

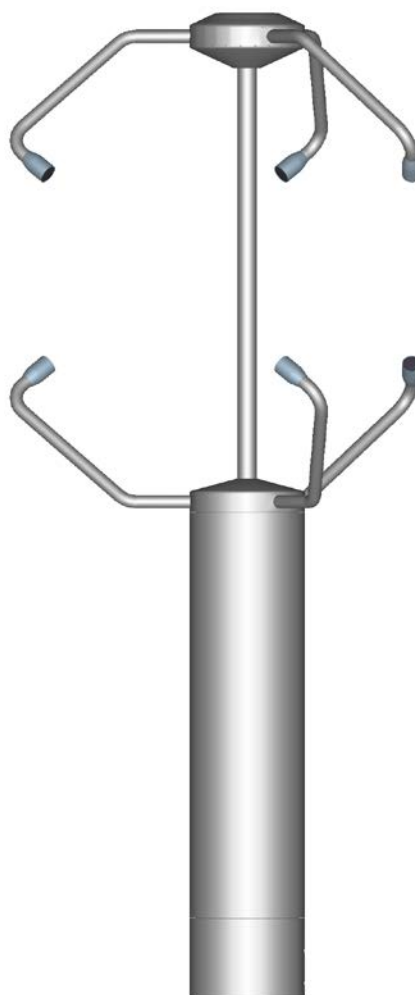
Operating Instructions

021507/09/13

Ultrasonic Anemometer 3D

4.383x.xx.xxx

from Software version V3.12



ADOLF THIES GmbH & Co. KG

Hauptstraße 76	37083 Göttingen Germany
Box 3536 + 3541	37025 Göttingen
Phone +49 551 79001-0	Fax +49 551 79001-65
www.thiesclima.com	info@thiesclima.com

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- Before operating with or at the device/product, read through the operating instructions. This manual contains instructions which should be followed on mounting, start-up, and operation. A non-observance might cause:
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 - Endangering of persons by electrical or mechanic effect
 - Damages at objects
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Patent Protection

This instrument is patent-protected.

Patent No.: EP 1 448 966 B1

Patent No.: US 7,149,151 B2

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1 Application

The **Ultrasonic Anemometer 3D** is used to detect the horizontal and vertical components of **wind velocity**, **wind direction** and **acoustic virtual temperature** in **3 dimensions**.

More than 70 different measurement values are available, such as:

- Wind velocity in X / Y / Z –direction
- Total wind velocity
- Wind velocity azimuth
- Wind direction azimuth
- Wind direction elevation
- Acoustic-virtual temperature [°C]
- Standard deviation of wind velocity in X / Y / Z- direction
- Standard deviation of the total wind velocity
- Standard deviation of the wind velocity azimuth
- Standard deviation of the wind direction azimuth
- Standard deviation of the wind direction elevation
- Standard deviation of the acoustic-virtual temperature
- Statistic functions such as variance, covariance, turbulence intensity
- Wind velocity X / Y / Z of the gust acc. to WMO
- Wind direction of the gust (elevation) acc. to WMO

For further measurement values see chapter 7.4.4.5 (measurement values available and data formats).

The device is particularly suitable for use in

- meteorology
- climatology
- traffic engineering, aviation and navigation
- indoor flow measurement
- as well as for alpine applications.

In relation to the classical anemometer the measuring principle (see section 2) provides for inertia-free measurement of rapidly changing variables with maximum precision and accuracy. It is particularly suitable for the measurement of gusts and peak values.

The level of accuracy achieved when measuring the air temperature (acoustic virtual temperature) surpasses that of classical methods, in which the temperature sensors are used with a weather and radiation shield, following correction of the influence of damp occurring with certain weather situations.

Output of the measured values can be either digital and / or analog.

Digital output:

An RS485/422 is available for serial communication. It can be operated in full or half duplex mode. For output of the measured values there are a number of predefined telegrams or a user-defined telegram (e.g. wind velocity, wind direction, acoustic virtual temperature, standard deviations, covariances, status information, etc.).

Analog outputs:

The X Y and Z-components of the wind velocity vector are output either as a current or voltage signal.

Alternatively, the analog outputs can also be switched as analog voltage inputs (max. 5). Data is then output only via the serial interface with the user-defined telegram (with 3 inputs in half duplex mode; with 5 inputs, 2 in multiplex with serial COM).

The serial or analog output of the data is either as an instantaneous value or as a sliding mean with an adjustable time slot.

Heating

For a multitude of applications the continuous output of solid measuring data of the wind velocity and direction is an indispensable requirement to the measuring system, even under meteorological extreme conditions such as icing situations.

The Ultrasonic is, therefore, equipped with a sophisticated heating system. This system keeps all outer surfaces that might disturb the measuring value acquisition in case ice formation, efficiently on a temperature above +5°C.

Also the measuring arms belong to the heated outer surfaces, as well as additionally the ultrasonic transducer and the housing – depending on the model.

Please take into consideration here, that the weakest link of the chain determines the complete functionality.

Instruments heating only a part of the construction rarely shows advantages compared with completely unheated instruments.

The Ultrasonic is in a position to generate measuring data with high accuracy even in unheated state at temperatures of up to below –40 °C. There is no temperature-depending quality of the measuring data. The heating is necessary only for avoiding the ice formation on the instrument construction, thus avoiding an involved failure in the measuring value acquisition.

The heating system avoids effectively an icing formation – depending on the model acc. to our in-house icing standard THIES STD 012002.

Mode of Operation:

The heating elements are activated via a 2-point controller by the acoustic-virtual temperature and a temperature sensor at an appropriate position inside the housing; they keep the temperature of the outer surfaces on approx. +5°C even at high wind velocities. This means that the full heating power is activated until the reference temperature is reached, and is repeatedly alternating switched on and off (2-point controller) by a hysteresis of approx. 2K.

The necessary integral heating power is depending on the thermal coupling of the surrounding air, and thus on the wind velocity.

The sensor arms, the centre rod, and the ultrasonic converters of model 4.3830.2x.xxx are heated, if necessary, automatically in case of critical ambient temperatures. Thus, the function is guaranteed even in case of snow fall and ice rain.

Thanks to additional ultrasonic transformer heating systems and additionally integrated housing heater the model No.4.383x.4x.xxx particularly suitable for extreme conditions in high mountain areas or other critical measuring locations where icing is to be expected.

These operating instructions describe all possible applications and settings.

The Ultrasonic Anemometer 3D is factory-set.

Identification for the factory setting is via the order No. and "Factory Setting".

Order number and setting see supplementary sheet "Factory Setting"

With these detailed operating instructions and via the serial interface of the Ultrasonic Anemometer 3D it is possible for customers to change the factory setting or to adjust it to new requirements.

The Ultrasonic Anemometer has Online Help for fast and convenient configuration.

An overview of commands and a brief explanation is output by the ULTRASONIC following input of the device ID followed by two question marks.

Input example:

Device ID is set to 00 (initial state)

Input: 00?? carriage return

Output: Entire list of commands with brief explanations

For Help with individual commands the device ID and the command followed by a ? is input, e.g. 00BR?

Output: Help for specific command

2 Mode of Operation / Measuring Principle

The **Ultrasonic Anemometer 3D** consists of 6 ultrasonic transformers, in pairs facing each other at a distance of 200 mm. The three resulting measurement paths are vertical in relation to each other. The transformers function both as acoustic transmitters and receivers.

The electronic control system is used to select the respective measurement path and its measuring direction. When a measurement starts, a sequence of 6 individual measurements is performed in all 6 directions of the measurement paths in a preselectable timing cycle.

The measuring directions (sound propagation directions) rotate clockwise (looking from above), firstly from top to bottom and then from bottom to top.

The mean values are worked out from the 6 individual measurements of the path directions depending on the measuring speed and output rate selected and used to make further calculations.

The time required for a measuring sequence is approx. 3.5 m sec at +20°C with the maximum measuring speed, which is only limited by the sound velocity over the measurement paths.

2.1 Measuring principle: wind velocity and direction

The propagation velocity of sound in calm air is superposed by the velocity component of an air flow.

A wind velocity component in the propagation direction of sound supports the propagation velocity; i.e. it increases it while a wind velocity component against the propagation direction reduces the propagation velocity.

The propagation velocity resulting from superposition leads to different propagation times of sound at different wind velocities and directions over a fixed measurement path.

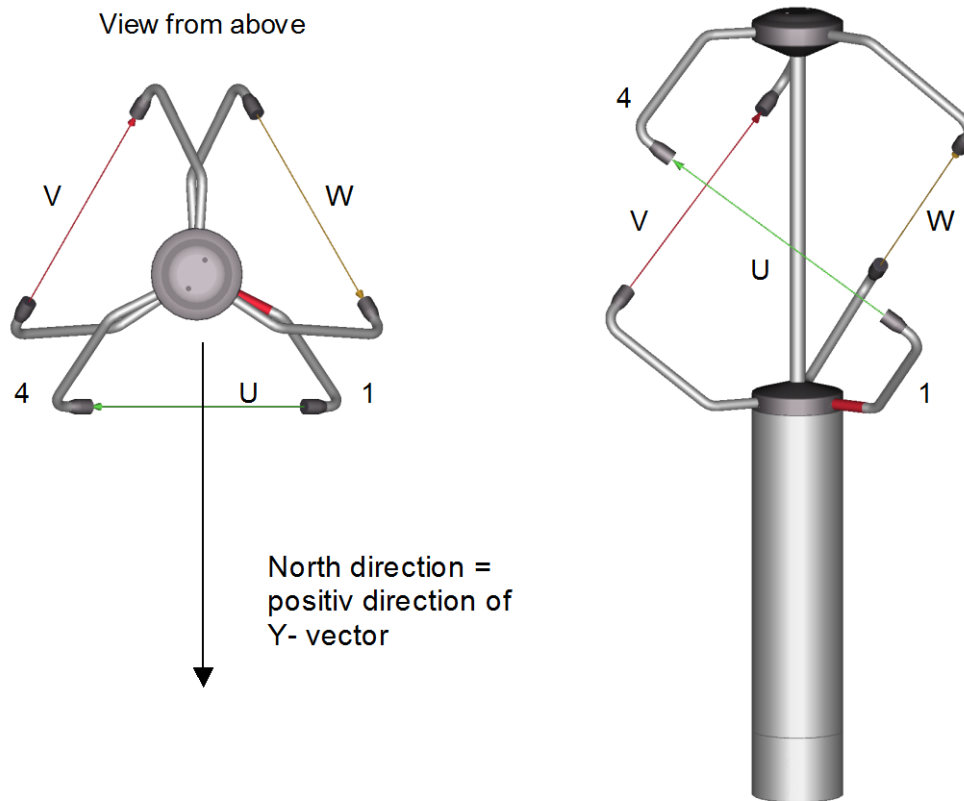
As the sound velocity greatly depends on the temperature of the air, the propagation time of sound is measured on each of the three measurement paths in both directions. This rules out the influence of temperature on the measurement result.

With the arrangement of three measurement paths vertically in relation to each other the measurement results of the sum and the angle of the three-dimensional wind velocity vector are obtained in the form of vectorial components vertical in relation to each other.

After measurement of the velocity components U, V and W, they are converted to the output formats selected by a digital signal processor (DSP) and then output.

The vectors U, V and W spanned by the measurement paths are transformed to a natural coordinate system X, Y and Z. The vectors X and Y lie in the horizontal plane if the device is exactly vertical when installed, with the Y-vector in the south-north direction and the X vector in the west-east direction. The Z vector is vertical to the X and Y vectors and describes the vertical wind component.

The Y vector points in a northerly direction and is vertical to the measurement path U, formed by the ultrasonic transformers 1 and 4. Transformer 1 is marked red.



2.2 Measuring principle: acoustic virtual temperature

The thermodynamic interrelationship between the propagation velocity of sound and the absolute temperature of the air is defined by a root function. The sound velocity is also more or less independent of the air pressure and only depends on the absolute air humidity to a minor extent. This physical interrelationship between sound velocity and temperature is ideal when measuring the air temperature as long as the chemical composition is known and constant.

The levels of gases in the atmosphere are constant and with the exception of water vapour content vary at most by a few 100 ppm (CO_2) even over lengthy periods.

Determination of gas temperature via its sound velocity is performed directly from measurement of its physical properties without the step of thermal coupling of this gas to a sensor which would otherwise be necessary.

The advantages of this measuring method are firstly its inertia-free reaction to the actual gas temperature, and secondly, the avoidance of measuring errors such as those that occur for example when a solid-state temperature sensor is heated by radiation or cooled through the evaporation of water on the sensor.

Many comparative tests between different weather and thermal radiation shield housings show the indirect effect of the above-mentioned sources of measurement errors on the temperature sensor. [1]

At sites with a high likelihood of icing-up ultrasonic anemometers are also used already as acoustic thermometers, as classical temperature sensors are no longer vented with weather and thermal radiation shield housings after icing-up. Due to the peyorated thermal coupling to the outer world they response only extremely time-delayed, or due to the missing discharge of the own power dissipation the measured temperature is too high.

Given the dependence, albeit low, of the sound propagation velocity on the air humidity level, the "acoustic virtual temperature" relates to dry air without any water vapour content.

The deviation of the measured "acoustic temperature" from the real air temperature shows linear dependence on the absolute humidity level of the air.

The amount of water vapour in the air proportionately increases the velocity of sound as H₂O molecules only have around half the mass of the other air molecules (O₂ and N₂).

The velocity of sound however only increases with the molar mass fraction of water vapour in the air to a disproportionately low degree.

The reason for this is the lower mean translatory velocity of the water vapour molecules in comparison with the other air molecules. With the more complex H₂O molecules greater degrees of freedom of motion are possible than with the more simple O₂ and N₂ molecules so that the total energy content (temperature) is divided between the possible degrees of freedom of translation and rotation as kinetic energy.

O₂ and N₂ molecules have 3 degrees of freedom of translation and 2 degrees of freedom of rotation, and H₂O molecules 3 degrees of freedom of translation and 3 degrees of freedom of rotation.

The adiabatic exponent γ of each gas is determined by the total number of degrees of freedom according to the following interrelationship:

$$\gamma = 1 + \frac{2}{n}$$

The adiabatic exponents measured for dry air γ_d and water vapour γ_v are:

$$\gamma_d = 1.399463 \text{ and } \gamma_v = 1.331$$

The dependence of the acoustic virtual temperature T_v on the water vapour content of the air can be calculated using the following relationship:

$$T_v = T_t \bullet \left[1 + \left[\frac{\gamma_v}{\gamma_d} - \frac{M_v}{M_d} \right] \bullet \frac{e}{p - \left[1 - \frac{M_v}{M_d} \right] \bullet e} \right] \quad [1]$$

where T_t is the acoustic virtual temperature of dry air and M_v the molar mass of water vapour, and M_d describes the molar mass of dry air. The ratios $\frac{M_v}{M_d}$ with the value 0.621978 and $\frac{\gamma_v}{\gamma_d}$ with the value 0.95108 can be included in the equation as fixed constants [3].

The ratio $\frac{e}{p - [0,378022] \bullet e}$ describes the water vapour pressure divided by the air pressure, corrected by the effect of the water vapour pressure on the air pressure.

The vapour pressure e can be calculated according to the relationship $e = \frac{RH}{100} \bullet e_s$ where RH stands for relative humidity and e_s for saturation vapour pressure.

The saturation vapour pressure is a function of temperature and can be calculated according to the Magnus formula with coefficient according to Sonntag

$$e_s(T) = 6,112 hPa \bullet e^{\frac{17,62 \bullet T}{243,12 K + T}} \quad [4]$$

with the temperature of interest where T must be specified in °C.

The following simplified expression with T as the temperature in Kelvin results for calculation of the acoustic virtual temperature measured with humid air:

$$T_v = T_t \bullet \left[1 + 0,329102 \bullet \frac{e}{p - [0,378022] \bullet e} \right]$$

The correcting effect of the water vapour pressure on the air pressure is relatively low, and is, for ex., approx. 2,8 % with +40 °C and 100 % relative humidity.

The water vapour pressures to be expected in the nature are clearly below. The error with the simplification of the formalism can consequently almost be neglected.

Simplified formula:

$$T_v = T_t \bullet \left[1 + 0,329 \bullet \frac{e}{p} \right]$$

Example:

With an air temperature of +20°C, relative humidity of 100 % and an air pressure of 1000 hPa an acoustic virtual temperature of 22.25°C is calculated from the sound velocity.

The acoustic virtual temperature is therefore 2.25°C above the actual air temperature and can be corrected accordingly using the above equation if the humidity level of the air is known, e.g. relative humidity and the air pressure.

Calibrated measurements performed in the climatic exposure test cabinet with different temperatures as parameters and relative humidity levels between 10 % and 90 % have shown that the factor in the above equation should be nearer 0.30.

$$T_v = T_t \bullet \left[1 + 0.30 \bullet \frac{e}{p} \right]$$

If required to improve accuracy of the calculated real air temperature, one or more iteration steps could be performed to determine the accurate saturation vapour pressure when using the measured relative humidity and the measured acoustic temperature as corrective variables as the real air temperature (corrected acoustic virtual-temperature) is necessary for the calculation of the saturation vapour pressure.

References:

- [1] Dr. Lanzinger, Eckhard (Deutscher Wetterdienst), Langmack, Hans (Universität Hamburg):
Measuring air temperature by using an ultrasonic anemometer
- [2] Musa, Mark (Meteo Swiss), Tammelin, Bengt (Finnish Meteorological Institute) et al.:
Measurement of temperature with wind sensors during severe winter conditions
- [3] Aspiration-Psychrometer tables, Deutscher Wetterdienst, 7. edition
- [4] Coefficient of the Magnus formula acc. to Prof. Dr. Sonntag

3 Preparation for Operation / Installation

Attention:

*The working position of the anemometer is vertical (sensor arms "above", connector "below").
During installation, de-installation, transport or maintenance of the anemometer it must be ensured that no water gets into the shaft or connector of the anemometer.*

3.1 Selection of installation site

As already mentioned, the ultrasonic anemometer transmits sound packages required to measure the propagation velocity. If these sound packages meet surfaces that reflect sound, they are thrown back as an **echo** and can result in **incorrect measurements** under unfavourable conditions.

It is therefore advisable to install the ultrasonic anemometer at a **minimum distance of 1 metre to objects in the measurement plane**.

In general, wind meters should register wind conditions over a wide area. To obtain comparable values when measuring the ground wind, measurement should be performed at a height of 10 metres above even and undisrupted terrain. Undisrupted terrain means that the distance between the wind transmitter and the obstruction should be at least ten times the height of the obstruction (s. VDI 3786). If it is not possible to comply with this provision, the wind meter should be installed at a height at which measured values are influenced by obstructions located in the vicinity to the least possible extent (approx. 6 - 10 m above the interference level). On flat roofs the anemometer should be installed in the middle of the roof and not at the edge to thus avoid any preferential directions.

3.2 Installation of anemometer

Proper installation of the ultrasonic anemometer is carried out using a tube socket R1½" (Ø 48.3 mm) and 50 mm in length. The inside diameter of the pipe socket must be at least 40 mm as the ultrasonic anemometer is electrically connected to the connector from below (s. Accessories: Connecting cable, compl.). After connection the ultrasonic anemometer is fitted onto the tube or mast socket.

The measurement path formed by transformer 1 (arm marked red) and 4 must be aligned in a west-east direction, see chapter 3.3. Precise vertical alignment of the device is also necessary.

The device is fixed and secured to the shaft with the Allen screws (AF 4 mm).

3.2.1 Device to Refuse Birds (optionally)

A protective pin prevents bigger birds from sitting on the instrument. The device consists of a pin (V4A) and a protective cap, and is screwed into the available thread on the arm carrier of the Ultrasonic Anemometer, if necessary.

Mounting:

Protective cap of the thread on the arm carrier of the Ultrasonic Anemometer is removed, for ex. by means of a screw driver. Pin is screwed tightly in to the thread acc. to figure for ex. by means of a pincer. The protective cap serves as mounting protection and is removed after installation of instrument.



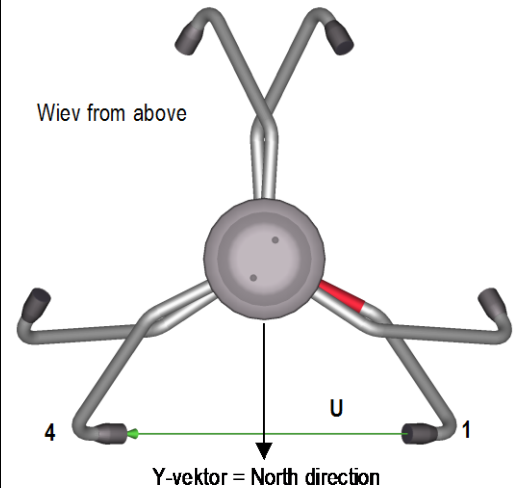
3.3 Alignment to north

For exact determination of the wind direction the anemometer has to be installed aligned **to the north** (true north).

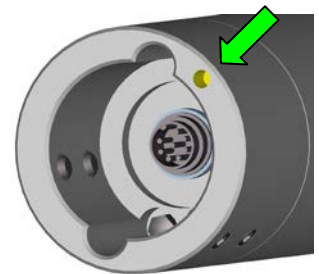
The position of the Y vector of the transformed natural coordinate system is vertical to the measurement path **U** formed by the ultrasonic transformers **1** and **4**.

The device must thus be aligned so that the direction of north is vertical to the path U away from the device; projection of the measurement path U onto the horizontal plane must thus be in a west-east direction.

When aligning the device to north using a compass, the magnetic variation (= deviation in direction of compass needle from true north) and local magnetic fields (e.g. iron parts, electric cables) should be taken into account.



In the bottom of the anemometer stand there is a **north- drilling**. The north- drilling serves for the use of a so-called north- ring with bolt. The north- ring is not included in delivery.



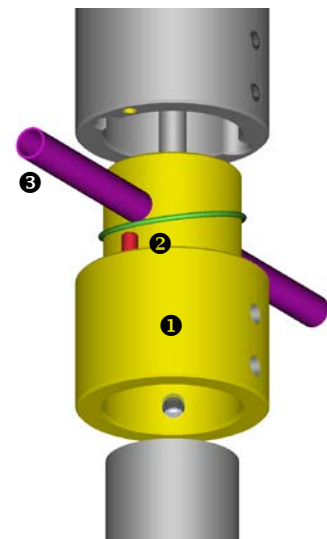
A North- ring **1** is available as an optional feature to assist with alignment and for simple replacement of the ultrasonic anemometer without readjustment of north.

