R&D: Ultrasonic Technology / Fingerprint Recognition

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Guide to Ultrasonic test system - LOPKUD-014
Software Revision 1.0 / 2002

Short description of the working principle

The device generates short sinusoidal burst, that is amplified and drivers with high power sending transducer. Receiver is able to receiver signal after its propagation in investigated material and the OPKUD card allows to see the received signal, precisely measure time of flight etc. Each signal can be sorted, compared with another signal etc. The software allows to measure attenuation, changes in signal frequency etc. Burst parameters, signal amplitude and much more can be controlled from the software.

Hardware

LOPKUD-014 is particularly well suited for measurements with high power, low frequency (<100kHz) ultrasonic waves. It can be used for testing materials with high attenuation (scattering), such as stones, concrete, wood etc. It can also be used for measurements with air ultrasound (contact less transmission measurements). The device has following elements:

- High power sender;
- High sensitivity selective receiver;
- Modified OPKUD card, containing TTL – burst generator;
- Power supply (220V)

Technical data:

I. Scope Card

A/D converter:

- Resolution:	8 bits
- Sampling frequency:	4 MHz

Analog parameters:

- Input channels:	1 (BNC)
- Output channel:	1 (BNC)

- Input amplifier gain:	0dB, 6dB, 14dB, 20dB
- Attenuator:	-20dB
- Input voltage:	AC, max. 10mVpp
- Input impedance:	200Ohm

Data buffer:	16kB
Triggering:	internal

II. Sender

- Frequency:	200kHz
- Output voltage	max: 500Vpp
- Burst length:	2-128 cycles
- Burst duration in % of time:	<2%

III. Receiver

-	Selective	200kHz
-	Amplification:	40dB,50dB,60dB,70dB,80dB,90dB,100dB
-	Attenuator:	20dB

Signals on the external connectors:

DB9 (male)

N_{trig}	- pulse generator control;
$K_{reg\ (out)}$	- software controlled preamplifier gain

DB9 (female)
RS232

BNC (female)

U_{in}	- measured input signal

BNC (male)

INPUT	- input of receiver
OUTPUT	- output of high voltage transmitting signal

Software:

System Requirements:

In order to use LOPKUD-system, following equipment is necessary:

Computer System:	IBM PC
Display Adapter:	SVGA Adapter working in mode 640x480 or higher (recommended 800x600)
Operations System:	Windows 95, Windows 98, ME, XP and Windows NT or 2000.

Overview of Hotkey Selection:

Hotkey	Function	Description
[F1]	Open	Load in a previously saved data file and restore the capture settings as they were when the data was saved
[F2]	Save as	This option creates one file that contains both the current settings and the current data. The setting saved are the same in the Save Settings option.
[F3]	Print	This option will create a hardcopy of the screen into IBM Graphics mode compatible printers. The printout will include everything currently on the screen.
[F4]	About us…	Short information about OPTEL
[F5]	Select port	From the settings window it is possible to change a board address, and rs232 port.
[F6]	Help	a general help screen is available that shows most hotkeys of the program
[F7]	RUN / STOP	enables / disables selected acquisition mode
F8]	Zoom / Spectrum	choose between Zoom and Spectrum display in bottom window (Zoom - zoom for timing display; Spectrum - A set of functions which perform transformations between the time domain and the frequency domain, and perform analysis in the frequency domain. These functions are based on the discrete implementation of the Fourier Transform. Several rely on frequency domain transformations to obtain the results indirectly).
[F9]	RF Signal / Detector	Choose between RF Signal and Detector display in upper and bottom window.
[F10]	Exit	Exit to system
[F11]	Show diagram	Show diagram of Ureg=f(N)
[F12]	Transition [on/off]....	close and open of RS232 transmission from sender.

On the scope screen:

Memory	three memories for the measured signals
Grid ON/OFF	toggle on/off the display of the division grid

Measuring - Cells:

Markers from Signal screen and Zoom / Spectrum screen.

