GENERAL ACOUSTICS

UltraLab®

ULS HF5-A

User Manual

User notes:

CONTENTS

1 GENERAL

1.1 Safety instructions

For your own safety and for the safe operation of the system, please read the following instructions carefully PRIOR to operating the system for the first time.

The ***UltraLab® ULS HF5-A*** laboratory instrument, as well as the associated ultrasound sensors, represent state-of-the-art technology and comply with the latest safety regulations.

The manufacturer has made every effort to guarantee safe operation. The user must ensure that the instrument is set up and installed in such a way that its safe usage is not impaired.

The instruments are factory tested and were delivered in a safe operational condition.

This User Manual contains information and warnings, which must be observed by the user under all circumstances to ensure safe operation of the instruments.

- **The instrument may only be put into operation by authorised persons and only operated by trained personnel. All users working with this instrument must read the User Manual prior to any operation.**
- **The user may only perform the repair and maintenance work described. Only the specified parts are to be used.**

Servicing work may only be carried out by authorised service technicians from *GENERAL ACOUSTICS***.**

- **All instruments and additional devices used for this purpose must be properly earthed.**
- **The earth leads must not be interrupted at any point.**
- **The** *UltraLab® ULS HF5-A* **laboratory instrument may only be operated within the specified temperature range of -20 to +70°C. Otherwise measurement inaccuracies and instrument faults or defects may occur.**

The temperature stability of connection cables must match the operating temperature of the measurement system.

- **The sensor should only be connected to the instrument when it is switched off.**
- **The sensors are to be treated with care and are only to be screwed in hand-tight; otherwise there is the risk of damage. Sufficient leverage is obtained from the sensor casing itself.**
- **Avoid electrostatic discharges.**
- **The** *UltraLab® ULS HF5-A* **instrument must not come into contact with liquids.**
- **Never operate the instrument at sites where water may get into the instrument.**
- **Also take care that the instrument is always operated above the water line of experimental reservoirs. Protect the instrument against falling into water.**
- **Isolate all system devices from the mains before undertaking cleaning. Ensure there is no current. Do not use aggressive cleaning chemicals, liquid cleaners or sprays; only use a damp cloth. Never bring this or any other cloth into contact with parts of the system that will subsequently conduct electricity.**

- **Never attempt to open instruments with objects or to insert objects into an instrument. The voltages existing in the instruments can lead to short-circuits and electric shocks.**
- **Ensure adequate ventilation when operating the** *UltraLab® ULS HF5-A***. As the instrument has low power consumption, it requires no additional ventilation under normal conditions. However, the instrument should never be placed on a source of heat (computer monitors, radiators ...).**

Only operate the *UltraLab® ULS HF5-A* **at the intended mains voltage of 230 VAC (optionally 110 VAC).**

- **For safety reasons, the** *UltraLab® ULS HF5-A* **is provided with a sealed appliance plug with earth contact for its mains power. In this context, only appliance cables and plugs with earth contacts may be used. Operation of the system is prohibited if you do not have this option. Never use an extension cable without an earth contact.**
- **The instrument is protected from mains voltage by a blowout fuse in the appliance plug. A fine-wire fast-blow fuse (**G fuse 5 x 20 mm**) compliant with IEC with a nominal value of** 0.8(f) A **is to be used as a replacement. Only the specified values may be used. Higher tripping values or bridging of fuses is not permissible. If the fuse repeatedly blows, the Service Department of** GENERAL ACOUSTICS **should be informed, as the cause would need to be resolved.**
- **We recommend protecting the circuit with FI protective switches to ensure safe operation of your complete system.**
- **Take care that power cables are not worn, abraded or otherwise defective. When routing connecting cables, make certain that the cables do not represent an obstacle or risk of tripping.**
- **When using extension cables, the total nominal current of all the devices connected must not exceed the allowable maximum current of the cable. The current ratings of all devices connected to a single plug should never exceed 15 A, unless the plug is specifically designed for this purpose. If you are unsure what type of mains power exists in your premises, ask your Safety Officer or an authorised electrician.**

It is imperative to isolate instruments from the mains in the following cases:

- **If power cables or plugs are worn or damaged.**
- **If water or any other liquid has found its way into one of the instruments.**
- **If the instrument is not working correctly despite following the specified operating instructions.**
- **If one of the instruments has fallen down or the chassis is damaged.**
- **If the instrument shows any noticeable departure from normal operation.**
- **If the sensor connections have become wet.**

With the exception of the actions explicitly specified in the manual, you should never attempt your own repairs on devices belonging to the *UltraLab® ULS HF5-A* **system. Besides the resulting revocation of warranty coverage, you also risk an electric shock or other injury from the components. All maintenance work, unless explicitly described in the manual, should only be carried out by** GENERAL ACOUSTICS**.**

2 INTRODUCTION

2.1 Overview

Ultrasound measurement of distances in laboratory measurement technology has become increasingly established in recent years. The advantages gained are quite clear: particularly in small-scale experimental set-ups, it is imperative to avoid any mechanical intervention that may affect the experiment, but at the same time, parameters must be measured and evaluated. This not only applies to laboratory operation and water. As the distance to an object is measured by sound propagation time measurement, and not by intensity measurement, as is the case in optical methods, ultrasound sensors have excellent background suppression. Almost all materials that reflect sound are reliably detected, irrespective of their colour. Even transparent materials and thin foils present no problems for our ultrasound sensors. As a result of their high sensitivity, our sensors are also predestined for the detection of liquid surfaces. The sensors measure in dusty air as well as through fine fog. Even thin deposition on the sensor membrane does not impair the sensor function. These characteristics, combined with extremely slender sound cones (with practically no side lobes), make for completely new laboratory applications.

