2-V17 sensors
2) UC2000-F43-2KIR2-V17 sensors

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8.3 Default values of UC...+U9/-FP sensors

Com-mand	Meaning	Default values		
		UC500	UC3000	UC6000
BR	Blind Range	0		
CBT	Constant Burst Time	0		
CCT	Constant Cycle Time	1		
CON	CONservative filter	2		
EM	Evaluation Method	MXN,5,2		
FDE	Far Distance of Evaluation	500	3000	6000
FSF	Fail Safe Function	0 [,-1]		
FTO	Filter Time Out	0		
MD	Master Device	OFF		
NDE	Near Distance of Evaluation	60	300	800
OM	Output Mode	00		
OPM	Operation Method	SS		
SD1[1]	Switching Distance 1/1	60	300	800
SD1[2]	Switching Distance 1/2	280	1650	3400
SD2[1]	Switching Distance 2/1	500	3000	6000
SD2[2]	Switching Distance 2/2	280	1650	3400
SH1	Switching Hysteresis 1	1		
SH2	Switching Hysteresis 2	1		
SSY	Startup Synchronized	0		
TO	Temperature Offset	0		
UDS	Use Dip Switches	1		
VS0	Velocity of Sound at 0 °C	33160		

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8.4 Default values of UC...-30GM sensors

Com-mand	Meaning	Default values:					
		UC300	UC500	UC1000	UC2000	UC4000	UC6000
BR	Blind Range	0					
CBT	Constant Burst Time	0					
CCT	Constant Cycle Time	1 ms	1 ms	1 ms	1 ms	12 ms	50 ms
EM	Evaluation Method	Averaging 5/2					
FDE	Far Distance of Evaluation	300 mm	500 mm	1000 mm	2000 mm	4000 mm	6000 mm
FSF	Fail Safe Function	0					
FTO	Filter Time Out	0					
NDE	Near Distance of Evaluation	60 mm		200 mm		500	800
OM	Output Mode	0					
OPM	Operation Method	NC					
RR	Reduced Range	0					
SD1[1]	Switching Distance 1/1	60		200		500	800
SD1[2]	Switching Distance 1/2	500		2000		4000	6000
SD2[1]	Switching Distance 2/1	500		2000		4000	6000
SD2[2]	Switching Distance 2/2	280		1100		2250	3400
SEN	SENsitivity	6					
SH1	Switching Hysteresis 1	1 %					
SH2	Switching Hysteresis 2	1 %					
SSY	Startup Synchronized	0					
TO	Temperature Offset	70					
VS0	Velocity of Sound at 0 °C	33160					

9 Command set

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Special features of UC...+U9/-FP sensors

These sensors are provided with DIP switches in which parameters can be stored.

Some commands use parameter values that are set using the DIP switches (switching points, limits of evaluation window, etc.).

Attention

Using the UDS query it is possible to check in advance of such commands whether or not the DIP switch setting is evaluated.
If the UDS flag is set to zero, then the applicable values are not those from the DIP switches, but (other) parameter values defined and stored previously. The reaction of the sensor varies accordingly.
Following UDS,1 the DIP switch setting applies!

Special features of UC... -F43 sensors

These sensors are designed for level measurement applications.

The UC300 sensor is designed as a two-head system. The two ultrasonic converters are fitted in a cavity in the housing. The minimum blind range is located within the cavity.

The UC2000 operates as a single-head system and has a blind range of approx. 100 mm.

As the sensor in level measurement applications normally receives one echo (for example, from the bottom of the empty container) the absence of the echo is evaluated as an error.

Note

Use of the parameter assignment software is made easier if you run the command NEF,0 at the start. This prevents the sensor from having to signal error status and therefore stop measuring every time there is a sensor or target movement where the sensor does not detect an echo.
This can also be achieved by selecting “No Error” “Malfunction Response” field.

Special features of UC... -30GM sensors

These sensors do not have a physical RS 232 interface. Communication with the PC or laptop is implemented using the simulation of an RS 232 interface, with connections that are shared with the temperature/teach-in plug.

As long as the sensor is connected with the interface of your PC or laptop the sensor cannot execute temperature compensation.

Note

The serial interface is only provided for setting sensor parameters. Some of the commands described can only be used with the interpreter inside ULTRA 2001. The complete parameter setting of the sensors is therefore only possible using the ULTRA 2001 software and ***not*** *via standard terminal programs.*

The temperature/teach-in plug must be fitted after the parameter assignment has been completed.

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AD [**A**bsolute **D**istance]

Command: AD	**Example: -**
Parameter: -	**Unit: -**
Response: Distance [mm]	**Range: -**
Reference: Master mode	

The AD command requests the calculated absolute distance. The sensor returns the measured value in [mm], sometimes even when it lies outside the evaluation range. However, operation in the blind range is not permitted. No guarantee can be given that the system will function properly in the area outside the detection range.

The response returned if no echo was received: Maximum value

(2 x detection range + 1).

Response in the case of faults: Error code E:

ADB [**A**bsolute **D**istance **B**inary]

Command: ADB	**Example: -**
Parameter: -	**Unit: -**
Response: Binary, distance	**Range: -**
Reference: AD	

The same result is returned as with AD, but in binary format.

The bytes corresponding to the binary value are, as a rule, non-printable ASCII characters, which are not displayed by the terminal program.

Example of the distance 1445 mm: Response = <05h><A5h> <CR>.

Response in the case of faults: Error code FFFEh

BR [**B**lind **R**ange]

Command: BR/BR,xxxx(x)	**Example: BR,400**
Parameter: Blind range	**Unit: mm**
Response: current, parameter Blind range	**Range: ½ blind range .. 2 x nominal detection range**
Reference: Single, two head system, blind range, NDE, OPM, L	

The BR command requests the current value of the configured blind range.

A response of 0 means that the sensor is not operating with an extended blind range, and the value from the data sheet is applicable.

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The response xxxxx specifies the width of the currently configured blind range in [mm].

BR,xxxxx is used to assign to the sensor a range similar to the blind range.

Up to this distance the sensor ignores any echos received. This has the effect of excluding any objects in the immediate vicinity of the sensor that are responsible for interference. As a rule a larger, "extended" blind range is created.

Note

Under ideal conditions the blind range can be reduced to almost 75 % of the range specified in the data sheet (the BR command accepts parameter values from 1). When working with a reduced blind range, it is essential that control measurements should be used for checking purposes (see "Logging series measurements" in the Ultra 2001 service program).

Range:	UC300	1 mm ... 600 mm
	UC2000	(1) 100 mm ... 4000 mm
Default values	UC300/UC2000	0

CBT [**C**onstant **B**urst **T**ime]

Command: CBT/CBT,x(xx)	**Example: CBT,0**
Parameter: Burst length	**Unit: Burst length in [µs]**
Response: Current burst length	**Range:** **UC...+U9/-FP: 0 = Variable** **(see below) 30 ≤ constant** **UC...-F43: 0 = Variable** **1, 2, 3 = Constant**
Reference: Propagation time measurement, measuring cycle time, CCT	

The command CBT inquires whether evaluation is to be performed using a constant or a variable burst length.

UC...+U9/-FP -IU:

Response 0: the sensor dynamically adjusts the burst length to the echo propagation time.

Response x(xx) : The constant burst length is currently set at x(xx) [µs].

The command CBT,x(xx) sets a new constant burst length and deactivates dynamic adjustment. The following values are possible:

5 µs .... 35 µs for UC 500 sensors

30 µs .... 300 µs for UC 3000 sensors

55 µs .... 500 µs for UC 6000 sensors

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Note

With CBT,0, objects that are close to the sensor and do not reflect ultrasound well result in a shortening of burst time because of the short echo propagation time; under certain circumstances this may result in the object being measured unreliably. Specifying a a constant burst length is a solution.

UC...-F43:

Response 0: the sensor dynamically adjusts the burst length to the echo propagation time.

Response x (1, 2, 3): The sensor is working at a constant burst length.

The command CBT,x determines whether the sensor is to send with a dynamic or constant burst length.

CBT,0: the sensor dynamically adjusts the burst length to the echo propagation time.

CBT,1: constant short burst for measurements in the blind range,

CBT,2: constant, longer burst (3 dB more transmitting power),

CBT,3: constant, longest burst (again 3 dB more transmitting power),

Default value UC 300 1

UC2000 0

Note

Under certain circumstances, very poorly reflecting objects may not be detected in the blind range.

The size of the blind range is a function of the burst length and the decay time. Different burst lengths will create different blind ranges, e.g. for UC2000... sensors the following applies:

Command/burst length	Blind range [mm]
CBT,1	**100**
CBT,2	**120**
CBT,3	**150**

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CCT [**C**onstant **C**ycle **T**ime]

Command: CCT/CCT,xxxx	**Example: CCT,10**
Parameter: 0/1, Pause	**Unit: Burst length in [µs]**
Response: see below	**Range: 0/1 ... 1000**
Reference: Propagation time meas., CBT	

The CCT command asks whether or not the sensor is operating with constant measurement cycle times.

A response of 0 means that it is not operating with fixed cycles. In other words, the evaluation aborts the measurement cycle no further echo is recorded within 2.5 times the time since the last echo. The sensor adjusts the repetition rate according to the echo propagation times currently being measured.

A response of 1 to 1000 means that the evaluation is performed with a constant measurement cycle. Pauses are inserted between the measurement cycles with lengths 1 ... 1000 [ms].

The CCT,0 command specifies evaluation with dynamic measurement cycles.

The CCT,xxxx command specifies evaluation with pauses between constant measurement cycles. The pause length can be set in the range 1 ... 1000 [ms].

The pauses increase the response times of the sensor.

Range:	UC300/UC2000	1 ... 1000 ms
Default value	UC300	1
	UC2000	1

Note

Note (UC..+U9/-FP):
The CCT,xxxx command is only effective if the sensor is not synchronized. If the sensor receives pulses via the synchronous input, then these will be treated as a higher priority.

CON [**CON**servative Filter]

Command: CON/CON,xxx	**Example: CON,5**
Parameter: Filter type, counter	**Unit: -**
Response Current filter	**Range: 0/1 ... 255**
Reference: Evaluation EM, ..., FTO	

Filter between evaluation and output of measured value.

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The command CON requests the filter type and filter depth set (xxx).

Response 0: The output filter is not active.

Response 1 ... 9: the filter is set to conservative, response 10 ... 255: sliding filter.

The values 1 .. 9/10 ... 255 are counter values (filter depth).

The command CON, xxx provides the sensor with the threshold value for the output filter.

xxx < 10: conservative output filter,

xxx ≥ 10: sliding output filter.

CON,0 deactivates the output filter.

Conservative output filter: The measurement result must lie closer than the switching point in an unbroken sequence before the switching output is switched over as frequently as specified by the command CON,xxx. If a single measurement lies beyond the switching point, the corresponding counter will be reset and xxx measurements in sequence must again lie below the switching point in order for the switchover to be performed. In order to switch the output back, the corresponding conditions apply, whereby the measurement results must then lie beyond the switching point.

Sliding output filter: An up/down counter is incremented when the measurement result lies closer than the switching point, and it is decremented for values equal to or beyond the switching point. If the counter reaches the value xxx, the output is switched. If the counter reaches the value zero, the switching output is switched back.

Note

In details provided elsewhere on the conservative filter, different terms are sometimes used, but they still describe the same algorithm: Conservative: also "strictly conservative", sliding: also "integrating".

DAT [software **DAT**e]

Command: DAT	**Example: -**
Parameter: -	**Unit: -**
Response see below	**Range: -**
Reference: ID, VER	

The command requests the date of the sensor software:

The response of the sensor to DAT is, for example: Date: 08/30/96 Time: 08:27:10

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DEF [**DEF**ault settings] see command **SUC**

DIP [read **DIP** switches]

Command: DIP	**Example: DIP**
Parameter: -	**Unit: -**
Response 3 hex. Character	**Range: 0....9, A.....F**
Reference: UDS	

Only for sensors **UC...-+U9/-FP**

Interrogates DIP switch settings.

In response the sensor sends three hexadecimal characters representing the switch positions in coded form:

Bit value 0 = Switch OFF, bit value 1 = Switch ON.

Response

First character: hexadecimal value of DIP switches 1 - 4,
second character: hexadecimal value of DIP switches 5 - 8,
third character: setting of DIP switch 9.

Example 1: The sensor response B91 h corresponds to switch position 1011 1001 1.
Example 2: With a response 111 h, only DIP switches 4, 8 and 9 are set.

EM [**E**valuation **M**ethod]

Command: EM/EM,NONE/DYN/PT1/ MXN	**Example: EM,NONE**
Parameter: see below	**Unit: encoded or counter**
Response see below	**Range: see below**
Reference: Propagation time measurement, FTO,CON	

The command determines the evaluation method for the sensor. Only one (or none) can be activated. The corresponding code is added to the command, separated by a comma:

EM **requests** which evaluation method is currently set with which parameters:

EM,NONENo evaluationEM,DYNDynamic evaluationEM,PT1Low-pass filter (PT1-)EM,MXNAveraging (with suppression of extreme values)

After the command **EM, NONE** no specific evaluation is carried out, and each measured value is output directly. The filters FTO and CON can be activated irrespective of EM.