Time of flight [us]: It is necessary to prepare the signal, that will be compared (correlated) with the actually measured signal. If the transducer sends a short signal, it is no problem with choosing a proper signal, but it is also possible to choose any other signal. After the chosen signal is visible on the Singal screen, and the markers positioned on the left and right limit of the chosen signal, it is necessary to switch the "Pattern". After it, the bottom screen shows the chosen signal with the comment: "Correlation Pattern". This step can be repeated until the chosen signal is perfect. In the second step the measurement should be started ("Measure").

Ureg[V].: sender signal amplitude

Description of software for measurement of time of flight.

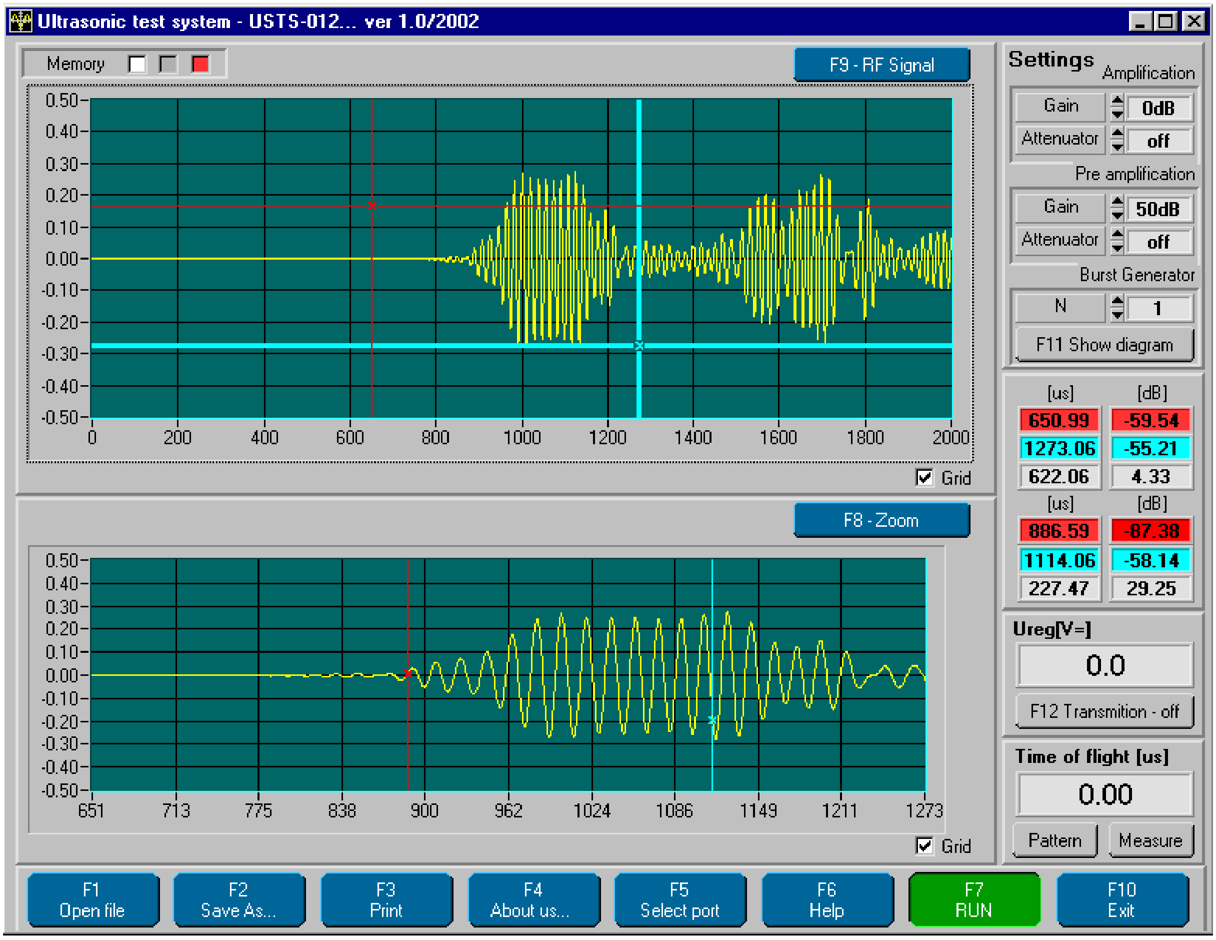
This software package allows to measure time of flight.