The easy-to-use *UltraLab® ULS HF5-A* laboratory instrument excels as a consequence of the diverse functions implemented, making it suitable for use in complex measurement tasks without having to set a series of parameters. The measurement object can be, for example, the water surface as a level or the moving water surface as a wave. This is where the temporally highly resolved distance measurement comes into its own. A complex measurement algorithm ensures high measurement accuracy and resolution, as well as a high degree of data confidence.

The *UltraLab® ULS HF5-A* is dedicated for sound propagation time measurement of very fast moving waves. This device has four independent channels, each one is equipped with an ultrasound sensor of the type USS13-HF. The data output is realised in analogue voltage signal between 0-10 Volt and digital via serial interface RS 232.

Due to high repetition rate of 50 Hz, every measurement unit detects high dynamic processes in an impressive resolution of 0.36 mm. Thanks to the application of a special reference sensor all fluctuations of the sound velocity will be compensated internally. That means, the data obtained from the measurement device are independent of all the sound velocity interfering parameters, e.g. temperature, air humidity, air pressure, etc. Nevertheless the last column of the data telegram contains the sound velocity in m/s.

After the switch on of the UltraLab device and a short system test procedure (needs some seconds), the device delivers continuous data.

An opto-isolated trigger input makes a synchronisation with external data acquisition possible.

The *UltraLab® ULS HF5-A* is equipped with an serial interface RS232. So it is possible to receive the output data stream at any PC with a help of a terminal program.

Please, for configuration of the terminal program on the PC see the respective chapters (chapter 4.2).

2.2 System components

The *UltraLab® ULS HF5-A* instrument system consists of the following components:

- 1 *UltraLab® ULS HF5-A* controller
- minimum of 1 ultrasound sensor of the type USS13-HF (maximum of 4 sensors)
- 1 ultrasound sensor of the type REF-300 for precise sound velocity measurement mounted in a calibrated distance unit
- shielded cables between the sensors and the instrument (4-pin LEMO plug / M12 industry standard)
- 1 cable between the REF sensor and the instrument (3-pin LEMO plug / M12 industry standard)

2.3 Sensor characteristics

Sensor identifier	Measurement frequency [kHz]	Measurement range [mm]	Technical resolution [mm]	Accuracy [mm]
USS13-HF	200	200 – 1.200	0.36	+/- 1

The *UltraLab® ULS HF5-A* sensors of the type USS13-HF are based on an ultrasound pulse echo technique. They have been developed for temporally and spatially high-resolution measurement of distances in air. The sensors permit a distance measurement from 200 mm up to 1200 mm. The advantages of the ultrasound sensors made by *GENERAL ACOUSTICS* in comparison to common ultrasound sensors can be described as follows:

- The acoustic beam pattern could be narrowed to a beam cone below 3° and is valid not only for the sending but also for the receiving process. This is important to reduce the area size of the acoustic footprint onto the water surface in order to get only some small sections instead of a full wave or many waves.
- The minor side lobe could quasi be eliminated. This means that there are no disturbances from objects outside the area of interest (e.g. basin walls, etc.).
- The sending power on one hand and the receiving sensibility on the other could be increased. This helps much to reduce the number of lost pings immensely, which may occur on very steep flanks of waves.
- The sampling rate is accelerated to 50 Hz. This great achievement allows to measure fast waves in highest accuracy even though a measurement carriage is moving against the wave direction.

2.4 The principles of measuring distances by means of (air) ultrasound

The *ULTRALAB®* ULS H*F5-A* sends out an acoustic pulse via the ultrasound sensor. The ultrasound pulse emitted is reflected on the measurement object and is received back as an echo.

A key aspect when it comes to measuring distances is the time required for the transmitted pulse to cover the distance to the respective measurement object and back. This sound propagation time is measured by the *ULTRALAB®* ULS *HF5-A* with high resolution.

The measured propagation times are averaged. A tolerance band (expectation range) is set around the average propagation time. Only measurement values that lie within the expectation range are admitted for further calculation of the measurement value. The average value is modified according to changes in distance.

The measured distance is either converted to a voltage signal (0-10V) proportional to the distance (analogue output) or displayed in a data telegramm via serial interface RS 232 (digital output).

An USS13-HF sensor i.e. *ULTRALAB®* ULS *HF5-A* system controller can be divided into three functional groups for purposes of illustration:

1. The ultrasound converter
2. The evaluation unit
3. The output (end) stage

The sound source (piezo crystal) is stimulated to oscillate for a brief period. This emits ultrasound waves.