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Dynamic evaluation:

The command EM,DYN[,N] compares the current measured value with an expected value, which is calculated from the last measured value and a differential change from the last measured value but one. If the measured value differs from the expected value, it is replaced once by the expected value. Only if a second measured value is also different will the measured value be accepted.

The parameter **N** allows the optional addition of the allowable percentage deviation (1 % to 15 %) of the measured value from the expected value. If no parameter or a zero is passed, then the deviation is set to 1 %. The value of this parameter cannot exceed 15 %.

Note

This evaluation is particularly well suited to situations in which the objects are constantly within the detection range, but are in motion.

Examples: EM,DYN or with a parameter EM,DYN,5

Range: Deviation N 0 % ... 15 %

Low-pass filter (PT1-):

The command **EM, PT1 [,N [,P [,C]]]** calculates the new measurement result from the measured value and the weighted last measurement result. In this way, after spontaneous jumps in measured values, the values are retrospectively brought into line with the current value.

Up to three parameters separated by commas can be appended to the command code EM, PT1, ... :

The first parameter **N** (0 ...1000) determines the weighting with which the last measurement result is put into the new measurement result,

the second parameter **P** (0 % ... 15 %) defines the allowable percentage deviation from the measured value for the acceptance window and

the third parameter **C** (0 ... 15) is a count threshold for rejecting deviant measured values.

Default values: The default values depend on the type of sensor used

Range:	Weighting N	0 ... 1000
	Deviation P	0 % ... 15 %
	Reject counter C	0 ... 15

Weighting:

The PT1 evaluation adds the actual measured value to the weighted final measurement result and from this calculates the new measurement result using the following formula:

$$E_{(neu)} = \frac{10 \cdot MW_{(neu)} + E \cdot N}{10 + N}$$

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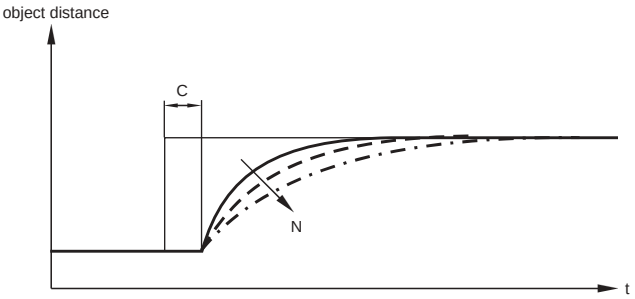
$E_{(new)}$ = new, weighted result of the evaluation
$MW_{(new)}$ = current value
E = last weighted result of the evaluation
N = weighting factor



The weighting exhibits typical low-pass response. After a sudden change in the measured values (distances/propagation times), the evaluation results are retrospectively brought into line with the current values on the typical curve. The larger the weighting factor N chosen, the shallower will the curve be, and in turn the longer the tracking will take.

Acceptance window (for PT1):

If P is not equal to 0 and the acceptance window is activated, then the measured value is compared with the previous measurement result. If the difference is greater than specified (in %) by P, the measured value is rejected - if the counter threshold has not yet been reached.

Counter threshold: Once the counter threshold has been exceeded, even deviant measured values are accepted. This means that the current measured values lay C-times in succession (!) outside the window defined by P.

Note

The counter associated with the acceptance window is reset to 0 if a measured value falls within the window again. This effectively filters out individual fault echos from a stationary target.

Example: EM,PT1,40,5,5

Averaging (with extreme value suppression):

With command **EM, MXN, M, N** the two parameters **M** and **N** specify how many measured values are included in the evaluation (M) and how many of them are suppressed as illegal values (N).

The algorithm produces the average of the last M measurements. Of these, the N measured values that deviate furthest from the interim mean value are suppressed.

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In this way, the measurement result is only calculated as the average of the remaining M minus N measured values.

M can take a value from 2 to 8 in this instance, and N must be less than M/2.

M	**8**	**7**	**6**	**5**	**4**	**3**	**2**
N_{max}	**3**	**3**	**2**	**2**	**1**	**1**	**0**

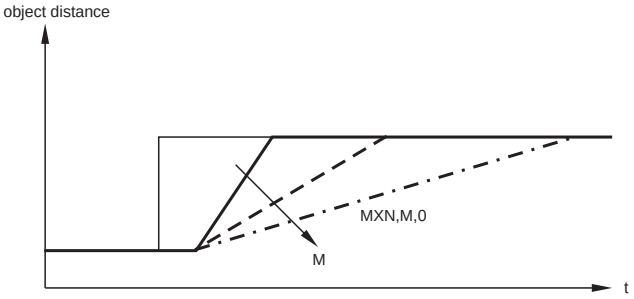
If only the first parameter is supplied, the evaluation N uses the largest permissible value. If the parameters are not specified, then the default values M = 5, N = 2 are used:

Example: EM,MXN(sets M = 5, N = 2)
EM,MXN,7(sets M = 7, N = 3)
EM,MXN,6,1(sets M = 6, N = 1)

Range: Measured values M 2 ... 8
Invalid values N < M/2

Effect:

When the measured values change suddenly, averaging responds by bringing the evaluation towards the new measured values in a linear manner. The parameter M determines the rise (steepness), and thus the approach time. The larger the value of M, the longer it takes to reach the current value.



ER [**E**cho **R**eceived]

Command: ER	**Example: -**
Parameter: -	**Unit: -**
Response 0 = No echo **1 = Echo**	**Range: 0/1**
Reference: OER, ODR	

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The command ER inquires whether or not the sensor has picked up an echo. The echo propagation time, i.e. the calculated distance, is of no interest.

Response 0: no echo picked up, Response 1: echo picked up.

FDE [**F**ar **D**istance of **E**valuation] see command **NDE**

FSF [**F**ail **S**afe **F**unction]

Series: **UC...+U9, UC...-FP and UC...-30GM**

Command: FSF/FSF,x	**Example: FSF,12**
Parameter: -	
Response see below	**Range: 0, 1, 2**
Reference: Switching response, OM, OPM, NDE, FDE	

The FSF command inquires which disturbance response/fault current is currently set.

The command FSF, x, determines the response of the sensor in the event of a disturbance.

The parameter **x** defines the reaction of the evaluation circuit with a number 0, 1 or 2.

x = 0 (**Type 0** Default value): The switching output and/or the analog output retain the current switching state/ output current in the event of an error.

x = 1 **(Type 1):** The sensor responds as if a **target had been detected**:The swit ching output switches (corresponds to the N/C / N/O function following command OM):

On sensors with an analog output this takes the value 0 V or 0 mA.

x = 2 **(Type 2):** The sensor responds as if **no target** had been detected: The switching output does not switch, it remains inactive (depending on command OM)

On sensors with an analog output this takes the value 10 V or 20 mA.

Example:

FSF,12 means fail-safe switching function Type 1 of the switch output 1 and Type 2 of the switch output 2

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Series UC...-F43

Command: FSF/FSF,xy,aa	**Example: FSF,01,40**
Parameter: -	**Unit: encoded/[0,1 mA]**
Response see below	**Range xy: 0,1,2** **Range aa: -1/0....40** **(-1 = Fault current inactive)**
Reference: Switching response, OM, NDE, FDE, NEF, UIS, ISS	

The FSF command inquires which disturbance response/fault current is currently set for the two relays and the analog output.

The digits **x y** refer to relay 1/relay 2, the current value **aa** to the analog output.

Range for parameters **x y**: Digits 0, 1 or 2 correspond to the required switching behavior in the event of a fault:

x/y = 0 (Type 0): In the event of a fault, the relays retain the current switching state,

x/y = 1 (Type 1): The sensor responds as if a **target had been detected**:

x/y = 2 (Type 2): The sensor responds as if **no target** had been detected:

The behavior of the relays depends on the switching function set with the OM command.

Irrespective of the switching of the relays, the fault current set with **aa** is present at the analog output if this was not prevented with aa = **-1**.

The command FSF, xy,aa determines the response of the sensor in the event of a disturbance.

The parameters x y determine the type of fail-safe switching function for relays 1/2 with options 0, 1 or 2:

Reaction of the relay outputs:

x/y = 0 (Type 0): The current switch status is retained

x/y = 1 (Type 1): N/O contacts remain closed or close, N/C contacts remain open or open

x/y = 2 (Type 2): N/O contacts switch, open; N/C contacts switch, close

A **fault current aa** can be appended to FSF,xy,.. for the analog output. It is set in units of **0.1 mA**: Values 1 ... 40 correspond to fault currents 0.1 ... 4.0 mA.

Deactivating fault current switching: **aa = -1** (FSF,xy,-1)

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Reaction of the analog output:

Output of the fault current x,y mA with aa = xy
Output of the last valid current with aa = -1

Range:	UC300/UC2000	0,1,2/-1, 0 ... 40
Default values:	UC300	00,39
	UC2000	00,39

Example 1: FSF,12,35

Status before the fault: Both relays are configured as N/O contacts, the liquid level is between switching points overflow and dry run protection (R1/R2), i.e. R1 is opened, R2 is closed. The analog output shows a current value corresponding to the level in the measuring window defined with NDE and FDE.

Reaction to the fault: R1 switches (closes), R2 remains unchanged (closed), the analog output shows a current of 3.5 mA.

Example 2: FSF,00,-1

The same initial situation as in example 1.

Reaction to the fault: The positions of relays 1 and 2 remain unchanged, the analog output continues to show the last valid current value.

FTO [**F**ilter **T**ime **O**ut]

Command: FTO/FTO,xxx	**Example: FTO,3**
Parameter: Filter depth	**Unit: Counter value**
Response: Current filter	**Range: 0 ... 255**
Reference: Evaluation EM, CON, OM	

Filter between echo propagation time evaluation and output of measured value.

The command FTO requests the filter depth set of the timeout filter (measuring cycles with no echo).

Response 0: the evaluation is operating without an input filter
Response xxx: the evaluation is using the filter, the filter depth (counter value) xxx is set.

The FTO,xxx command instructs the sensor software how many measurement cycles that have detected no echo are to be ignored. These messages (with no echo!) will not be evaluated until an internal counter has a value less than that specified with

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FTO. Not until the number of measurements (with no echo) exceeds the value of xxx is the resulting maximum value for the propagation time calculated.

Range: UC300/UC2000 0/1 ... 255
Default values:UC300/UC2000 0

Note

This parameter (filter depth) is useful in order to keep the output signal stable, for example, with objects that do not reflect ultrasound well (if an echo is not always received) or with liquids in a state of motion (when the ultrasonic pulse passing through the liquid is occasionally reflected to the side by surface movement).

ID [sensor **ID**entification and version]

Command: ID	**Example: -**
Parameter: -	**Unit: -**
Response: see below	**Range: -**
Reference: VER, DAT	

The sensor is requested to return its identification and may respond, for example, with:

Sensor: P&F UC3000+U9+E6-R2 Eprom: 1801U079 Version: 100

MA [**M**ain **A**pplication]

Command: MA/MA,A/MA,S	**Example: MA,A**
Parameter: A,S	**Unit: encoded**
Response: A/S	**Range: A = Analog output/ S = Switch function**
Reference: NDE, FDE, SD1/2/3	

Only for sensors UC...-F43:

This command has **no** influence on the switching behavior of the relays or the output of the analog current value. The command defines (and queries) the meaning of the green LED on the sensor:

A - Analog output: The green LED is lit if an object is located in the evaluation window defined by NDE and FDE.

S - Switching function: The green LED is lit if an object is detected nearer than the selected switching point SD2 but further than SD1, i.e. in level measurement applications, in the range between the dry run and overflow alarm.

The green LED flashes outside of these ranges!

Command MA: Which main application is set?

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Response A or S

Command MA,A: Set LED indication for analog output
Command MA,S: Set LED indication for switching function

Default value S

MD [**M**aster **D**evice]

Command: MD/MD,AD...OFF	**Example: MD,DAD**
Parameter: data transfer	**Unit: encoded**
Response: see below	**Range: see below**
Reference: AD, RD, RT, SSx, ADB, RDB, RTB, OFF	

The command MD, ... is used to set the mode of operation of the sensor: Master or slave mode.

A sensor normally operates in slave mode.

Slave mode: The sensor generally only responds to commands. If a periodic distance inquiry is required, the sensor must be sent an AD command from time to time.

Master mode: When each measurement is complete, the sensor automatically forwards the result to the serial interface.

The commands MD,AD ... MD, RTB put the sensor into master mode; the associated parameter (after the comma) determines how the data will be transmitted.

The conditions associated with data transmission are identical to those for the commands AD, RD, RT, ADB, RDB, RTB and SS.

MD,AD: [Absolute Distance] absolute distance in mm, in ASCII format

MD,RD: [Relative Distance] relative distance in digits (12 bit) in ASCII format (for sensors of type IU with analog output).