On initial installation this north- ring is mounted loose so it still rotates on the measuring mast. The north pin **2** of the north- ring must show northward.

The direction bearing tube **3** also supplied is inserted through the horizontal bores of the north- ring.

With this tube a conspicuous point in the landscape, building, tree or hill to the north can be selected, a bearing taken and the adapter fixed to the measuring mast with the screws.

The direction bearing tube is then removed and the ultrasonic anemometer mounted on the north pin of the north- ring and screwed in place.



Remark: For Model 4.3832.40.340 only

In the bottom there is a **south-drilling with cylinder pin**.

The cylinder pin is opposite to the „measurement path **U**“ and opposite to the North-drilling.



3.4 Cables, Cable preparation, Coupling socket Installation

A prepared connecting cable can be supplied for the ultrasonic anemometer (see Accessories).

If the user wishes to procure the cable himself, the cable must have the following properties:

8 cores; 0.5 to 0.75 mm² core cross-section for supply; min. 0.14 mm² core cross-section for data communication; max. 8 mm cable diameter, resistant to ultraviolet rays, overall shielding.

The coupling socket (mating connector) is included in the scope of supply. This is placed in the bottom of the box for shipment.

The pin assignment can be found in these operating instructions (section 3.5).

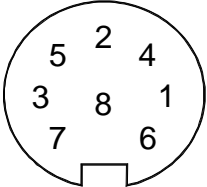
Coupling socket 507550 (Binder, Serial 423), EMC with cable clamp	
<ol style="list-style-type: none"> Stringing parts on cable acc. to plan given above. Stripping cable sheath 20 mm Cutting uncovered shield 15 mm Stripping wire 5mm. <p>Cable mounting 1 Putting shrink hose or insulating tape between wire and shield.</p> <p>Cable mounting 2 If cable diameter permits, put the shield backward on the cable sheath.</p> <ol style="list-style-type: none"> Soldering wire to the insert, positioning shield in cable clamp. Screwing-on cable clamp. Assembling remaining parts acc. to upper plan. Tightening pull-relief of cable by screw-wrench (SW16 und 17). 	<p>Cable mounting 1 View X</p> <p>Cable mounting 2 View X</p>

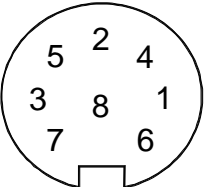
Figure 1: Coupling socket installation

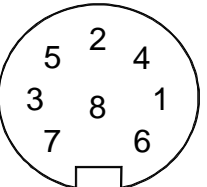
3.5 Connector pin assignment (functional examples)

Note:

- The exact functional assignment can be found in the supplementary sheet "Factory Setting".
- Pins 1 to 6 (inclusive) are electrically isolated from the supply voltage and the housing.

• Serial interface, full duplex			View of solder terminal of coupling socket
Pin	Assignment	Function	
1	RXD-	serial interface	
2	TXD-	serial interface	
3	ADIO	function not preset	
4	RXD+	serial interface	
5	TXD+	serial interface	
6	AGND	analog ground	
7	AC/DC	Supply, reverse-polarity protected	
8	AC/DC	Supply, reverse-polarity protected	
⏏	Shield		

• Serial interface, half duplex and Analog output			View of solder terminal of coupling socket
Pin	Assignment	Function	
1	Vx	analog output Vx	
2	TXD- / RXD-	serial interface	
3	Vz	analog output Vz	
4	Vy	analog output Vy	
5	TXD+ / RXD+	serial interface	
6	AGND	analog ground	
7	AC/DC	Supply, reverse-polarity protected	
8	AC/DC	Supply, reverse-polarity protected	
⏏	Shield		

• Serial interface, half duplex and Analog input			View of solder terminal of coupling socket
Pin	Assignment	Function	
1	0-10,0V	analog input	
2	TXD- / RXD-	serial interface	
3	0-10,0V	analog input	
4	0-10,0V	analog input	
5	TXD+ / RXD+	serial interface	
6	AGND	analog ground	
7	AC/DC	Supply, reverse-polarity protected	
8	AC/DC	Supply, reverse-polarity protected	
⏏	Shield		

4 Maintenance

As the device does not have moving parts, i.e. is not subject to wear during operation, no servicing is required.

Attention:

During storage, installation, de-installation, transport or maintenance of the anemometer it must be ensured that no water gets into the shaft or connector of the anemometer.

5 Calibration

The ultrasonic anemometer does not contain any adjustable components such as electrical or mechanical trimming elements. All components and materials used show invariant behaviour in terms of time. This means that no regular calibration is required due to ageing. Errors in measured values are only caused by mechanical deformation of the transformer arms and associated changes in measurement path lengths.

The acoustic virtual temperature can be used to check the measurement path length. A change of 0.17 % in the measurement path length and thus a measuring error of 0.17 % for the wind velocity corresponds to a deviation in the virtual temperature of 1 K at 20°C.

With a 6 K temperature deviation there is thus a measuring error of approx. 1 % for the wind velocity

Important:

Mechanical deformation of the measuring arms results in errors in the measured values, which involve the output of error telegrams / error signals to the analogue interfaces.

In the event of any change in the measurement paths of the anemometer it is recommended to contact the manufacturer regarding recalibration.

6 Warranty

Damages caused by improper handling or external influences, e.g. lightning, do not fall under the warranty provisions. The warranty entitlement expires if the device is opened.

Important:

The ultrasonic anemometer must be returned in the original packaging as the warranty entitlement otherwise expires with mechanical damage, e.g. deformation of measuring arms.

7 Functional Description

The functioning of the ULTRASONIC anemometer is described below. Due to the internal structure certain functions depend on other functions. Such dependency is described in each case. There are also restrictions regarding the functional definition of the cable connector. This is due to the double assignment of individual PINs.

7.1 Serial communication

The ULTRASONIC provides an RS485 / RS422 interface for serial communication. It can be operated either in full or half duplex mode and at different baud rates.

A standard terminal program is used for communication with the ULTRASONIC. With a Windows-based operating system Hyper Terminal is included in the scope of supply. It has to be subsequently installed if required.

As the manufacturer generally has no knowledge about possible use of the ULTRASONIC in a bus system, the device includes a wave terminating resistor, which can be connected by the software for halve-duplex operation. A terminating resistor is provided for in the layout of the device and can be fitted if required.

When starting the ULTRASONIC, the communication parameters are output to the serial interface. Output takes place at 9600.8N1. The baud rate, duplex modus and the ID are output:

Example:

```
THIES ULTRASONIC
!00BR00005
!00DM00001
```

The ULTRASONIC starts with ID 0, a baud rate of 9600.8N1 and full duplex mode.

7.1.1 Duplex mode

Duplex mode decides the type of physical connection. In full duplex mode the send and receive signals are each transmitted via separate pairs of cables. This means it is possible to send and receive signals as required.

In half duplex mode transmission of the send and receive signals is via the same pair of cables: see **Command DM**.

For bus operation in halve duplex mode (RS485), in which the ULTRASONIC is generally the "slave", it is necessary for the line transmitter to be switched to the high impedance state in the transmission pauses so as not to suppress the responses of the other bus users.

With point-to-point connections in full duplex mode (RS422) it may be important depending on the interference conditions on the communication lines to leave the line transmitter activated during the transmission pauses so that a maximum differential input level results in a high signal-to-noise ratio.

The **Command DM** (duplex mode) can be used to select half duplex mode in which the line transmitter is only ever switched on with transmission. For full duplex operation there are 2 modes, one for bus mode (RS 485) in which the line transmitter is controlled as in half duplex mode, and an additional mode (RS 422) in which the line transmitter also remains switched on with receive. See **Command DM**.

For the ULTRASONIC there are restrictions on the parameter combination or function of the terminals depending on the transmission type selected. Due to the limited number of connector contacts multiple assignment of the connections are necessary. The following table shows the functional options for the modes full and half duplex.

Full duplex mode	Half duplex mode
Independent telegram output possible (see Command TT)	Independent telegram output possible effective from software version V3.10. Telegram output is activated one minute after instrument start or respectively after setting the commands.
Bus mode possible (RS 485, DM=00001), bus mode not possible (RS 422, DM=00002)	Bus mode possible (RS 485, DM=00000)
No output of analog values to PIN RXD- and RXD+	Output of analog values possible
No readin of ID from external PINs (see Command XI)	Reading of ID from external PINs possible (see Command XI)
Analog inputs to PINs RXD- and RXD+ not possible. (see Command AA , Command AB)	Analog inputs to PINs RXD- and RXD+ possible (see Command AA , Command AB)

Table 1: Restrictions in full and half duplex mode

7.1.2 Response delay

With serial communication it should be remembered that the ULTRASONIC reacts very quickly to incoming telegrams. The response time of the device is in the low millisecond range. The delay between the receive and send signal for various interface converters may be too short. It is possible that an interface converter has not switched over between the modes 'send' and 'receive' in this time. The result is incomprehensible telegrams.

To avoid this effect the ULTRASONIC is equipped with the parameter RD (Response delay). With this parameter the response is additionally delayed by the selected value in milliseconds on receive.

The parameter can be preset depending on the article number of the device.

7.1.3 General telegram structure

For serial communication the ULTRASONIC has a fixed telegram format, which also permits communication in bus mode. It has the following form:

NNBB<cr> <cr> stands for Carriage Return (Enter key)

for a data enquiry or

NNBBPPPPP<cr> <cr> stands for Carriage Return (Enter key)

for a parameter change.

The individual letters have the following meaning:

NN: Two-position ID of the ULTRASONIC. It can be selected in the range from 00 to 98. The presetting of the ID is '00': see also **Command ID** and **Command XI** with ID 99 every device transmits a response, regardless of the actual selection.

BB: Two-position command. A complete list can be found in section **Command List**.

PPPPP: If a new parameter is to be set, the parameter is changed with a 5-position value. The parameter is always right-justified; i.e. it thus has to be padded from the left with zeros.

Example:

Telegram No. 4 is to be interrogated. The relevant command is:

00TR00004<cr> <cr> stands for Carriage Return (Enter key)

The prerequisite is that the ULTRASONIC ID has the value '0'.

Example:

With the command

00BR<cr> <cr> stands for Carriage Return (Enter key)

the parameter selected for the baud rate is returned.

!00BR00005

Note:

The input buffer of the ULTRASONIC can be emptied by transmitting Carriage Return <CR>. If the ULTRASONIC possibly has invalid characters in the input buffer, the input buffer can be processed by transmitting Carriage Return. In this case it is recommended transmitting a Carriage Return at the beginning of a telegram, e.g.:

<cr>00BR<cr> <cr> stands for Carriage Return (Enter key)

7.1.4 Return values of ULTRASONIC

After a valid command has been input, the ULTRASONIC sends acknowledgement, e.g. acceptance of the parameter or output of a data telegram.

For a standard command the response starts with a '!', followed by the ID and the parameter value. If the input command is TR or TT, the ULTRASONIC transmits a data telegram as the response. If the command cannot be processed for a certain reason, the device transmits a telegram with the error code 'CE' (Command Error). The meanings of the values for CE are summarised in **Table 2**.

Value output in CE telegram	Meaning
8	Incorrect access mode
16	Parameter not in valid range
4 or 32	Violation regarding parameters of other commands

Table 2: Return values with incorrect interpretation of command

7.1.5 Acces Mode

For configuration the ULTRASONIC has a set of commands, which determine behaviour in terms of the propagation time. The commands are broken down into three levels:

- interrogation mode
- user mode
- configuration mode

Interrogation mode:

This mode includes commands, which do not influence the parameters of the ULTRASONIC. They include for example output of the system status and interrogation of the data telegram with TR.

User mode:

This mode includes commands, which alter the behaviour of the ULTRASONIC. These parameters can be changed by the user. The system behaviour of the device is altered with these commands. This group of commands includes e.g. settings for data transmission and averaging.

Configuration mode:

This mode includes commands, which were set when adjustment of the device was performed at the factory. They can be equated with calibration. These parameters must not be changed.

To distinguish between commands of the three groups when parameterising the ULTRASONIC the device is equipped with an access key KY. Inputting of this key accesses the individual levels. Access to commands at a higher level includes access to commands at a lower level.

Access key	Response from ULTRASONIC	Command level
00KY00000	WRITE PROTECTED !00KY00000	Interrogation mode (preset)
00KY00001	USER ACCESS !00KY00001	User mode
00KYxxxxx	CONFIG ACCESS !00KYxxxxx	Configuration mode Key must be from the asked manufacturer

Table 3: Access key for different command levels

After the access key has been changed, the ULTRASONIC transmits a response, which contains not only the parameter input but also the access mode.

After parameters have been changed with the key '00001' or '00234' the ULTRASONIC must be reset to the locked state with the command 00KY00000.

Example:

00KY00001	
USER ACCESS	Response from ULTRASONIC
!00KY00001	Response from ULTRASONIC
00AV00005	Change in averaging time
00KY00000	
WRITE PROTECTED	Response from ULTRASONIC
!00KY00000	Response from ULTRASONIC

7.1.6 Baud rate

The baud rate is used to select the transmission speed via the RS485 / RS422. The parameter range is from 1200 baud to 921.6 Kbaud.

To prevent accidental reprogramming of the baud rate over 115.2 Kbaud, the baud rates above 115.2 Kbaud are accessed with the command BX.

Reprogramming of the baud rate with the command BR has an immediate effect on the ULTRASONIC. After the dispatch of a command, the user program used must be set to the corresponding baud rate.

When using a baud rate in the extended range (230400 baud .. 921600 baud) the ULTRASONIC includes an additional safety mechanism which prevents unintentional adjustment of the baud rate. When the command BX is used, the ULTRASONIC immediately switches over its baud rate but does not store this change. With the next restart the ULTRASONIC starts with the old baud rate. To store the change the baud rate of the PC must be set to the new speed, and the same command transmitted to the ULTRASONIC once again. After transmission the ULTRASONIC acknowledges the command with the output 'Baud rate saved'.

Example:

The baud rate is to be changed to 962100 baud:

Command:	Response ULTRASONIC	Comment
00KY00001	USER ACCESS	Permit access
	!00KY00001	
00BX00103	For saving change baud rate and insert command again	
		Change baud rate of PC to 921600 here
00BX00103	Baud rate saved	
	!00BX00103	

7.1.7 Device ID

The device ID specifies the address to which the ULTRASONIC is to respond during serial communication. The device ID lies in the range from '00' to '98'. The preset ID is '00'. Every telegram from the ULTRASONIC starts with the ID set. Under certain conditions this provides for bus mode, see **Bus mode**.

The ID is reprogrammed with the command 'ID'. The new ID of the ULTRASONIC is specified as the parameter. After the change has been made, the ULTRASONIC responds to the new address immediately.

Example:

00KY00001	
USER ACCESS	Response from ULTRASONIC
!00KY00001	Response from ULTRASONIC
00ID00004	ID changed to address 4
!04ID00004	ULTRASONIC confirms new ID
	The ULTRASONIC now responds to the new ID '04', i.e. including after a restart
04AV	Interrogation of averaging time with new ID
!04AV00005	Return of averaging time

On interrogation the device ID 99 is an extended ID. If this ID is used on interrogation, devices transmit a response, regardless of the ID selected. It is also possible to specify the ID on startup via the external signals to PIN 1, PIN 4 and PIN 3 (ADIO). For this purpose the parameters of the commands AA, AB, AC and XI must be set properly: see **Command AA**, **Command AB**, **Command AC**, **Command XI**.

7.1.8 Bus mode

The concept of ID-based communication allows ULTRASONICS to be operated in a bus system. The prerequisites for this are:

- Half duplex mode or full duplex mode in duplex mode 2 (send-controlled line transceiver)
- Different IDs of individual bus users
- Master-slave structure, i.e. there is a device in the bus (control, PC...) that performs cyclic enquiry of the data of the individual ULTRASONICS and possibly parameterises the ULTRASONICS.

In bus mode there are no restrictions on parameterizability and program upload. A station can also be provided with a new program in bus mode for a specific purpose. With an update the program update must be performed for every ULTRASONIC.

In bus mode it is recommended not using an ULTRASONIC with the ID '00' as this ID is reserved for devices that are integrated in the bus for the first time.

7.2 Analogue and digital I/O

In addition to output of the data via the serial RS485, the ULTRASONIC can also output data using an analog interface. These outputs can also be optionally switched as analog inputs which read in an external voltage of 0.. 10.0 V, carry out digital conversion and perform output via the user-specific telegram. The ULTRASONIC is also equipped with the cable PIN 3 (ADIO), which includes digital input/output functions in addition to the analogue input. Internally the ULTRASONIC is equipped with a list of the channels to be updated. The list only includes the channels used by the device. Every channel requires a conversion time of approx. 2.5 ms. Signals are available at PIN 1, PIN 4 and PIN 3 (ADIO). The channels WG/RXD-, WR/RXD+ and ADIO are available. The individual channels are automatically included / removed from the list of channels using the commands AA, AB, AC and AN.

7.2.1 Analogue Inputs

The signals at PIN 1, PIN 4 and PIN 3 (ADIO) of the connector can be switched as analog inputs under certain conditions. PIN 1 and PIN 4 are then only available as inputs when half duplex mode is selected and the ports have been set accordingly using the commands AA, AB and AC, see, **Command AA, Command AB, Command AC**.

The function of PIN 3 (ADIO) is independent of duplex mode and can be switched as an analog input at any time.

The measured values read in can be output with the user-specific telegram, see **User-specific telegram**. The input voltage range is 0..10.0 V. The sampling rate can be adjusted using the **Command AU**. The parameter specifies the sampling interval in ms. All AD/DA channels are sampled / written within one interval. The next interval is initiated on expiry of AU. If the time specified by AU is shorter than the required interval time, the start of the next update will be delayed. An interval involving all channels takes approx. 3 ms. The parameters AY, AZ; BY, BZ; CY, CZ are available for scaled output of the analog measured values. These parameters can be used for linear conversion of the measuring range (0..10.0 V) to a numerical value.

The _Y parameters always indicate the value corresponding to 0 V, and the _Z parameters the value corresponding to 10.0 V. As the ULTRASONIC's command interpreter does not support negative numbers or decimal points, the scaling values have to be converted before input. The formula for conversion is as follows:

Command value = 30000 + (measured value*10)

Example:

A temperature sensor is to be connected to PIN 3 (ADIO). The sensor has the following characteristic values:

0 V -> -40°C

10.0 V -> 80°C

The parameter CY describes the measured value for 0V. It is calculated as follows:

Command value = 30000 + (-40*10) = 29600

The lower value is described with command 00CY29600.

The parameter CZ describes the measured value for 10.0 V. The value is to be scaled to +80°C.

Conversion is as follows:

Command value = 30000 + (80*10) = 30800

The higher value is scaled with command 00CZ30800.

The user-defined telegram is used to output the data values. If the measured value of PIN 3 (ADIO) is to be output with a sign, two characters before the decimal point and one character after, the definition

00UT@58,05,1,1@

has to be added. See also **User-specific telegram**.

For further information see, **Command AA**, **Command AB**, **Command AC**, **Command AY**, **Command AZ**, **Command BY**, **Command BZ**, **Command CY**, **Command CZ**.

7.2.2 Analogue Outputs

The analogue outputs at PIN 1, PIN 4 und PIN 3 (ADIO) offer the possibility of outputting the following measuring values:

- Vx, Vy, Vz
- WS (wind speed azimuth), WD (wind direction azimuth), und VT (virtual-temperature)

Through parameter AG is determined which measuring value is delivered at the analogue outputs.

The analogue values can be output both as voltage and as current. It is also possible to select whether a constant offset of 20 % of the end of the measuring range is output with the current or voltage output. This provides for the interfaces 4..20 mA or 2..10 V. See the table for the possible combinations.

	Parameter SC=0	Parameter SC=1
Parameter AN=0	0..10 V	2..10 V
Parameter AN=1	0..20 mA	4..20 mA
Parameter AN=2	No output	No output

Parameter AA= 0; AB = 0

Table 4: Configuration of analogue outputs to PIN 1, PIN 4 and PIN 3 (ADIO) with parameters AN and SC

7.2.3 Scaling of analogue Wind Velocities

With the analogue wind velocity the user has the option of specifying the velocities for the terminal value of the measuring range with the command AR. In the preset value the scaling is 0..60m/s, see **Command AR**.

The terminal scaling value is specified in m/s. For example, the command 00AR00030 scales the analogue output range of 0..30 m/s respectively –30 m/s... 30 m/s wind velocity (see below). With a setting of 2..10 V and the output of WS, WD and VT this results in the following:

WV =0 m/s -> 2 V and

WV=30 m/s -> 10 V

See also **Command AR**.

7.2.3.1 Output of Vx, Vy, Vz

With the output of the analogue wind speeds Vx, Vy, Vz please consider that the speed is signed. This is guaranteed by the fact that the zero point is connected to half the output voltage respectively output current. With the output of 0...10V 5 V correspond to a speed of 0 m/s. The parameter AR determines then the scaling of the positive and negative speeds.

With a setting of 2..10 V, 00AR00030 and the output of Vx,Vy,Vz there are the following correspondents:

Vx=Vy=Vz = -30 m/s -> 2 V

Vx=Vy=Vz = 0 m/s -> 6 V

Vx=Vy=Vz = 30 m/s -> 10 V

7.2.3.2 Output of the Virtual Temperature

The output of the acoustic virtual-temperature is carried out in the selected output format (voltage or current, with or without offset). The temperature is hereby linearly indicated over a range of – 40°C to +80°C on the output range (for ex. 0 V to 10 V). The scaling range cannot be changed.

7.2.4 Correction to north

The command NC is used to turn the output wind direction angel clockwise. Therefore, this value is always added to the measured angle in the device. The angle transition of the resulting wind direction stays at 360°. The north correction, for example, is used as additional correction in case the ULTRASONIC could not be aligned directly to the North through its reference coordinate system.

See also **Command NC**.

7.3 Data acquisition

The main function of the ULTRASONIC firmware is data acquisition and preparation. For data acquisition sound impulses are transmitted by the sensors in a clockwise direction and received by the sensor opposite. The propagation time measured is a measure of the velocity. A measuring cycle is complete when every sensor has performed transmit and receive once. The complete data record is then time-stamped and passed on to the next level. After the plausibility check the individual components are calculated and, depending on the setting, either output (see **Instantaneous values and output of raw measured values**) or written to the averaging buffer (see **Averaging**) prepared and output.

