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R&D: Ultrasonic Technology / Fingerprint Recognition

Description of a device and software for precise sound velocity measurement

Short description of the system

The device contains ultrasonic testing card OPKUD01/100, pulser&receiver OPGUD and cuvette with transducers attached on its opposite sides. OPKUD card is controlled by the software, that makes measurements, communicates with the user and calculate the sound speed.

Technical data:

I. Ultrasonic card

- A/C converter
  - resolution: 8 bit
  - sampling rate: 50 or 100MHz [1]

- Analogue parameter:
  - channels: 1
  - Input voltage: max. 1Vpp
  - input impedance: 50Ohm, 10pF
  - bandwidth: 0.1-25MHz
  - amplifier: -20dB until 40dB
  - buffer length: 1-16kB[1]

- trigger
  - internal (with software)
  - external (TTL signal max. 2 kHz)

- posttriger 0-256us [1]

[1] – software controlled

II. Pulser&Receiver

The device works on following basis: Transducer is used as capacitor, pulser generates a voltage on this capacitor and than, after a preset level is reached, very quick switch is used to short circuit the transducer (in about 20ns).

- pulser :
  - voltage 50V- 360V (software controlled, 8 levels possible)
- receiver:
  - amplification: 40dB

Method of measurement:

Cuvette is filled with measured fluid and the time is measured that sound needs to travel between the walls (in the fluid) and in the walls. The first or some of the following reflections can be used as result, that will be evaluated by the software.

A following method for measurement of time of flight of sound is used:

We assume, that the goal of the user is the measurement of fluids, that has only small differences of sound velocity, and the it is possible to assume, that a signal practically do not change, only its time of flight. We are using the feature of the card, that causes, that pulse generated by the pulser is synchronized with the clock of the card with high precision (significantly higher than 1ns) and measure the change of signal amplitude. This allows to achieve highest possible resolution and accuracy.

It should be told, that it would be also possible to measure another fluids too, having different acoustical properties (for example larger attenuation) and thus changing the form of the pulse in the way, that the above described method will be not suitable. For this purpose another method can be used – but the precision of time of flight measurement will be lower.

After the TOF will be estimated, using one or another procedure, following formulas are used for calculation of sound speed:

We have a fluid container, where sound travels only partially in the fluid and we can write following equation:

$$T = T_1 + T_2$$

Where:

T_1 sound propagation time not in the fluid (in walls);

T_2 sound propagation time in fluid.

We can measure propagation time in the whole system, filled with water (T_W), that has sound velocity C_W, or with measured fluid T_X (sound velocity C_X). If we know the length of the sound path (L) in measured fluid, we are able to calculate the sound speed in this fluid:

$$T_{2W} = \frac{L}{C_W}$$

$$T_1 = T_W - T_{2W}$$

T_1 can be obtained after measurement with water. This measurement should be done from time to time, but it can be assumed, that it will be not necessary to repeat it very often, because it is realistic, that parameters of the system do not change very quickly.

$$C_X = \frac{L}{(T_X - T_1)}$$

where: C_X - sound velocity in measured medium

Formula 1. Sound velocity in measured medium

The user of the software (and device) must know and input in the proper place the length of the sound path in water (L). Alternatively it can also input the sound speed (for example in water) that causes, that software can calculate the path length.

To make a measurement, it is necessary to decide, which signals should be used for measurement. It is possible to use signals coming after one time travel through the cuvette or after they was reflected many times. Signals can be chosen using cursor gates.

It is necessary to tell, that using multiple reflections causes, that absolute accuracy is lower (it depends on precision of length or sound speed measurement in water multiplied by the amount of reflections), but sensitivity (relative accuracy) higher. Thus: choosing multiple reflections for measurement can be interesting for comparison of different fluids.