For each measurement it is necessary to choose reference signal and compare it with the signal, coming from the measured medium (reflected or transmitted through it). This allows to use this software with almost any kind of samples, containments etc. For people using this software it is necessary to have some knowledge about such kind of measurements, physics of ultrasounds etc

I. Introduction to the work with the software

First step

Reference signal should be prepared, the best way to do it is to use pure (distilled) water. Using markers in the upper window most important part of the signal should be chosen. In the bottom window signal between markers from the upper window can be seen - magnified. See picture 1.



Ultrasonic test system - USTS-012... ver 1.0/2002

Settings

Amplification

Gain 0dB

Attenuator off

Pre amplification

Gain 50dB

Attenuator off

Burst Generator

N 1

[us]	[dB]
650.99	-59.54
1273.06	-55.21
622.06	4.33

[us]	[dB]
886.59	-87.38
1114.06	-58.14
227.47	29.25

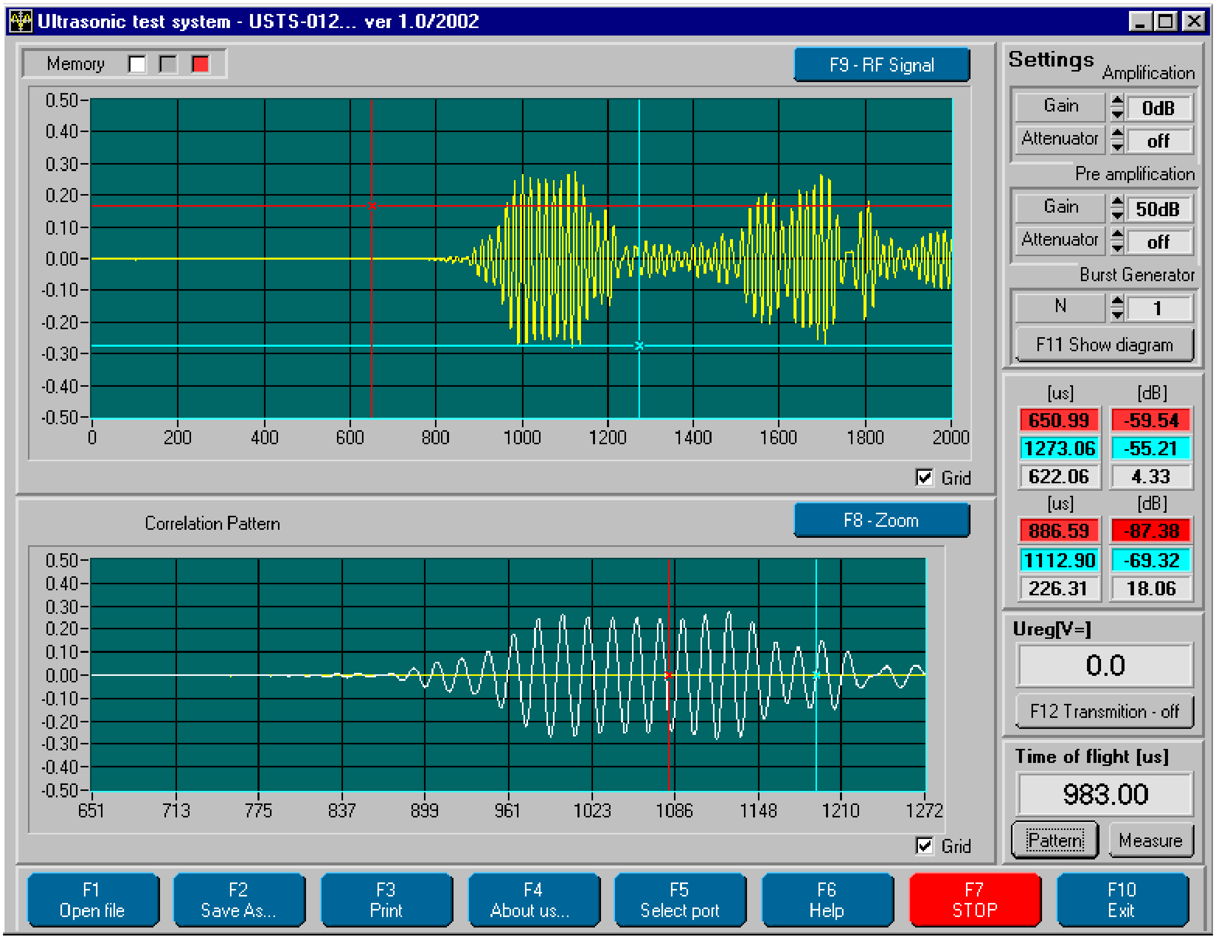
Ureg[V=] 0.0

Time of flight [us] 0.00

Picture 1.

Second step

Button “Pattern” should be used. After pressing this button, chosen signal appears in bottom screen in white color together with information: "Correlation pattern". It means this signal from this moment will be “reference signal”. See picture 2.



Ultrasonic test system - USTS-012... ver 1.0/2002

Settings

Amplification

Gain 0dB

Attenuator off

Pre amplification

Gain 50dB

Attenuator off

Burst Generator

N 1

[us]	[dB]
650.99	-59.54
1273.06	-55.21
622.06	4.33
[us]	[dB]
886.59	-87.38
1112.90	-69.32
226.31	18.06

Ureg[V=]

0.0

Time of flight [us]