For a resulting wind velocity < 0.1 m/s the wind direction and wind velocity are set to zero. The wind direction 0° is reserved for no wind. If the wind direction is equal to zero with WV > 0.1 m/s, the interface outputs 360°.

The last valid instantaneous value of the wind velocity is always used as the output value for this criterion.

Correlation between wind direction, wind vectors, and analogue output values.

The measurement system of the ULTRASONIC 3D is an orthogonal co-ordinate system with the vectors X, Y and Z. The system is aligned in a way that the X-vector indicates to the East, the Y-vector to the North, and the Z-vector faces „upwards“. The wind speeds in the XYZ-co-ordinate system are determined as follows:

Wind direction	Sign Data telegram	Analogue Output voltage	Wind direction Azimuth	Wind direction Elevation
Wind from above (V_z)	Negative	$V_{PIN3} < FS/2$		$>0^\circ$
Wind from below (V_z)	Positive	$V_{PIN3} > FS/2$		$<0^\circ$
Wind from the North (V_y)	Negative	$V_{PIN4} < FS/2$	0°	
Wind from the South (V_y)	Positive	$V_{PIN4} > FS/2$	180°	
Wind from the East (V_x)	Negative	$V_{PIN1} < FS/2$	90°	
Wind from the West (V_x)	Positive	$V_{PIN1} > FS/2$	270°	

Table 5: Relation wind vectors to the XYZ-co-ordinate system

FS/2 means the output value at 0 m/s. It is always half the output value range, irrespective of parameter SC.

The meteorological wind direction is opposed to the angle count direction of the vectors of the orthogonal coordinate system.

7.3.1 Instantaneous values and output of raw measured values

The output of instantaneous values is generally a special case. Due to the high acquisition speed of the measured values averaging of the data is sensible in most cases. If instantaneous values are to be output, averaging must not be switched on. The parameter AV should be set to '0', see **Command AV**.

The OR parameter is used to adjust the output rate with independent output. With a value of '0' a telegram is output whenever a new measured value is determined. If the baud rate is set high enough and a short user-specific telegram is defined in this mode, the raw measured values of the ULTRASONIC can be output.

Note:

The user-specific telegram contains a data value 'Time stamp' (index 7), which is incremented with every new measured value. If the difference of the measured value counter between two output telegrams is one, every measured value is output. In the standard setting the acquisition of measured values takes place every 20 ms.

To maximise the acquisition of measured values (a new measured value approx. every 2.5 ms), the following steps must be performed:

Switch off plausibility	00PC00000
Set measuring delay to zero:	00MD00000
Automatic measuring adjustment off:	00MA00000

All measured values of the ULTRASONIC can now be output if the high baud rate is high enough. It is recommended creating a user-specific telegram and having it independently output by the ULTRASONIC (00TT00006). The data field Time stamp (index 7 in user-defined telegram) shows the time of the measured value relative to system startup in ms.

If averaging is switched off with independent data output, the averaging buffer is automatically geared to the output interval OR switched on. With AV00000 and OR00100 for example, sliding averaging is automatically performed over 100 ms.

7.3.2 Measurement in burst mode

Another measuring method is measurement in burst mode. Here the ULTRASONIC performs measurement and stores the measured values in the internal data memory. If the internal data memory is full, or the required number of measuring values is achieved, the ULTRASONIC outputs the measured values via the serial interface. Burst mode can be used to register measured values at a high speed and to output them at a lower baud rate. In burst mode max. 40,000 measuring cycles can be stored. The memory depth can be selected with parameter BS, see **Command BS**.

Moreover, the burst mode offers the possibility of recording and outputting data, as well, before the trigger event. This function is determined by the parameter BP. BP indicates the time in ms when the data recording starts before the real trigger event.

Burst mode is activated with the command 00AC00016 or 00AC00017, see **Command AC**. Here the PIN 3 (ADIO) is used as the trigger signal to start measurement.

In the burst mode it is also possible to record the analogue data of the channel WG/RXD+ as well. For this, however, the instrument must be switched into half duplex mode.

No data is output during measurement in burst mode. Once measurement has finished, the measured data is output in the output telegram selected, see **Command TB**.

On activating the burst mode the internal milliseconds counter is reset. After activation the burst mode must be started within 49 days in order to avoid a timer overflow. After termination of burst mode the trigger time is stated with the data output. During the data output a telegram „trigger“ is displayed in place of the trigger signal. This output indicates the trigger time.

Parameterisation of burst mode

Before the start of burst mode system parameters can be adjusted for the acquisition of measured values:

- The number of measured values used is selected with the parameter BS.
- To achieve a maximum measuring speed the parameter MD can be switched to 0 and MA to 0, see **Command MA** and **Command MD**. This switches on the maximum measuring frequency.
- It may be sensible to switch off the plausibility filter with 00PC00000, see **Command PC**.

Start burst mode

- Leave PIN3 (ADIO) open or connect to 5 V potential.
- Select the required output telegram with command TB, see **Command TB**.
- Select the required buffer depth for measurement, see **Command BS**.
- Select the speed for acquisition of the measured values with MD and MA.
- Set the value for the pre-trigger by BP; for ex. the parameter PB00100 records the data 100 ms before the trigger event, as well.
- Poss. switch the plausibility check off with command PC.

- Activate burst mode with command 00AC00017.

The ULTRASONIC will output the text:

Burst mode init.

Starts when ADIO goes low.

- Measurement can now be started via the PIN 3 (ADIO). Once the measured value buffer is filled, the data will be output automatically. It is not possible to halt output.

Working with an additional analogue measured value.

Burst mode is capable of registering an additional analogue measured value, storing and outputting it with the telegram. To output the analogue measured value it is necessary to create a user-defined telegram in which the analogue measured value is also output.

Only the measured value at PIN 4 can be acquired additionally as analogue value.

To include the analogue measured value from PIN 4 in the burst measurement, configure the system as follows:

- Switch the system to half duplex mode, see **Command DM**.
- Switch PIN 4 as the analog input with command AB00001, see **Command AB**.
- Set the value for the pre-trigger by BP; for ex. the parameter PB00100 records the data 100 ms before the trigger event, as well.
- Format the analog value with commands BY and BZ, see **Command BY**, **Command BZ**.
- Adjust the sampling speed of the input with command AU, see **Command AU**.
- Configure a user-specific telegram, see **User-specific telegram**.
- Configure burst mode as described above.

Examples of burst mode configuration

Simple burst mode configuration

00KY00001

00TB00002 (VDT output telegram)

00BS00100 (100 measurements in burst mode)

00AC00016 (Activate burst mode)

Burst mode configuration with maximum measuring speed, without plausibility check and scientific output telegram

00KY00001	
00TB00012	(Data output after measurement: Scientific output telegram)
00BS00100	(100 measurements in burst mode)
00BP00100	Recording of data 100 ms before the trigger event
00MD00000	(No delay between measurements)
00MA00000	(Switch-off of automatic measuring speed adjustment)
00PC00000	(Switch-off of plausibility)
00AC00016	(Activate burst mode)

Burst mode configuration with maximum measuring speed, with plausibility check, analog measured value and user-specific output telegram

00KY00001	
00DM00000	(Switch to half duplex mode. ATTENTION!! Adapt wiring of RS485!!!)
00KY00001	
00AB00001	(Activate analogue input)
00TB00006	(Data output after measurement: User-specific output telegram)
00UT@12,6,2@,@13,6,2@,@63,5,0@,@7,9,0@\0d	(Configuration of user-specific telegram with Wind speed, Wind direction, analogue measuring value, time stamp)
00US00002	(Storage of user-specific telegram)
00AU00001	(Update of analog inputs to maximum speed (max. 3 ms))
00BS00100	(100 measurements in burst mode)
00BP00100	Recording of data 100 ms before the trigger event
00MD00000	(No delay between measurements)
00MA00000	(Switch-off of automatic measuring speed adjustment)
00PC00007	(Switch-on of plausibility)
00AC00016	(Activate burst mode)

Ending burst mode

- End burst mode with command 00AC00000
- Activate required output telegram with command TT

Restrictions in burst mode

Measurement in burst mode is subject to the following restrictions:

- No standard deviations and covariances are calculated in burst mode.
- The mean value buffer is deleted after burst mode.
- Burst mode does not function in bus mode.
- When using the analog input, the first two analog measured values may contain incorrect values depending on the setting. Such behaviour is due to technical reasons and cannot be prevented.
- In the period of the pre-trigger the recorded analogue values are invalid.

7.3.3 Statistic- Functions

7.3.3.1 Averaging

Given the high data acquisition rate averaging is recommended in most cases. The averaging period is freely selectable from 600 ms to 100 minutes within wide limits. See also **Table 8:**

Adjustment of averaging periods with parameter AV under Command AV.

It is a basic rule that only valid values are written to the averaging puffer. The size of the buffer is not determined by the number of data records but by the difference in the time stamp between the first and last data record. As a result any missing measured values do not influence the averaging result. The content level of the averaging buffer is shown in the status value of the ULTRASONIC. It is the ratio between the memory actually occupied and the maximum required memory (calculated value). Output is performed in eight or 16 steps, see **Status information**.

The Ultrasonic incorporates two different practical procedures for averaging:

- one **procedure for generating vectorial mean values** and
- one **procedure for generating scalar mean values**

These different procedures can be selected for averaging wind velocity as well as wind direction depending on the actual application.

Vectorial averaging involves the wind direction for averaging of the wind velocity, and wind velocity for averaging of the wind direction.

Both averaged variables, wind velocity and wind direction, thus each undergo evaluation with the other measured variable.

This averaging procedure is well suited to measuring and evaluating the propagation of pollutants, for example.

Scalar averaging averages the two variables, wind velocity and wind direction, independently of each other.

This averaging procedure leads to comparable results with mechanical wind velocity and wind direction pickups.

The scalar averaging procedure is suited e.g. to location analysis for wind turbines where only the wind vector variable relevant for the generation of energy is of interest and not its direction.

The vectorial and scalar procedure can be used within one output telegram independently of the wind velocity and wind direction.

For this purpose one of the four possible combinations is selected using the Command **AM** as for **Average Method**.

Command for selection of averaging procedure:

AM00000 (Average Method) Vectorial averaging of velocity and direction

AM00001 Scalar averaging of velocity and direction

AM00002 Scalar averaging of velocity and vectorial averaging of direction

AM00003 Vectorial averaging of velocity and scalar averaging of direction

7.3.3.2 Standard deviation

Calculation of the standard deviation is another feature offered by the ULTRASONIC. The standard deviation values are determined for the wind velocities, wind direction and virtual temperatures with an averaging time > 1sec. Values are calculated according to the following formula:

$$S = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} (\bar{x} - x_k)^2} \quad \text{where} \quad \bar{x} = \frac{1}{N} \sum_{k=0}^{N-1} x_k$$

Standard deviation is switched on with the command "DE00001". When using standard deviation the averaging memory used is limited to 2000 measured values. Otherwise there are no restrictions when using standard deviation. Which calculated values are available when using standard deviation can be found under **Available measured values and data formats** in the section **User-specific telegram**.

In the presetting calculation of the values for standard deviation is switched off. It must be switched on explicitly with the command 00DE00001.

7.3.3.3 Calculation of Turbulence Variables

The calculation of the turbulence variables meets extensively the requirements of VDI 3786 page 12. Basis for the calculation of turbulence variables is the calculation of mean values over typically 10 min up to 60 min. For this, the respective averaging period must be set in the instrument, see **Command AV**. For the calculation of the turbulence variables the parameter CO is, furthermore, to be set to 1 or 2, see **Command CO**. There is the following difference between parameters 1 and 2 with command CO:

Parameter 00001:

The coordinate system X,Y,Z is not turned to the main wind direction. All calculations refer to the physical coordinated system of the ULTRASONIC.

Parameter 00002:

The coordinate system is turned to the main wind direction, resulting from the measuring values in the averaging buffer. The turning occurs in way that the X-component of the averaged wind speed vector indicates to the main wind direction, the Y- and Z-component are then reset. The calculation of all turbulence parameters refer to this coordinate system. See also to this "coordinate transformation". The coordinate rotation affects only on the calculation of the turbulence variables, not on other values, such as standard deviation or output Vx, Vy, Vz and respective angle values.

Calculation of mean values

$$\bar{x} = \frac{1}{N} \sum_{k=0}^{N-1} x_k$$

Dispersions

$$\sigma_x^2 = \frac{1}{N-1} \sum_{k=0}^{N-1} (x_k - \bar{x})^2$$

and Covariances

$$\overline{x'y'} = \frac{1}{N-1} \sum_{k=0}^{N-1} [(x_k - \bar{x})(y_k - \bar{y})]$$

Values are output by means of the use-defined telegram, see also **7.4.5 User-specific telegram**.

Turbulence parameter	Formula
Horizontal Wind	$v_h = \sqrt{x^2 + y^2}$
Turbulence intensities	$\mathcal{I}_x = \frac{\sigma_x}{v_h}, \mathcal{I}_y = \frac{\sigma_y}{v_h}, \mathcal{I}_z = \frac{\sigma_z}{v_h}$
Shearing stress speed	$u_* = \sqrt[4]{(\overline{x'z'^2} + \overline{y'z'^2})}$
Shearing stress	$\tau = \rho * u_*^2$
Ground friction coefficient	$C_D = \left(\frac{u_*}{v_h}\right)^2$
Sensible heat flow	$Q_H = \rho * c_p * \overline{z'T'}$
Obukov length	$L = -\frac{u_*^3}{K * \frac{g}{T} * \overline{z'T'}}$
Dynamic temperature	$T_* = -\frac{\overline{z'T'}}{u_*}$
Vertical impulse power	$I_v = \sqrt{u_*}$

Important turbulence parameters and their formulas

Symbols and Abbreviations

Symbol / Abbreviation	Signification	Measurement
\mathcal{I}	Turbulence Intensity	ms^{-1}
u_*	Shearing stress speed	ms^{-1}
$\overline{x'z'}$	Covariance Vx and Vz	m^2s^{-2}
$\overline{y'z'}$	Covariance Vy and Vz	m^2s^{-2}
$\overline{z'T'}$	Covariance Vz and acoustic virtual temperature	mKs^{-1}
ρ	Air density	kgm^{-3}

c_p	Specific heat with constant pressure	$\text{JK}^{-1}\text{kg}^{-1}$
Q_H	Sensible heat flow	Wm^{-2}
L	Obukhov-length	m
K	of Karman-constant	
g	Gravitation constant	ms^{-2}
T_*	Dynamic temperature	K
I_v	Vertikaler Impulsstrom	m^2s^{-2}

The following constants are used for the calculation in the ULTRASONIC:

Constant	Value
ρ	1.2 kgm^{-3}
c_p	$1004,67 \text{ JK}^{-1}\text{kg}^{-1}$
K	0,41
g	$9,81 \text{ ms}^{-2}$

7.3.3.4 Coordination Transformation

When parameter CO00002 is set a rotation of the coordination system into the main wind direction is carried out before calculation of the turbulence variable. This rotation is applied to the used mean values V_x , V_y , V_z as well as to each single measuring value in the averaging buffer. After rotation V_x is situated in the direction of the main wind vector. The coordinate rotation affects only on the calculation of the turbulence variables, not on other values, such as standard deviation or output V_x , V_y , V_z and respective angle values.

The transformation matrix is as follows:

$$A = \begin{bmatrix} \cos(\theta)\cos(\phi) & \sin(\theta)\cos(\phi) & \sin(\phi) \\ -\sin(\theta) & \cos(\theta) & 0 \\ -\cos(\theta)\sin(\phi) & -\sin(\theta)\sin(\phi) & \cos(\phi) \end{bmatrix}$$

$$\text{with } \theta = \tan^{-1}\left(\frac{\overline{V_y}}{\overline{V_x}}\right) \text{ and } \phi = \tan^{-1}\left(\frac{\overline{V_h}}{\overline{V_x}}\right) \text{ and } \overline{V_h} = \sqrt{\overline{V_y}^2 + \overline{V_z}^2}$$

Calculation of the transformed wind speeds

$$\begin{bmatrix} V'_x \\ V'_y \\ V'_z \end{bmatrix} = A * \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix}$$

7.3.4 Gust Acquisition

With preset averaging the ULTRASONIC acquires mean values of wind velocity and wind direction. It is expedient, with some application, to output the maximum wind velocity within the mean value period and the respective wind direction.

From software version V3.02 this function is supported. The maximum wind velocity in the mean value buffer is acquired through the command GU ('gust'). The length of gust is set in 100 ms increments through the parameter of the command GU. It ranges from 100 m to 3 sec. The parameter value 0 deactivates the gust measurement.

The maximum value of the wind direction is the wind direction of the maximum wind velocity.

The measurement values of the gust measurement are output in the user-specific telegram. It is about the parameters 69, 70 and 71. The following measurement values are acquired as gust values:

- Total wind velocity Vxyz
- Angle azimuth
- Angle elevation

Example:

00GU00010 Activates the gust acquisition. The length of gust is 1 second.

00GU00000 Deactivates the gust measurement.

The measurement values of the gust can be output only by means of the user-specific telegram. see **7.4.5**.

Example:

00AV00003 one minute averaging

00GU00030 Length of gust is 3 seconds (WMO-recommendation for gust length)

00UT\02@11,04,01@ @13,03@ @17,05,01,01@ @69,04,01@ @70,03@ @58,02,02@\0D\03

User-specific protocol. Query through TR00006 or TT00006

VDT-telegram plus gust

(STX) Vxyz WDxy VT WV_gust WDxy_gust status(CR)(ETX)

00US00002 storing of the user-specific telegram

00TT00006 automatic output of the data telegram

The measurement values of the gusts have the following characteristic:

- The preset time for the gust must be less than the preset averaging period.
See **Command AV**.
- If the period of the mean values is less than or even the period of gust, zero is output for the wind velocity and wind direction of the gust.
- In case the wind velocity of the gust is < 0,1 m/s, 0 is output for the wind direction.
- If the calculated wind direction is 0, it is set to 360.

7.4 Serial data output

The transmission of data via the RS485 / RS422 interface is known as serial data output. Two modes are available for data transmission:

- independent transmission of data
- transmission of data via interrogation telegram

Independent transmission of the data is selected using the command 00TT000XX, with XX standing for the relevant telegram number. In this case the ULTRASONIC transmits its data cyclically in the interval selected with the parameter OR.

7.4.1 Data enquiry

The command TR is used for data enquiry via the ULTRASONIC. The command has no access protection. After processing the command the device sends back the appropriate response telegram. The time between the last character in the request telegram and the first character in the data telegram is < 0.5 ms.

The user-defined telegram and the telegrams, as for the definitions described under '**Fixed telegram formats**', are available as data telegrams.

7.4.2 Independent telegram output

Independent telegram output is selected using the command TT. After a valid telegram type has been input, the ULTRASONIC independently transmits the data telegram selected. The transmission interval is set in ms using the command OR. The telegram is transmitted every 100 ms as standard. If the baud rate selected does not allow the output cycle to be observed (the time for data transmission is greater than the output interval time), it is possible that telegram output cannot be carried out. If the averaging time is 0 with independent data output, see **Command AV**, the output rate is automatically used as the averaging time.

Remark:

An independent telegram output in full-duplex mode is possible, and effective from software version V3.10 also in half-duplex mode.

7.4.3 Fixed telegram formats

For telegram output several predefined telegrams are available for independent output (**Command TT**) and data request (**Command TR**). The detailed structure is described in '**Predefined Data Telegrams**'. A reference list of telegram formats can be found in **Table 6**.

Telegram number	Telegram description
00001	Wind velocity and wind direction of azimuth and elevation
00002	Wind velocity and wind direction of azimuth and elevation as well as acoustic virtual temperature
00003	Wind velocity and wind direction of azimuth, wind velocity of elevation as well as acoustic virtual temperature
00004	NMEA telegram
00005	XYZ vectors and acoustic virtual temperature
00006	User-specific telegram
00007	XYZ vectors with acoustic virtual temperature and their standard deviations
00008	XYZ vectors with acoustic virtual temperature and their co-variances
00009	XYZ vectors with their turbulence intensities and acoustic virtual temperature
00012	Scientific diagnostics telegram

Table 6: List of predefined data telegrams

7.4.4 Generation of check sum

The check sum or proof total is the result of the bitwise EXOR link of the bytes output in the telegram.

The EXOR link encompasses all bytes between the telegram start character "STX", or "\$" with the NMEA telegram and the byte "*" as the identifying character for the start of the check sum.

The bytes "STX" or "\$" and "*" are thus not taken into account for calculation of the check sum!

7.4.5 User-specific telegram

The ULTRASONIC offers the user the option of specifying his own telegrams. A formatted text can be used to output the internal measured and status values of the ULTRASONIC. Over 60 different values are available for output.

The user-defined telegram with the telegram number 6 is output. For example, the input of 00TR00006 prompts the ULTRASONIC to output the user-defined telegram.

The commands UA, UT, UR and US available to define the user-defined telegram. See also: **Command UA**, **Command UR**, **Command US**, **Command UT**. These commands can be used to create a new telegram, extend an existing telegram, delete telegram information and lastly, to store the telegram definition in the EEPROM.

The measured values are selected and the format specified in the formatted text. **Table 7** shows a list of the available data.

The formatted text also includes the option of outputting a fixed character string. The definition

00UAHello World\0d<cr> <cr> stands for Carriage Return (Enter key)

generates the telegram output

Hello World

7.4.5.1 Generation of a new user-specific telegram

The command UT is used to overwrite an existing telegram in full. For example with the command:
00UTWind velocity: @11,6,2@m/s\0d<cr> <cr> stands for Carriage Return (Enter key)

the output

Wind velocity: 001.64 m/s

is returned with the telegram output. (The prerequisite is of course that the current wind velocity is 1.64 m/s).

7.4.5.2 Attachment of definitions

The command UA can be used to attach new definitions at the end. Here it must be borne in mind that the attachment of definitions may require more memory than telegram definition with the command UT.

Internally the ULTRASONIC is equipped with over 30 definition blocks. Each of these blocks can accommodate the definition of one data value or 5 fixed characters. It must be borne in mind that once a block has been defined, it cannot be extended.

The user-specific telegram can receive up to 28 definitions. One definition can include 1 to 5 characters, i.e. even a single semicolon covers a definition.

Example:

The definition

00UAHELLO<cr> <cr> stands for Carriage Return (Enter key)

generates a new block which contains the character string HELLO.