Requirements for using the software:

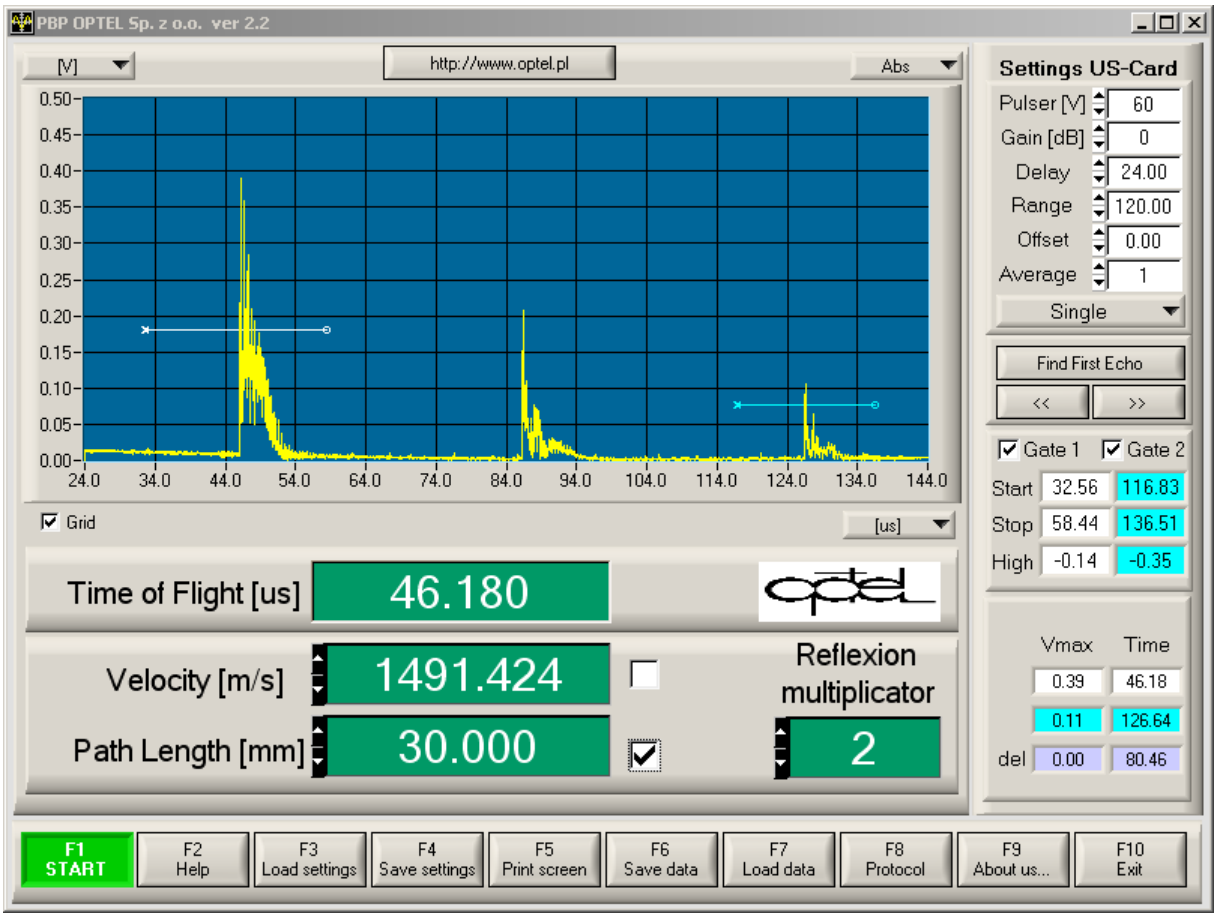
System:

Computer:	PC
Graphic card:	SVGA with 640x480 or higher resolution (800x600 is optimum)
System:	Windows 95, Windows 98, ME, XP or Windows NT, 2000.

The software is delivered in the version ready for installation. It can be installed in any directory, chosen by the user. We recommend to install it in the directory: „C:\OPTEL\". The software creates two subdirectories: „PROTOCOL" and „SET".

Screens and functions keys description

Main screen of the software is as follow:



Picture 1. Main screen

Explanation of function of windows and function keys:

Windows in the left part of the screen, having to do with a graph screen:

1. The switch in the upper left part of the graph screen allows to choose units for the vertical axis. Possible are following units: V, % and db.
2. The switch in the upper right side of the screen allows to set the method of data visualization. It is possible to show data in the form of an absolute value (Abs), RF data (HF), only positive value (positive) or only negative value (neg).
3. The switch in the lower right side of the graph allows to choose units for the horizontal axis of the graph screen, possible are following units: μs, mm and sample.
4. Window „Time of flight" shows the time, when the signal in the first gate arrives.
5. Window „Velocity" shows the calculated sound speed in measured material.
6. Window „Path Length" shows the calculated sound path length in measured medium (cuvette length).