MD,RT: [RunTime] Measured echo propagation time in machine cycles (1 Mz = 1.085 µs)

MD,SS: [Switching States] logical status of the switching outputs

Sensors of type E6/E7: two figures (first for output 1, second for output 2)

Sensors of type IU: one figure for the switch output

Sensors of type 8B: no parameter.

Digit = 0: output not switched, digit = 1: output switched

MD,ADB: Absolute distance in binary format

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MD,RDB: Relative distance in binary format (for sensors of type IU with analog output).

MD,RTB: Echo propagation time in binary format

MD,OFF: Terminates master mode

Note

In the case of binary transmissions the response bytes are, as a rule, non-printable ASCII characters, which are not output by the terminal program.
The relative distances inquire about the position of the object in a measuring window defined with the configuring commands NDE and FDE or through the DIP switches. The resolution is 4095 digits.

Attention

The switching points and range limits defined using the DIP switches only take effect when DIP switch evaluation has been activated with UDS,1. The corresponding stored parameter values take effect following a UDS,0 command.

Data output only on changes:

If only changing measured values are to be transferred in master mode, then a results filter D can be added in to the command. As long as the measured value remains stable, no transfer of measured values is carried out.

In the event of a fault, the sensor transfers an "E" error code or FFFE with binary data.

Examples:

MD,DAD: The distance is shown in mm if the distance to the object changes.

MD,DRT: The measure for echo propagation time is the number of machine cycles. The numbers are output only if the distance changes.

NDE [**N**ear **D**istance of **E**valuation]
FDE [**F**ar **D**istance of **E**valuation

Command: NDE/FDE,xxxxx	**Example: NDE/NDE,500**
Parameter: Distance	**Unit: mm**
Response Measurement window size	**Range: Blind range ...** **2 x detection range**
Reference: BDE, UDS, RD, RDB	

The limits of the measuring window for an analog output must be defined. The window limits can be reset or queried.

The commands NDE/FDE **(without parameters)** query the size of the measuring window nearer to/further from the sensor.

Response: Window sizes max. 5-digit in mm.

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The command **NDE**,xxxxx defines the evaluation limit of the analog output **closest the sensor**, the command **FDE**,xxxxx the evaluation limit of the analog output **furthest from the sensor**.

Valid values lie between the blind range and 2 x the detection range.

NDE < FDE: Analog output with rising ramp,
NDE > FDE: Analog output with falling ramp,
NDE = FDE: The analog output forms a switching point.

The current value changes suddenly from 20 mA to 4 mA, if an object approaches and reaches the point.

Note

Under ideal conditions, the sensor can also pick up echos from distances greater than the detection range; the sensor therefore accepts parameters of up to double the nominal detection range.

Range: UC3001 ... 600
UC2000100 ... 4000

Default values: UC30025/300
UC2000100/2000

Attention

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. Following UDS,1 the DIP switch setting applies.

NEF [**No E**cho is **F**ailure

Command: NEF/NEF,0/NEF,1	**Example: NEF,1**
Parameter: 0,1	**Unit: -**
Response 0/1	**Range: 0 = inactive** **1 = Active**
Reference: ER, FSF	

The command determines the response of the sensor in the event that **no echo** is picked up.

With level measurement applications the sensor normally receives one echo (for example, from the bottom of the empty container). Following command NEF,1 the absence of the echo is evaluated as a fault and the sensor switches to fault status.

With other applications, for example the detection of objects, the temporary absence of an echo is a normal state and must not be evaluated as a fault (NEF,0).

Command NEF: Query what has been set?

Response 0 or 1

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Command NEF,1: fault status, if the echo is absent
Command NEF,0: no fault status, if the echo is absent.

Default value depends on the sensor

OPM [**Op**eration **M**ode]

Command: OPM/OPM,xy	**Example: OPM,SS**
Parameter: cod. Mode	**Unit: -**
Response Current operating mode	**Range: Letters**
Reference: Evaluation, SD1, SDx[y], UDS	

Only for sensors **UC...+U9/-FP/-30GM:**

The command OPM requests which operation mode is currently set for the switching output and/or IU output.

The response consists of one or two letters (xy): the first for output 1, the second for output 2 (if present). Meaning of xy: see below.

The command OPM, xy defines the operation mode of the switching outputs and/or the IU analog output:

The first letter (**x** = S .... L) determines the operation mode output 1,

the second letter (**y** = S ... L) that of switching output 2 and/the IU output.

The following operation modes are possible for the switching outputs:

S Switching point
W Window mode
R Reflex photoelectric sensor
H Double switching point mode
L Range monitoring

The **IU output** can only work in two operation modes:

S Standard mode
L Range monitoring

The sensor acknowledges the passing of parameters with 80 h or incorrect values with 81 h <invalid parameter>.

Attention

The switching points and range limits defined using the DIP switches only take effect when DIP switch evaluation has been activated with UDS,1. The corresponding stored parameter values take effect following a UDS,0 command.

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OM [**O**utput **M**ode]

Command: OM/OM,xy	**Example: OM,10**
Parameter: -	**Unit: -**
Response 0/1/00/10 /01 /11/.../1I	**Range: 0 = N/O contact** **1 = N/C contact** **UC...-F43: I = Inactive**
Reference: UDS	

The command OM inquires about the currently set behavior of the outputs.

Response 0: N/O contact,
Response 1: N/C contact,
Response I: inactive (UC...-F43: operating coil de-energized).

The command OM,xy determines how the outputs are to be configured:

UC...+U9/-FP (type E6/E7) sensors:

In the command OM,xy **x** applies to switch output **1**, **y** to output **2**.

With 0 an output is configured as an **N/O contact**, with 1 as an **N/C contact**.

Attention

The switching function is encoded in the same way for PNP sensors (types E6/E0) and NPN sensors (types E7/E2).

Attention

Following **UDS,1** *the settings of the DIP switches have a higher priority, i.e. if DIP 9 = ON then both switch outputs will operate as N/O contacts irrespective of the flag OM; if DIP 9 = OFF, on the other hand, then the switch outputs will operate as N/C contacts.*

The OM parameter setting is saved and is effective following UDS,0.

UC...-F43 sensors:

The OM command queries the set operation of both relays.

The response for both relays at the same time is xy:

x applies to relay 1, y to relay 2.

Response 0: the relay operates as an N/O contact,

Response 1: the relay operates as an N/C contact,

Response I: the operating coil is de-energized, the relay drops out.

The command OM,**xy** accordingly reconfigures the behavior of relays 1/2.

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The working contact can be defined with **"0"** as an **N/O contact**, with **"1"** as an N/C contact or with **"I"** as **inactive** (the operating coil is de-energized, the relay drops out).

Range: UC300/UC20000,1,I
Default values UC300/UC200000

RD [**R**elative **D**istance]

Command: RD	**Example: -**
Parameter: -	**Unit: -**
Response 4 digits	**Range:** **UC...+U9/-FP -IU: 0...4095** **UC...-F43: approx. 800 ... 4000**
Reference: RDB, NDE, FDE, (UDS)	

Interrogation of relative distance in [Digit].

The position of an object within a range defined by NDE and FDE (or via DIP switches) for the output of the analog value is calculated. The 12 bit D/A converter provides a resolution of 4095 digits.

UC...+U9/-FP -IU sensors:

The sensor responds accordingly to the window limit nearest the sensor with 0 and to the one furthest away with 4095. A value between and 4095 corresponds to each intermediate position.

UC...-F43 sensor:

The evaluation is adjusted here so that the sensor at the window limit nearest the sensor responds with 800 and with 4000 at the window limit furthest away from the sensor. Typical values for the near/far limit are 807/4003. Deviations by a few digits occur due to the calibration of the sensor.

The numerical values 800 (807) ... 4000 (4003) correspond to the position in the window. (parenthesis values apply to UC2000).

With every distance < NDE the sensor responds with 800,

With distances > FDE with 4000.

Response in the case of faults: E.

Attention

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. Following UDS,1 the DIP switch setting applies.

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RDB [**R**elative **D**istance **B**inary]

Command: ADB	**Example: -**
Parameter: -	**Unit: Digit, binary**
Response Binary code	**Range: see RD**
Reference: RD, NDE, FDE,(UDS)	

Query of the relative distance as with RD in [Digit], but in binary format.

In other words, the position of an object is determined in measurement range defined with NDE and FDE. The bytes corresponding to the binary value are, as a rule, non-printable ASCII characters, which are not displayed by the terminal program.

Response in the case of faults: Error code FFFEh

Attention

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. Following UDS,1 the DIP switch setting applies.

REF [**REF**erence Distance]

Command: REF,xxxxx	**Example: REF,300**
Parameter: Distance	**Unit: mm**
Response -	**Range: see below**
Reference: Evaluation, temperature comp., VS0, TEM, TO	

A query of the reference distance is not possible.

A target must be located at a precisely measured distance within the detection range of the sensor.

The command REF,xxxxx defines a reference distance for the sensor in mm. The sensor calculates a new sound velocity for 0 °C (**VS0**) from this value, the measured echo propagation time and the temperature offset.

Restriction: VS0 can only accept values from 60000 > VS0 > 10000 [1] [0.01m/s = cm/s].

[1] 60000 > VSO > 12000 with sensor type UC2000-F43-2KIR2-V17.

If a sensor has to work in a different gas mixture than air, the REF command determines the VS0 for this gas.

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RR [**R**educed **R**ange]

Command: RR/RR,x	**Example: RR,400**
Parameter: Distance	**Unit: mm**
Response: Detection limit in [mm]	**Range:** **UC300: 0, 30 ... 1000** **UC500: 0, 30 ... 1000** **UC1000: 0, 100 ... 4000** **UC2000: 0, 100 ... 4000** **UC4000: 0, 250 ... 8000** **UC6000: 0, 400 ... 12000**
Reference: FSF, NEF	

The command RR queries the set detection limit. The response is a number value in [mm]. Response 0 means that no reduced range is set.

Command RR,x defines the upper detection range limit with x standing for the detection limit in [mm]. Command RR,0 switches off the Reduced Range function.

Echos beyond this detection range are treated as if no echo is present.

RUC [**R**ecall **U**ser **C**onfiguration] see command **SUC**

RST [sensor software **R**e**S**e**T**]

Command: RST	**Example: -**
Parameter: -	**Unit: -**
Response (acknowledge)	**Range: -**
Reference: -	

The sensor performs a Reset as a result of this command. The command is acknowledged (80h).

RT [**R**un **T**ime]

Command: RT	**Example: -**
Parameter: -	**Unit: Mz = 1,085 µs**
Response Machine cycles	**Range: -**
Reference: Nef, RTB, ER	

The command RT requests the echo propagation time. The returned value is given in machine cycles (1.085 µs).

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If the sensor does not receive an echo, the sensor gives the value for the timeout in machine cycles following NEF,0.

Following NEF,1 the sensor responds with error code “E”.

RTB [**R**un**T**ime **B**inary]

Command: RT	**Example: -**
Parameter: -	**Unit: Mz = 1,085 µs**
Response Machine cycles	**Range: -**
Reference: -	

The command RTB requests the echo propagation time like with RT. The response (number of machine cycles [1.085 µs]) is given in binary format. The response bytes are, as a rule, non-printable ASCII characters, which are not output by the program.

The NEF command determines the response of the sensor in the event that no echo is picked up.

With detection ranges of 6000 mm echo propagation times are > 10000 h. UC 6000 sensors therefore respond with 3 bytes, and the other sensors with 2 bytes.

Response in the case of faults: Error code FFFEh

SD1[1] [**S**witching **D**istance **1.1**]
SD1[2] [**S**witching **D**istance **1.2**]
SD2[1] [**S**witching **D**istance **2.1**]
SD2[2] [**S**witching **D**istance **2.2**]

Command: SD1/SD11,xxxx(x)	**Example: SD12,1200**
Parameter: Switching point	**Unit: mm**
Response current switching point	**Range: Blind range ... 2 x nominal switching distance**
Reference: UDS, OPM (H/W/L), SH1, SH2	

The commands **no parameters** query the current switching points of the sensor.

Commands **with parameters** redefine the switching points. Valid values lie between the blind range and double the detection range. The parameters are entered

with **UC...-+U9/-FP** sensors digit values with 5 digits,

with **UC...-F43** sensors as values with up to 4 digits in [mm]

and are separated from the command code by a comma.

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Sensors UC...-+U9/-FP/-30GM:

The commands SD**1**[1] and SD**1**[2] refer to switching output **1**, commands SD**2**[1] and SD**2**[2] to switching output **2**.

The value in bracket [1] determines the **first** switching point (close to the sensor) for all operating modes, the value in bracket [2] the **second** switching point (distant from sensor) for window mode W, double switching point mode H range monitoring mode L.

Examples:

SD21 queries switching point of switch output 2 close to the sensor.

SD12,05000 sets the switching point of output 1 furthest from the sensor to 5 m.

SD12,00400 sets the switching point of output 2 nearest to the sensor to 400 mm.