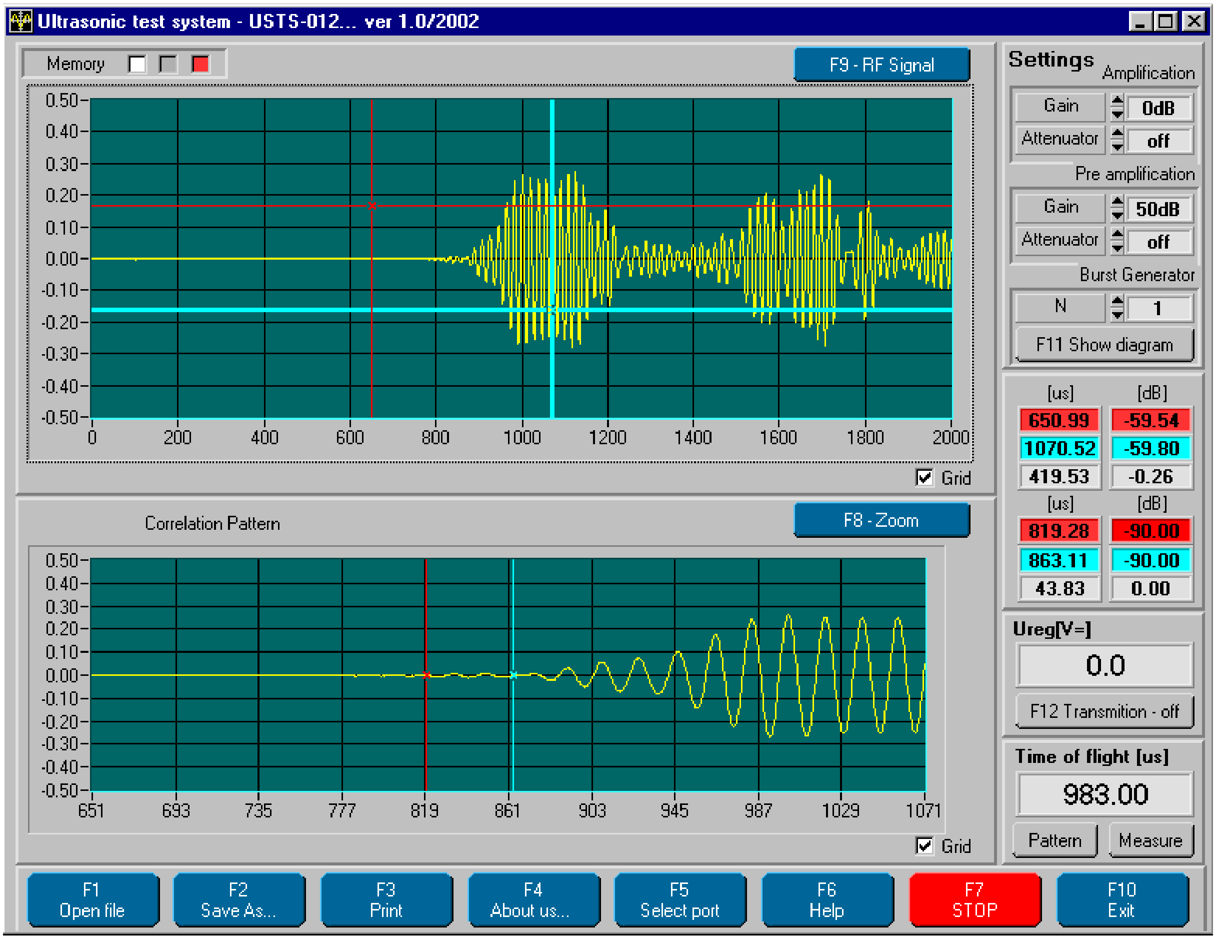
983.00

Picture 2.

From this moment key called "Measure" should be used – all subsequent operations will use signal stored before (pattern) as reference for comparison with actually measured signal. See picture 3. For time of flight measurement the display will show 0 – nothing changed.

Third step

In this moment we have to repeat operations described in the first step. In upper window we choose - using markers the most important part of signal we are getting from measured medium. In the bottom window we can see only signal between markers from the upper window. See picture 4. Pay attention on marker position (it is changed now). It means now we have another signal (with time offset for example).



Ultrasonic test system - USTS-012... ver 1.0/2002

Settings

Amplification
Gain 0dB
Attenuator off

Pre amplification
Gain 50dB
Attenuator off

Burst Generator
N 1

[us]	[dB]
650.99	-59.54
1070.52	-59.80
419.53	-0.26
[us]	**[dB]**
819.28	-90.00
863.11	-90.00
43.83	0.00

Ureg[V=]
0.0

Time of flight [us]
983.00

Picture 4.

In this moment we have all information which is necessary for calculation of time of flight (and another functions too), and then the button "Measure" should be used . On the bottom window we can see two earlier prepared signals (white – reference signal; red - measure signal) in this case we receive result different from zero.

II. The time of flight and sound velocity measurement method.

In most cases we can assume, that the signal will change after propagation - simple geometrical comparison of signals won't work properly. This is the reason, why we are using following algorithm for comparison of two signals with different time of flight:

a) FFT with Hamming window is made.