Making a mark at the key „Velocity” causes, that the software calculates the sound speed in measured medium, assuming, that the path length is known. Making the mark at „Path Length” causes the calculation of path length.

If multiple reflections are used, it is necessary to set, which reflection is used in the window „reflection multiplicator”. If the amount of reflection is not correct, the worth showed will be multiplied by the factor that will depend on the proportion of the correct worth and chosen one.

Windows on the right side of the screen:

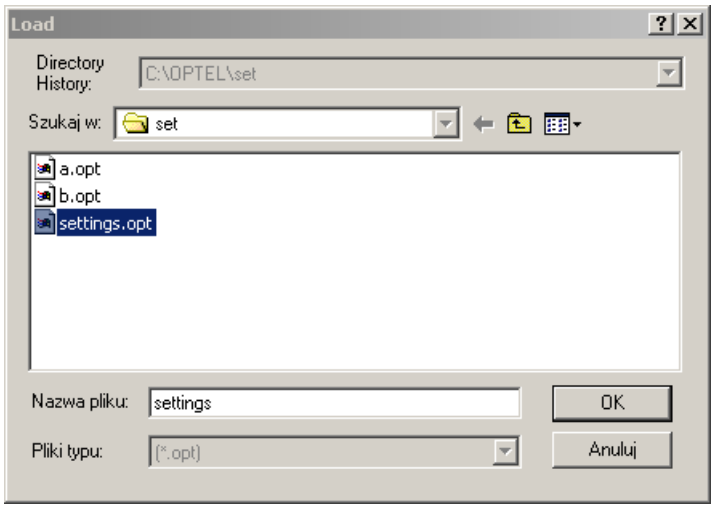
Upper part of the right side of the screen allows to set parameters of ultrasonic card and pulser&receiver. To chose correct parameters, some knowledge of the function of card is necessary. The user can also set parameters, see the results and find the best working ones. The best setting will occur, if the signal on the screen will have the amplitude of about 2/3 of screen height.

7. Window „Pulser” allows to set the voltage of the pulser (60 - 360V)
8. „Gain” sets the amplifier on the card.
9. „Delay” defines the delay after trigger, that decides, when the graph should begin – in relation to the trigger signal.
10. „Range” defines the length of the signal, measured by the card (length of the signal window).
11. „Offset” allows to shift the signal graph vertically. It is a software function (not implemented in the hardware).
12. „Average” allows to set the amount of signals, that will be taken to obtain the signal, that will be used for measurement.
13. Switch „Single/Dual” allows to set, if the software should work with one transducer, that sends and receives the signal (mode “single”) or with two, where one is sending, and the second is receiving (mode “dual”).
14. The key „Find first echo” starts a function, that seeks the first echo, and automatically places it on the beginning of the graph.
15. The keys below allow to find subsequent
16. Beneath the windows can be found, that shows the position of gates and signal value in this gates. Marking the gate causes, that it can be switched on or off. Positioning of gate can be done with the mouse and cursor.

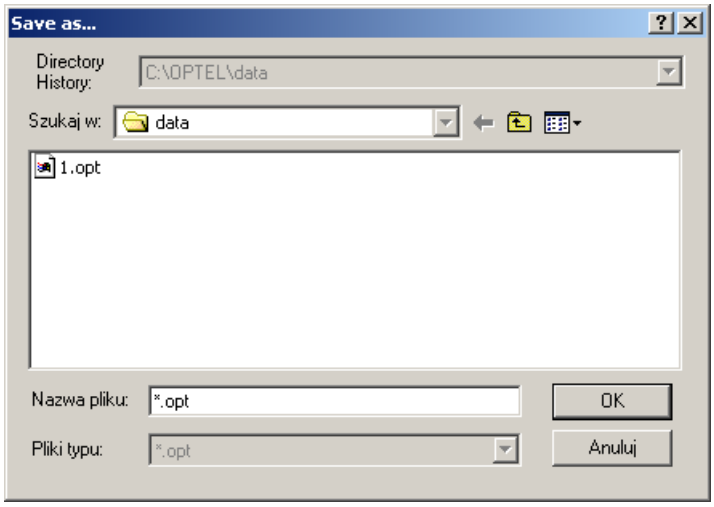
Description of function keys

F1 Start/Stop — Starts or stops the measurement.