Attention

Only sensors UC...-+U9/-FP
Following UDS,1 **the DIP switches are active.** *The switching points set with the switches have priority. When queried, the sensor responds with the values corresponding to the switch positions. The entered value is stored and becomes available once the DIP switches are deactivated (UDS,0).*

UC...-F43 sensors:

SD1 is assigned to relay 1 - Dry run monitoring

SD2 is assigned to relay 2 - Overflow monitoring

For example, the level for dry run protection is set with SD1,290 to 290 mm. Remember that the empty height above the liquid is specified. The remaining level must be calculated using the tank dimensions.

Range:	UC300	1 ... 600
	UC2000	100 ... 4000
Default values:	UC300	50/25
	UC2000	100/1000

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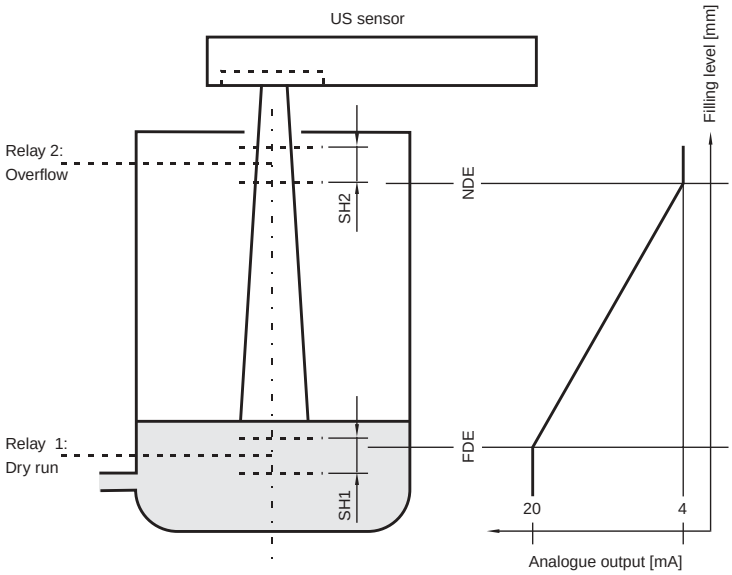

Simultaneous querying or setting of several switching points by chaining commands is not possible. Each switching point/ each relay requires its own command.

Note

SEN [**SEN**sitivity]

Command: SEN/SEN,xx	**Example: SEN,15**
Parameter: Response value	**Unit: -**
Response: 3 ... 31	**Range: 3 ... 31**
Reference: -	

The SEN command queries the current response sensitivity of the sensor.

The command SEN,xx transfers the value for the required response sensitivity.

The default parameter setting is 6. Higher values reduce sensitivity. The setting is nonlinear. The higher the parameter value, the greater the change in sensitivity.

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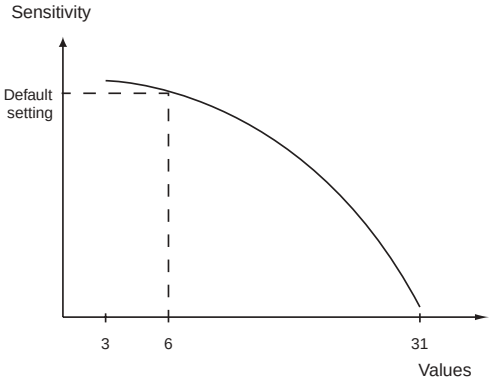

SH1 [**S**witching **H**ysteresis **1**]
SH2 [**S**witching **H**ysteresis **2**]

Command: SH1/2,xx	**Example: SH1,12**
Parameter: Hysteresis	**Unit: %**
Response 0....15	**Range: 0.....15**
Reference: UDS, SDx, SDx[y]..SD22	

The commands SH1/SH2 request information on how large the current switching hystereses for the corresponding switching/relay outputs are.

The command SH1,xx determines the switching hysteresis around the switching point for Switch output/relay 1: the selectable value 0 % ... 15 % is referred to the switching distance.

The command SH2,xx determines the switching hysteresis for switch output/relay 2.

SS1 [**S**witching **S**tate **1**]
SS2 [**S**witching **S**tate **2**]

Command: SS1/SS2	**Example: SS1**
Parameter: -	**Unit: -**
Response 0/1	**Range: -**
Reference: UDS, OM	

The logical state of the switching/ relay outputs of the sensor is queried:

SS1 requests switching output 1, SS2 requests switching output 2.

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Response 0: The output filter is not active, not switched.
Response 1: The output filter is active, has switched.

No account is taken of any N/C or N/O function.

Attention

Following UDS,1 the DIP switches are active!
The parameters from the switches have higher priority. The commands SS [1/2] have responses according to the switch positions.
The values defined for the switching points are stored, and are available when the DIP switches are deactivated (UDS,0).

SUC [**S**tore **U**ser **C**onfiguration]
RUC [**R**ecall **U**ser **C**onfiguration]
DEF [**DEF**ault settings]

Command: SUC
Command: RUC
Command: DEF

The command **SUC** causes the sensor to **save** all the specified parameter values in the sensor.

The **RUC** command reads these saved values and restores them in the sensor.

The saved parameter values are not lost through the DEF command, nor through a reset or failure of the operating voltage. The values stored using the SUC command remain available until such time as they are overwritten by a new SUC command.

The command **DEF** causes the sensor to restore the factory settings for the parameters (which are stored in the sensor itself). In this process any current parameters are lost if they were not previously saved using SUC (see table of default values).

SSY [**S**tartup **Sy**nchronized]

Command: SSY,0/1	**Example: SSY,1**
Parameter: 0/1	**Unit: -**
Response 0/1	**Range: 0 = No synchr. 1 = Synchr.**
Reference: Sychronous operation	

Only for sensors with synchronisation input/output.

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This command determines whether the sensor goes immediately into normal mode (SSY,0) after a reset (power on), or whether it starts with synchronized mode (SSY,1).

Following SSY,1 the operational standby time is extended. When the synchronisation input/output is open the sensor waits for approx. 1 second before changing over into normal mode.

Note:

If the sensor is to work in synchronized mode, the command SSY,1 must be issued in advance.

TEM [**TEM**perature]

Command: TEM/TEM,xxxxx	**Example: TEM,80**
Parameter: Temperature	**Unit: 0,1 Kelvin**
Response Temperature	**Range: see below**
Reference: Temperature measurement, TO, VS0	

The TEM command requests the temperature measured by the temperature probe at the sensor. The sensor responds with 0.1 [Kelvin].

If the command TEM,xxxxx is used to specify a default temperature value for the sensor, it will then calculate the resulting temperature offset **TO** from this and the measured value.

The value passed must be set such that the restriction of **±** 200 [0.1 K] for TO is adhered to.

The sensor will reject incorrect values with 81h <invalid parameter>.

TO [**T**emperature **O**ffset]

Command: TO/TO,xxxx	**Example: TO,80**
Parameter: Temperature	**Unit: 0,1 Kelvin**
Response Temperature	**Range: -200 ... +200**
Reference: Temperature measurement, TEM, VS, VS0	

The command TO reads the current temperature offset.

The command TO,xxxx sets a constant temperature offset in the sensor for the measured temperature.

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The offset takes into account the difference between the temperature in the measurement section and at the temperature probe (generally in the sensor housing). From this the sensor calculates the echo propagation times corresponding to the switching distances in conjunction with the temperature.

The parameter is also accepted with a **minus sign**.

Example: TO,-183 means an offset of -18.3 °C

UDS [**U**se **D**ip **S**witches]

Command: UDS/UDS,x	**Example: UDS,1/UDS,0**
Parameter: 0, 1	**Unit: -**
Response 0/1	**Range:** **0 = DIP switch not active** **1 = DIP switch active**
Reference: Evaluation, SD11/12/21/22, SH1/2, OPM, OM	

Only for sensors with DIP switches.

The command UDS queries whether the sensor software is currently working with the settings of the DIP switches or with stored parameter values.

Command UDS,0: the DIP switches settings are ignored,

Command UDS,1: DIP switch settings will be evaluated. This affects the following:

Parameter	**UDS,0**	**UDS,1**
Switching point 1	**Command SD1**	**DIP switch 1-4**
Switching point 2	**Command SD2**	**DIP switch 5-8**
Switching function	**Command OM**	**DIP switch 9**

Attention

Note that the command UDS,x has an effect on the action of other sensor commands, e.g. commands RD, RDB, NDE, FDE, SD11 ... SD22, SS1/2, OM.

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VER [sensor **VER**sion]

Command: VER	**Example: -**
Parameter: -	**Unit: -**
Response see below	**Range: -**
Reference: DAT, ID	

The command VER queries the version code of the sensor.

It returns four coded characters indicating the sensor type:

- the **first two** characters indicate the **detection range**:

  05 : 500 mm
  02 : 2000 mm
  03 : 3000 mm (300 mm with UC300-F43-2KIR2-V17)
  04 : 4000 mm
  06 : 6000 mm

- the **third** character indicates the **sensor type**:

  0 : not defined
  1 : UJ3000+U1+8B-RS or UJ6000-FP-8B-RS
  2 : UJ3000+U1+E22+RS or UJ6000-FP-E22+RS
  3 : UJ3000+U1+IU+RS or UJ6000-FP-IU+RS
  4 : UJ3000+U1+RS or UJ6000-FP+RS
  5 : UC3000+U9+E6/E7+R2 or UC6000-FP-E6/E7+R2
  6 : UC3000+U9+IUE0/E2+R2 or UC6000-FP-IUE0/E2+R2
  7 : UC...-30GM-E6R2/E7R2-V15 or UC...-30GM-IUR2-V15
  8 : UC...-F43-2KIR2-V17

- the **fourth** the character indicates the software version

VS [**V**elocity of **S**ound]

Command: VS	**Example : -**
Parameter: -	**Unit: 0,01 m/s = cm/s**
Response Velocity of sound	**Range: -**
Reference: VS0, TO, evaluation, temperature measurement	

The command VS reads the currently used velocity of sound.

The 5-digit response represents the unit [0.01 m/s = cm/s]. Thus, the response 35057 means that the evaluation is operating with a velocity of sound of 350.57 m/s.

The result is a function of **VS0**, the measured temperature and the temperature offset **TO**.

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Note

The velocity of sound cannot be set!

VS0 [**V**elocity of **S**ound at **0** °C]

Command: VS0,xxxxx	**Example : VS0,33160**
Parameter: Velocity of sound	**Unit: 0,01 m/s = cm/s**
Response Velocity of sound	**Range:** **10000 ... 60000 (UC300... and UC500...)** **12000 ... 60000 (all UC with larger range)**
Reference: TEM, REF, TO, VS	

The command VS0 queries the value for the velocity of sound at 0 °C currently used by the software. This value has a major influence on the distance determined by the echo propagation time.

The command VS0,xxxxx defines the sound velocity value for 0 °C [cm/s]. This value is changed if a sensor has to work in a different gas mixture than air.

The effect of different VS0 on the distance calculated with a fixed reference distance of 356 mm:

Input	Velocity of sound [m/s]	Distance [mm]
VS0,10 000	**100**	**107**
VS0,60000	**600**	**644**
Default value	**331,6**	**356**

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Description and command set of UJ sensors

UJ3000	+U1+8B	+RS
UJ3000	+U1+E22	+RS
UJ3000	+U1+IU	+RS
UJ3000	-FP-8B	+RS
UJ6000	-FP-E22	+RS
UJ6000	-FP-IU	+RS

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1 General information on type E22/8B/IU sensors

All ultrasonic sensors have a blind range between the sound decoupling layer and the measurement range. If an object is located within the blind range, a false echo can result which corresponds to two or three times the distance to the object, i.e. the evaluation results are false.

The geometry of the decoupling layer determines the form of the sound beam, and thus the size of the measurement range. With good reflectors and in favorable conditions, ultrasonic sensors can even pick up echoes from distances greater than the sensing range. For this reason switching points can sometimes be set for the sensors up to double the distance of the nominal sensing range. However, there can be no guarantee that the object will always be detected reliably.

When ultrasonic sensors are provided with DIP switches, their assignment is typically as follows:

DIP switches 1 ... 8 define the switching points, DIP switch 9 the switching behavior (N/O/N/C contact) and switch 10 defines whether the sensor outputs transfer measurement values or whether they are used for communication via the serial interface.

Attention

If the sensor is connected to a serial port with DIP switch 10 set incorrectly, this may result in irreparable damage to the port. DIP 10 must be set to OFF!

As a rule, DIP switches 1 ... 4 are used to set the switching points / measurement window limits closer to the sensor, and DIP switches 5 ... 8 are used for those further from the sensor (see data sheet or the appendix to this document).

2 Propagation time measurement

Ultrasonic sensors determine the distance to an object by measuring the time delay that elapses between the sending out of an ultrasonic package and the arrival of the echo reflected by the object.

After sending the ultrasonic package (burst), the sonic transducer needs a certain length of time for the vibration to die out. An echo cannot be received during this period. Once the transducer has come to rest it can then be stimulated again by the echo, and can send out an echo signal. The time taken for the vibration to die out causes a blind range immediately in front of the sensor.