b) In frequency domain, frequency with maximum amplitude is chosen and using relatively sharp windowing only this frequency and frequencies from its neighborhood are taken.
c) Inverse FFT is done.
d) Center point of achieved signal is taken as time mark, telling us the moment of "coming" of this signal.

Time of flight can be measured from zero point (start of pulse) or from the time of “coming” of another signal, stored as pattern – as described above.

If the path length is known, it is possible to calculate the sound velocity in the measured material, using comparison with reference fluid – for example water.

If the experimental setup have a containment with measured fluid, where only a part of the sound propagation path is in the measured fluid, we can wrote following formula:

$$T=T_1+T_2$$

Where T_1 is time of propagation outside of measured fluid and T_2 in this medium. We can measure time of flight in the whole system (T) filled with water (T_W, that has velocity C_W), or measured fluid T_X (velocity C_X). If we know the path length (L) in measured fluid, we can calculate the velocity of sound in this medium:

$$T_{2w}=L/C_W$$
$$T_1=T_W-T_{2W}$$

This (T_1) can be obtained after measurement with water, and this measurement must be done only from time to time, since parameters of system doesn’t change quickly.

$$C_X \text{ (sound velocity in measured medium) } = L/(T_X-T_1)$$

The user of the software must know the path length (L), and choose appropriate signals (not only direct transmission must be chosen, but also multiple reflections for example).

DESCRIPTION OF DRIVER

This software package includes low level driver with DLL for almost all kind of system: Windows 95, Windows 98, Windows ME, Windows 4.0 NT, Windows 2000 and Windows XP.