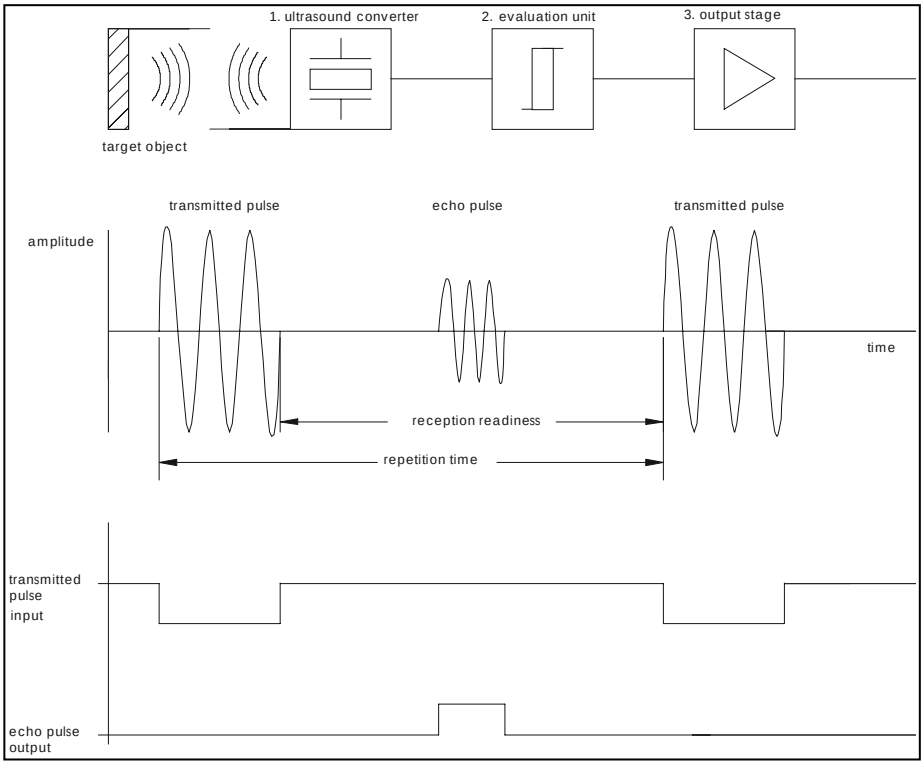

Figure 1: The functionality of an ultrasound-based distance sensor

The sound source is then switched to receive (comparable with a microphone) and the incident pulses are evaluated. The propagation time of the sound to a possible target is determined within the defined measurement window. An analogue voltage or a digital value as an output is proportional to the measured distance.

3 START UP AND MEASUREMENT SETUP

3.1 Sensor connectors

The *UltraLab® ULS HF5-A* is equipped with four independent channels.

All four sensor cables are connected to the *UltraLab® ULS HF5-A* controller by a 4-pole LEMO socket at the front of the control panel. The reference sensor cable (REF-300) is connected by a 3-pole LEMO socket on the right hand side of the control panel. Right above to it a BNC socket is located (TRIG IN). Here, the cable can be connected coming from the remote PC for purpose of time synchronisation (for digital data output only). It is an opto-isolated TTL type input, which triggers the time stamp to start counting every single data sample (see chapter 4.2: Data Telegram).

At the rear panel the internal power socket including a fuse (0.8 (f) A) is installed. Here, 230 volt has to be connected with. Furher, a serial interface RS 232 cable can plugged in for digital data reading on any terminal program. The digital data of all four channels will be exported via this socket.

Please note:

After switching on of the power supply it needs 20 seconds for initiation of the system. After 10 seconds of internal tests the system starts the count down from 10 (for digital data output only). Right after the initiation time the data telegram follows.

3.2 Physical setup of the sensors:

Example from Figure 2: The expected wave or level fluctuations are around **600 mm**.

The sensor's range varies from 200mm up to 1200mm below the sensor's lower edge. As environmental disturbances always increase with distance, it should be attempted to bring the measuring range as close as possible to the sensor. Therefore, a measurement set-up as shown in the lower figure would be ideal. The window limits are at **200** mm and the measuring window away from the sensor at 1200 mm below the sensor edge. This results in a measuring range of 1200-200=**1000 mm**, the value representing the expected max. wave amplitude. The sensor's analogue output distributes the output voltage of 10V across the measuring range of 1000mm:

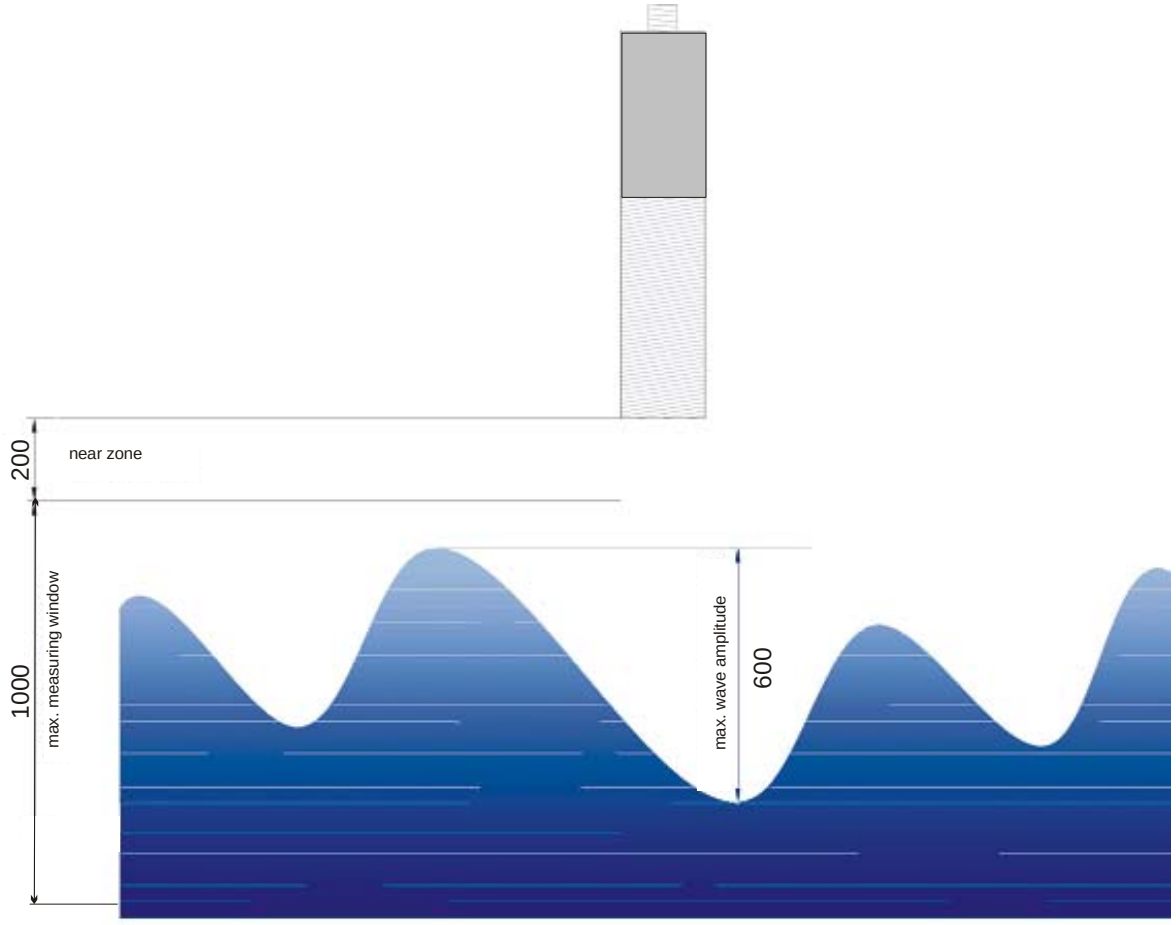

Figure 2: Measuring setup

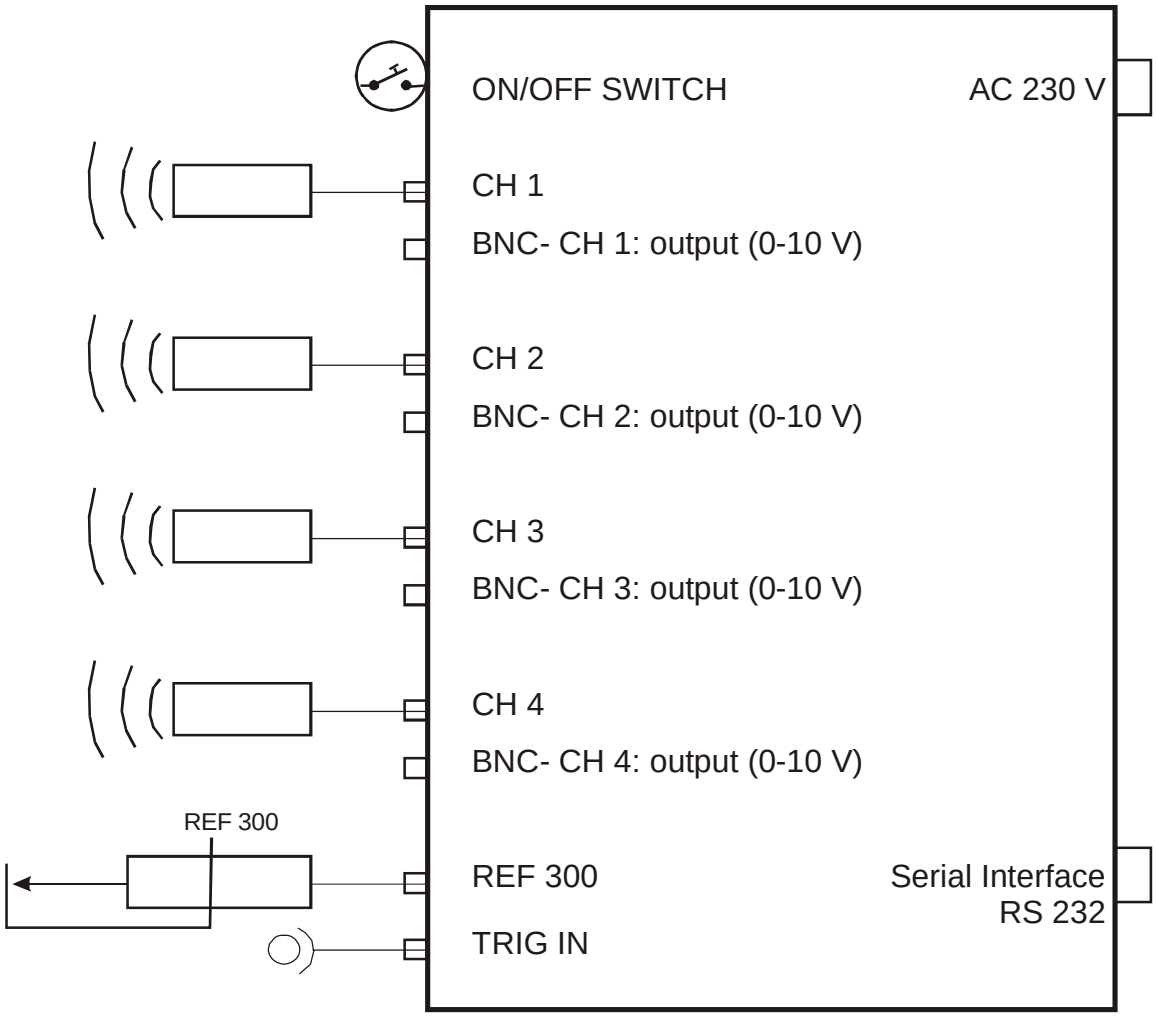

Figure 3: Connection scheme for the *UltraLab® ULS HF5-A*

3.3 Fluctuation in air velocity compensated by reference measurement

The most accurate type of compensation is that of a direct reference measurement. This is necessary for extremely variable conditions or for the purpose of highest accuracy. In the case of density variation or stratification of air masses, through which the ultrasound pulse must penetrate, it is necessary to measure the real speed of sound. The *UltraLab® ULS HF5-A* is equipped with a reference sensor REF-300 which has an extremely high accuracy. The reference sensor emits sound along a path of maximum possible length, parallel to the measurement channel, through the same medium/media as the measurement path itself, onto a fixed target at a defined distance. The same influences on the speed of sound are necessarily measured as those on the measuring path itself. Due to data recording of the ultrasound velocity and the internal calibration of the data received from all four channels, the influence of temperature, air pressure, as well as air humidity variations can be excluded. This method can consequently be used for highly accurate compensation of all parameters affecting the sound velocity. The highly precise reference sensor including the reference track should be mounted