The (measurement) range of the sensor is directly dependent on the sound reflection properties of the object. Good reflectors can be detected from up to double the nominal sensing range. On the other hand, an object situated close to the sensor can produce several echo signals (as the ultrasonic package passes backwards and forwards several times between the target and the sensor housing). This can lead to

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incorrect evaluation, for example, if the first echo falls in the blind range and only the second echo is recognized as an echo signal.

Blind range and range are functions of the energy contained in the burst: The longer the burst, the greater the range, but by the same token the time for the vibration to die out and thus the blind range of the ultrasonic transformer also increase.

Variable burst and cycle times, parameter assignment options (CCT,CBT)

By default, the sensor adapts the burst length to match the measured echo propagation time. If the propagation time measured is short, then the sensor will shorten the burst down to its minimum length, and the burst will be set to the maximum length if the sensor receives a distant echo. If the sensor is unable to detect any echo, it toggles the burst length between maximum and minimum.

Sensors with ports offer the opportunity to determine the response of the sensor externally. Thus, for example, the command **CBT** can be used to assign a fixed value to the burst length. The burst sent out always has the same length irrespective of the echo propagation time measured.

The command **CCT**, on the other hand, defines the measurement cycle time / repetition rate of the sensor. With the constant option, the sensor does not adjust the length of the measurement cycle according to the current echo propagation time. An additional, random wait time can be added to the constant measurement cycle in order to reduce any reciprocal effect that adjacent sensors may have on one another.

The evaluation is performed between measurement of the echo propagation time and the output corresponding to the sensor type (switching output / analog output).

3 Param. assignment/eval. of the meas. echo propag. times(EM,...)

Propagation time measurement produces an echo propagation time corresponding to the distance of the object. Disturbances can occur, caused for example by electromagnetic effects, interference noise, multiple echoes or echoes from other ultrasonic sensors.

Various filtering and evaluation methods are employed to improve the degree of disturbance immunity:

- Timeout filter (FTO)
- Dynamic evaluation/weighting evaluation (EM,DYN/EM,BEW)
- Static evaluation/averaging evaluation (EM,xxx / EM,Mx)
- Conservative filter (CON)

(see Figure 3.1 on page 83)

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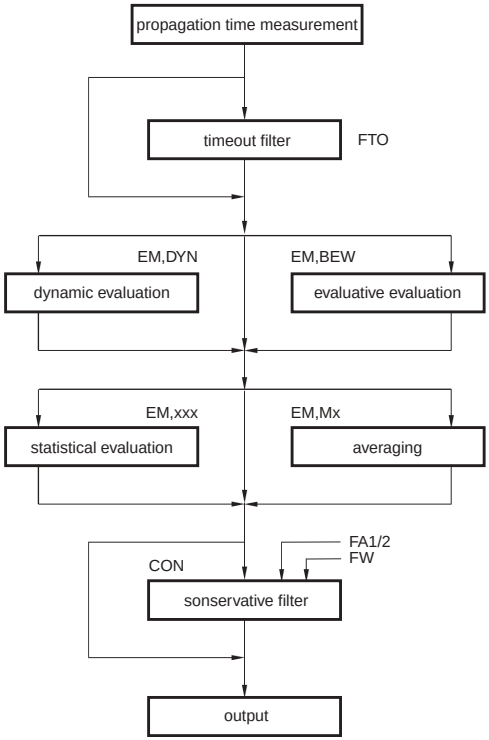

Figure 3.1: Evaluation methods

How the evaluation is performed can be regulated via the serial interface: each stage can be activated or deactivated using a parameter. When one of the alternative methods is selected, the others are deactivated.

3.1 Timeout filter, Masking out measurements without echo (FTO)

If an echo is received, the sensor stores the measured propagation time. If a measurement occurs without an echo, the stored value can be inserted as the echo propagation time. The number of substitutions is specified in the FTO command.

In the case of a parameter of 3, for example, in the event of three consecutive incorrect measurements, the propagation time is replaced by the last propagation time measured. If a fourth incorrect measurement follows, the value for the maximum distance is inserted.

This filter stage is deactivated by FTO,0.

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3.2 Dynamic or weighted evaluation

3.2.1 Dynamic evaluation (EM, DYN)

The current echo propagation time is compared with the last measurement. If both times are the same within certain limits, the new time replaces the old one. The difference in the two times is stored as a trend indicator.

If, however, both times vary greatly, then the time is replaced once by an interpolated value calculated from the last measured value and the stored difference. If there is a second strong deviation the new measured value is then accepted. Faulty individual measurements can be suppressed in this way.

Dynamic evaluation can only be activated or deactivated.

3.2.2 Weighted evaluation (EM,BEW)

The currently measured echo propagation delay is compared to see if it is the same as the three previous times (within a tolerance). If the newly measured time agrees approximately with one of the previous times, then this time is accepted (two out of the four measured values are identical!).

If this is not the case, the three previous propagation times are compared: if they approximately agree, the propagation time is replaced by its average value.

If only two of these three times agree, then the time is replaced by the average value of these two times.

However, if all four times differ completely, the newly measured time is accepted (as no better decision is possible).

The weighted evaluation can only be activated or deactivated.

3.3 Static or averaging evaluation

3.3.1 Static evaluation (EM,xxx)

A specified number of propagation times is added up and the highest and lowest measured values are stripped out. The average value of the remaining measured values is then accepted as the valid propagation time. The number of the propagation times to be added is specified in the EM command as a parameter (EM,xxx/xxx = 3 ... 255).

Note: The measurement result is not output until the number of the propagation times to be added has been attained. Large values of xxx result in very long sensor response times.

With EM,3, the highest and lowest propagation times are suppressed.Thus only one more propagation time determines the measurement result.

3.3.2 Averaging evaluation (EM,Mx)

The last 2, 3 or 4 measured propagation times are averaged and become the new, valid propagation time. No check is made for widely deviating measured values. The number of propagation times to be averaged is specified as a parameter (EM,Mx / x = 2 ... 4).

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3.4 Conservative filter (CON)

The fourth and final stage in the evaluation is performed with the conservative filter. The filter determines how many times a valid measurement result must be present before the corresponding output switches. The threshold for the conservative filter is specified by the command CON,xxx.

If xxx < 10, the filter is highly conservative, i.e. the propagation time must produce the corresponding measurement result in unbroken sequence, otherwise the corresponding counter is reset to zero.

If xxx ³ 10, the filter behaves integrally floating, i.e. the counter is incremented if the propagation time produces the measurement result, and decremented if not. If the counter reaches the threshold set by xxx, the output switches. If the counter reaches zero, it switches back.

With CON,0 the conservative filter is deactivated.

Note:

In details provided elsewhere on the conservative filter, different terms are sometimes used, but they still describe the same algorithm:

Conservative: also “strictly conservative”, integrating: also “integrating”

4 Output of the results

4.1 Sensors of type E22

Sensors of type E22 have two independent switching outputs, which are also used as data lines for the RS 232 serial interface. With DIP switch 10 = ON, the lines operate as switching outputs, and with DIP 10 = OFF for the interface.

DIP switches 1 ... 8 are used to specify the switching points for both outputs (see appendix), DIP switch 9 determines their switching function as N/O contact (ON) or N/C contact (OFF). The function of the DIP switches can also be deactivated via the serial interface (command UDS,0): the values produced by the switches are not used then, but the parameters sent via the interface (or the default values).

4.2 Sensors of type 8B

Sensors of type 8B have an 8 bit data output, a fault output, a test input and a serial interface. The 8 bit outputs and the fault output are switching outputs.

UJ3000+U1+8B+RS:

Sensing range: 300 mm ... 3000 mm.

The default value for the resolution in the axial direction is 11 mm (1 LSB). For distances ≤300 mm, 0000 0001 is transmitted; the bit string 1111 1110 then corresponds to a distance of 3083 mm (at a sound velocity of 344 m/s).

UJ6000-FP-8B+RS:

Sensing range: 800 mm ... 6000 mm.

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The default value for the resolution in the axial direction is 21 mm (1 LSB). For distances ≤800 mm, 0000 0001 is transmitted; the bit string 1111 1110 then corresponds to a distance of 6113 mm (at a sound velocity of 344 m/s).

4.2.1 Data output format (ODF)

The measurement result can be output either as an 8 bit value or in binary coded decimal (BCD). The bits are then transmitted multiplexed.

4.2.1.1 8 Bit output

The evaluation range defined by NDE and FDE is divided by the 8 bit resolution into 254 units.

NDE < FDE: this relative distance data produces binary coded (8 bit value) values of 1 ... 254 in the evaluation range corresponding to the distance measured. Measurement results outside the measurement window are characterized as follows:

Measurement result < NDE: Output 0000 0001 (01h),

Measuring result > FDE: Output 1111 1110 (FEh).

The bit combinations 00h and FFh are not used.

NDE > FDE: NDE and FDE are reversed before the calculation and the output value inverted before being output.

4.2.1.2 BCD coded:

With this output, the BCD coded digits are communicated on data lines 0 ... 3, and the weighting of the digits on data lines 4 ... 6.

The least significant position corresponds to a 1 on data line 4. The data is transferred with the weighting output at the same time on data lines 4, 5, 6.The most significant data line 7 is not used.

All data lines revert to zero following an output (see diagram).

Example: Output of value 157

	0001	0111	corresponds to 7
	0010	0101	corresponds to 5
	0100	0001	corresponds to 1
Bit	7....4	3....0	**Total 157**

4.2.2 Test input

Test port E1 (gray/pink) is used to check the function of the switching outputs. If the operating voltage $+U_B$ +U B is applied to the test port for longer than 1 ms, all outputs (8 bit outputs and the fault output) are disconnected and reconnected for 200 ms. The switching of the outputs between 0000 0000 and 1111 1111 carries on for as long as the positive voltage is applied.

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4.3 Sensors of type IU

Sensors of type IU each have an analog output and a switching output. Both outputs operate with DIP 10 = ON as data outputs and at DIP 10 = OFF (RS 232) for the serial interface.

DIP switches 1 ... 8 are used to set the evaluation limits (see appendix), DIP 9 defines the switch function as a N/O contact (ON) or N/C contact (OFF). The switching point lies at the center of the evaluation range that was set using the DIP switches.

The operation of the DIP switches can also be deactivated via the serial interface using the UDS command: The parameters sent (or the default values) for the evaluation limits, switching point or switching function apply. When setting the parameters via the interface, the switching point can be set independently of the evaluation limits.

Current / voltage output

Depending on the load, the analog output switches between current output and voltage output. With a load resistance R_L < 500 Ohm, the analog output supplies output currents of 4 ... 20 mA, depending on the distance determined. With a load resistance R_L > 1 kOhm, the analog output supplies output voltages of 2 V ... 10 V, depending on the distance.

5 All sensor commands at a glance

Command	Meaning	Type	Parameter/Response/ Acknowledge	Sensors	Page
AD	**A**bsolute **D**istance	read	Distance in [mm]	All	91
BDE	**B**oth **D**istances of **E**valuation	set	Evaluation limits in [mm]	8B, IU	91
CBT	**C**onstant **B**urst **T**ime	read/ set	Burst length in [µs]	All	92
CCT	**C**onstant **C**ycle **T**ime	read/ set	Pause time in [ms]	All	93
CON	**CON**servati ve filter	read/ set	Type of filter, encoded, counter threshold value	All	93
DAT	Software **DAT**e and version	read	Date, time	All	94
DEF	**DEF**ault settings	Command	Default settings	All	94

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DIP	Read **DIP** switches	read	DIP switch setting	E22, IU	95
EM	**E**valuation **M**ethod	read/ set	Evaluation method, encoded	All	95
ER	**E**cho **R**eceived	read	Echo no/yes	All	97
FA1	**F**ilter **A**ctive for Output **1**	read/ set	Output filter /inactive/active	All	98
FA2	**F**ilter **A**ctive for Output **2**	read/ set	Output filter inactive/active	All	98
FDE	**F**ar **D**istance of **E**valuation	read/ set	Far measurement window sze. [mm]	8B, IU	98
FTO	**F**ilter **T**ime **O**ut	read/ set	Filter yes/no, filter depth	All	99
FW	**F**ilter **W**indow	read/ set	Filter width in [%]	8B, IU	99
ID	Sensor **ID**entificatio n	read	Type, version	All	100
MD	**M**aster **D**evice	read/ set	Master/Slave mode	All	100
NDE	**N**ear **D**istance of **E**valuation	read/ set	Near evaluation window sze. [mm]	8B, IU	102
ODF	**O**utput **D**ata **F**ormat	read/ set	Data format	8B	103
ODR	**O**bject in **D**etection **R**ange	read	Object in sensing range	All	103
OER	**O**bject in **E**valuation **R**ange	read	Object in evaluation range	All	104
OM	**O**utput **M**ode	read/ set	N/C/N/O response	All	104