The definitions

UAH<cr> <cr> stands for Carriage Return (Enter key)

UAA<cr> <cr> stands for Carriage Return (Enter key)

UAL<cr> <cr> stands for Carriage Return (Enter key)

UAL<cr> <cr> stands for Carriage Return (Enter key)

UAO<cr> <cr> stands for Carriage Return (Enter key)

occupy 5 blocks, in which only one character each is seized. The output leads to the same result in both cases, but considerably more memory is used in the second version.

A new block is generally always started with a definition of a measured value. Definition of a measured value is always framed with the character '@'. A new block is also occupied after a measured value definition. If this is taken into consideration on inputting, the same effective memory occupancy can be achieved using the command UA as with the command UT.

The method using the least amount of memory is to input the complete telegram using the command UT.

7.4.5.3 Deletion of definitions

The deletion of definitions always relates to the last blocks in the definitions list, see **Attachment of definitions**.

The command UR00002 can be used to delete the last two definition blocks, for example. It should be noted that a definition, input using UA or UT, can be divided up internally into several blocks. It is therefore recommended proceeding step by step when deleting definitions and checking the effect in telegram 6.

7.4.5.4 Storage of definitions

After the user-defined telegram has been input, it can be stored using the command 00US00002. Storage is necessary to ensure that the ULTRASONIC loads the defined telegram on the next restart.

7.4.5.5 Available measured values and data formats

The measured values (shown by a number) and the output format of the measured value are defined in the user-specific telegram within the formatting characters '@' Here every measured value is an object of a data type. Data types are for example TEXT, NUMBER or WHOLE_NUMBER. The wind velocity is for example the data type NUMBER, see

Example:

The wind velocity is to be output in the user-specific telegram. From the table given below it can be seen that the wind velocity has the index 11. The formatting string thus starts with

00UT@11

It can also be seen from the table that the WV is the data type NUMBER. If the wind velocity is to be output without a sign using a total of 6 characters (including comma) and 2 decimal places, the complete formatting string is as follows:

00UT@11,6,2@

If a line feed is to also be added to the end of the output, the ASCII character 13 (0Dh) must be attached.

00UT@11,6,2@\0d<cr> <cr> stands for Carriage Return (Enter key)

Measured value number	Description	Data type
0	Reserved	
1	Path measured value U Top -> Bottom (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER
2	Path measured value V Top -> Bottom (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER
3	Path measured value W Top -> Bottom (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER
4	Path measured value U Bottom -> Top (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER
5	Path measured value V Bottom -> Top (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER

6	Path measured value W Bottom -> Top (counter value) With averaging this is the mean value of all measured values	WHOLE_NUMBER
7	Time stamp of last measured data record (value in ms, relative to system start-up).	WHOLE_NUMBER
8	Wind velocity in X direction (Positive means wind from westerly direction)	NUMBER
9	Wind velocity in Y direction (Positive means wind from southerly direction)	NUMBER
10	Wind velocity in Z direction (Positive means wind from below)	NUMBER
11	Total wind velocity	NUMBER
12	Wind velocity azimuth	NUMBER
13	Wind direction azimuth	NUMBER
14	Wind direction elevation	NUMBER
15	Reserved	
16	Reserved	
17	Acoustic virtual temperature [°C]	NUMBER
18	Acoustic virtual temperature of U path [°C] This value is not contained in the averaging buffer. The last measured value in the averaging interval is output. If the last measurement fails to generate a valid value, -273,15 is displayed.	NUMBER
19	Acoustic virtual temperature of V path [°C] This value is not contained in the averaging buffer. The last measured value in the averaging interval is output. If the last measurement fails to generate a valid value, -273,15 is displayed.	NUMBER
20	Acoustic virtual temperature of W path [°C] This value is not contained in the averaging buffer. The last measured value in the averaging interval is output. If the last measurement fails to generate a valid value, -273,15 is displayed.	NUMBER
21	Measured value counter Specifies the number of data records measured since system startup.	WHOLE_NUMBER
22	Standard deviation of wind velocity in X direction	NUMBER
23	Standard deviation of wind velocity in Y direction	NUMBER
24	Standard deviation of wind velocity in Z direction	NUMBER
25	Standard deviation of total wind velocity	NUMBER
26	Standard deviation of wind velocity azimuth	NUMBER
27	Standard deviation of wind direction azimuth	NUMBER
28	Standard deviation of wind direction elevation	NUMBER
29	Reserved	NUMBER
30	Reserved	NUMBER
31	Standard deviation of acoustic virtual temperature	NUMBER
32	Reserved	
33	Reserved	
34	Reserved	
35	Reserved	
36	Variance of X path (Square of the standard deviation of the average wind component in parallel to the main wind direction)	NUMBER
37	Variance of Y path (Square of the standard deviation of the average wind component horizontal-uprightly to the main wind direction)	NUMBER
38	Variance of Z path (Square of the standard deviation of the average wind component vertical-uprightly to the main wind direction)	NUMBER
39	Covariance between VX and VY $\overline{x'y'}$	NUMBER
40	Covariance between VX and VZ $\overline{x'z'}$	NUMBER

41	Covariance between VY and VZ $\overline{y'z'}$	NUMBER
42	Covariance between VX and acoustic virtual temperature $\overline{x'T'}$	NUMBER
43	Covariance between VY and acoustic virtual temperature $\overline{y'T'}$	NUMBER
44	Covariance between VZ and acoustic virtual temperature $\overline{z'T'}$	NUMBER
45	Turbulence intensity X	NUMBER
46	Turbulence intensity Y	NUMBER
47	Turbulence intensity Z	NUMBER
48	Shearing stress speed $[u_*]$	NUMBER
49	Shearing stress $[\tau]$	NUMBER
50	Ground friction coefficient $[C_D]$	NUMBER
51	Sensible heat flow $[Q_H]$	NUMBER
52	Obukhov-length $[L]$	NUMBER
53	Dynamic temperature $[T_*]$	NUMBER
54	Vertical pulse current $[I_v]$	
55	Reserved	
56	Reserved	
57	Status information (4BYTE)	WHOLE_NUMBER
58	THIES status (2Byte)	WHOLE_NUMBER
59	Reserved	
60	Storage interval (specifies the time interval in which the data is written to the averaging memory)	WHOLE_NUMBER
61	Quantity of data in the mean value buffer	WHOLE_NUMBER
62	Read-in analogue measured value from pin 1	NUMBER
63	Read-in analogue measured value from pin 4	NUMBER
64	Read-in analogue measured value from pin3 (ADIO)	NUMBER
65	Read-in analogue measured value of reference voltage (980..1010)	
66	Reserved	
67	Exclusive Or check sum of data flow	CHECK_SUM
68	ULTRASONIC ID	WHOLE_NUMBER
69	Wind velocity XYZ of the gust (see command GU)	NUMBER
70	Wind direction of the gust (azimuth) (see command GU)	NUMBER
71	Wind direction Elevation (see command GU)	NUMBER
72	Measured internal supply voltage	NUMBER
73	Internal temperature of housing	NUMBER

Table 7: Measured values and data types for user-specific telegram

7.4.5.6 Data formats

As already described under '**Available measured values and data formats**' every data value is derived from a specific type. To indicate this the types each have their own formatting definition. The formatting string is specified after the measured value number on inputting, with the formatting string and measured value number being separated here by a comma.

Example:

The command

00UTHello World @17,8,2,1@\0d<cr> <cr> stands for Carriage Return (Enter key)

defines output of the text 'Hello World', followed by the acoustic virtual temperature (formatted: 8 characters in total, 2 characters after the comma, with sign) and one line feed.

7.4.5.6.1 Output of fixed texts

The ULTRASONIC is equipped with an internal data format TEXT that is at once the simplest and most universal data format. It is used to output a fixed text within the telegram output. This data format requires no further formatting characters. For example, the command

00UTHello World\0d<cr>

defines the output telegram

Hello World

Within this data type all ASCII characters are available via the key character '\'. It must nevertheless be borne in mind that the ASCII code is specified with 2 characters in the hexadecimal format. The input

00UT\41

thus generates an A in the output. The key character \ was introduced in order to include a control character like STX, ETX, CR in a telegram. The input

00UA\0d

attaches a line feed to the telegram.

A constant text can be positioned anywhere in the telegram definition (it should of course not interrupt the formatting of another data type). For example, the following definition is conceivable:

00UTWV = @12,6,2@ WD = @13,3@\0d<cr> <cr> stands for Carriage Return (Enter key)

The following output string is conceivable:

WV = 000.06 WD = 210

7.4.5.6.2 Data format *WHOLE_NUMBER*

A whole number is a number which is output without a decimal point. It may however include a sign or/and be in hexadecimal format.

Format:

@'Measured value','Number of characters','Format'@

With

Measured value: see **Table 7**.

Number of characters: Number of characters output including any sign

Format: Format of number shown

- | | |
|----|------------------------------|
| 0: | without sign and decimal |
| 1: | with sign and decimal |
| 2: | without sign and hexadecimal |
| 3: | with sign and hexadecimal |

The number of characters and the 'Format' do not have to be specified; in this case they are padded with the values '3' (Number of characters) and '0' (Format).

Example1:

00ut@60@\0d<cr> <cr> stands for Carriage Return (Enter key)

Outputs the storage interval with three places without a sign. (Only with averaging switched on is display not equal to zero)

Example2:

00ut@54,3,2@h\0d<cr> <cr> stands for Carriage Return (Enter key)

Outputs the storage interval with three places without a sign as a hexadecimal value. (Only with averaging switched on is display not equal to zero).

7.4.5.6.3 Data format *NUMBER*

A floating point number is known as a number. It is formatted as for the *WHOLE_NUMBER* with the addition that a place after the decimal point can be included.

Format:

@'Measured value','Number of characters','Decimal places','Format'@

With

Measured value: see **Table 7**.

Number of characters: Number of characters output including decimal points and any sign

Decimal places': Number of decimal places

Format: Format of number shown

- | | |
|----|------------------------------|
| 0: | without sign and decimal |
| 1: | with sign and decimal |
| 2: | without sign and hexadecimal |
| 3: | with sign and hexadecimal |

The number of characters, decimal places and the 'Format' do not have to be specified; in this case they are padded with the values '3' (Number of characters) '0' (Decimal places) and '0' (Format).

Example 1:

00ut@13@\0d<cr> <cr> stands for Carriage Return (Enter key)

Outputs the wind direction with three places before the decimal point, no places after the decimal point and in decimal format.

7.4.5.6.4 Data format CHECK_SUM

The data format CHECK_SUM supports calculation of a check sum on the basis of a bitwise exclusive OR link. The CHECK_SUM has the following format:

@67,'First','Last', 'Number of characters','Format'@

with

67:	Measured value identifier for EXOR check sum
First:	Number of character at which generation of the check sum starts. This character is included in the calculation (counting method starts with 0)
Last:	Number of character at which generation of the check sum ends. This character is not included in the calculation.
Number of characters:	Number of characters output including any sign
Format:	Format of number shown
0:	without sign and decimal
1:	with sign and decimal
2:	without sign and hexadecimal
3:	with sign and hexadecimal

Example 1:

With a constant text 'AABBCC' the check sum is to be generated using the characters BB. The output is hexadecimal with 2 characters:

00UTAABBCC XOR=@67,2,4,2,2@h\0d<cr> <cr> stands for Carriage Return (Enter key)

The output is

AABBCC XOR=00h

The XOR link of two identical characters is always 0.

Example 2:

With a constant text 'AABBCC' the check sum is to be generated using the character 'B'. The output is hexadecimal with 2 characters:

00UTAABBCC XOR=@67,2,3,2,2@h\0d<cr> <cr> stands for Carriage Return (Enter key)

The output is

AABBCC XOR=42h

The check sum value is 42h. The ASCII value of 42h is 'B', which is the character to be checked itself.

7.4.6 Status information

In the ULTRASONIC two different status bytes are available:

- extended status information
- THIES status

The THIES status is derived from the extended status information. The structure of the status values is described below.

7.4.6.1 Extended status information

The extended status is structured bitwise. The individual bits in the status value have the following meanings:

Bit number	Function	Description	
Bit 0	General malfunction	Averaging time < 10 sec	An error is output when no new measured value can be determined during a period of 10 sec.
		Averaging time ≥ 10 sec	An error is output when, based on a one-second measuring rate, less than 50 % of values are contained. Example: With an averaging time of 10 seconds 5 measured values must be contained in the averaging buffer.
Bit 1	Heating criterion	Is one when the criterion for switch-on of the heating is satisfied.	
Bit 2	Heating on	Is one when heating is switched on.	
Bit 3	Reserved	Is always zero	
Bit 4	Static malfunction	Is set when a static malfunction has occurred, e.g. lasting violation of VT, no measured values. (> 1min)	
Bit 5 .. Bit 7	Reserved	It always zero	
Bit 8	Used averaging memory	Specifies the averaging memory occupied. Bit 1 to bit 3 indicate the filling level of the averaging buffer in binary format. 0: buffer $0 < x \leq 1/16$ 1: buffer $1/8 < x \leq 1/8$ filled 2: buffer $1/8 < x \leq 3/16$ filled 3: buffer $3/16 < x \leq 1/4$ filled 4: buffer $1/4 < x \leq 5/16$ filled 5: buffer $5/16 < x \leq 3/8$ filled 6: buffer $3/8 < x \leq 7/16$ filled 7: buffer $7/16 < x \leq 1/2$ filled 8: buffer $1/2 < x \leq 9/16$ filled 9: buffer $9/16 < x \leq 5/8$ filled 10: buffer $5/8 < x \leq 11/16$ filled 11: buffer $11/16 < x \leq 3/4$ filled 12: buffer $3/4 < x \leq 13/16$ filled 13: buffer $13/16 < x \leq 7/8$ filled 14: buffer $7/8 < x \leq 15/16$ filled 15: buffer $15/16 < x \leq 1$ filled	
Bit 9			
Bit 10			
Bit 11			
Bit 12..Bit15	Reserved	Is always zero	
Bit 16..Bit31	Reserved	Is always zero	

7.4.6.2 THIES status

The THIES status is structured bitwise. The individual bits in the status value have the following meanings:

Bit number	Function	Description
Bit 0	General malfunction	Averaging time < 10 sec An error is output when no new measured value can be determined during a period of 10 sec.
		Averaging time \geq 10 sec An error is output when, based on a one-second measuring rate, less than 50 % of values are contained in the averaging buffer. Example: With an averaging time of 10 seconds at least 5 measured values must be contained in the averaging buffer.
Bit 1	Used averaging memory	Specifies the averaging memory occupied. Bit 1 to bit 3 indicate the filling level of the averaging buffer in binary format. 0: buffer $0 < x \leq 1/8$ 1: buffer $1/8 < x \leq 1/4$ filled 2: buffer $1/4 < x \leq 3/8$ filled 3: buffer $3/8 < x \leq 1/2$ filled 4: buffer $1/2 < x \leq 5/8$ filled 5: buffer $5/8 < x \leq 3/4$ filled 6: buffer $3/4 < x \leq 7/8$ filled 7: buffer $7/8 < x \leq 1$ filled
Bit 2		
Bit 3		
Bit 4	Reserved	Is always zero
Bit 5	Static malfunction	Is set when a static malfunction has occurred, e.g. lasting violation of VT, no measured values. (> 1 min)
Bit 6	Heating criterion	Is one when the criterion for switch-on of the heating is satisfied.
Bit 7	Heating on	Is one when heating is switched on.

7.4.6.3 Status information in Bavaria Hesse format

A separate operational status and error status are generated for the Bavaria Hesse command interpreter. They have the following structure:

Bavaria Hesse operational status:

Bit number	Function	Description
Bit 0		Always zero
Bit 1	Used averaging memory	Specifies the averaging memory occupied. Bit 1 to bit 3 indicate the filling level of the averaging buffer in binary format. 0: buffer $0 < x \leq 1/8$ 1: buffer $1/8 < x \leq 1/4$ filled 2: buffer $1/4 < x \leq 3/8$ filled 3: buffer $3/8 < x \leq 1/2$ filled 4: buffer $1/2 < x \leq 5/8$ filled 5: buffer $5/8 < x \leq 3/4$ filled 6: buffer $3/4 < x \leq 7/8$ filled 7: buffer $7/8 < x \leq 1$ filled
Bit 2		
Bit 3		
Bit 4	Reserved	Is always zero
Bit 5	Heating criterion	Is one when the criterion for switch-on of the heating is satisfied.
Bit 6	Heating on	Is one when heating is switched on.
Bit 7	Reserved	Is always zero

Bavaria Hesse error status:

Bit number	Function	Description
Bit 0	General malfunction	Averaging time < 10 sec An error is output when no new measured value can be determined during a period of 10sec.
		Averaging time >= 10 sec An error is output when, based on a one-second measuring rate, less than 50 % of values are contained in the averaging buffer. Example: With an averaging time of 10 seconds at least 5 measured values must be contained in the averaging buffer.
Bit 1	Static malfunction	Is set when a static malfunction has occurred, e.g. lasting violation of VT, no measured values. (> 1 min)
Bit 2..7	Reserved	Always zero

7.5 Behaviour in extreme exceptional circumstances

The ULTRASONIC is equipped with a highly effective internal fault detection and correction system. This allows it to detect incorrect measured values using the history and to discard them.

It cannot however be ruled out that the ULTRASONIC will get into a situation in which the acquisition of new data is impossible. In this case the error bits are set in the status values and a defined value possibly output at the analog outputs.

It is a basic rule that the measured values output are always valid and can be interpreted by the target system (unless a specific error telegram is output in the case of error). However, what may happen in the case of error is that the data becomes 'too old', i.e. it is not updated over a certain time and freezes. In this case the error bits are set in the status byte and the analog outputs are set to a defined value. If a special error telegram is defined with a serial telegram, this is output.

If the parameter RF is uneven zero, the ULTRASONIC carries out a restart, in case not valid measuring value has been acquired during the stated time interval see **Command RF**.

7.5.1 In the event of error

Error may occur under the following circumstances:

Averaging time < 10 sec (parameter AV)	An error is output when no new measured value can be determined during a period > 10 sec.
Averaging time >= 10 sec (parameter AV)	An error is output when, based on a one-second measuring rate, less than 50 % of values are contained in the averaging buffer. Example: With an averaging time of 10 seconds at least 5 measured values must be contained in the averaging buffer.

7.5.2 Behaviour of analogue outputs

If the analogue outputs are active, they are switched to the minimum or maximum value in the case of error. The parameter EI determines which of the two values is output, see **Command EI**.

7.5.3 Behaviour of telegram output

In the case of error the relevant error telegram is output. In parallel the error information is shown in the status byte: see **Fixed telegram formats**.

7.6 Heating control

To prevent the instrument from freezing, and to avoid consequential error measurements, the ULTRASONIC is equipped with built-in heating for the sensor arms. In standard mode the heating is controlled by the system status.

In addition, there is a PT1000 temperature sensor in the ULTRASONIC instrument base. The values of this sensor are used as plausible information for heating control. For further information see the **Command HT**. The control of the heating by the software can be configured in 6 modes. The individual control conditions for the heating are given under command HT

For the switch-on criterion the following requirements must be met:

1. Continuous failure of the measuring value acquisition of at least 10s.
2. The supply voltage must be higher than the set threshold (see HC).

HT0:

Heating remains permanently switched off.

HT1:

Heating software-controlled by virtual-temperature. (Softstart)

Activate measuring arms:

Virtual-temperature < parameter HL [Kelvin], or faulty measuring value acquisition.

De-activate measuring arms:

After 10 seconds, and virtual-temperature > parameter HH [Kelvin], and activating criterion not satisfied.

Activating Ultrasonic transducer heating:

Virtual-temperature < parameter HL [Kelvin], or faulty measuring value acquisition.

De-activating Ultrasonic transducer heating:

When the virtual-temperature > parameter HL [Kelvin] **and** the switch-on criterion is no longer met, the ultrasonic transducer heating remains active for an hour, and then shuts down.

HT2:

Softstart by ramp function (125s), afterward the heating remains active permanently.

HT 3:

Heating software controlled (Softstart)

Switch on heating of transducer arms:

Virtual temperature < 2°C or PT1000 temperature < 5°C, or disturbed data acquisition and PT1000 temperature < 25 °C

Switch off heating of transducer arms:

Virtual-temperature > 7°C and PT1000 temperature > 8°C, and switch-on criterion not met.

Switch on transducer heating:

Virtual temperature < 2°C or PT1000 temperature < 5°C, or disturbed data acquisition and PT1000 temperature < 10°C

Switch off transducer heating:

When virtual-temperature > 2°C **and** PT1000 temperature > 5°C **and** the switch-on criterion is no longer met at PT1000 temperature <10°C, the ultrasonic transducer heating remains active for an hour, and then shuts down.

HT 4:

Heating software controlled (Softstart)

Switch on heating of transducer arms:

Virtual-temperature < 2°C or PT1000 temperature < 5°C, or switch-on criterion and PT1000 temperature < 25°C

Switch off heating of transducer arms:

Virtual-temperature > 7°C and PT1000 temperature > 8°C and switch-on criterion not met.

Switch on transducer heating:

Virtual temperature < -25°C or PT1000 temperature < -20°C, or switch-on criterion and PT1000 temperature < 5°C

Switch off transducer heating:

When virtual-temperature > -20°C **and** PT1000 temperature > -15°C **and** the switch-on criterion is no longer met at PT1000 temperature <5°C, the ultrasonic transducer heating remains active for an hour, and then shuts down.

HT 5 (for operation with housing heating):

Heating software controlled for operation with housing heating (Softstart)

Switch on heating of transducer arms:

Virtual-temperature < 2°C or PT1000 temperature < 5°C, or switch-on criterion and PT1000 temperature < 15°C

Switch off heating of transducer arms:

Virtual temperature > 7°C and PT1000 temperature > 15°C and switch-on criterion not met.

Switch on transducer heating:

Virtual-temperature < -25°C or PT1000 temperature < -20°C, or switch-on criterion and PT1000 temperature < 15°C

Switch off transducer heating:

When virtual-temperature > -20°C **and** PT1000 temperature > -5°C **and** the switch-on criterion is no longer met at PT1000 temperature <15°C, the ultrasonic transducer heating remains active for an hour, and then shuts down.

HT 6:

The heating is immediately switched on permanently but not clocked (as HT 2, w/o softstart)

The heating is switched on only in case that the supply voltage is above the value, which is stated by parameter "HC", in addition to the above-mentioned criterions. The parameter HC determines the threshold of the supply voltage when the heating is activated.