horizontal, upside down nearby the *UltraLab® ULS HF5-A* sensors. It should be pointed out that the reference sensor has to be protected from splashing water and no object has to be between sensor and target, in order to avoid wrong data.

Warning: The reference distance is highly calibrated. The slightest deviation may cause inaccuracy of the measurements.

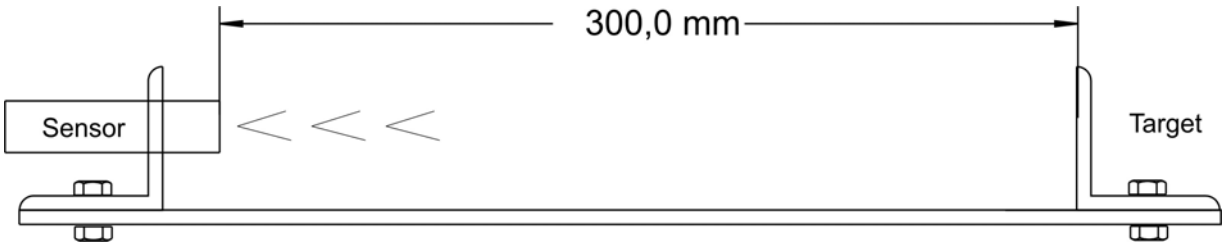

Figure 4: Reference sensor REF-300 mounted on calibrated distance unit

4 MEASUREMENT DATA OUTPUT

4.1 Calculation of the calibration curve for analogue output (BNC)

The ultrasound measurement system outputs a voltage proportional to distance of between 0 and 10 V at the BNC output of the benchtop instrument. From Figure 5, it may be seen that the calibration curve is a) a straight line and b) does not pass through the origin. This means that a) the conversion of distance to voltage is linear and b) an offset (offset = 0.2 m) has to be added to the distance value because all ultrasound sensors have a so-called blind zone starting directly at the sensor's lower edge (see specifications of the individual sensors). Using an example, it will be shown here how the calibration curve is calculated with the parameters. It is recommended that the experimental set-up be measured beforehand, the expected wave heights determined and then to set the sensors accordingly. If e.g. wave heights of 10 mm are expected, the sensor should be placed close to the expacted waves but considering the blind zone of the sensor.

$$h_m = U_m \times 0.1\ m/V + 0.2\ m$$

whereas:

h_m = measured height to the sensor's low edge

U_m = measured Voltage

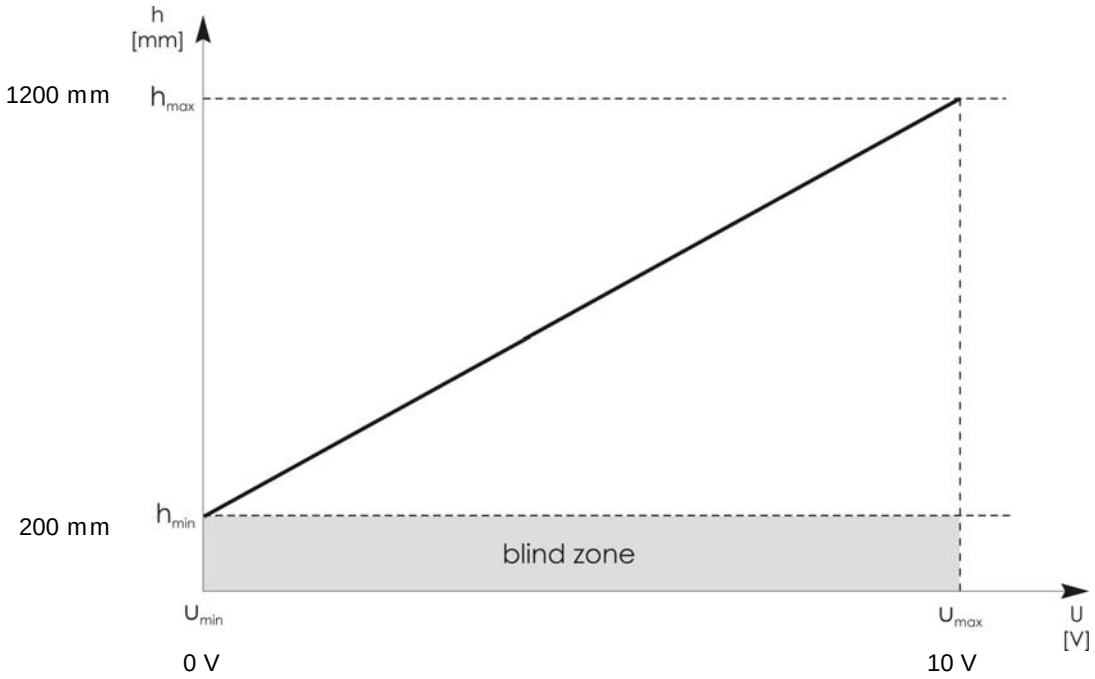

Figure 5: The calibration curve

4.2 Data telegram and trigger

Via the serial interface RS 232 the *UltraLab® ULS HF5-A* transmits ASCII telegrams to a PC. There, a program like Hyperterminal can be used to view and log the data externally. The settings in Hyperterminal are described in chapter 4.2.1.

The telegrams contain six numbers separated by <tab> characters and ending with <CR> <LF>:

1 The time stamp
2 Measuring channel 1 [in xxxx.xx mm]
3 Measuring channel 2 [in xxxx.xx mm]
4 Measuring channel 3 [in xxxx.xx mm]
5 Measuring channel 4 [in xxxx.xx mm]
6 Reference channel with the actual value of the sound velocity [in xxx.xx m/s]

A TTL type I/O port triggers the time stamp to start counting the telegrams beginning from 0000000, 0000001, 0000002, ..., up to 9999999 (see first column of 6). Before the time stamp is triggered or after the measurement has stopped the value of the time stamp is –1.
At that moment, the measuring system software program on the PC starts to measure, the rising edge of the time-stamp-reset-signal at the I/O-port – being on high level - switches the count. This situation continues until the measurement is stopped. Then the decreasing edge of the time-stamp-reset-signal provokes a negative value –1 for the telegram column 1.
Nevertheless of the time stamp status the applied sensors are continuously sending measuring data for data preview purposes to the external PC.

The TTL level – trigger input is connected by a BNC socket at the front of the control panel. It is electrically isolated from internal electronics by an opto-coupler.

```
//------------------------------
// Ultralab ULS HF5-A
// Version 1.0
// General Acoustics GmbH, 2007
//------------------------------
//
// wait a moment ...
//
// N        CH1      CH2      CH3      CH4      REF
0000000 0946.97 0940.89 0345.44 0932.77 343.58
0000001 0946.97 0940.89 0345.44 0932.77 343.58
0000002 0946.97 0940.89 0345.44 0932.77 343.58
0000003 0946.97 0940.89 0345.44 0932.77 343.58
0000004 0946.97 0940.89 0345.44 0932.77 343.58
0000005 0946.97 0940.89 0345.44 0932.77 343.58
0000006 0947.07 0940.89 0345.44 0932.77 343.58
0000007 0946.97 0940.89 0345.44 0932.77 343.58
0000008 0946.97 0940.90 0345.44 0932.77 343.58
0000009 0946.97 0940.89 0345.44 0932.77 343.58
0000010 0946.97 0940.89 0345.44 0932.77 343.58
0000011 0946.97 0940.89 0345.44 0932.77 343.58
0000012 0946.97 0940.89 0345.44 0932.77 343.58
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0000024 0946.97 0940.89 0345.44 0932.77 343.58
0000025 0946.97 0940.89 0345.44 0932.77 343.58
0000026 0946.97 0940.89 0345.44 0932.77 343.58
0000027 0946.97 0940.89 0345.44 0932.77 343.58
0000028 0946.97 0940.90 0345.44 0932.77 343.58
0000029 0946.97 0940.89 0345.44 0932.77 343.58
0000030 0946.97 0940.89 0345.44 0932.77 343.58
```

Figure 6: Example of data telegram

Please note:

After switching on of the power supply it needs 20 seconds for initiation of the system. After 10 seconds of internal tests the system starts the count down from 10 (for digital data output only). Right after the initiation time the data telegram follows.

4.2.1 Serial

Select Modify. The Settings will be activated. Select Module and then click on Settings.

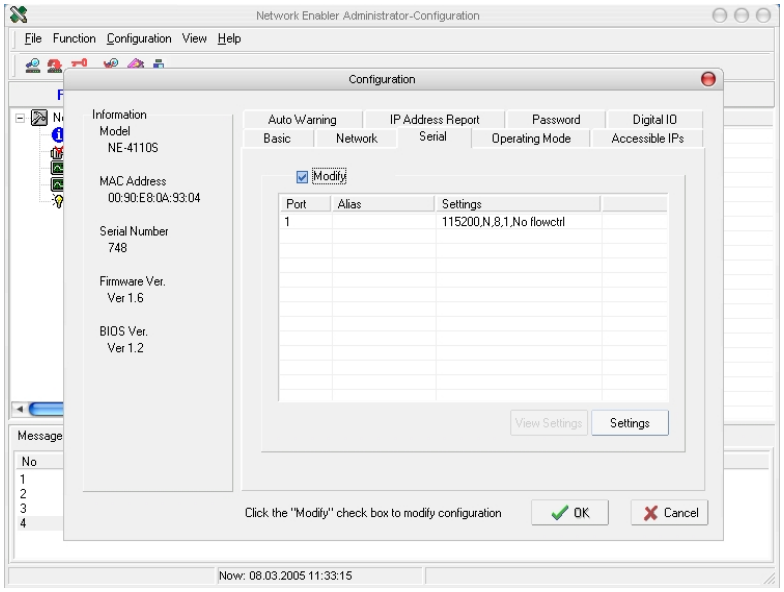

Figure 7: Serial

The interface parameters are adjusted here. These are not freely eligible, but permanently bound to the *UltraLab® ULS HF5-A*. A change of the parameters leads to sending no usable data.