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RD	**R**elative **D**istance	read	Relative distance, digit	8B, IU	105
REF	**Ref**erence Distance	adjust	Reference distance in [mm]	All	106
RST	Sensor soft-ware **R**e**S**e**T**	Com-mand	Reset acknowledgment	All	106
RT	**R**un **T**ime	read/ set	with/without pause	All	107
SD1	**S**witching **D**istance **1**	read/ set	Near switching point in [mm]	E22, IU	107
SD2	**S**witching **D**istance **2**	read/ set	Far switching point in [mm]	E22	107
SH1	**S**witching **H**ysteresis **1**	read/ set	Switching hysteresis in [%]	E22, IU	108
SH2	**S**witching **H**ysteresis **2**	read/ set	Switching hysteresis in [%]	E22	108
SS1	**S**witching **S**tate **1**	read	Switch output 1 active/inac-tive	E22, IU	108
SS2	**S**witching **S**tate **2**	read	Switch output 2 active/ inactive	E22	108
UDS	**U**se **D**ip **S**witches	read/ set	0/1 for inactive/active DIP	E22, IU	109
VER	sensor **VER**sion	read	Version code	All	109
VS	**V**elocity of **S**ound	read	Sound velocity in [cm/s]	All	110

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6 Default values of the sensors

	UJ3000			UJ6000		
Com-mand	+E22	+8B	+IU	+E22	+8B	+IU
VS	34400					
SD1	300		1650	800		3400
SD2	3000			6000		
NDE		300	300		800	800
FDE		3083	3000		6113	6000
SH1	10		10	10		10
SH2	10			10		
UDS	1		1	1		1
FTO	3					
EM	OFF/4					
CON	4	0	0	4	0	0
FA1	1	0	0	1	0	0
FA2	1	0	0	1	0	0
FW		10	10		10	10
OM	3					
ODF		8B			8B	
MD	OFF					
CCT	1					
CBT	0					
RT	0					

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7 Command set

Attention

Some commands work with parameter values that are set in the DIP switches (switching points, evaluation window limits, etc.).
Using the UDS query it is possible to check in advance of such commands whether or not the DIP switch setting is evaluated. If the UDS flag is set to zero, then the applicable values are not those from the DIP switches, but (other) parameter values defined and stored previously. The reaction of the sensor varies accordingly.
Following UDS,1 the DIP switch setting applies!
Commands: RD, NDE/FDE, BDE, SS1/SS2, SD1/SD2, SH1/SH2, OM, MD, OER.

AD [**A**bsolute **D**istance]

Command: AD	Example: -
Parameter: -	Unit: -
Response: Distance	Range: -
Reference: Master mode	

The AD command requests the calculated absolute distance.

The sensor returns the measured value as a 5-digit value in [mm], sometimes even when it lies outside the evaluation range. However, operation in the blind range is not permitted. No guarantee can be given that the system will function properly in the area outside the evaluation range.

The response returned if no echo was received: Maximum value

(2 x sensing range + 1).

Response in the case of faults: Error code E.

BDE [**B**oth **D**istances of **E**valuation]

Command: BDE,xxxx,yyyy	Example: BDE,400,2000
Parameter: Distance	Unit: mm
Response: Window limits	Range: Blind range ... 2 x sensing range
Reference: Evaluation EM, NDE, FDE	

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Simultaneous setting of the evaluation limits nearest to (xxxx) and furthest from (yyyy) the sensor for sensors of type 8B and IU. The values are entered in millimeters, 4-digit and separated by commas. The valid values correspond to NDE and FDE.

Range: UJ3000 300 ... 6000 mm
UJ6000 800 ... 12000 mm

Evaluation limits not interrogated with BDE!

Note 1:

If the selected window limits are too close to each other and therefore clip the 8 bit resolution, the sensor rejects this value with 81h <invalid parameters>.

Note 2:

NDE < FDE: Positive output ramp.

NDE > FDE: Negative output ramp.

Note 3:

Under ideal conditions, the sensor can also pick up echoes from distances greater than the evaluation range; the sensor therefore accepts parameters of up to double the nominal evaluation range.

Important!

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. If a UDS value of 1 is specified, the switch settings are used, i.e. the parameters will be ignored for the time being and stored in the sensor. UDS,0 activates this "default setting".

CBT [**C**onstant **B**urst **T**ime]

Command: CBT/CBT,xxxx	Example: CBT,55
Parameter: Burst length	Unit: µs
Response: See below	Range: See below
Reference: Propagation time measurement, measuring cycle time, CCT	

The command CBT inquires whether evaluation is to be performed using a constant or a variable burst length.

Response 0000: the sensor dynamically adjusts the burst length to the echo propagation time.

Response xxxx: the burst has a constant length of xxxx [µs].

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The command CBT,xxxx defines a constant burst with a length of xxxx [µs] and simultaneously deactivates the dynamic adjustment.

Range: UJ 3000 20 .... 500 µs
UJ 6000 50 ... 1000 µs

CCT [**C**onstant **C**ycle **T**ime]

Command: CCT/CCT,xxxx	Example: CCT,1
Parameter: Measuring cycle	Unit: Pause length in [ms]
Response: See below	Range: 0 (dynam.)/1 ... 100 (const. Measuring cycle)
Reference: Propagation time meas., RT, CBT	

The command CCT asks whether the sensor adjusts its measuring cycles to the echo it detects or uses constant cycles.

Response 000: the sensor adjusts the repetition rate according to the echo propagation times currently being measured. The evaluation interrupts the cycle if no further echo is received within 2.5 times the time since the last echo.

Response 1 ... 100: evaluation is carried out using constant measuring cycles irrespective of the propagation times. Pauses are inserted between the measuring cycles. The length of the pauses is specified as a value of between 1 and 100 [ms].

The command CCT,0 specifies that the evaluation will be carried out using dynamic measuring cycles.

The command CCT,xxx specifies that the evaluation will be carried out using constant measuring cycles, between which pauses of between 1 and 100 [ms] are inserted.

The pauses increase the response times of the sensor.

Range: Pause length 1 ... 100 [ms]

CON [**CON**servative Filter]

Command: CON/CON,xxx	Example: CON,5
Parameter: Filter type, counter	Unit: -
Response: Current filter	Range: 0 ... 255
Reference: Evaluation EM, FA1/2, FW	

Filter between evaluation and the output:

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The command CON requests the currently selected type of filter or depth of filter (xxx).

Response xxx < 10: the filter is acting as a conservative filter,x

Response xxx ³ 10: the filter is acting as a floating filter.

The command CON, xxx determines the type of filter and the threshold value for the output filter:

for values < 10 the filter is acting as a conservative filter,

for values ≤ 10 the filter is acting as a floating filter.

The command CON,0 deactivates the filter.

Conservative output filter: At least x (1 to 9) consecutive measuring results need to be closer to the selected switching point before the output switches. If a single measured value is beyond the switching point, the counter is reset and x consecutive measurements need to be closer to the switching point again for the output to switch. The counting conditions apply for the switching back of the output.

Floating output filter: An up-down counter increments when the measuring result is closer than the switching point and it decrements in the case of values that are equal to or beyond the switching point. If the counter equals the value xxx (10 to 255), the output is switched. The counter switches back if it reaches the value of zero.

Range: 1 ... 9 conservative filter

10 ... 255 floating filter

Note:

In other parts of this documentation, other terms are used to describe the conservative filter, although they refer to the same algorithm:

Conservative: also “strictly conservative”, floating: also “integrating”

DAT [software **DAT**e]

Command: DAT	Example: -
Parameter: -	Unit: -
Response: See below	Range: -
Reference: ID, VER	

The command requests the date of the sensor software:

The response of the sensor to DAT is, for example: Date: 10/14/94 Time: 08:27:10

DEF [**DEF**ault settings]

Command: DEF

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DIP [read **DIP** switches]

Command: DIP	Example: DIP
Parameter: -	Unit: -
Response: 3 hex. Character	Range: 0....9, A.....F
Reference: -	

Interrogates DIP switch settings.

In response the sensor sends three hexadecimal characters representing the switch positions in coded form:

Bit value 0 = Switch OFF, bit value 1 = Switch ON.

First character: hexadecimal value of DIP switches 1 - 4,

Second character: hexadecimal value of DIP switches 5 - 8,

Third character: setting of DIP switch 9.

Example 1: The sensor response B91h corresponds to switch position 1011 1001 1.

Example 2: With a response 111 h, only DIP switches 4, 8 and 9 are set.

EM [**E**valuation **M**ethod]

Command: EM/EM, DYN/BEW/xxx/Mx	Example: EM,M3
Parameter: See below	Unit: Encoded or counter
Response: See below	Range: See below
Reference: Propagation time measurement, FTO,CON	

The command determines the evaluation method for the sensor. The corresponding code is appended to the command, separated by a comma:

Queries:

EM Asks which evaluation method is currently set.

Example of responses:

OFF,000 no evaluation method activated

DYN,M3 dynamic and averaging evaluation, 3 measured values are averaged

BEW,016 weighted and static evaluation, 16 measured values are added together

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Settings:

EM,DYN	**dynamic** evaluation or
EM,BEW	**weighted** evaluation
EM,xxx	**static** evaluation or
EM,Mx	**averaging** evaluation

The evaluation algorithm treats dynamic and weighted evaluation as mutually exclusive, similarly static and averaging evaluation.

The command **EM,DYN1** activates the **dynamic** evaluation,

the command EM,DYN0 deactivates it.

Dynamic evaluation: The current echo propagation time is compared against the previous one. If they are identical within certain limits, the new propagation time replaces the old one. The difference between the two propagation times is saved as a trend indicator.

If both propagation times differ significantly, then the propagation time is replaced once by an interpolated value calculated from the last measured value and the stored difference. If there is a second strong deviation the new measured value is then accepted. Erroneous individual measurements can be suppressed in this way.

The command **EM,BEW1** activates **weighted** evaluation,

the command EM,BEW0 deactivates it.

Weighted evaluation: The current echo propagation time is compared to see if it is the same as the three previous ones (within a certain limit). If the newly measured time agrees approximately with one of the previous ones, then this time is accepted (two out of the four values are identical!).

If this is not the case, the three previous delays are compared with one another: if they are approximately equal, the propagation time is replaced by the average of these three values.

If only two of these three times agree, then the time is replaced by the average value of these two values.

However, if all four values differ completely, the newly measured time is accepted (as no better decision is possible).

The command **EM,xxx** activates **static** evaluation (xxx = 0/3...255),

the command EM,0 deactivates static evaluation.

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Static evaluation: A specified number of delays is added up and the highest and lowest measured value in these is stripped out. The average value of the remaining added up measured values then becomes the current time. The number of propagation times to be added up is entered as a parameter in the EM command (EM, xxx / xxx = 3 ... 255)..

Note:

The measurement result is not output until the number of propagation times to be added has been attained. Large values of xxx result in very long sensor response times.

With EM,3, the highest and lowest propagation times are suppressed. Thus only one more propagation time determines the measurement result.

The command **EM,Mx** activates **averaging** evaluation (x = 0/2, 3, 4)

The command EM,M0 deactivates averaging evaluation.

Averaging evaluation: The last 2, 3 or 4 measured propagation times are averaged and become the new valid propagation time. No check is made for widely deviating measured values. The number of times to be averaged is specified in the parameter (EM,Mx/x = 2 ... 4).

Parameters may be combined, for example: EM, DYN1, M3.

ER [**E**cho **R**eceived]

Command: ER	Example: -
Parameter: -	Unit: -
Response:0 = No echo 1 = Echo	Range: 0/1
Reference: OER, ODR	

The command ER inquires whether or not the sensor has picked up an echo. The echo propagation time, i.e. the calculated distance, is of no interest.

Response 1: echo picked up, Response 0: no echo picked up.

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FA1 [**F**ilter **A**ctivate **1**]

FA2 [**F**ilter **A**ctivate **2**]

Command: FA1/FA1,x	Example: FA1,0
Parameter: Filter active/inactive	Unit: -
Response: Current filter	Range: 0,1
Reference: Evaluation EM, CON, FW	

The commands FA1/2,x can be used to activate or deactivate the filter for the individual outputs of the sensor identified by CON.

The command FA1 inquires whether or not the CON filter is active for output 1 (the 8B outputs in the case of type 8B the analog output in the case of type IU).

The command FA2 inquires whether or not the CON filter is active for output 2 (switching output A1 in the case of Type IU).

Response 0: CON filter not active, Response 1: CON filter active.

The command FA1, 1 or FA2, 1 activates the output filter,

the command FA1, 0 or FA2, 0 deactivates the output filter for the **individual** output 1/2.

For sensors of different types, the commands refer to:

	E22	8B	IU
FA1	A1	8B	IU
FA2	A2	-	A1

FW	-	8B	IU

FDE [**F**ar **D**istance of **E**valuation] (see command **NDE**)

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FTO [**F**ilter **T**ime **O**ut]

Command: FTO/FTO,xxx	Example: FTO,3
Parameter: Filter depth	Unit: Counter value
Response: Current filter	Range: 0 ... 255
Reference: Evaluation EM, CON, OM	

Filter between echo propagation time measurement and evaluation:

The FTO command requests the filter depth set for the measurement cycles **without echo**.

The FTO,xxx command instructs the sensor software how many measurement cycles that have detected no echo are to be ignored. These measurements (with no echo) are not evaluated until an internal counter exceeds the value transferred with FTO. Not until the number of measurements (with no echo) exceeds the value of xxx is the resulting maximum value for the propagation time calculated.