The supply voltage can be inquired by the „command PW“. Additionally it can be output in the user-specific telegram. If the available hardware does not support the control of the supply voltage, a message „Heating ctrl not supported“ is output on entering the command (ID) PW.

The measurement of the operating voltage is carried out after alignment via a low pass by means of an analogue-digital-converter. Due to the very high complexity it was dispensed with a real effective value measurement. Thus the measuring values are measured exactly by „Command PW with DC-supply, however, with AC-supply they are between effective- and peak value, that means they are measured too high.

For setting the automatic threshold between supply in heated standard operation and unheated back-up operation the following procedure is recommended:

1. On supply of instrument for standard operation the measuring value of parameter „PW“ should be read-out preferably with active heating (Consideration of voltage drop at supply and cable with active heating under full-load, see **Command HT**).
2. Reading-out of value on supply of instrument in back-up-operation with inactive heating.
3. Setting of automatic threshold on mean value between the measured values by „command HC“, see **Command HC**.

7.7 Instruments with Housing Heating (4.383x.4x.xxx)

The body of instruments with housing heating are heated by an internal heating foil. The controlling is made via hardware and software. The hardware control ensures that the housing temperature is not > 10°, the software activates the heating when required (see command HT).

PIN3 (ADIO) has to be set to 9 or 20 with instruments with housing heating, because with this model the ADIO pin is used to control the housing heating. Another value is not acceptable.

An exception is model 4.383x.42.300. With this variant the software-based heating control is deactivated by a hardware modification. In this case, the housing heating is controlled only via the internal temperature control.

7.8 Output of all system parameters

Most parameters of the ULTRASONIC are stored internally in an EEPROM. The command SS can be used to output all stored parameters.

Before amending parameters it is recommended making a backup copy of existing settings and storing them in a text file, see also **Command SS**.

7.9 Enquiry about software version

The command SV is used to enquire about the software version. For further information see **Command SV**.

7.10 Bavaria Hesse mode

The standard version of the ULTRASONIC contains a command interpreter for the Bavaria Hesse telegram. For further information refer to own documentation.

The command interpreter for the Bavaria Hesse variant is switched on using the command 00CI00001, see also **Command CI**.

For the coding of the operational status and error status see **Status information**.

All commands of the ULTRASONIC are also available in the Bavaria Hesse command interpreter. They are embedded in the command <CTR B>ST0....<CTRL C>. For example, the command <CTR B>ST000KY00001<CTRL C> can be used to switch on user access and <CTR B>ST000AM00001<CTRL C> to adjust the averaging time.

In addition, in various combinations of measuring instrument addresses are available in Bavaria Hesse mode, see **Command BH**.

7.11 Forcing a restart

The command RS can be used to force a restart of the ULTRASONIC. The commands

00KY00001<cr>

00RS00001 <cr>

will restart the ULTRASONIC after approx. 3 sec, see also **Command RS**.

7.12 Energy-saving mode

The ULTRASONIC does not itself have an energy-saving mode. However, it can be configured so that it only has to be supplied with power for a limited period. The following parameters can be used for optimisation:

Switch on fast boot:

Startup with the parameter 00FB00001 or 00FB00002 prevents the ULTRASONIC from first starting the bootloader and waiting for a program update.

Signal when averaging buffer is full:

The PIN 3 (ADIO) can be switched so that it is set to + 5 V when the averaging buffer of the ULTRASONIC has reached a content level > 7/8. Here the shortest adjustable averaging time is 600 ms: see also, **Command AC**, **Command AV**.

The signal can be used to disconnect the ULTRASONIC from the voltage supply.

Switch off heating:

With the command 00HT00000 the heating of the ULTRASONIC is switched off completely, see **Command HT**.

7.13 Boot loader

Whenever the ULTRASONIC is restarted, the device first starts a bootloader. The function of the program is to start program upload. For this a specific program containing the new firmware must be started at a connected PC. After identification the program upload then starts automatically. If the bootloader does not know its remote station, the ULTRASONIC firmware starts. The bootloader can be bypassed if the parameter

00FB00001 or FB00002

is set.

7.13.1 X-Modem Boot loader

For the uploading of new firmware via the serial interface the protocol XMODEM CRC is used with a reference length of 128 byte per package Necessary are a PC and a terminal program with a respective possibility of setting. Tested and released is the boot loader with Windows-hyper terminal and ZOC (V4.11).

Operation:

The boot loader starts always with 96000 baud, 8 data bits, no parity, and a stop bit (9600,8,N,1) On starting the instrument the following data are output: version, used ID, and the set duplex mode of the ULTRASONIC. For re-starting the instrument without cutting-off the supply please use the reset-command „<id>RS00001“.

XModem Loader CRC

Version 3.04

Insert 00UP00001 to start bootloader

In order to continue to parameterize the boot loader, please enter the command <id>UP00001 together with the ID, here: 00UP00001. Alternatively, the command<id>UP00002 can be transmitted directly in order to start the transfer immediately. For entering the command the user has approx. 10 minutes. If no valid command or <id>UP00000 is entered within this time period the ULTRASONIC firmware starts. When entering <id>UP00001 the ULTRASONIC turns into the boot loader mode where further details can be stated. The following output appears:

*use <id>BR000XX to set baudrate
use <id>ID000XX to set ID
use <id>DM0000X to set duplex mode
use <id>UP00000 to cancel upload
use <id>UP00002 to start upload*

- The command codes have to be entered always in capital letters (in „normal“ operation also lower case letters are accepted).
- The baud rate can be changed through BR. All baud rates, containing 8 data bits, are valid. For further parameter see chap. **Command BR**.
- The instrument address can be set by ID. Valid valued are here within the range 0 <= ID <= 99.
- The duplex mode is changed by BD. <id>DM00001 is full duplex, <id>DM00000 is halve duplex.
- The program transfer is started by the command <id>UP00002.
- By <id>UP00000 the transfer program is terminated and the LNM firmware is started.

Remark:

All parameters which are changed here, are valid only for the time period of the boot loader. They do not change the values in the global parameter memory.

After entering of the command <id>UP00002 the ULTRASONIC starts the data transfer, by sending cyclically the sigh "C". The user has now approx. 30sec. for starting the transfer program of the terminal. When the transfer program is started the data transfer initiates with secured CRC-check sum. Erroneous and disappeared data packages are resent automatically, so that the received data are error-free.

Only when the binary data are completely available on the ULTRASONIC, the new program is written into the program memory. After successful transmission the new program starts automatically.

If the transmission is stopped, the ULTRASONIC starts automatically the firmware available after a respective timeout (20 s).

7.14 Fastboot

See **Energy-saving mode**.

7.15 Plausibility

To identify incorrectly measured values the ULTRASONIC offers an internal plausibility check, which assesses measured values using the history. Incorrect measured values can be caused for example by heavy rainfall or foreign bodies in the measurement path.

If an incorrect measured value is identified, the ULTRASONIC sets its acquisition of measured values to the maximum speed. In this mode it is more likely to obtain a valid measured value in fault conditions (e.g. rain). A complete data record is now made approx. every 4 ms using all 6 sensors so that the ULTRASONIC generates approx. 285 measured values per second.

For setting the plausibility check see also **Command MD**, **Command PC**.

7.16 Online Help

For a short description of commands the ULTRASONIC contains an Online Help, which provides information about individual commands. The Help text for the command is returned by inputting the command and a '?'.
If the command

00?? <cr> <cr> stands for Carriage Return (Enter key)

is input, the ULTRASONIC will list all commands with the relevant Help.

Example:

Help with setting the baud rate is to be called up, see **Command BR**.

With the command

00BR?<cr> <cr> stands for Carriage Return (Enter key)

the ULTRASONIC provides the following response:

BR: Set / get Baud rate

0 -> reserved	10 -> 1200 7E1
1 -> reserved	11 -> 1200 7E1
2 -> 1200 8N1	12 -> 4800 7E1
3 -> 2400 8N1	13 -> 9600 7E1
4 -> 4800 8N1	14 -> 19200 7E1
5 -> 9600 8N1	15 -> 38400 7E1
6 -> 19200 8N1	16 -> 57600 7E1
7 -> 38400 8N1	17 -> 115200 7E1
8 -> 57600 8N1	
9 -> 115200 8N1	

8 Configuration of Ultrasonic Anemometer by Customer

The Ultrasonic Anemometer is factory-set prior to delivery to the customer. Setting is described in the supplementary sheet "*Factory Setting*".

It is possible for the customer to alter the factory setting of the Ultrasonic Anemometer or to adapt it to new requirements. Here it should be borne in mind that with a change in settings, the order number allocated at the factory can then no longer help with identification.

The Anemometer 3D can be configured via its serial data interface using commands.

see section

- Access mode (Command KY)
- Command list

Any standard terminal program such as "Procomm", "Telix" or a Windows terminal program (e.g. Hyper Terminal) can be used for this purpose.

Recommendation:

After performing configuration please amend the supplementary sheet "Factory Setting" and also send in to the manufacturer in the event of maintenance or repair.

8.1 Storing of Parameter Data Set

The ULTRASONIC is able to store internally three complete parameter data sets. By the commands SP and RP complete parameter sets are stored respectively read-out from the memory and applied. Parameter sets are stored, for ex. In case that tests with different instruments settings (for ex. different user-defined telegrams) shall be carried out. When a configuration with user-defined telegram has been made, this can be stored and another configuration can be effected. This can be stored, too. By downloading the respective configuration the user can now select from the stored configurations.

By the command 00SP0001 for ex. all parameters are stored into the buffer '1'. By command 00RP00001 all parameters are read and applied by the system. After back-reading the data from the buffer by **Command RP** a system start is carried out automatically, see also **Command SP**.

The buffer with the index '0' contains all values of the delivery, and cannot be overwritten.

8.2 Establishing of Delivery Condition

The parameter data set on delivery is stored in the parameter data set '0'. By calling 00RP00000 the instrument is set into the condition of delivery. After reading a system start is carried out automatically.

8.3 Administration of User Information

The instrument provides a data buffer of 32 texts with 32 signs each, where any text can be stored. By the command UD this buffer is administered. The format of entry is

00Udn,xxxx

with

n: index 1..32

xxxx: text with a maximum length of 32 signs

Storing of user information:

The command

00UD1, THIES ULTRASONIC

stores the text 'THIES ULTRASONIC' at data position one. The query

00UD1

provides the result

01: THIES ULTRASONIC.

During the query the data set number is always included in the output in order to allow a selective changing.

The query

00UD

returns all user-specific texts, for ex.

01: THIES ULTRASONIC

03: mounted at Göttingen

Deletion of Definitions

Data sets must be deleted individually. For this, the data set number followed by a comma, is necessary. The input of

00UD3,

deletes the text at position 3.

9 Command List, Short

	Command	Description
Command AA	<id>AA<para5>	Functions for PIN 1
Command AB	<id>AB<para5>	Functions for PIN 4
Command AC	<id>AC<para5>	Functions for PIN 3 (ADIO)
Command AG	<id>AG<para5>	Group of analogue output values
Command AM	<id>AM<para5>	Selection of averaging method (Average mode)
Command AN	<id>AN<para5>	Analog output mode (Analog output)
Command AR	<id>AR<para5>	Scaling of analog wind velocity output (Analog range)
Command AS	<id>AS<para5>	Set the analogue outputs to a fixed value
Command AT	<id>AT<para5>	Checks the analogue in-/outputs
Command AV	<id>AV<para5>	Averaging time (Average)
Command AU	<id>AU<para5>	Update of analog inputs
Command AY	<id>AY<para5>	Scaling of minimum value for analog input PIN 1
Command AZ	<id>AZ<para5>	Scaling of maximum value for analog input PIN 1
Command BH	<id>BH<para5>	Selects the Bavaria Hesse measuring instrument addresses
Command BL	<id>BL<para5>	Returns the version of the bootloader
Command BP	<id>BP<para5>	Time for pretrigger in burst mode
Command BR	<id>BR<para5>	Select baud rate (Baud rate)
Command BT	<id>BT<para5>	Set the bus terminating resistor
Command BS	<id>BS<para5>	Buffer range in burst mode
Command BX	<id>BX<para5>	Select baud rate (Baud rate extension)
Command BY	<id>BY<para5>	Scaling of minimum value for analog input PIN 4
Command BZ	<id>BZ<para5>	Scaling of maximum value for analog input PIN 4
Command CA	<id>CA<para5>	Adjustment value for analog outputs in 0.1 per mil
Command CB	<id>CB<para5>	Adjustment value for analog outputs (offset correction)
Command CI	<id>CI<para5>	Selects command interpreter (Command interpreter)
Command CO	<id>CO<para5>	Switches calculation of covariances on / off
Command CY	<id>CY<para5>	Scaling of minimum value for analog input PIN 3 (ADIO)
Command CZ	<id>CZ<para5>	Scaling of maximum value for analog input PIN 3 (ADIO)
Command DA	<id>DA<para5>	Data request in Bavaria Hesse command interpreter
Command DE	<id>DE<para5>	Standard deviation (Deviation)
Command DF	<id>DF<para5>	Set initial values (Default values)
Command DM	<id>DM<para5>	Duplex mode
Command EI	<id>EI<para5>	Analog value in case of error (Error inversion)
Command FB	<id>FB<para5>	Fast boot
Command GU	<id>GU<para5>	Maximum value of WV and WD in the averaging buffer (gust acquisition)
Command HC	<id>HC<para5>	Threshold of the supply voltage for switch-on suppression of heating (heating control)
Command HL	<id>HL<para5>	Lower threshold temperature for turning heating into Kelvin
Command HH	<id>HH<para5>	Upper threshold temperature for turning heating into Kelvin
Command HT	<id>HT<para5>	Heating control (Heating)
Command ID	<id>ID<para5>	ULTRASONIC ID
Command IT	<id>IT<para5>	Internal temperature of housing
Command KY	<id>KY<para5>	Access mode (Key)
Command MA	<id>MA<para5>	Automatic adjustment of measured value acquisition (Measurement automation)
Command MD	<id>MD<para5>	Measuring interval (Measurement delay)

Command NC	<id>NC<para5>	Correction to north (North correction)
Command OH	<id>OH<para5>	Query of the operating hours counter
Command OR	<id>OR<para5>	Telegram output interval (Output ratio)
Command OS	<id>OS<para5>	Scaling of wind velocity output (Output scale)
Command PC	<id>PC<para5>	Plausibility test (Plausibility check)
Command PR	<id>PR<para5>	Periodic receive time (Receive time)
Command PT	<id>PT<para5>	Periodic send time (Period transmit time)
Command PW	<id>PW<para5>	Output of measured supply voltage (power)
Command RC	<id>RC<para5>	Correction factor of read-in analog values
Command RD	<id>RD<para5>	Delayed response (Response delay)
Command RF	<id>RF<para5>	Restart with invalid measuring value
Command RP	<id>RP<para5>	Read parameter data set
Command RS	<id>RS<para5>	Restart ULTRASONIC (Reset)
Command SH	<id>SH<para5>	Serial number (High Word) (Serial number high word)
Command SL	<id>SH<para5>	Serial number (Low Word) (Serial number low word)
Command SC	<id>SC<para5>	Minimum value of analog outputs (Start current)
Command SP	<id>SP<para5>	Store parameter data set (Store Parameters)
Command SS	<id>SS<para5>	System status (System status)
Command SV	<id>SV<para5>	Software version (Software version)
Command TB	<id>TB<para5>	Specifies data telegram outputting data after burst measurement
Command TC	<id>TC<para5>	TC Temperature correction (Temperature correction)
Command TF	<id>TF<para5>	Transformer for generating acoustic signals
Command TR	<id>TR<para5>	Telegram request (Transmit request)
Command TT	<id>TT<para5>	Autonomous telegram output (Telegram Transmission)
Command UA	<id>UA<para5>	Addition of definitions to user-defined telegram (Add user telegram item)
Command UD	<id>UD,<para5>	User-defined text (User data)
Command UR	<id>UR<para5>	Deletion of one or more definitions at the end of the user-defined telegram (Remove user telegram item)
Command US	<id>US<para5>	Save user-specific telegram definition (User telegram save)
Command UT	<id>UT<para5>	User-specific telegram (User telegram)
Command VC	<id>VC<para5>	Constant velocity correction (Velocity correction)
Command VT	<id>VT<para5>	Angle-dependent velocity correction (Velocity table)
Command XI	<id>XI<para5>	External ID (External ID)

10 Command List

Command AA

T<id>AA<para5> Functions for PIN 1
Access: User mode
Description: Sets the mode for PIN 1. Values for this parameter can only be changed when the ULTRASONIC is switched to half duplex mode (see **Command DM**). For the signal line PIN1 the following function is specified:

Parameter description:

- 0: Analog input signal is not used. Full duplex mode is possible (see **Command DM**).
- 1: PIN 1 is used as analog input. The analog voltage value at PIN 1 is read in cyclically by the system and digital conversion performed. The analog output value for WV is switched off (see **Command AN**).
With a maximum input voltage of 10.0 V the digital value output is 65536 (16 bit) with a resolution of 152 ppm.
The prerequisite for this mode is half duplex mode (see **Command DM**).
- 2: Self test of analog wind velocity output
In this state the analog output signal of the wind velocity is read back via the analog input signal. The prerequisite is that the analog wind velocity output is switched as a voltage output.
(see **Command AN**).
PIN 1 must not be connected externally. The analog values are output by the ULTRASONIC, and are re-imported. The analog voltage value at WV/RXD- undergoes digital conversion cyclically and is read in by the system.
The digital value read-in can be output via the user-defined telegram (see **User-specific telegram**).
The prerequisite for this mode is half duplex mode (see **Command DM**).
- 3: Analog output of wind velocity in azimuth. Is output when AN != 2, see **Command AN**.
- 4: Input used as SONIC ID (Bit 0). If the mode is selected in which the ULTRASONIC is to receive its ID via the external lines, this PIN must be configured as follows: 00AA00004. (see also **Command XI**).

When using AA, AB and AC the parameter AN must not be switched to two!!! See also **Command AN**.

Range of values: 00000..00004
Initial value: 00000

Command AB

T<id>AB<para5> Functions for PIN 4
Access: User mode
Description: Sets the mode for PIN 4. The values for this parameter can only be changed when the ULTRASONIC is switched to half duplex mode (see **Command DM**). For the signal line PIN4 the following function is specified:

Parameter description:

- 0: Signal is not used. Full duplex mode is possible (see **Command DM**).
- 1: PIN 4 is used as analog input. The analog voltage value at PIN 4 is read in cyclically by the system and digital conversion performed. The analog output value for WD is switched off (see **Command AN**). The prerequisite for this mode is half duplex mode (see **Command DM**). With a maximum input voltage of 10.0V the digital value output is 65536 (16bit) with a resolution of 152 ppm.
- 2: Self test of analog wind direction output
In this state the analog output signal of the wind direction is read back via the analog input signal. The prerequisite is that the analog wind direction output is switched as a voltage output (see **Command AN**). PIN 4 must not be connected externally. The analog values are output by the ULTRASONIC, and are re-imported. The digital value read-in can be output via the user-defined telegram (see **User-specific telegram**). The prerequisite for this mode is half duplex mode (see **Command DM**).
- 3: Analog output of wind direction in azimuth. Is output when AN != 2, see **Command AN**.
- 4: Input used as SONIC ID (Bit 1). If the mode is selected in which the ULTRASONIC is to receive its ID via the external lines, this PIN must be configured as follows: 00AB00004. (see also **Command XI**).

When using AA, AB and AC the parameter AN must not be switched to two!!! See also **Command AN**.

Range of values: 00000..00004
Initial value: 00000

Command AC

T<id>AC<para5> Functions for PIN 3 (ADIO)

Access: User mode

Description: Sets the mode for PIN 3 (ADIO). It can either be switched as an analog input, digital input or digital output. The functions of the PIN 3 (ADIO) are independent of the duplex mode selected.

Attention:

***For instruments of artikel no. 4.383x.4x.xxx
the parameter AC must be set to 11, 13, or 20 only.***

Parameter description:

- 0: Signal is not used.
- 1: PIN is used as analog input. The analog voltage value is read in cyclically by the system. Input resistance 200 kΩ. With a maximum input voltage of 10.0V the digital value output is 65535 with a resolution of 16 bit or approx.15 ppm.
- 2: Reserved
- 3: Analogue output of acoustic virtual temperature. Is output when AN != 2, see **Command AN**.
- 4: Input used as SONIC ID (Bit 2). If the mode is selected in which the ULTRASONIC is to receive its ID via the external lines, this PIN must be configured as follows: 00AC00004. (see also **Command XI**). Input resistance 200 kΩ.

- 5: PIN is switched as digital output. The output is set to +5 V when the averaging buffer is filled to over 80 % for the first time after startup. This function can be used when the ULTRASONIC is to be operated so that it is to be disconnected from the voltage supply after complete measurement, see also **Energy-saving mode**.
- 6: PIN 3 (ADIO) is switched as digital output. The output is set to 0 V.
- 7: PIN 3 (ADIO) is switched as digital output. The output is set to + 5 V.
- 8: The PIN 3 (ADIO) is used for heating control. A level of < 2 V switches the heating off, and a level of > 3 V activates parameterised heating control, see **Command HT**. Input resistance 200 kΩ.
- 9: The PIN 3 (ADIO) is used for heating control. A level of < 3 V switches the heating off, and a level of > 2 V activates parameterised heating control, see **Command HT**. Input resistance 200 kΩ.
- 10: As for 8) with additional 10 k pull-up resistor at PIN 3 (ADIO)
- 11: As for 9) with additional 10 k pull-down resistor at PIN 3 (ADIO)
- 12: As for 8) with additional 10 k pull-down resistor at PIN 3 (ADIO)
- 13: As for 9) with additional 10 k pull-up resistor at PIN 3 (ADIO)
- 14: Triggers a single measurement on rising edge, when PIN 3 (ADIO) is set to +5V. This mode can be used for synchronous measurement acquisition. Required pulse length > 1 µsec. Input resistance 10 kΩ pull down.
- 15: Starts the continuous measurement on rising edge, when PIN 3 (ADIO) is set to + 5 V. Required pulse length. > 1 µsec. The current measurement can be stopped again by command input AC15. Input resistance 10kΩ pull down.
- 16: Starts measurement in burst mode when PIN 3 (ADIO) is set to 5 V. Required pulse length < 10 ms. If PIN 3 (ADIO) is open, no measurement is started. (Internal pull-down resistor switched on) If PIN 3 (ADIO) is fixed to +5 V, burst mode is started automatically when previous measurement ends.
- 17: Starts measurement in burst mode when PIN 3 (ADIO) is switched to AGND. If PIN 3 (ADIO) is open, no measurement is started. (Internal pull-up resistor switched on) If PIN 3 (ADIO) is fixed to AGND, burst mode is started automatically when previous measurement ends. Input resistance 10 kΩ pull up.
- 18: For wind directions < 170° ADIO-pin outputs 5 V, for wind directions > = 170° 0 V.
- 19: PIN 3 (ADIO) output the internal status of heating. A level of 0 V means: heating off, level of 5 V means: heating on.
- 20: PIN 3 (ADIO) output the internal status of heating. A level of 0 V means: heating off, level of 5 V means: heating on.
Parameter is used when instrument is equipped with housing heater. The "high"-level at ADIO de-activated the housing heater.