- Baud Rate 115200 baud/s
- Parity None
- Data Bits 8
- Stop Bits 1
- Flow Control None
- FIFO Enable

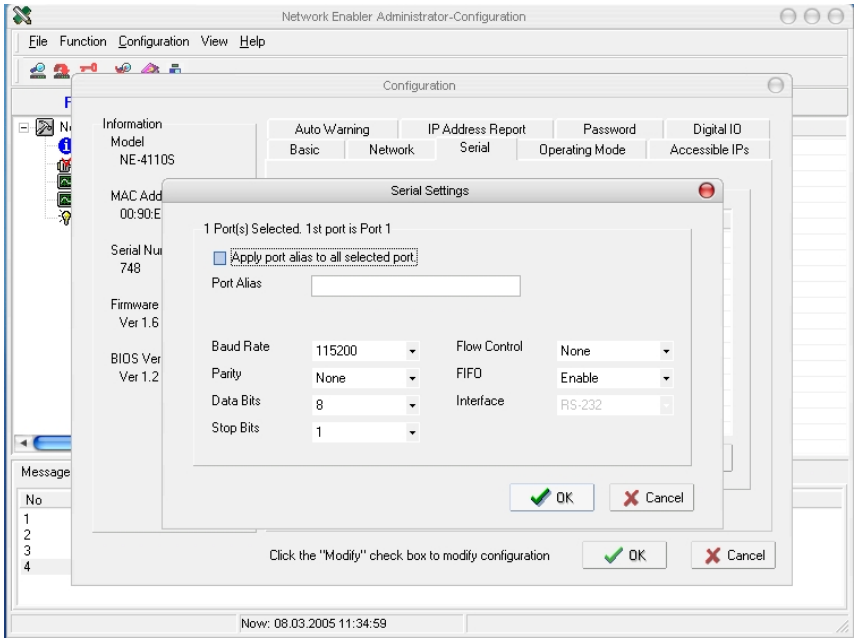

Figure 8: Interface parameters

4.2.2 Operation Mode

Select Modify. Select Module and click on Settings.

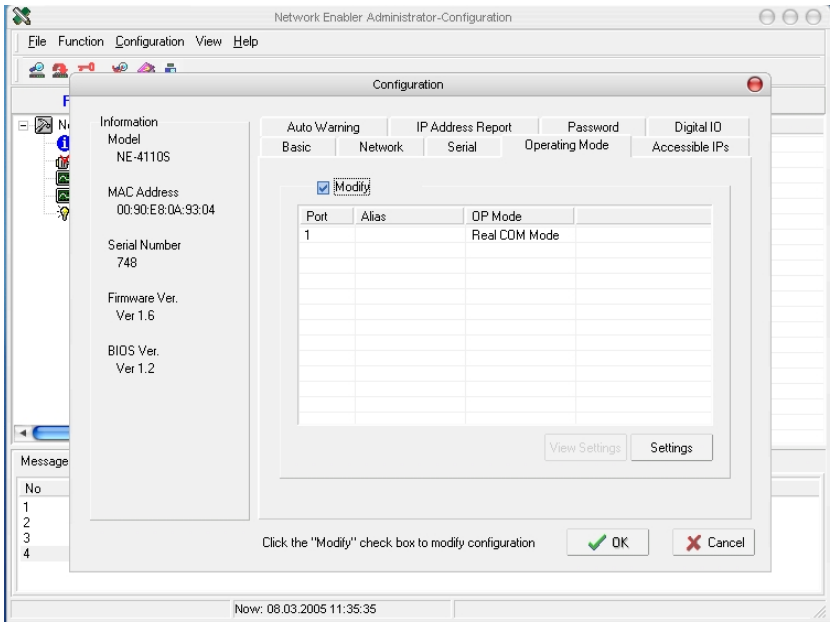

Figure 9: Operation mode

Mode Choice

- Real COM Mode (further Settings) — Transparent line with up to 4 connections (default)
- TCP Server Mode (further Settings) — The module is the server and the connections are established by the client (computer)
- TCP Server Mode (further Settings) — The module is the client and establishes a connection to a server (computer)
- UDP Mode (further Settings) — Improved TCP mode

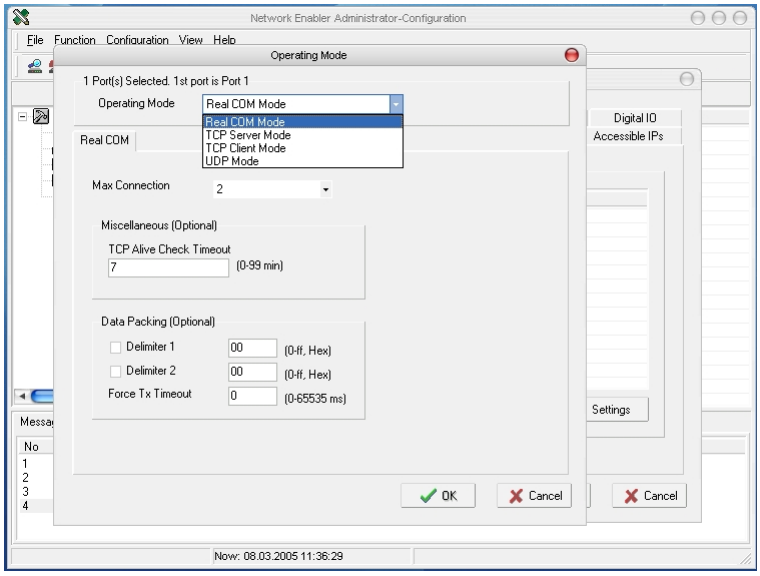

Figure 10: Mode choice

4.2.3 Real COM Mode

The real COM Mode is adjusted and recommended by *GENERAL ACOUSTICS*. In this mode (transparent connection) four connections to different computers can be established.