The command FTO,0 deactivates the filter.

Note:

This parameter is useful for ensuring a stable output signal with objects, for example, that do not reflect ultrasound well (if an echo is not always received) or with liquids in a state of motion (when the ultrasonic pulse passing through the liquid is occasionally reflected to the side by surface movement).

FW [**F**ilter **W**indow]

Command: FW/FW,xx	Example: FW,1 0
Parameter: Window width	Unit: %
Response: Current window width	Range: 5....25
Reference: Filter CON, FA1	

In the case of sensors of type 8B and IU, the command FW defines an evaluation window around the measured value for the conservative filter. The window width is set as a percentage of the measured value (5 to 25 %).

Sudden changes to the measured value that push the value beyond the window limits are processed by the CON filter. How many times such measured values have to lie outside the window before they affect the result, is specified using the CON command.

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The command FW requests the size of the window.

The response xx provides the current width as a percentage of the measured value.

The command FW,xx sets the width of the window as a percentage of the measured value.

Range: 5 ... 25 %Default value: 10 %

ID [sensor **ID**entification and version]

Command: ID	Example: -
Parameter: -	Unit: -
Response: See below	Range: -
Reference: VER, DAT	

The sensor is requested to return its identification and may respond, for example, with:

Sensor: P&F UJ6000+FP+E22+RS Eprom: 18-01U3

MD [**M**aster **D**evice]

Command: MD/MD, AD...OFF	Example: MD,AD
Parameter: Data	Unit: encoded
Response: See below	Range: See below
Reference: AD, RD, RT, SSx, ADB, RDB, RTB, UDS	

The command MD, ... is used to set the mode of operation of the sensor: master or slave mode.

A sensor normally operates in slave mode.

Slave mode: The sensor generally only responds to commands. If a periodic distance inquiry is required, the sensor must be sent an AD command from time to time.

Master mode: When each measurement is complete, the sensor automatically forwards the result to the serial interface.

The commands MD,AD ... MD, OR put the sensor into master mode; the associated parameter (after the comma) determines how the data will be transmitted.

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The conditions associated with data transmission are identical to those for the commands AD and RD.

MD,AD: [Absolute Distance] absolute distance in mm, 5-digit in ASCII format

MD,RD: [Relative Distance] relative distance in digits (8 bit) in ASCII format (for sensors of type IU and 8B with analog value output).

MD,SS: [Switching States] logical status of the switching outputs

sensors of type E22: two figures (first for output 1/second for output 2)

sensors of type IU: one figure for the switching output

sensors of type 8B: no parameter available.

digit = 0: output not switched, digit = 1: output switched

MD,OR: [Object in Range] a two-digit figure provides information about the detection of an object:

first digit: object in evaluation range (0/1 corresponds to no/yes)

second digit: object within evaluation range (0/1 corresponds to no/yes)

(evaluation range: area between evaluation limits in the case of types 8B and IU or between switching points in the case of type E22)

MD,OFF terminates master mode

Note 1:

In the case of binary transmissions the response bytes are, as a rule, non-printable ASCII characters, which are not output by the terminal program.

Note 2:

The relative distances inquire about the position of the object in a measuring window defined with the configuring commands NDE and FDE or through the DIP switches. The resolution is 254 digits.

Important!

The switching points and range limits defined using the DIP switches only take effect when DIP switch evaluation has been activated with UDS,1. The corresponding stored parameter values take effect following a UDS,0 command.

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NDE [**N**ear **D**istance of **E**valuation]

FDE [**F**ar **D**istance of **E**valuation]

Command: NDE/FDE,xxxxx	Example: NDE/NDE,500
Parameter: Distance	Unit: mm
Response: Window limit	Range: Blind range ... 2 x sensing range
Reference: BDE, UDS	

NDE/FDE (no parameters) are used to request the limits of the measurement window nearer to/further from the sensor for the output of analog values from 8B or IU sensors.

The command **NDE**,xxxxx defines the limit of the analog output **nearest to the sensor**,

the command **FDE**,xxxxx the limit **furthest from the sensor**.

Note 1:

If the selected window limits are too close and therefore clip the 8 bit resolution, the sensor rejects this value with 81h <invalid parameter>.

Note 2:

NDE < FDE: Positive output ramp.

NDE > FDE: Negative output ramp.

Note 3:

Under ideal conditions, the sensor can also pick up echoes from distances greater than the evaluation range; the sensor therefore accepts parameters of up to double the nominal evaluation range.

Range: UJ 3000 300 ... 6000 mm

UJ 6000 800 ... 12000 mm

Important!

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. If a UDS value of 1 is specified, the switch settings are used, i.e. the parameters will be ignored for the time being and stored in the sensor. UDS,0 activates this "default setting".

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ODF [**O**utput **D**ata **F**ormat]

Command: ODF, 8B/BCD	Example: ODF, BCD
Parameter: 8B, BCD	Unit: Binary coded, cm
Response: Distance, encoded	Range: -
Reference: NDE, FDE, evaluation	

This command and its parameter (8B or BCD) determines the data format of the transmission for sensors with an **8 bit output** :

ODF, 8B: the relative object distance is output in parallel with a resolution of 8 bits.

NDE < FDE: Bit string 0000 0001 <01h>, if object distance ≤ NDE,
Bit string 1111 1110 <FEh>, if object distance ≥ FDE.

NDE > FDE: Bit string 0000 0001 <01h>, if object distance ≥ NDE,
Bit string 1111 1110 <FEh>, if object distance ≤ FDE.

The bit strings 0000 0000 <00h> and 1111 1111 <FFh> are **not used**

The bit string that is output remains on the output until it is next updated.

ODF, BCD:(binary coded decimal) the absolute distance to the object is multiplexed and output as a three figure decimal number to a resolution of 1 cm. The sensor forwards the figure in BCD format on data lines 0 to 3 followed by the weighting of the figures on data lines 4 to 6. The least significant digit corresponds to a 1. The most significant bit is not used.

All data lines revert to zero following an output.

(See “Data output format (ODF)” on page 86.)

Important!

The command UDS has an effect on the present evaluation limits and hence the result.

ODR [**O**bject in **D**etection **R**ange]

Command: ODR	Example: -
Parameter: -	Unit: -
Response: 0 = No target in sensing range, 1 = Target	Range: -
Reference: OER, ER, MD, OR	

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The command inquires whether or not an object has been detected within the **sensing range** (area between blind range and nominal evaluation range):

Response 0: no target within sensing range,

Response 1: target detected within sensing range.

OER [**O**bject in **E**valuation **R**ange]

Command: OER	Example: -
Parameter: -	Unit: -
Response: 0 = No target in evaluation range, 1 = Target	Range: -
Reference: ODR, ER, MD,OR, UDS	

The command inquires whether or not an object was detected within the **evaluation range**.

Evaluation range for sensors of type 8B and IU:

the area between the limits of the evaluation range.

Evaluation range for sensors of type E22:

the area between the two switching points.

Response 0: no target within evaluation range,

Response 1: target detected within evaluation range.

Important!

The command UDS has an effect on the present switching points/evaluation limits and hence the result.

OM [**O**utput **M**ode]

Command: OM/OM,xy	Example: OM,23
Parameter: -	Unit: -
Response: See below	Range:2 = N/O contact 3 = N/C contact
Reference: UDS, SS1, SS2	

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The command OM inquires about the current configuration of the outputs (N/C / N/O).

Response 2: functions as N/O contact,

Response 3: functions as N/C contact.

The command OM,xx determines how the outputs are to be configured:

The **first** of the two characters following the command code refers to **switching output 1**,

the **second** to **switching output** 2 (with sensors of type E22).

Parameter value **2**: Output functions as **N/O contact**.

Parameter value **3**: Output functions as **N/C contact**.

The number of existing switching outputs determines whether one or two parameters are appended to the command.

Type 8B and IU sensor: The interference type 8B and the switching output on type IU sensors are configured as N/O contacts with the command OM,2 and as N/C contacts (pnp) with OM,3.

Sensors of type E22: Following an OM,23 command, output 1, for example, will function as a N/O contact but output 2 as a N/C contact (pnp).

Important!

The switch settings will take precedence as long as the DIP switches are active.The parameters passed with the OM,xx command are saved and only take effect following a UDS,0 command.

RD [**R**elative **D**istance]

Command: RD	Example: -
Parameter: -	Unit: Digit
Response: 3 digits	Range: 0...254
Reference: AD, NDE, FDE, BDE	

Sensors of type 8B or IU are requested to return the relative distance [digit].

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In other words, the position of an object within a range defined by NDE and FDE (or via DIP switches) for the output of the analog value is calculated. The 8 bit D/A converter provides a resolution of 254 digits. The sensor responds accordingly to the window limit nearest the sensor with 0 and to the one furthest away with 254. A value between 0 and 254 corresponds to each intermediate position.

Note:

Echos from distances < NDE: Response 001.

Echos from distances > FDE: Response 254.

Important!

The command UDS determines whether the evaluation limits are defined through the DIP switch settings or parameter values. Following UDS,1 the DIP switch setting applies.

REF [**REF**erence Distance]

Command: REF,xxxxx	Example: REF,5000
Parameter: Reference distance	Unit: mm
Response: None	Range: -
Reference: Evaluation, temperature comp., VS0, TEM, TO	

A target must be located at a precisely measured distance within the evaluation range of the sensor. This reference value is passed to the sensor as a value in [mm] using the command REF,xxxxx. The sensor calculates a new sound velocity from this value and the calculated echo propagation time and saves it as a new reference value.

This parameter **cannot be interrogated**.

If the parameter is missing, the sensor responds with 82h.

RST [sensor software **R**e**S**e**T**]

Command: RST	Example: -
Parameter: -	Unit: -
Response: Acknowledge with 0	Range: -
Reference: -	

The sensor performs a reset as a result of this command. The command is acknowledged (80h).

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RT [**R**andom**T**ime]

Command: RT/RT,x	Example: RT,0
Parameter: Pause 0/1	Unit: Encoded
Response: Current value (0 or 1)	Range:0 = None 1 = With pause
Reference: CCT, CBT	

The command RT asks the sensor whether or not it is using random length pauses between two time measurements:

Response 0: no pauses, Response 1: with random length pauses.

The command RT,0 prevents the pause,

The command RT,1 specifies that pauses of random length are to be inserted between the time measurements.

Important!

This command has a completely different impact in the case of UC sensors.

SD1 [**S**witching **D**istance **1**]

SD2 [**S**witching **D**istance **2**]

Command: SD1/SD2,xxxxx	Example: SD1,1200
Parameter: Switching point	Unit: mm
Response: See below	Range: See below
Reference: UDS, SH1, SH2	

The commands SD1/SD12 (**no parameters**) query the current switching points.

The response is dependent on whether or not the DIP switches are active:

UDS,1 = DIP switches are active: Responds showing the current switching points.

UDS,0 = DIP switches are not active: Responds with values from previous SD1/ SD2,xxxxx commands.

Commands **with parameters** define the switching points of the sensor. Valid values lie between the blind range and double the evaluation range. The parameters are entered as 5-digits values in [mm] and are separated from the command by a comma.

Range: Sensors UJ3000 300 ... 6000
Sensors UJ6000 800 ... 12000

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The command SD**1**,xxxxx determines the **first** (close to sensor) switching point for all modes of operation,

the command SD**2**,xxxxx the **second** (distant from sensor) switching point (not in the case of IU type sensors).

Important!

If the **DIP switches are activated** (UDS,1), the switching points in the DIP switches have priority. The entered value is stored and becomes available once the DIP switches are deactivated (UDS,0).

SH1 [**S**witching **H**ysteresis **1**]

SH2 [**S**witching **H**ysteresis **2**]

Command: SH1,xx/SH2,xx	Example: SH1,12
Parameter: Range	Unit: %
Response: 0....15	Range: 0....15
Reference: UDS, SD1, SD2	

The commands SH1/SH2 request information on how large the current switching hystereses for the switching points on outputs 1/2 are.

The command SH1,xx defines the switching hysteresis switching output 1: the value is in the range 0 to 15 % of the switching distance.

The command SH2,xx defines the switching hysteresis switching output 2 (in the case of sensors of type E22).

Important!

The hysteresis remains at 10 % as long as the DIP switches are active (UDS,1). The value specified using SH, xx only becomes effective following a UDS,0 command.

SS1 [**S**witching **S**tate **1**]

SS2 [**S**witching **S**tate **2**]

Command: SS1/SS2	Example: SS1
Parameter: -	Unit: -
Response:0 = Not active 1 = Active output	Range: -
Reference: UDS, SD1, SD2, SH1, SH2, UDS	

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The commands SS1/SS2 interrogate the logical status of the switching outputs.
SS1 interrogates switching output 1, SS2 switching output 2.

A response of 0 means: the object is further away than the switching point.
A response of 1 means: the object is nearer than the switching point.
No account is taken of any N/C or N/O function.

Important!