Range of values: 00000..000020
Initial value: 00000

Command AG

T<id>AG<para5> Setting the group of analogue outputs (Analogue group)
Access: User mode

Description: This command determines the group of analogue values, being output to PIN 1, PIN 4, PIN 3 (ADIO).

Parameter description:

- 0: Output of Vx, Vy, Vz
- 1: Output of WG, WR, VT

The scaling of the analogue outputs depends on the selected output values.

Measuring value	Output	Remark
Vx,Vy,Vz	-(AR)...+(AR)	See Command AR
WG,WR	0...(AR)	See Command AR
VT	-40°C...+80°C	Fixed scaling

The output of Vx, Vy, Vz must be signed. For this, the wind speed of 0,m/s is connected in the middle of the output interval. With the output of 4...20 mA, 0 m/s corresponds to a current of 12 mA.

Value range: 00000..00001
Initial value: 00000

Command AM

T<id>AM<para5> Selection of averaging method (Average mode)
Access: User mode

Description: This command can be used to select the type of averaging method. Averaging can be either vectorial or scalar: see also **Averaging**.

Parameter description:

- 0: vectorially averaged velocity and vectorially averaged angle
- 1: scalarly averaged velocity and scalarly averaged angle
- 2: scalarly averaged velocity and vectorially averaged angle
- 3: vectorially averaged velocity and scalarly averaged angle

Range of values: 00000..00003
Initial value: 00000

Command AN

T<id>AN<para5> Analog output mode (Analog output)
Access: User mode

Description: Sets the mode for output of the analog value. This command can be used to switch between the current output and voltage output. Any change in the value always relates to all outputs PIN 1, PIN 4 and PIN 3 (ADIO) simultaneously. The output value range can be selected with the **Command SC**. It is either 0..20 mA (0..10 V) or 4..20 mA (2..10 V), see **Command SC**.
The command can only be changed when the mode half duplex is selected: see **Command DM**.

When using analog data output PIN 1, PIN 4 and PIN 3 (ADIO) have to be switched individually as analog outputs to be included in the internal list for DA conversion. The interval for AD/DA conversion is extended by approx. 5 ms per channel.

Parameter description:

- 0: Voltage output (With parameter AA, AB and AC PIN 1, PIN 4 and PIN 3 (ADIO) have to be switched as analog outputs as required).
- 1: Current output (With parameter AA, AB and AC PIN 1, PIN 4 and PIN 3 (ADIO) have to be switched as analog outputs as required).
- 2: Analog outputs are not used. Internal calculation and output of these analog values is switched off completely when AN=2 is set and AA=AB=AC=0.

Range of values: 00000..00002
Initial value: 00000

Command AR

<id>AR<para5> Scaling of analog wind velocity output (Analog range)
Access: User mode
Description: Specifies the range used for scaling of the analog wind velocity output. The standard ULTRASONIC scales the wind velocity as follows:
 0..10 V (2..10 V) corresponds to 0..60 m/s resp. -60 m/s..60 m/s see command AG.
 It may however also be sensible to scale the wind velocity of 0..30 m/s:
 0..10 V (2..10 V) corresponds to 0..30 m/s resp. -30 m/s..30 m/s see command AG.
 The end of the measuring range is specified with this parameter. Specification is made in m/s.

Parameter description:

0..100: Specifies of the end of the measuring range of the wind velocity (WV).

If the command AR00045 is input for example, 10 V or 20 mA corresponds to a wind velocity of 45 m/s.

Range of values: 00001..00100
Initial value: 00060

Command AS

<id>AS<para5> Sets the analogue outputs to a fixed value
Access: User mode
Description: Sets the analogue outputs to a fixed value. The value is stated in increments for the internal AD transformer. Value ,0' for AS deactivates the function. Function is used for instrument adjustment.

Value range: 00000...65535
Initial value: 0000

Command AT

<id>AT<para5> Checks the analogue in-/outputs.
Access: User mode
Description: Connects different voltages to the outputs and read them in again. Operates only in half-duplex mode. The analogue in-/outputs must not be connected.

Value range: 00000...65535
Initial value: 0000

Command AU

<id>AU<para5> Update of analog inputs/outputs
Access: User mode
Description: This command is used to specify the time interval in which the analog inputs are sampled and the outputs are written. The parameter defines the interval between two complete update intervals in ms.
 A conversion time of approx. 2.5 ms is required per channel. If parameter AU is set to 0, the analog inputs/outputs are not sampled / updated.
 In the configuration each of the three PINs PIN 1, PIN 4 and PIN 3 (ADIO) can be switched individually as an analog output. The time for AD conversion for the individual channels is totalled here.
 When using analog data output (see **Command AN**) the channels PIN 1, PIN 4 are used simultaneously and require a conversion time of approx. 5 ms.

Example:
 PIN 3 (ADIO) is switched as an analog input.
 The sampling interval is 50 ms (with AU00050). The ULTRASONIC finishes conversion after approx. 3 ms if no other analog channel is switched on.

Range of values: 00001..256
 Initial value: 50

Command AV

<id>AV<para5> Averaging time (Average)
 Access: User mode
 Description: This command can be used to specify the period over which the ULTRASONIC averages its measured values. Given the high measuring speed of up to 4 ms for the generation of a measured value, the use of averaging is sensible in most cases.

Parameter description:

Parameter for AV	Selected averaging time
0	No averaging
1	Averaging over 1 s
2	Averaging over 10 s
3	Averaging over 60 s
4	Averaging over 120 s
5	Averaging over 10 min
6..60000	Averaging over n* 100 ms, e.g. 00AV00025 means averaging over 2.5 s

Table 8: Adjustment of averaging periods with parameter AV

The averaging memory is designed as a sliding memory. With every measurement the measured value is provided with a time stamp. The mean value buffer is only so large for data over the averaging period to be contained in the memory.
 On startup the data of the averaging memory is instantly valid. Averaging is performed immediately using the measured values available.
 If an averaging period of AV00000 is selected, the averaging period is calculated from the selected output interval OR (see **Command OR**). The averaging period is calculated as follows:

$$T [100 \text{ ms}] = \text{OR}$$

Range of values: 00000..60000
 Initial value: 10

Command AY

<id>AY<para5> Scales minimum value of analogue input PIN 3
 Access: User mode
 Description: The measured values of the analogue inputs can be output scaled. The command AY can be used to specify the output value for an input voltage of 0 V. The value for parameter AY is calculated as follows:
 Parameter value = 30000 + (setpoint*10)

See also **7.2.1** and **Command AZ**.

Command AZ

<id>AZ<para5>

Access:

Description:

Scales maximum value of analog input PIN 1

User mode

The measured values of the analog inputs can be output scaled. The command AZ can be used to specify the output value for an input voltage of 10.0 V. The value for parameter AZ is calculated as follows:
Parameter value = 30000 + (setpoint*10)

See also 7.2.1 and command AY.

Command BH

<id>BH<para5>

Access:

Description:

Selects the Bavaria Hesse measuring instrument addresses

User mode

The ULTRASONIC contains several command interpreters. The THIES command interpreter is active in standard mode. **Command CI** can be used to change the command interpreter. If the Bavaria Hesse interpreter is selected, the measured values for wind direction, wind velocity and acoustic virtual temperature are interrogated under different measuring instrument addresses. The command BH specifies which measuring instrument addresses are active. The following combinations are available for selection:

Parameter description:

Parameter value	Measuring instrument address
-----------------	------------------------------

	WV _{Azimuth}	WD _{Azimuth}	VT	WV _{Elevation}	WD _{Elevation}
0	011	001	022	---	---
1	400	410	420	---	---
2	202	201	211	---	---
3	011	001	021	---	---
4	081	082	083	---	---
5	001	002	003	---	---
6	802	801	106	804	803

Table 9: Measuring instrument addresses in Bavaria Hesse command interpreter

See also **Command CI**, Bavaria Hesse mode.

Command BL

<id>BL<para5>

Access:

Description:

Returns the software version of the bootloader

Query mode

On query of the parameter the software version of the bootloader is returned. For interpretation the output version must be divided by 100. An output value 00BL00300 represents the version V3.00. Number ,3' means the main version, 00 is the build-label.

Command BP

<id>BP<para5>

Determine the pretrigger in the burst mode.

Access

User mode

Description:

States the time (ms) of the data recording in the burst mode before the real trigger event.

Value range:

00000..65535

Initial value:

100 ms

Command BR

<id>BR<para5>

Select baud rate (Baud rate)

Access:

User mode

Description:

ULTRASONIC communication can take place at different baud rates. The adjustment range is from 1200 baud to 921 Kbaud. The baud rate can be selected with the commands BR and BX. With the command BR the baud rate is specified in the range from 1200 baud to 115200 baud. The command BX specifies the baud rate from 230400 baud to 921600 baud. The following baud rates are defined for BR:

Parameter description:

	1200	2400	4800	9600	19200	38400	57600	115.2K
8N1	2	3	4	5 *	6	7	8	9
7E1	10	11	12	13	14	15	16	17
7O1	18	19	20	21	22	23	24	25
8N2	26	27	28	29	30	31	32	33
7E2	34	35	36	37	38	39	40	41
7O2	42	43	44	45	46	47	48	49

Table 10: List of baud rates with telegram BR

When interrogating the baud rate using the command BR, the ULTRASONIC gives back the last programmed baud rate selected either using the command BR or BX.

Range of values:

2..49

Initial value:

00005

Command BS

<id>BS<para5>

Sets buffer size in burst mode

Access:

User mode

Description:

When burst mode is activated, this parameter can be used to select the buffer size. The maximum buffer size is 40,000 complete measuring cycles. Burst mode is activated with command 00AC00016 or 00AC00017, see **Command AC**.

Range of values:

1..40000

Initial value:

1000

Command BT

<id>BT<para5> Set bus terminating resistor
Access: User mode
Description: Connects a 100R resistance between the lines TXD+ und TXD- in case BT00001 is set. With BT00000 the resistance is switched off.
Value range: 0...1
Initial value: 0

Command BX

<id>BX<para5> Select baud rate (Baud rate extension)
Access: User mode
Description: ULTRASONIC communication can take place at different baud rates. The adjustment range is from 1200 baud to 921 Kbaud. The baud rate can be selected with the commands BR and BX. With the command BR the baud rate is specified in the range from 1200 baud to 115200 baud. The command BX specifies the baud rate from 230400 baud to 921600 baud. The following baud rates are defined for BR:

Parameter description:

101:	230400 baud	8,N,1
102:	460800 baud	8,N,1
103:	921600 baud	8,N,1

Table 11: List of baud rates with telegram BX

Programming of the extended baud rate includes a safety mechanism which does not allow a baud rate to be selected with the command BX when communication cannot be established at this baud rate. With most PCs the maximum baud rate is set at 115200 baud. It is not possible to select a higher baud rate. If the ULTRASONIC has a baud rate >115200 Kbaud, communication with the device may not be possible. To work with such baud rates a standard PC requires a special extension card.

To set the ULTRASONIC to an extended baud rate the procedure given below must be followed:

Initial situation:

The communication with the ULTRASONIC is available (for ex. 9600 baud).

Change baud rate:

The user selects a new baud rate, e.g. 230400 baud.

The ULTRASONIC changes its baud rate, but does not yet store the parameter.

The user sets his PC to the new baud rate.

He repeats the input to change the baud rate (same command as above).

This is the signal to the ULTRASONIC that communication functions at the new baud rate, and it stores the parameter internally.

If the user is unable to set the new baud rate, the ULTRASONIC must be restarted. It will then automatically set the last valid baud rate (here 9600 baud)

Example:

00KY00001<cr>

Opens access key

00BX00103<cr>

ULTRASONIC baud rate changed to
921600 Baud

Set baud rate at PC to 921600 baud

00BX00103<cr>

Repeat command for baud rate. The
ULTRASONIC stores the baud rate. This
baud rate is loaded with every restart.

When interrogating the baud rate using the command BX, the ULTRASONIC gives back the last programmed baud rate selected either using the command BR or BX.

Range of values: 101..103

Initial value: The command BR is responsible as the initial value for the baud rate.

Command BY

<id>BY<para5> Scales minimum value of analog input PIN 3
Access: User mode
Description: The measured values of the analog inputs can be output scaled. The command BY can be used to specify the output value for an input voltage of 0 V. The value for parameter BY is calculated as follows:
 $\text{Parameter value} = 30000 + (\text{setpoint} \times 10)$

See also 7.2.1 and Command BZ.

Command BZ

<id>BZ<para5> Scales maximum value of analog input PIN 3
Access: User mode
Description: The measured values of the analog inputs can be output scaled. The command BZ can be used to specify the output value for an input voltage of 10.0 V. The value for parameter BZ is calculated as follows:
 $\text{Parameter value} = 30000 + (\text{setpoint} \times 10)$

See also 7.2.1 and Command BY.

Command CA

<id>CA<para5> Calibration value for analogue current/ voltage outputs (slope).
Access: Configuration mode
Description: Specifies a value in 0.1 per mil used for multiplication of the internally calculated output values. The value must be smaller than 60,000 as the internal amplifier is 1 % too high.

Range of values: 59000..61000
Initial value: Device-dependent

Command CB

<id>CB<para5> Calibration value for the analogue current/voltage outputs (offset correction)
Access: Configuration mode
Description: States a value in increments which is used to correct the internally calculated output values. A value of 1000 represents a correction of 0.

Value range: 800..1200
Initial value: Device-dependent

Command CI

<id>CI<para5>

Access:

Description:

Selects command interpreter (Command interpreter)

Configuration mode

The ULTRASONIC contains several command interpreters. The THIES command interpreter is active in standard mode. The **Command CI** can be used to change the command interpreter. The command interpreter decides the format of the commands input. "THIES" is selected as the standard command interpreter. It awaits commands in the form:

XXBBnnnnn<CR> Telegram to change a parameter

XXBB<CR> Interrogation telegram

With

XX -> two-position ID (Initial value is 00, see **Command CI**).

BB -> two-character command identifier

nnnnn ->5-character parameter

<CR> -> Carriage return as delimiter

When changing a parameter it should be ensured that the appropriate access key is selected, see **Command KY**.

Parameter description:

0: Standard Thies command interpreter

1: Bavaria Hesse command interpreter

Range of values: 0..1

Initial value: 0

Command CO

<id>CO<para5>

Description:

Activates/inactivates the calculation of the turbulence variables.

For the calculation of the turbulence variable the parameter must be set to 00001 or respectively 00002.

Parameter 00001:

The coordinate system X, Y, Z is not turned into the main wind direction. All calculations refer to the physical coordinate system of the ULTRASONIC.

Parameter 00002:

The coordinate system is turned into the main wind direction, resulting from the mean value buffer. The turning occurs in a way, that the X-component of the mean value indicates to the main wind direction; the Y- and Z-components are then to zero. The calculation of all turbulence parameters refer to this coordinate system, and is carried out with every currently measured data record. See also **Coordination Transformation**.

0: Calculation of the turbulence variable is switched off.

1: Calculation of the turbulence variable is switched on, no coordinate rotation.

2: Calculation of the turbulence variable with rotation of the coordinate system into the main wind direction.

Value range: 0..2

Initial value: 0

Command CY

<id>CY<para5>

Access:

Description:

Scales minimum value of analogue input PIN 3 (ADIO)

User mode

The measured values of the analogue inputs can be output scaled. The command CY can be used to specify the output value for an input voltage of 0 V. The value for parameter CY is calculated as follows:
Parameter value = 30000 + (setpoint*10)

See also 7.2.1 and **Command CZ**.

Command CZ

<id>CZ<para5>

Access:

Description:

Scales maximum value of analog input PIN 3 (ADIO)

User mode

The measured values of the analog inputs can be output scaled. The command CZ can be used to specify the output value for an input voltage of 10.0 V. The value for parameter CZ is calculated as follows:
Parameter value = 30000 + (setpoint*10)

See also 7.2.1 and **Command CY**.

Command DA

<id>DA<para5>

Access:

Description:

Data request in Bavaria Hesse command interpreter

Interrogation mode

Requests data in Bavaria Hesse format. The command DA complies with the Bavaria Hesse specification. It can be used either with or without the measuring instrument addresses.

Range of values:

Initial value:

Depending on measuring instrument addresses selected, see **Command BH**.

No initial value

Command DE

<id>DE<para5>

Access:

Description:

Standard deviation (Deviation)

User mode

Switches calculation of standard deviation on or off.

The ULTRASONIC includes an option for calculation of the standard deviation. When calculation is switched on, the standard deviation for the wind direction, velocity and temperature is determined. As calculation of the standard deviation is very time-consuming depending on the averaging period, it can be switched on / off separately. Standard deviation is not active when instantaneous values are output.

Parameter description:

- 0: Standard deviation off
- 1: Standard deviation on

Some standard deviation values are output in telegram 5. All further values are available in the user-defined telegram, see **Fixed telegram formats** and **Application**.

If calculation of the standard deviation is set, the number of the data records in the mean value buffer is limited to 2000.

Range of values:

Initial value:

0..1

0

Command DF

<id>DF<para5> Set initial values (Default values)
Access: Configuration mode
Description: Sets all parameters to their initial value.
After this command all parameters of the ULTRASONIC are written to their initial value.

Parameter description:

- 1: Sets all parameters in RAM to the initialisation value.
Values in EEPROM are preserved.
- 2: Sets all parameters in EEPROM to the initialisation value.

Attention:

The values in EEPROM are overwritten!!! Do not use this command. It may cause the ULTRASONIC to stop functioning.

Range of values: 1..2
Initial value: No initial value

Command DM

<id>DM<para5> Duplex mode
Access: User mode
Description: Duplex mode decides the type of physical connection. In full duplex mode the send and receive signals are each transmitted via separate pairs of cables. This means it is possible to send and receive signals as required.
In half duplex mode transmission of the send or receive signals is via the same pair of cables:
Depending on the setting there are restrictions on the function of the connector PINs of the ULTRASONIC, see **Command AA**, **Command AB**, **Command AC**, **Command TT**, **Serial data output**, **Duplex mode**.

Effective from software version V3.10 the independent telegram output can be activated also in half duplex operation. Here, the telegram output is active only after one minute so that in the meantime further commands can be transmitted to the instrument. In case of an instrument-restart the telegram output in half duplex mode, and with independent telegram output the telegram output is activated only one minute after instrument start. With active independent telegram output it might be not possible to communicate with the instrument. A restart is necessary when commands should be transmitted to the instrument. As no data are output within the first minute it is possible to transmit commands to the instrument.

It is only possible to switch from half duplex to full duplex mode with the following prerequisites:

- PIN 1 and PIN 4 must not be switched as analog inputs / analog outputs, see **Command AA** and **Application**.

Parameter description:

- 0: Half duplex mode
- 1: Full duplex mode (RS485 transmission drivers switched off if no data sent)
- 2: Full duplex mode (RS485 transmission drivers not switched off)

Range of values: 0..2
Initial value: 1

Command EI

<id>EI<para5> Analog value in case of error (Error inversion)
Access: User key
Description: Specifies whether 0 or maximum value is output at the analog outputs in the case of error. If the ULTRASONIC establishes a static error during a measurement, it will output an error under certain conditions. This output is designed to prevent the user from interpreting incorrect measured values. If the analog signals of wind direction and wind velocity are used for evaluation, the ULTRASONIC switches the outputs to the maximum or minimum output value in the case of error. This parameter is used to specify whether the minimum or maximum value is output in the case of error.

Parameter description:

- 0: Analog outputs are set to maximum in the case of error
- 1: Analog outputs are set to 0 in the case of error
- 2: Analog output of wind velocity is set to 0 in the case of error
Analog output of wind direction is set to maximum in the case of error

The output in the case of error does not depend on parameter SC, see **Command SC**. Either 0 or maximum is output in the case of error.

Range of values: 0..2
Initial value: 0

Command FB

<id>FB<para5> Fast boot
Access: User mode
Description: The ULTRASONIC is equipped with a bootloader that is called up automatically on startup of the device. The function of the bootloader is to load a new program into the memory of the ULTRASONIC. For this purpose the bootloader transmits a specific character string via the RS485 and waits for an appropriate response. If the device receives a valid response, the program update starts.
The command FB can be used to order the ULTRASONIC to bypass the bootloader on the next startup. In this case no attempt is made to initiate an update via the RS485. This means that the ULTRASONIC starts its main program more quickly. Startup behaviour is influenced with the parameter FB.

Parameter description:

- 0: Fast boot switched off. After a restart the THIES-boot loader starts first, the main program afterwards.
- 1: Fast boot switched on. On system startup the first data telegram is available after 200 ms (averaging switched off).
- 2: The boot loader suppresses output of the start parameters with 9600 baud (from boot loader- version V1.43).
- 3: Fast boot switched off. After a restart the X-modem boot loader starts first, the main program afterwards.

Value range: 0..3
Initial value: 0

Command GU

<id>GU<para5> Maximum value in the averaging buffer (gust acquisition)
Access: User mode
Description: When using mean value buffers, with this parameter the maximum wind velocity and the respective wind direction (gust) can be acquired in the mean value buffer. The value of the command GU indicates the time length of the gust in 100 ms-increments. The gust acquisition is deactivated through GU00000. For this, please see also section gust acquisition. The values of the gust measurement can be output only in the user-specific telegram.

Parameter description:

0: gust acquisition deactivated.
>0: Gust acquisition activated. The length of the gust must be less than the preset averaging period.

Example:

AV00003
GU00030

The instrument acquires the maximum gust in the gliding mean value buffer (here 1 minute). The gust value is the mean value from 3 seconds. All values in the averaging buffer are checked gradually. The acquisition of the gust is carried out after each measurement.