F3 Load Settings — Loads stored settings:



F4 Save Settings — Stores settings chosen by the user:

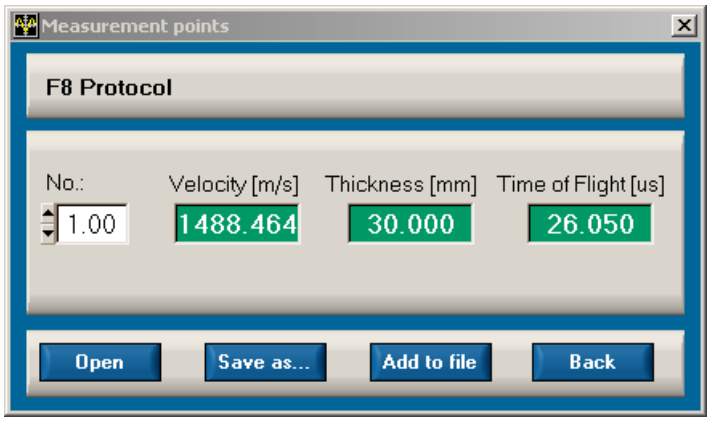


F5 Print screen — prints the screen

F6 Save data — Saves data in the file

F7 Load data — Reads data from the file

F8 Protocol — Allows to work with protocol, loading and storing of protocol, adding data to protocol.



F10 Exit Exits software

How to work with the software

The software starts in the configuration (parameter settings), that was stored by the user, during the last session. Before starting the measurements, the user should input necessary values of parameters (sound speed in water or path length).

The proper setting of such parameters as **gain, depth, level** requires some knowledge, the main rule is: the signal should be seen in the center of measuring window and his amplitude should be not larger than 2/3 of the window height (and not more than 1Vpp).

After settings are done, the velocity measurement should be started. To do this, the key **[F1] START/STOP should be pressed.**

The result of measurement is shown in the following window:

and after it is calculated, based on the formula 1 in the following fields:

and:

Measurement protocol

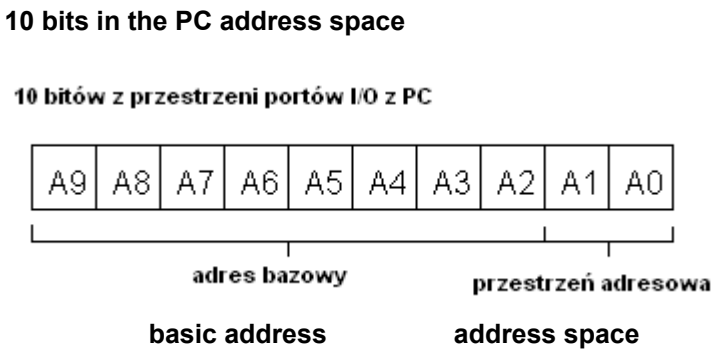
The software allows to make protocol of measurements. F8 key on the main panel allows to control this. After each start of the software in the subdirectory ***protocol*** a text file with the name „protokol.txt" is created.

The function „add to file" automatically adds the actual measurement results to the protocol file, together with description and date and time of measurement.

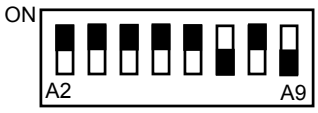
In a short time we will add the function, that allows to make measurements with a given period of time, and store them in a protocol file.

Setting of I/O address of the OPKUD card

Because OPKUD card is using ISA-bus connector, it is possible to set it I/O address. To do it, dip-switch J1 should be set in the following way:



For example the address 280 should be set as follow:



'ON' is logical '0', 'OFF' - is logical '1' .

Actualized in August 2003