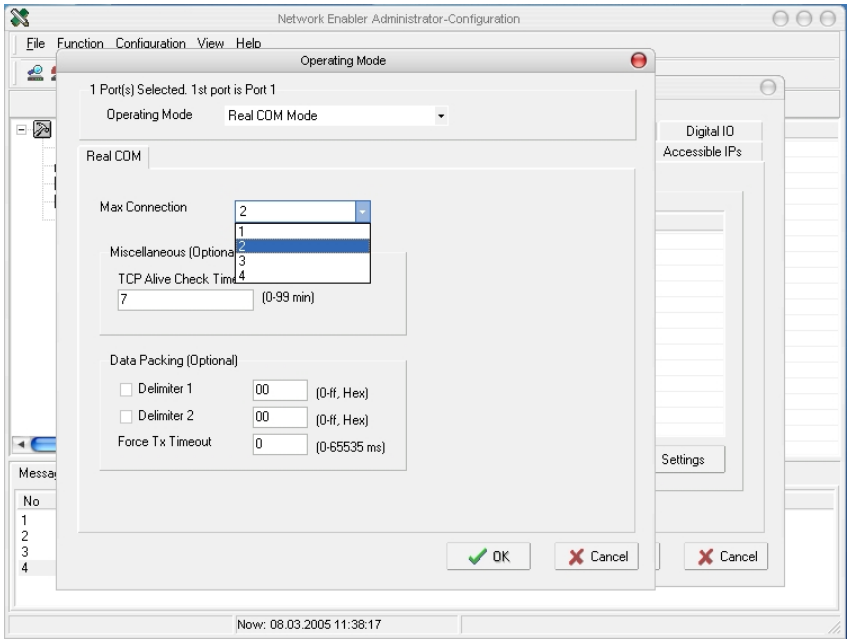

Figure 11: Real COM Mode

5 WARRANTY STATEMENT

(1) Warranty period

GENERAL ACOUSTICS GmbH, as manufacturer, will, itself or through its authorised sales partners, provide end-users with warranty coverage on all *GENERAL ACOUSTICS* products purchased as new and unused for a period of 12 months from the date of sale.

(2) ***GENERAL ACOUSTICS*** **procedure**

Any part, which has been correctly used and is found to be defective as a result of manufacturing and/or material faults within the above-mentioned warranty period, will either be repaired or replaced with a new part by *GENERAL ACOUSTICS* after expert opinion has been sought. Material and/or labour costs arising as a result will not be charged. All exchanged parts become the property of *GENERAL ACOUSTICS*

(3) Conditions for labour rendered under warranty

Instruments delivered must have been operated correctly, unauthorised modifications or repairs must not have taken place and the benchtop instrument must not have been opened.

(4) No warranty claim exists in the following cases

- Parts subject to normal wear
- Damage caused by incorrect maintenance, fitting and addition of non-approved parts and devices, as well as unauthorised modification of components
- Damage caused by electrolysis
- Damage caused by fire or accident, incorrect usage, misuse or negligence
- Damage/rust/corrosion caused by the entry of water

(5) Explicit or tacit guarantees

These guarantees confer special rights to you, and you may also have other rights, which differ from country to country or from province to province. Where these guarantee claims apply, all other explicit or tacit guarantees provided by *GENERAL ACOUSTICS* automatically lose their validity, incl. all market access guarantees or guarantees of fitness for every specific purpose. Conversely, the guarantees thus arising are limited to the period of this warranty. Neither sales partners nor traders are authorised to make any other assurances, representation of facts or warranty offers than those contained in the warranty conditions.

6 CE CONFORMITY STATEMENT

The instrument conforms to the requirements of the EEC directive 89/336/EWG and the revisions through 92/31/EWG and 93/68/EWG Article 5 pertaining to "Electromagnetic Compatibility", as well as 73/23/EWG and the revisions through 93/68/EWG Article 13 pertaining to "Safety".

7 TECHNICAL SPECIFICATIONS

Instrument model	*UltraLab® ULS HF5-A*
Sensors	USS13-HF, IP 65, M30x1.5
Measuring range	From 200 mm up to 1200 mm
Technical resolution	Up to 0.36 mm
Accuracy	1 mm
Sample rate	50 Hz
Data readout	Digital via data telegram (RS 232 and/or Analogue via BNC socket (0-10 V)
Electric power supply	230 VAC, 250 mA (110 VAC optional)
Chassis	ca. 330 / 160 / 270 mm width / height / depth IP 50
Temperature range	-20 ...+70°C
Delivery package	*UltraLab® ULS HF5-A* instrument, max. 4 ultrasound sensors USS13_HF, sensor cables, 1 reference sensor REF-300 including calibrated distance unit, 1 reference sensor cable, 1 power supply cable, 1 User Manual