DESCRIPTION OF DLL FUNCTION

DESCRIPTION OF CONTROL FUNCTION CARD OPKUD - 02

Basic control functions:

InitializeCard	initiating of mode of work
InitializeMeasurmen	initiating of measurement
SetPreGain	settings of pre-amplification
SetGain	settings of amplification
SelectN	select number of impulse in burst
AcquireData	data acquisition

BackData	back data
ResetCard	reset of card
Att_ON	on attenuator
Att_OFF	off attenuator
preAtt_ON	on pre-attenuator
preAtt_OFF	off pre- attenuator
SetPom	start of measurement
ClearPom	stop of measurement

Description of function:

---

int InitializeCard(int base_address, int mode);

Arguments:
base_address - base address of card (hex)

mode

- 0 - internal trigger mode
- 1 - external trigger mode

InitializeCard function initializes card in trigger mode and quantity of gathered samples.

---

void InitializeMeasurment(void);

InitializeMeasurment function initialize measurement only for work in internal trigger mode.

---

void SetPreGain(int pregain);
Argument:
pregain

- 0 - corresponds with 20dB
- 1 - corresponds with 30dB
- 2 - corresponds with 40dB
- 3 - corresponds with 50dB
- 4 - corresponds with 60dB
- 5 - corresponds with 70dB
- 6 - corresponds with 80dB

SetPreGain function settings of pre- amplification.

---

void SetGain(int gain);

Argument:
gain
- 0 - 1V/V (0dB)
- 1 - 2V/V (6dB)
- 2 - 5V/V (14dB)
- 3 - 10V/V (20dB)
- 4 - 20V/V (26dB)
- 5 - 50V/V (34dB)
- 6 - 100V/V (40dB)

SetGain function fixes gain on card

int AcquireData(int vector_len);

Argument:
vector_len   - length of array
AcquireData function realizes data acquisition from cards.
Function turns back 0 when data acquisition is correct else 1.

int BackData(int index);
Argumet:
index - index to data table;

BackData - turns back one item of data table.

void ResetCard(void);

ResetCard function reboots card.

void Att_ON(void);

attenuator on (-20dB it is used)

void Att_OFF(void);

attenuator off

---

void preAtt_ON(void);

pre-attenuator on (-20dB it is used)

---

void preAtt_OFF(void);

pre- attenuator off

---

void SetPom(void);

This faction start measure

---

void ClearPom(void);

This faction stop measure

ATTENTIONS:

logic “0” = 0V,
logic “1” = 5V,

What you are to do when card works:
Step 1. InitializeCard
Step 2. InitializeMeasurment
Step 3. Set all settings like gain, attenuator, numbers of impulse
Step 3. SetPom
Setp 4. AcquireData(x)
Step 5. in loop (x) times {BackData}
Step 6. ClearPom

RS 232 Transmission

RS232 Configuration:

Baud Rate:	19200
Parity:	no
Data Bits:	8
Stop Bits:	1

Do not use FIFO buffer.

Initialize of transition is when we send “r” by RS232 to the units, units back 2 sign
The first one is Ureg and the second one is “FF”

Ureg = 5.0*read_first_bits/255.

Short example in c++

```
void SetHardware (void)
{


        InitializeCard(adres,1);

        Set Attenuator
        if(att==1)
        {
               Att_ON();
        }
        if(att==0)
        {
               Att_OFF();
        }

        Controlling preAttenuator
        if(patt)
        {

               Set_Cntr1();
        }
        if(!patt)
        {
               Clear_Cntr1();
        }


        Controlling number of impuls in burst
        SelectN(n);

        Set Frequency of samping
        SetFrequency(1);

        Set PreGain
        SetPreGain(pregain);
        SetGain
        SetGain(gain);

        SetDelay(0);
        SetPom();







}





void GetData (void)

{
int k,z, q=0,w=0;

        InitializeMeasurment();
        czas=AcquireData(16384);
        ResetCard();
        if(czas==1)
        {
                DisplayPanel(p_brak);  // error card
        }
        if(czas==0)
        {
                HidePanel(p_brak);
        }

        for (k=0; k<16384; k++)
                {
                        {
                                        data[k]=BackData(k);
                                        tspec[k]=(double) data[k];
                        }

                }


}
```