Value range: 0..30
Initial value: 0

Command HC

<id>HC<para5> Voltage threshold for heating suppression (Heating Control)
Access: User mode
Description: With this parameter the minimum supply voltage, when the heating control is activated, is stated in volt. If the supply voltage falls below this value, the heating is de-activated respectively switched off. Effective from firmware V3.09 and the hardware-revision V08-08 the parameter is supported. By means of the command (ID) PW it might be determined if the available instrument supports this option. If (ID) PW returns a numerical value, the heating control is supported. If the heating control is not supported, the instrument responses with the output:
„System power ctrl not supported“

Value range: 5..48
Initial value: 10

Command HL

<id>HL<para5> Lower threshold temperature for switching the heating (Heating low)
Access: User mode
Description: This parameter is used to indicate the lower threshold temperature for the heating control for HT00001. If the acoustic virtual-temperature falls below this value the heating is switched on. Input is performed in Kelvin.
0 °C -> 273 Kelvin; 2°C -> 275 Kelvin

Value range: 220 K..320 K
Initial value: 275

Command HH

<id>HH<para5> Upper threshold temperature for switching the heating (Heating high)
Access: User mode
Description: This parameter is used to indicate the upper threshold temperature for the heating control for HT00001. If the acoustic virtual temperature exceeds this value the temperature criterion for activating the heating is not satisfied. In case all other criterions for de-activating the heating are satisfied, the heating is switched off. Input is performed in Kelvin.
0 °C -> 273 Kelvin; 7°C -> 280 Kelvin
Value range: 220 K..320 K
Initial value: 280

Command HT

<id>HT<para5> Heating control (Heating)
Access: User mode
Description: To prevent icing the ULTRASONIC is equipped with an effective heating system that heats the sensor arms and the ultrasonic converter itself if necessary. The command HT can be used to influence the heating function. It is a basic rule that heating is switched on clocked. The basis for this is a pulse duration of 100 ms. On startup the ratio between switched-on heating to switched-off heating is 1:100. After every further 100 ms this ratio shifts 5 ms towards switched-on heating. After 2 seconds the arm heating is completely active. Instruments with PTC heating also have clocked activation.

Time after switch-on[ms]	Time heating on	Time heating off
0	1	99
100	6	94
200	11	89
...
1900	96	4
2000	Completely on	

Table 12: Pulse control factor with switch-on of heating

Parameter description:

- 0: heating permanently off
- 1: heating software-controlled by virtual-temperature
- 2: heating permanently on
- 3: Heating software-controlled by virtual-temperature and housing temperature
- 4: Heating software-controlled by virtual-temperature and housing temperature
- 5: Heating software-controlled by virtual-temperature and housing temperature
- 6: The heating is immediately switched on permanently but not clocked.

Remark:

Detailed description ref to „heating control“ chapter 7.6.

The temperature criterion for control of the heating is always derived from the last valid measured value and not from the current mean value.

In continuous operation the heating system is protected by temperature monitoring. If the temperature of the sensors exceeds approx.70°C, the heating automatically switches off. If a threshold value is not attained, it switches back on.

See also Command HC

Range of values 0...6
Initial value: Depending on instrument

Command ID

<id>ID<para5>
Access: User mode
Description: This command is used to specify the ID of the ULTRASONIC when the parameter XI is set to 0: see **Command XI**. The ID is used in every telegram of the ULTRASONIC when the command interpreter 'THIES' is selected, see **Command CI**. After the ID has been changed, the ULTRASONIC immediately responds to the new identifier.

The ID 99 is an extended ID. The ULTRASONIC always responds to commands with the ID 99 (with correct baud rate). The ID 99 must not be used in bus mode.

Example:

00KY00001	Open with user key
00ID00023	Change ID from 0 to 23
!23ID00023	ULTRASONIC acknowledges change
23DM	Interrogation of duplex mode with new ID
!23DM00000	Response from ULTRASONIC
23ID00000	Change ID from 23 to 0
!00ID00000	ULTRASONIC acknowledges change

Range of values: 0..99
Initial value: 0

Command IT

<id>IT<para5>
Access: Interrogation mode
Description: Returns the internal temperature of housing in 0.1°. The resolution of temperature is approx. 0.1°C. A value of 256 means 25,6°C. The internal temperature of housing is used for heating control. The time constant for adjusting the internal temperature of housing to the outside temperature is approx. 20 min.
The internal temperature of housing can be used with all instruments effective from delivery date October 2009, and software version V3.10.

Command KY

<id>KY<para5>
Access: Access mode (Key)
Access: Interrogation mode
Description: To change the parameters of the ULTRASONIC access authorisations are necessary for most commands. This prevents any accidental change in parameters. Access takes place on three levels:

- interrogation mode
- user mode
- configuration mode

Parameter description:

00000:	Interrogation mode Parameters which have no access restrictions are those not stored in the EEPROM, e.g. cyclic telegram enquiry or output of system status.
00001:	User mode (USER ACCESS) The user key protects parameters, which influence the behaviour of the ULTRASONIC, e.g. averaging time and baud rate. The user can change these parameters but he must realise that a change will alter the behaviour of the ULTRASONIC. Before every change it is recommended using the command SS to output and save the current configuration.
xxxxx:	Configuration mode (CONFIG ACCESS) Parameters protected with this key should not be changed. They are partly set on adjustment of the device at the factory. If these parameters are misadjusted, complete malfunction may result. For the sake of completeness these parameters are included in this documentation although they should not be changed.

After a restart the system is always switched to interrogation mode. If a command is entered incorrectly or an invalid command input, the ULTRASONIC immediately sets the access mode to interrogation mode.

Range of values: 0,1, xxxxx
Initial value 0

Command MA

<id>MA>>para5> Automatic adjustment of measured value acquisition (Measurement automation)
Access: User mode
Description: Specifies whether the measuring interval MA is automatically changed when an incorrect measurement is identified, see **Command MA**.

Parameter description:

0:	An incorrect measured value identified during the plausibility check has no influence on the interval for the acquisition of measured values.
>0:	An incorrect measured value identified during the plausibility check causes the measuring interval to be set to the selected value and measurement performed with this frequency in the case of error. With error the parameter MA replaces the measured value interval MD. If MD and MA have the same value, the measuring speed does not change in the case of error. The measuring interval is reset when 4 consecutive data records contain no error.

Range of values: 0..100
Initial value 2

Command MD

<id>MD>>para5> Measuring interval (Measurement delay)
Access: User mode
Description: Specifies the time in ms waited between two ultrasonic pulses. The ULTRASONIC is designed so that it cyclically measures the path run times of the individual paths. The parameter MD specifies how long the period between two ultrasonic pulses is. In standard mode this time is 5ms, so that every 30ms a complete data record is made from all sensors. If the ULTRASONIC identifies an incorrect measurement, the value MD can be set to 0, i.e. the send pulses directly follow each other, see **Command MA**. If for example a sensor is blocked, the change in MD is identified by the higher sound frequency given off by the ULTRASONIC.

Range of values: 0..1000
Initial value: 00005

Command NC

<id>NC<para5> Correction to north (North correction)
Access: User mode
Description: With correction to north a constant angle is also added to the measured angle. This value is used to correct a known angle error. If the ULTRASONIC is for example not aligned directly to north but to north-east, the wind direction will always show 45° too little. In this case a north correction of 45 must be selected.
Correction to north affects the values in the data telegrams as well as the analog output values.

Range of values: 0..360 in 1° steps
Initial value: 00000

Attention:

When using the north correction (NC ≠ 0) the direction (sign) of the wind components Vx und Vy is output in inverted form. This affects all telegrams and analogue outputs!

Command OH

<id>ZB<para5> Operating hours counter
Access: Query mode
Description: The operation hours counter states the actually accumulated operating hours of the instrument as 5-digit-number. Hence, a maximum of 99999 hours of operating time can be counted without carryover. This corresponds to a period of approx. 11,4 years.
The counter reading remains, of course, in case of power failure or de-installation of the instrument.

Initial value: 0

Command OR

<id>OR<para5> Telegram output interval (Output ratio)
Access: Query mode
Description: With independent telegram output this parameter is used to specify the time interval in which telegrams are output via the serial interface. Specification is made in milliseconds. If the output speed is faster than the data can be transmitted, the available output is discarded. If the output is faster than acquisition of the measured values, the measured values available are output again.
If the averaging period is 0ms (see Command AV), the averaging period corresponds to the output interval regardless of whether independent telegram output is selected. Independent telegram output is only possible in full duplex mode.
See also **Independent telegram output, Command TT, Command DM.**

Parameter description:

- 0: A telegram is always output when the internal acquisition of measured values has calculated a new data record.
- 1..60000 Gives the output interval in milliseconds.

Range of values: 0..60000 [ms]
Initial value: 00100

Command OS

<id>OS<para5>

Scaling of wind velocity output (Output scale)

Access:

User mode

Description:

This command is used to specify in which unit of measurement the wind velocity is output in the serial telegram. Different units of measurement are available here.

Parameter description:

Parameter	Unit of measurement	Conversion factor related to m/s
0	m/s	1
1	Km/h	1m/s => 3.6 km/h
2	miles/h	1m/s => 2.236936292 miles/h
3	knots	1m/s => 1.94253590 kn

Table 13: Conversion factors between different wind velocities

Range of values:

0..3

Initial value:

0

Command PC

<id>PC<para5>

Plausibility test (Plausibility check)

Access

User mode

Description:

Switches the plausibility checks on/off. Every complete measured value is checked when Plausibility is switched on. It is checked whether the measured value is internally plausible and whether it fits into the sequence of measured values acquired. If this is the case, it is released for further processing.

If this is not the case, the measured value is discarded. In the standard configuration this has the following effects:

- The heating is switched on, see **Command HT**.
- The measured value acquisition interval is set to the value of MA, see **Command MD**.

Range of values:

0..7

Initial value:

7

Command PR

<id>PR<para5>

Periodic receiver time (Receiver time)

Access:

Configuration mode

Description:

This value sets the receive time period in the serial register in the analog section of the ULTRASONIC. This value must not be changed under any circumstances. It is factory-set.

Range of values:

13..99

Initial value:

Device-dependent

Unit:

100ns

Command PT

<id>PT<para5>	Periodic transmitter time (Period transmitter time)
Access:	Configuration mode
Description:	The value sets the transmit time period in the serial register in the analogue section of the ULTRASONIC. This value must not be changed under any circumstances. It is factory-set.
Range of values:	13..99
Initial value:	Device-dependent
Unit:	100ns

Command PW

<id>PW<para5>	System voltage (Power)
Access:	User mode
Description:	Returns the measured supply voltage in Volt. Effective from software version V3.09 and hardware 08-08 the parameter is supported. If the available instrument does not support the measurement of the supply voltage, the text „System power ctrl not supported“ is output on inquiry.

Command RC

<id>RC<para5>	Correction factor for analog input values (Reference Correction)
Access:	Configuration mode
Description:	The command specifies a correction factor in 10ppm for the measured values of the analog inputs. The value is factory-adjusted and must not be changed.
Range of values:	0...1000
Initial value:	Device-dependent

Command RD

<id>RD<para5>	Delayed response (Response delay)
Access:	User mode
Description:	With this command the response is delayed by the time specified in ms via the serial interface.
Range of values:	0...1000
Initial value:	5
Unit:	ms

Command RF

<id>RF<para5>	Restart with invalid measuring values (Restart at fail)
Access:	User mode
Description:	By this command it is determined after which period the ULTRASONIC carries out a restart, in case no valid data have been measured. A parameter value of 0 inactivates the function. A restart is triggered only in case no valid measuring value has been acquired within the stated time interval.
Value range:	0; 10...1000
Initial value:	60
Unit:	Seconds

Command RP

<id>RP<para5>	Read parameter data set
Access	User mode
Description	<p>With this command a pre-stored data set can be loaded; see also command SP. After loading a restart is carried out automatically. The data set with the index '0' contains the parameters on delivery and cannot be overwritten.</p> <p>The data sets '1' and '2' are available for use.</p>
Value range	0..2

Command RS

<id>RS<para5>	Restart ULTRASONIC (Reset)
Access:	User mode
Description:	With transmission of this command the ULTRASONIC watchdog is no longer operated. This results in a cold start after approx. 2 sec. The ULTRASONIC performs a complete restart.

Parameter description:

- 1: The ULTRASONIC performs a cold start. It behaves as after connection of the supply voltage.

Range of values:	00001
Initial value:	No initial value

Command SH

<id>SH<para5>	Serial number (High Word) (Serial number high word)
Access:	Configuration mode
Description:	During factory adjustment of the ULTRASONIC every ULTRASONIC is given a serial number. This serial number allows the ULTRASONIC to be clearly identified. Storage of the serial number is divided up into high and low bytes. The serial number must not be changed.
Range of values:	0..65535

Command SL

<id>SH<para5> Serial number (Low Word) (Serial number low word)
Access: Configuration mode
Description: During factory adjustment of the ULTRASONIC every ULTRASONIC is given a serial number. This serial number allows the ULTRASONIC to be clearly identified. Storage of the serial number is divided up into high and low bytes. The serial number must not be changed.

Range of values: 0..65535

Command SC

<id>SC<para5> Minimum value of analogue outputs (Start current)
Access: User mode
Description: When using analog outputs the minimum value to be output can be selected. This does not influence the terminal value of the outputs. The minimum value is 0% or 20% of the terminal value. Depending on the parameter AN the selected minimum value is converted to a current or voltage value. This provides for current and voltage outputs with 0..20 mA, 4..20 mA, 0..10 V, and 2..10 V, see **Command AN**.
See also: **Command AA**, **Command AB**, **Command AC**.

Parameter description:

- 0: Minimum value 0 % of maximum value
- 1: Minimum value 20 % of maximum value

Together with the parameter AN the analogue outputs can be configured as follows:

	Parameter SC=0	Parameter SC=1
Parameter AN=0	0..10 V	2..10 V
Parameter AN=1	0..20 mA	4..20 mA

Parameter AA= 3; AB = 3, AC=3

Tabelle 14: Configuration of analogue outputs PIN 1, PIN 4 and PIN 3 (ADIO) with parameters AN and SC

Range of values: 0..1
Initial value: 0

Command SP

<id>SP<para5> Store parameter data set
Access: User mode

Description: A data set can be stored by this command. All parameters are stored internally and can be reloaded by RP, see **Command RP**. The data set with index '0' contains the parameters on delivery and cannot be overwritten.

The data sets '1' and '2' are available for use.

Value range 0..2

Command SS

<id>SS<para5> System status (System Status)
Access: Interrogation mode
Description: Outputs the selected parameters of all commands. All parameters stored in the EEPROM are output here.
Before parameters of the ULTRASONIC are changed, this command should be used to generate and save a list of set parameters, e.g. by copying parameters to a text file.

Parameter description:

No parameter is necessary when using the command SS. Callup with selected device ID 00 is as follows:
00SS<cr> with <cr> Carriage Return (Enter key)

Range of values: No value range
Initial value: No initial value

Command SV

<id>SV<para5> Software version (Software Version)
Access: Interrogation mode
Description: This command reads out the current software version and gives it back. For interpretation the version output must be divided by 100. The output value 00SV00123 represents version V1.23.
'1' means the main version, 23 is the build label.

Command TB

<id>TB<para5> Telegram in burst mode
Access: Interrogation mode
Description: The command TB is used to select the telegram which outputs the data after a burst measurement ends. All data telegrams are permissible. See also **Command TR**.

Range of values: 1..13
Initial value: 2

Command TC

<id>TC<para5> Temperature correction (Temperature correction)
Access: Configuration mode
Description: When measuring the acoustic virtual temperature the orthogonal wind component to the measured section lengthens the acoustic path, and thus results in a too lowly calculated acoustic virtual temperature. The orthogonal wind artificially lengthens the propagation time of the ultrasound, ultimately resulting in corruption of an acoustic virtual temperature. Parameter TC is used to take account of the crosswind component and to correct the acoustic virtual temperature.

Parameter description:

0: correction deactivated
1: correction activated

Range of values: 0...1
Initial value: 1

Command TF

<id>TF<para5>	Transformer for generating acoustic signals (Transformer)
Access:	configuration mode
Description:	Indicates the type of the used transformer for generating the analogue signals.
Range of values:	0..1 h
Initial value:	instrument-dependent

Command TR

<id>TR<para5>	Telegram request (Telegram request)
Access:	Interrogation mode
Description:	The command TR is used to specifically request a telegram from the ULTRASONIC. After interpretation the ULTRASONIC sends back the requested telegram. The device specifies a series of predefined telegrams, as well as the option for the user to configure his own telegram: see Fixed telegram formats, User-specific telegram . In half duplex mode the command TR is the sole option for requesting measured values via the RS485/RS422 interface.

The response time of the ULTRASONIC with a telegram request is defined as follows: The time interval after receipt of the last character until transmission of the first character of the response telegram is also < 1ms with standard deviation switched on (measured at RXD+ and TXD+ of RS485/RS422).
The command RD can be used to delay the response of the ULTRASONIC.

Telegram number	Telegram description
00001	Wind velocity and wind direction of azimuth and elevation
00002	Wind velocity and wind direction of azimuth and elevation as well as acoustic virtual temperature
00003	Wind velocity and wind direction of azimuth, wind velocity of elevation as well as acoustic virtual temperature
00004	NMEA telegram
00005	XYZ vectors and acoustic virtual temperature
00006	User-specific telegram
00007	XYZ vectors with acoustic virtual temperature and their standard deviations
00008	XYZ vectors with acoustic virtual temperature and their co-variances
00009	XYZ vectors with their turbulence intensities and acoustic virtual temperature
00012	Scientific diagnostics telegram

Range of values:	1..13
Initial value:	No initial value

Command TT

<id>TT</id>	Autonomous telegram output (Telegram Transmission)
Access:	User mode
Description:	Determines the number of the telegram, which the ULTRASONIC sends cyclic-autonomously. The telegrams available are the same as specified under Command TT . Command OR determines the time interval for transmitting the telegrams. The autonomous transmission is possible only in full-duplex mode, see Command DM . If TT = 0, the autonomous telegram output is switched off.
Range of values:	0...13
Initial value:	0

Command UA

<id>UA</id>	Addition of definitions to user-defined telegram (Add user telegram item)
Access:	Interrogation mode
Description:	In the user-specific telegram this command can be used to add a new definition to the end of the telegram: see, User-specific telegram, Command US . The data generated can be interrogated using the command TR00006 or TT00006, see also Command TR, Command TT .
Range of values:	Character string
Initial value:	No initial value

Command UD

<id>UD,</id>	User-defined text (User data)
Access	User mode
Description:	<p>The instrument makes a data buffer of 32 texts available with 32 characters each, where any text may be stored. This buffer is managed by Command UD. The format of the input is</p> <p>00UDn,xxxx with n: Index 1..32 xxxx: Text with maximum length of 32 characters Query: 00UD returns all user-specific texts, for ex. 01: THIES ULTRASONIC 03: location Wasserkuppe 00UDn mit 0<n<33 returns text with index ,n' see also Administration of User Information.</p>
Value range:	character string
Initial value:	no initial value

Command UR

<id>UR<para5> Deletion of one or more definitions at the end of the user-defined telegram (Remove user telegram item)
Access: Interrogation mode
Description: This command can be used to delete one or more definitions from the end of the user-defined telegram. The ULTRASONIC internally splits the character strings given to it into separate definitions. For example, the output of a variable is always an independent definition.
This command can be used to delete definitions step by step: see also **User-specific telegram, Command US**.
The data generated can be interrogated using the command TR00006 or TT00006, see also **Command TR, Command TT**.

Parameter description:

0..30 Number of definitions to be deleted at the end of the user-specific telegram.

Range of values: 0..30

Initial value: No initial value

Command US

<id>US<para5> Save user-specific telegram definition (User telegram save)
Access: User mode
Description: This command can be used to store the current definition of the user-specific telegram in the EEPROM. All changes made with the commands UA, UR and UT are not permanently saved. The command US is used to store definitions in the EEPROM.
The data generated can be interrogated using the command TR00006 or TT00006, see also **Command TR, Command TT**.

Parameter description:

2: Saves the telegram definition in the internal EEPROM.

Range of values: 2

Initial value: No initial value

Command UT

<id>UT<para5> User-specific telegram (User telegram)
Access: Interrogation mode
Description: This command can be used to create a new definition of the user-specific telegram. Any existing definition is overwritten: see also **User-specific telegram, Command US**.
The data generated can be interrogated using the command TR00006 or TT00006, see **Command TR, Command TT**.

Range of values: Character string

Initial value: No initial value

Command VC

<id>VC<para5>	Constant velocity correction (Velocity correction)
Access:	Configuration mode
Description:	Specifies the factor used to correct the velocity. Specification is made per mil. This factor must not be changed.
Range of values:	0..2000
Initial value:	1055

Command VT

<id>VT<para5>	Angle-dependent velocity correction (Velocity table)
Access:	Configuration mode
Description:	Switches the calculation on/off which corrects the wind velocity as a function of wind direction.