The command UDS determines whether the limits are defined through the DIP switch settings or parameter values. If a UDS value of 1 is specified, the switch settings are used; UDS,0 means the parameters will be used.

UDS [**U**se **D**ip **S**witches]

Command: UDS/UDS,x	Example: UDS,1/UDS,0
Parameter: 0, 1	Unit: -
Response: See below	Range:0 = Not active 1 = Active
Reference: Evaluation, SD1, SD2, SH1/2, OM	

The command UDS determines whether the limits are defined through the DIP switch settings or parameter values.

Command UDS,0: the DIP switches are not active,
Command UDS,1: DIP switch settings will be evaluated.

Attention

In the case of sensors that use the DIP switches to determine switching hysteresis, switching function (N/C / N/O) or evaluation limits in addition to the switching distance, following UDS,0 the DIP switch setting does not apply, but the values or functions entered and saved via the interface.

VER [sensor **VER**sion]

Command: VER	Example: -
Parameter: -	Unit: -
Response: See below	Range: -
Reference: DAT, ID	

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The sensor is interrogated for its version code.

It returns four coded characters indicating the sensor type:

- the **first two** characters indicate the **sensing range**:
  - 05 : 500 mm
  - 02 : 2000 mm
  - 03 : 3000 mm
  - 04 : 4000 mm
  - 06 : 6000 mm
- the **third** character indicates the **sensor type**:
  - 0 : undefined
  - 1 : UJ3000+U1+8B-RS/UJ6000-FP-8B-RS
  - 2 : UJ3000+U1+E22+RS/UJ6000-FP- E22+RS
  - 3 : UJ3000+U1+IU+RS/UJ6000-FP- IU+RS
  - 4 : UJ3000+U1+RS/UJ6000-FP+RS
  - 5 : UC3000+U1+E6/E7+R2/UC6000-FP-E6/E7+R2
  - 6 : UC3000+U1+IU+E0/E2+R2 / UC6000-FP- IU-E0/E2+R2
  - 7 : UC....-30GM-E6/E7-V15-R2
  - 8..F undefined
- the **fourth** the character indicates the **software version** (e.g. C).

VS [**V**elocity of **S**ound]

Command: VS/VS,xxxxx	Example: VS,34000
Parameter: Velocity of sound	Unit: 0.01 m/s = cm/s
Response: Velocity of sound	Range: -
Reference: VS0, TO, evaluation, temperature measurement	

The command VS reads the velocity of sound currently being used for calculating the distance from the propagation time. The 5-digit response represents the unit [0.01 m/s = cm/s]. Thus, the response 34400 means that the evaluation is operating with a velocity of sound of 344.0 m/s...

VS,xxxxx passes a new sound velocity value to the sensor [cm/s].

This new value is stored and has a **significant effect on the calculation of the distance**.

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8 Appendix

Setting the switching points/evaluation limits of type E22/IU sensors via DIP switches

8.1 Sensors of type E22

If ultrasonic sensors are equipped with DIP switches, these have a typical layout:

DIP switches 1 ... 8 specify the switching points, DIP switch 9 specifies the switching mode (N/C/N/O) and switch 10 specifies whether the sensor outputs transmit the measured value or are used for communication via the serial interface.

Normally, DIP switches 1 ... 4 are used to set the near switching point/measurement window limit and DIP switches 5 ... 8 are used to set the far switching points/measurement window limits (see the appropriate data sheet).

8.1.1 Sensor UJ3000+U1+E22+RS:

Sensing range 300 mm ... 3000 mm.

Switching value settings (table of values)

Switch 1 2 3 4	Switching distance [cm]	Switch 5 6 7 8	Switching distance [cm]
0000	30	0000	40
0 0 0 1	45	0 0 0 1	55
0 0 1 0	60	0 0 1 0	70
0 0 1 1	75	0 0 1 1	85
0 1 0 0	90	0 1 0 0	100
0 1 0 1	105	0 1 0 1	115
0 1 1 0	120	0 1 1 0	130
0 1 1 1	135	0 1 1 1	145
1000	150	1000	160
1 0 0 1	170	1 0 0 1	180
1 0 1 0	190	1 0 1 0	200
1 0 1 1	210	1 0 1 1	220
1 1 0 0	230	1 1 0 0	240
1 1 0 1	250	1 1 0 1	260

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1 1 1 0	270	1 1 1 0	280
1 1 1 1	290	1 1 1 1	300

1 = ON; 0 = OFF

8.1.2 UJ6000-FP-E22-RS:

Sensing range 800 mm ... 6000 mm.

Switching value settings (table of values)

Switch 1 2 3 4	Switching distance [cm]	Switch 5 6 7 8	Switching distance [cm]
0000	80	0000	95
0 0 0 1	110	0 0 0 1	125
0 0 1 0	140	0 0 1 0	155
0 0 1 1	170	0 0 1 1	185
0 1 0 0	200	0 1 0 0	215
0 1 0 1	230	0 1 0 1	245
0 1 1 0	260	0 1 1 0	275
0 1 1 1	290	0 1 1 1	305
1000	320	1000	335
1 0 0 1	350	1 0 0 1	365
1 0 1 0	380	1 0 1 0	400
1 0 1 1	420	1 0 1 1	440
1 1 0 0	460	1 1 0 0	480
1 1 0 1	500	1 1 0 1	520
1 1 1 0	540	1 1 1 0	560
1 1 1 1	580	1 1 1 1	600

1 = ON; 0 = OFF

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8.2 Sensors of type IU

If the near evaluation limit is set to a lower value than the evaluation limit, far from the sensor the analog output generates a rising ramp. Conversely, the analog output generates a falling ramp if the first evaluation limit is set larger than the second evaluation limit.

It is not permitted to set the same value for both evaluation limits:the sensor flashes red for a setting error.

The switching point of the sensor is in the middle of the two set evaluation limits.

8.2.1 UJ3000+U1+IU+RS:

Sensing range 300 mm ... 3000 mm.

Setting the evaluation limits (table of values)

Switch 1 2 3 4	Switching distance [cm]	Switch 5 6 7 8	Switching distance [cm]
0000	30	0000	30
0 0 0 1	45	0 0 0 1	45
0 0 1 0	60	0 0 1 0	60
0 0 1 1	75	0 0 1 1	75
0 1 0 0	90	0 1 0 0	90
0 1 0 1	105	0 1 0 1	105
0 1 1 0	120	0 1 1 0	120
0 1 1 1	140	0 1 1 1	140
1000	160	1000	160
1 0 0 1	180	1 0 0 1	180
1 0 1 0	200	1 0 1 0	200
1 0 1 1	220	1 0 1 1	220
1 1 0 0	240	1 1 0 0	240
1 1 0 1	260	1 1 0 1	260
1 1 1 0	280	1 1 1 0	280
1 1 1 1	300	1 1 1 1	300

1 = ON; 0 = OFF

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8.2.2 UJ6000-FP-IU+RS:

Sensing range 800 mm ... 6000 mm.

Setting the evaluation limits (table of values)

Switch 1 2 3 4	Switching distance [cm]	Switch 5 6 7 8	Switching distance [cm]
0000	80	0000	80
0 0 0 1	110	0 0 0 1	110
0 0 1 0	140	0 0 1 0	140
0 0 1 1	170	0 0 1 1	170
0 1 0 0	200	0 1 0 0	200
0 1 0 1	230	0 1 0 1	230
0 1 1 0	265	0 1 1 0	265
0 1 1 1	300	0 1 1 1	300
1000	335	1000	335
1 0 0 1	370	1 0 0 1	370
1 0 1 0	405	1 0 1 0	405
1 0 1 1	440	1 0 1 1	440
1 1 0 0	480	1 1 0 0	480
1 1 0 1	520	1 1 0 1	520
1 1 1 0	560	1 1 1 0	560
1 1 1 1	600	1 1 1 1	600

1 = ON; 0 = OFF

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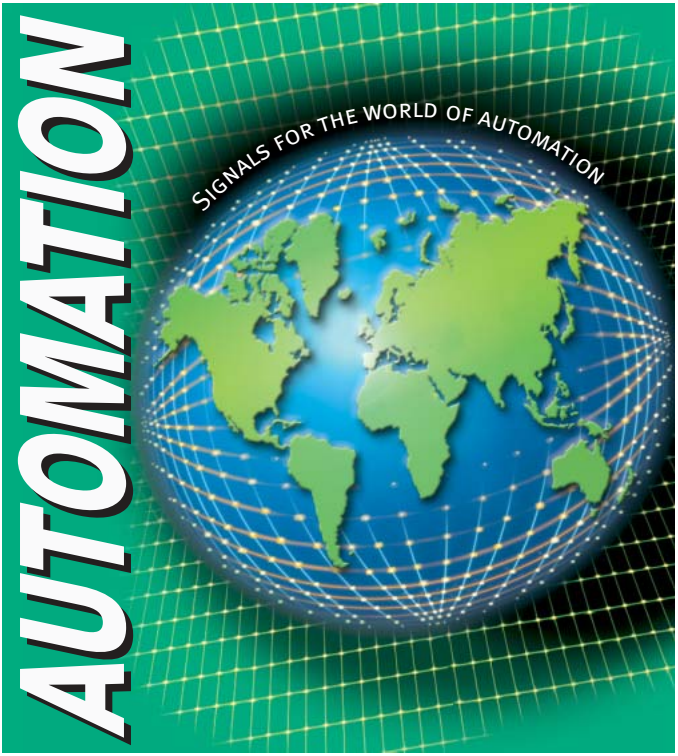

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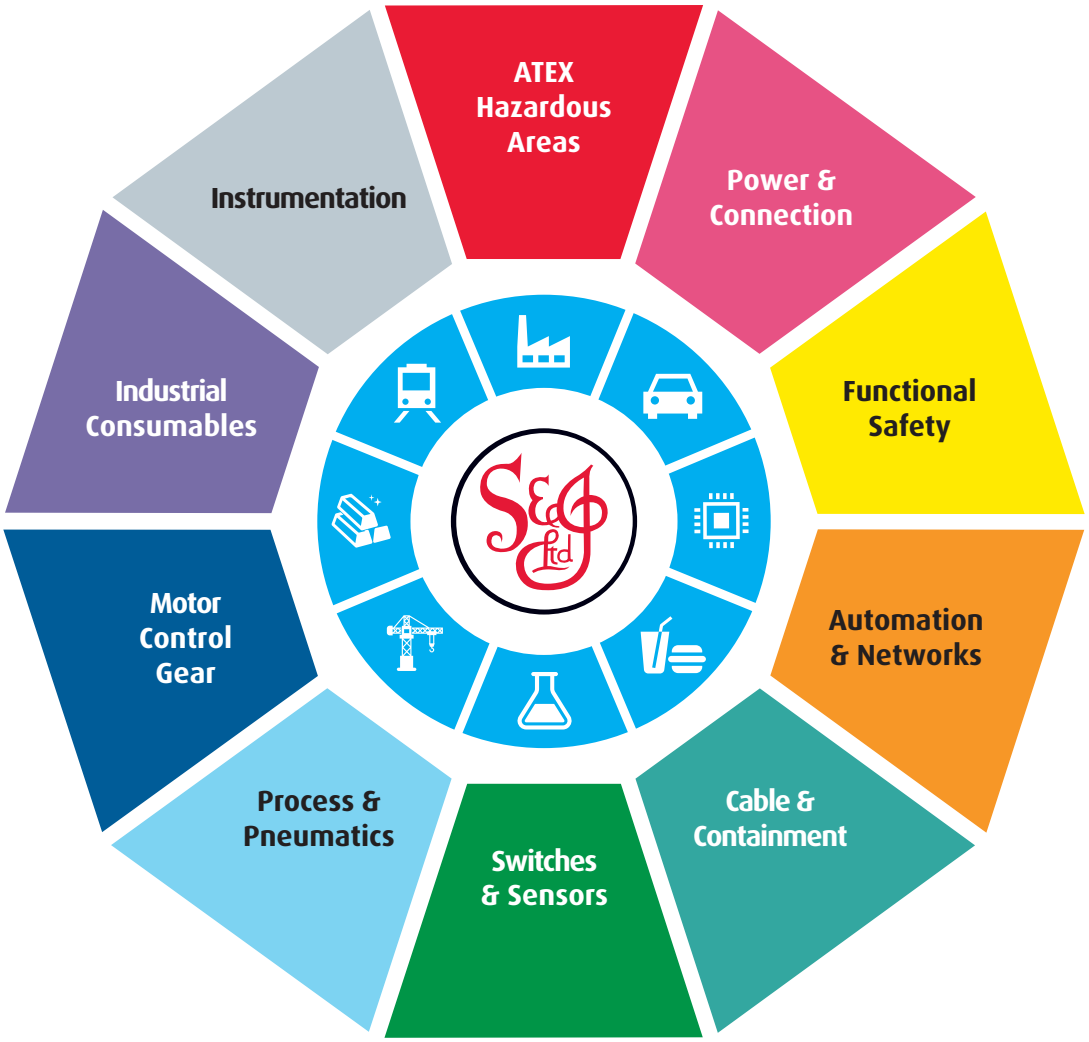

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