Parameter description:

0:	Switches correction off
1:	Switches correction on

Range of values:	0..1
Initial value:	1

Command XI

<id>XI<para5>	External ID (External ID)
Access:	User mode
Description:	<p>When set, the instrument ID is determined via the external lines WV/RXD- (BIT 0), WD/RXD+ (BIT 1) and ADIO (BIT 2) Here the channels must be configured accordingly. See Command AA, Command AB, Command AC.</p> <p>On startup the ULTRASONIC reads in the ID and stores it in the EEPROM.</p> <p>Reprogramming of the ID is output via the RS485 as a command sequence on startup.</p> <p>If the parameter is set to 0, the ULTRASONIC reads its ID out from the internal EEPROM.</p> <p>The individual inputs are LOW-active, that means with a level of 0V the respective ID-bit is set to one. An open input equals a high-level, which means that the respective ID-bit has the valence of 0.</p>

Parameter description:

0:	ULTRASONIC reads ID from internal EEPROM
1:	ULTRASONIC reads ID from external lines

Range of values:	0..1
Initial value:	0

11 Predefined Data Telegrams

11.1 Telegram 00001

Wind velocity and direction horizontal, velocity and direction vertical with sign

Command: TR00001 Command: TT00001

Telegram structure:

(STX)WVA;WDA;WVE;WDE;THIES status;CS(CR)(ETX)

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	xxx.x	Wind velocity azimuth
6	;	Semicolon (3Bh)
7	xxx	Wind direction azimuth
10	;	Semicolon (3Bh)
11	±xxx.x	Wind velocity elevation (Z-component)
17	;	Semicolon (3Bh)
18	±xx	Wind direction elevation
21	;	Semicolon (3Bh)
22	xx	THIES status hexadecimal
24	;	Semicolon (3Bh)
25	xx	Check sum hexadecimal (1..25)
27	(CR)(ETX)	(Carriage return); (ETX)
29		

Telegram output in case of error:

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	FFF.F	
6	;	Semicolon (3Bh)
7	FFF	
10	;	Semicolon (3Bh)
11	FFFF.F	
17	;	Semicolon (3Bh)
18	FFF	
21	;	Semicolon (3Bh)
22	xx	THIES status hexadecimal
24	;	Semicolon
25	xx	Check sum hexadecimal (1..24)
27	(CR)(ETX)	(Carriage return); (ETX)
29		

11.2 Telegram 00002

Wind velocity and direction horizontal, velocity and direction vertical with sign as well as acoustic virtual temperature

Command: TR00002 Command: TT00002

Telegram structure:

(STX)WVA;WDA;WVE;WDE;VT;THIES status;CS(CR)(ETX)

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	xxx.x	Wind velocity azimuth
6	;	Semicolon (3Bh)
7	xxx	Wind direction azimuth
10	;	Semicolon (3Bh)
11	±xxx.x	Wind velocity elevation (Z-component)
17	;	Semicolon (3Bh)
18	±xx	Wind direction elevation
21	;	Semicolon (3Bh)
22	±xx.x	Acoustic virtual temperature
27	;	Semicolon (3Bh)
28	xx	THIES status hexadecimal
30	;	Semicolon (3Bh)
31	xx	Check sum hexadecimal (1..30)
33	(CR)(ETX)	(Carriage return); (ETX)
35		

Telegram output in case of error:

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	FFF.F	
6	;	Semicolon (3Bh)
7	FFF	
10	;	Semicolon (3Bh)
11	FFFF.F	
17	;	Semicolon (3Bh)
18	FFF	
21	;	Semicolon (3Bh)
22	FFF.F	
27	;	Semicolon (3Bh)
28	xx	THIES status hexadecimal
30	;	Semicolon (3Bh)
31	xx	Check sum hexadecimal (1..30)
33	(CR)(ETX)	(Carriage return); (ETX)
35		

11.3 Telegram 00003

Wind velocity and direction horizontal, velocity vertical with sign as well as acoustic virtual temperature

Command: TR00003 Command: TT00003

Telegram structure:

(STX)WVA;WDA;WVE;VT;THIES status;CS(CR)(ETX)

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	xxx.x	Wind velocity azimuth
6	;	Semicolon (3Bh)
7	xxx	Wind direction azimuth
10	;	Semicolon (3Bh)
11	±xxx.x	Wind velocity elevation
16	;	Semicolon (3Bh)
17	±xx.x	Acoustic virtual temperature
22	;	Semicolon (3Bh)
23	xx	THIES status hexadecimal
25	;	Semicolon (3Bh)
26	xx	Check sum hexadecimal (1..25)
28	(CR)(ETX)	(Carriage return); (ETX)
30		

Telegram output in case of error

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	FFF.F	
6	;	Semicolon (3Bh)
7	FFF	
10	;	Semicolon (3Bh)
11	FFFF.F	
16	;	Semicolon (3Bh)
17	FFF.F	
22	;	Semicolon (3Bh)
23	xx	THIES status hexadecimal
25	;	Semicolon (3Bh)
26	xx	Check sum hexadecimal (1..25)
28	(CR)(ETX)	(Carriage return); (ETX)
30		

11.4 Telegram 00004

NMEA V 2.0

Command: TR00004 Command: TT00004

Telegram structure: \$WIMWV,xxx.x,R,xxx.x,N,A*xx(CR)(LF)

Ch. No.	Format	Function
0	\$WIMWV	Fixed text
6	,	Comma (2Ch)
7	xxx.x	Wind direction azimuth
12	,	Comma (2Ch)
13	R	'R' (52h)
14	,	Comma (2Ch)
16	xxx.x	Wind velocity azimuth
20	,	Comma (2Ch)
21	x	K,N,M,S: scaling-dependent
22	,	Comma (2Ch)
23	x	V,A : A = valid; V= invalid
24	*	Check sum identifier (2Ah)
25	xx	Check sum hexadecimal (1..24)
27	(CR)(LF)	(Carriage return); (LF)
29		

Telegram output in case of error

Ch. No.	Format	Function
0	\$WIMWV	Fixed text
6	,	Comma (2Ch)
7	,	Comma (2Ch)
8	R	'R' (52h)
9	,	Comma (2Ch)
10	,	Comma (2Ch)
11	x	K,N,M,S: scaling-dependent
12	,	Comma (2Ch)
13	V	V= invalid
14	*	Check sum identifier (2Ah)
15	xx	Check sum hexadecimal (1..14)
17	(CR)(LF)	(Carriage return); (LF)
19		

11.5 Telegram 00005

XYZ vectors with acoustic virtual temperature

Command: TR00005 Command: TT00005

Telegram structure:

(STX)VX;VY;VZ;VT;THIES status;CS(CR)(ETX)

Ch. No.	Format	Function
0	(STX)	STX (02h)
1	±xxx.xx	Wind velocity X component
8	;	Semicolon (3Bh)
9	±xxx.xx	Wind velocity Y component
16	;	Semicolon (3Bh)
17	±xxx.xx	Wind velocity Z component
24	;	Semicolon (3Bh)
25	±xx.x	Acoustic virtual temperature
30	;	Semicolon (3Bh)
31	xx	THIES status
33	;	Semicolon (3Bh)
34	xx	Check sum hexadecimal (1..34)
36	(CR)(ETX)	(Carriage return); (ETX)
38		

Telegram output in case of error:

The telegram format corresponds to that of the data telegram with appropriate status value.

11.6 Telegram 00006

User-specific telegram

Command: TR00006 Command: TT00006

Note:

Description see User-specific telegram section 7.4.5.

11.7 Telegram 00007

XYZ vectors with acoustic virtual temperature and its standard deviations

Command: TR00007 Command: TT00007

Note:

To calculate the standard deviation parameter DE must be set to 00001.

Telegram structure:

VX;VY;VZ;VT;StdvX;StdvY;StdvZ;StdvT;THIES status;CS(CR)

Ch. No.	Format	Function
0	±xxx.xx	Wind velocity X component
7	;	Semicolon (3Bh)
8	±xxx.xx	Wind velocity Y component
15	;	Semicolon (3Bh)
16	±xxx.xx	Wind velocity Z component
23	;	Semicolon (3Bh)
24	±xx.xx	Acoustic virtual temperature
30	;	Semicolon (3Bh)
31	xxx.xx	Standard deviation X component
37	;	Semicolon (3Bh)
38	xxx.xx	Standard deviation Y component
44	;	Semicolon (3Bh)
45	xxx.xx	Standard deviation Z component
51	;	Semicolon (3Bh)
52	xx.xx	Standard deviation acoustic temperature
53	;	Semicolon (3Bh)
58	xx	THIES status
60	;	Semicolon (3Bh)
61	xx	Check sum hexadecimal (0..61)
63	(CR)	(Carriage return)
64		

Telegram output in case of error:

The telegram format corresponds to that of the data telegram with appropriate status value.

11.8 Telegram 00008

XYZ vectors with acoustic virtual temperature and its covariances

Command: TR00008 Command: TT00008

Note:

To calculate the covariances the parameter CO must be set to 00001.

Telegram structure:

VX;VY;VZ;VT;CovaXY; CovaXZ; CovaXT; CovaYZ; CovaYT; CovaZT;THIES status;CS(CR)

Ch. No.	Format	Function
0	±xxx.xx	Wind velocity X component
7	;	Semicolon (3Bh)
8	±xxx.xx	Wind velocity Y component
15	;	Semicolon (3Bh)
16	±xxx.xx	Wind velocity Z component
23	;	Semicolon (3Bh)
24	±xx.xx	Acoustic virtual temperature
30	;	Semicolon (3Bh)
31	±xxx.xx	Covariance XY
38	;	Semicolon (3Bh)
39	±xxx.xx	Covariance XZ
46	;	Semicolon (3Bh)
47	±xxx.xx	Covariance XT
54	;	Semicolon (3Bh)
55	±xxx.xx	Covariance YZ
62	;	Semicolon (3Bh)
63	±xxx.xx	Covariance YT
70	;	Semicolon (3Bh)
71	±xxx.xx	Covariance ZT
78	;	Semicolon (3Bh)
79	xx	THIES status
81	;	Semicolon (3Bh)
82	xx	Check sum hexadecimal (0..61)
84	(CR)	(Carriage return)
85		

Telegram output in case of error:

The telegram format corresponds to that of the data telegram with appropriate status value.

11.9 Telegram 00009

XYZ vectors and their turbulence intensities as well as acoustic virtual temperature

Command: TR00009 Command: TT00009

Note:

To calculate the turbulence intensities the parameter CO must be set to 00001.

Telegram structure:

VX;VY;VZ;VT;TiX;TiY;TiZ;THIES status;CS(CR)

Ch. No.	Format	Function
0	±xxx.xx	Wind velocity X component
7	;	Semicolon (3Bh)
8	±xxx.xx	Wind velocity Y component
15	;	Semicolon (3Bh)
16	±xxx.xx	Wind velocity Z component
23	;	Semicolon (3Bh)
24	±xx.xx	Acoustic virtual temperature
30	;	Semicolon (3Bh)
31	xxx.xx	Turbulence intensities X component
37	;	Semicolon (3Bh)
38	xxx.xx	Turbulence intensities Y component
44	;	Semicolon (3Bh)
45	xxx.xx	Turbulence intensities Z component
51	;	Semicolon (3Bh)
52	xx	THIES status
54	;	Semicolon (3Bh)
55	xx	Check sum hexadecimal (0..55)
57	(CR)	(Carriage return)
68		

11.10 Telegram 00012

Scientific diagnostics telegram

Command: TR00012 Command: TT00012

Telegram structure:

WVA;WDA;WVE;WDE;VT;VXYZ;VX;VY;VZ;VTU;VTV;VTW;CUTB;CUBT;CVTB;CVBT;CWTB;CWBT;

Ch. No.	Format	Function
0	xxx.xx	Wind velocity azimuth
6	;	Semicolon (3Bh)
7	xxx.x	Wind direction azimuth
12	;	Semicolon (3Bh)
13	±xxx.xx	Wind velocity elevation
20	;	Semicolon (3Bh)
21	xxx.x	Wind direction elevation (0..90)
26	;VT:	Fixed text
30	±xxx.xx	Acoustic virtual temperature
37	;	Semicolon (3Bh)
38	xxx.xx	Wind velocity (XYZ)
44	;VX:	Fixed text
48	±xxx.xx	Wind velocity X component
55	;	Semicolon (3Bh)
56	±xxx.xx	Wind velocity Y component
63	;	Semicolon (3Bh)
64	±xxx.xx	Wind velocity Z component
71	;TU:	Fixed text
75	±xx.xx	Acoustic virtual temperature U component
81	;	Semicolon (3Bh)
82	±xx.xx	Acoustic virtual temperature V component
88	;	Semicolon (3Bh)
89	±xx.xx	Acoustic virtual temperature W component
95	;	Semicolon (3Bh)
96	xxxxx	Delay of distance U top down CUTB
101	;	Semicolon (3Bh)
102	xxxxx	Delay of distance U bottom up CUBT
107	;	Semicolon (3Bh)
108	xxxxx	Delay of distance V top down CVTB
113	;	Semicolon (3Bh)
114	xxxxx	Delay of distance V bottom up CVBT
119	;	Semicolon (3Bh)
120	xxxxx	Delay of distance W top down CWTB
125	;	Semicolon (3Bh)
126	xxxxx	Delay of distance W bottom up CWBT
131	;	Semicolon (3Bh)
132	xxxxx	Internal counter
137	;	Semicolon (3Bh)
138	xxxxx	Time interval in which values are written to main averaging memory
143	;	Semicolon (3Bh)
144	xxxxx	Number of values in main averaging memory
149	;	Semicolon (3Bh)

150	xx	THIES status
152	;	Semicolon (3Bh)
153	xxxx	Telegram status, Extended status information (hexadecimal)
157	;	Semicolon (3Bh)
158	xxxxxxx	Internal tickcount in ms of processor
165	(CRLF)	(Carriage return, line feed)
167		

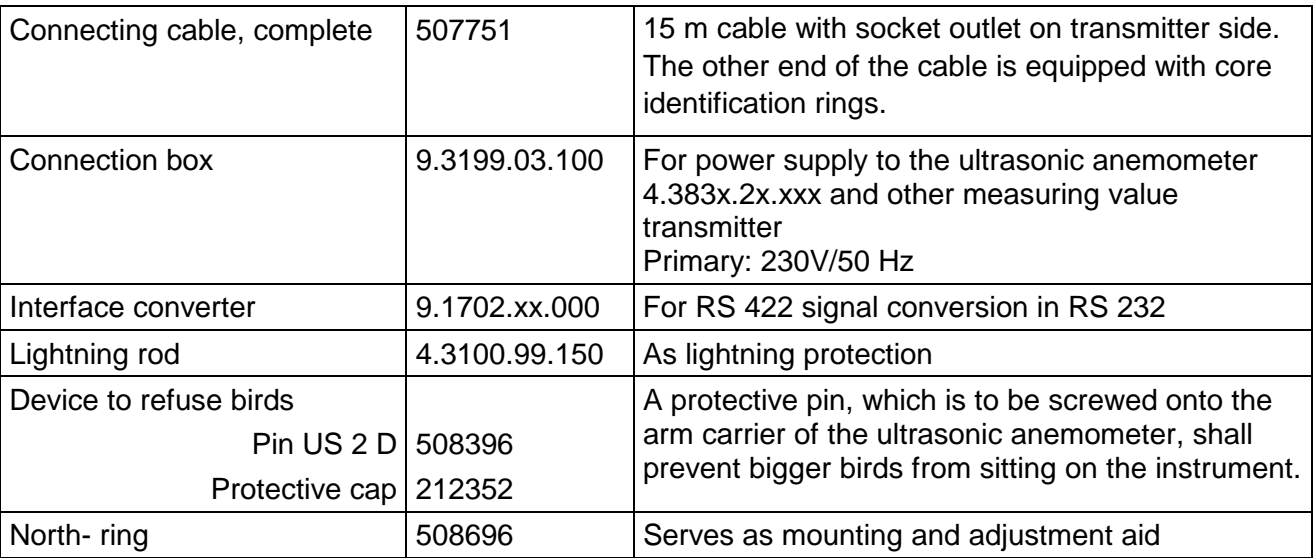
12 Technical Data

Wind velocity	Measuring range	0.01...85 m/s (Starting threshold: 0,01 m/s) Up to 99.99 m/s is measured and output Scaling of analogue output freely selectable in wide ranges.	
	Accuracy	≤ 5 m/s:	± 0.1 m/s rms (root mean square over 360°)
		> 5 m/s ≤ 35 m/s:	± 1% rms of measured value (root mean square over 360°)
		> 35 m/s ≤ 65 m/s:	± 2% rms of measured value (root mean square over 360°)
		> 65 m/s ≤ 85 m/s:	± 3% rms of measured value (root mean square over 360°)
	Resolution	0.1 m/s:	in telegrams No. 1 to 4
		0.01 m/s:	in telegrams No. 5 to 12 and user-defined telegrams
Wind direction	Measuring range Azimuth Elevation	0...360° 0.. 360°, 0.. 540°, 0.. 720° for analogue output, adjustable -90°... +90°	
	Accuracy	± 1° with wind velocity > 1 m/s ≤ 35 m/s	
		± 2° with wind velocity > 35 m/s ≤ 65 m/s	
		± 4° with wind velocity > 65 m/s ≤ 85 m/s	
	Resolution	1°:	in telegrams No. 1 to 4
		0.1°:	in telegrams No. 5 to 12 and user-defined telegrams
Acoustic virtual temperature	Measuring range	- 40 ... + 70 °C not specified, but useful measuring range: -75 °C...+75°C	
	Accuracy	± 0.5 K	
	Resolution	0.1 K (in telegrams No. 1 to 5)	
Data output digital	Interface	RS 485 / RS 422 Electrically isolated from supply voltage and housing	
	Baud rate	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600 adjustable	
	Output	Instantaneous values, wind velocity,/direction and acoustic virtual temperature Sliding mean values 0.5 sec.. 100 min freely selectable Standard deviations, covariances and turbulence intensities for wind velocity/direction and acoustic virtual temperature Predefined data telegrams or user-defined data telegram	
	Output rate	1 per 1msec to 1 per 60 seconds adjustable in msec steps	
	Status identification	Heating, failure of measurement path, ΔT path temperatures	

Data output analogue Electrically isolated from supply voltage and housing	Outputs	0 ... 20 mA / 0... 10 V or 4... 20 mA / 2... 10 V for Wind vectors X, Y and Z or for <i>Wind velocity (azimuth)</i> , <i>Wind direction (azimuth)</i> and <i>acoustic virtual- temperature (in preparation)</i> .
		Burden on current output maximum 400 Ω
		Source impedance with current output, typically 250000 Ω
		Burden on voltage output minimum 4000 Ω
		Source impedance with voltage output, typically 4 Ω
	Output	Wind vectors X, Y and Z Instantaneous values or sliding mean values 0.5 sec..100 min freely selectable
	Output rate	Updating rate 7.5 to 256 msec adjustable
	Resolution	16 bit
Analog inputs	Number	Up to five analog inputs possible (3x standard, 2x additionally configurable in consultation with manufacturer)
	Data processing	Output of measured values in user-specific telegram
	Input voltage	0...10.0 V
	Sampling rate	0.1Hz...100Hz per channel
	Resolution	16 bit
	Accuracy	0.1 % in range -40°C... +70°C
	Linearity Effective noise free Bits	INL: typ. < 6 LSB Typ. 14 Bit* * with DC-supply for prevention of dyn. crosstalk in the connecting line
General	Internal measuring rate	Up to 285 complete measuring sequences per second at 20 °C (6 individual measurements)
	Bus mode	Bus mode of up to 98 devices possible
	Measuring mode	Standard measuring mode (continuous measurement) Burst mode: Measurement at maximum speed followed by output (max. 40,000 measured values) Synchronous measurement: Measurement specified by external clock pulse via PIN 3 (ADIO) input (max. 250Hz). Measurement can be initiated via rising or falling edge (selectable) of trigger signal. Start of measurement <0.5 ms after flank detection. Triggered individual measurement: The flank of an external signal is used for measurement. Measurement can be initiated via rising or falling edge (selectable) of trigger signal. Start of measurement < 0.5 ms after flank detection.
	Program update	Program update also possible in bus mode
	Temperature range	Operating temperature – 50°C... + 80°C heated – 30°C... + 80°C unheated Storing – 50°C... + 80°C Measuring operation possible with heating up to - 75°C
Operating voltage	Supply: electronics - w/o Heating	U: 8...78 V DC or 12...55 V AC, 45...65Hz P: typ. 1,5 VA, max. 2,5 VA

(with 4.383x.2x.xxx)	Supply: electronic + heating - with heating of sensor arms, centre rod and US-converter	U: 24V AC/DC $\pm 15\%$, 45...65Hz P: typ. 150 VA @ 24V
(with 4.383x.4x.xxx)	Supply: electronic + heating - with heating of sensor arms, centre rod, US-converter and ..housing	U: 48V AC/DC $\pm 15\%$, 45...65Hz P: typ. 360 VA , max. 400 VA @ 48V
	Protection type	IP 67 (in case of conventional mounting and screwed and converted coupling socket (if necessary), see chapter „Preparation for operation“)
Without US transformer heating	Icing-up resistance	As per THIES STD 012001
With US transformer heating	Icing-up resistance	As per THIES STD 012002
	EMC	EN 55022:1998 class B; EN 55024:1998 EN 61326:1997, A3:2003; Interference field strength and noise immunity both class B
	Housing material	Stainless steel (V4A), 1.4571 acc. to DIN EN 10088-2
	Installation type	On mast tube 1½", e.g. DIN 2441
	Connection type	8-pole plug connection in shaft
	Weight	3.4 kg

14 Accessories (available as optional features)



15 EC-Declaration of Conformity

Document-No.: 000605

Month: 01 Year: 14

Manufacturer: **ADOLF THIES GmbH & Co. KG**

Hauptstr. 76
D-37083 Göttingen
Tel.: (0551) 79001-0
Fax: (0551) 79001-65
email: Info@ThiesClima.com

Description of Product: **Anemometer Ultrasonic 3D**

Article No.	4.3830.20.300	4.3830.20.340		
	4.3830.21.310	4.3830.21.317	4.3830.21.400	4.3830.21.940
	4.3830.22.300	4.3830.22.320	4.3830.22.321	4.3830.22.419
	4.3830.40.340	4.3830.41.301	4.3830.42.300	4.3830.44.399

specified technical data in the document: **021506/09/13**

The indicated products correspond to the essential requirement of the following European Directives and Regulations:

2004/108/EC	DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC
2006/95/EC	DIRECTIVE 2006/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
552/2004/EC	Regulation (EC) No 552/2004 of the European Parliament and the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation)

The indicated products comply with the regulations of the directives. This is proved by the compliance with the following standards:

Reference number	Specification
EN61000-6-2:2005	Electromagnetic compatibility Immunity for industrial environment
EN61000-4-4:2002 level 4 4kV	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
EN61000-4-5:2001 level 4 4kV	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test
EN61000-6-3:2006	Electromagnetic compatibility Emission standard for residential, commercial and light industrial environments
EN61010-1:2001	Safety requirements for electrical equipment for measurement, control and laboratory use. Part 1: General requirements

Place: Göttingen

Date: 20.01.2014

Legally binding signature:

issuer:

.....
Wolfgang Behrens, General Manager

.....
Joachim Beinhorn, Development Manager

This declaration certifies the compliance with the mentioned directives, however does not include any warranty of characteristics.
Please pay attention to the security advises of the provided instructions for use.

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ADOLF THIES GmbH & Co. KG

Hauptstraße 76 37083 Göttingen Germany
P.O. Box 3536 + 3541 37025 Göttingen
Phone +49 551 79001-0 Fax +49 551 79001-65
www.thiesclima.com info@thiesclima.com



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