

OPSCAN

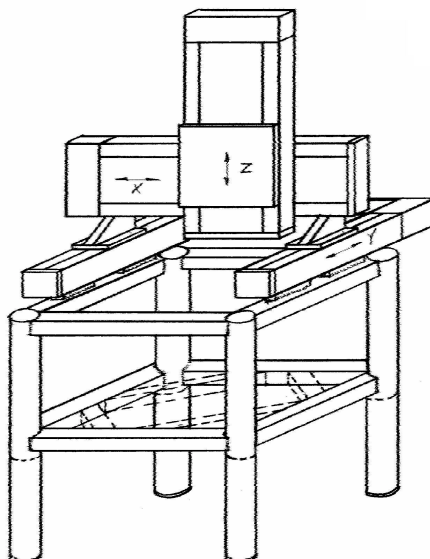
Ultrasonic 3 Axes Scanning System

Version 1.0

Operator's and Installation Manual

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1. Description of the OPSCAN system

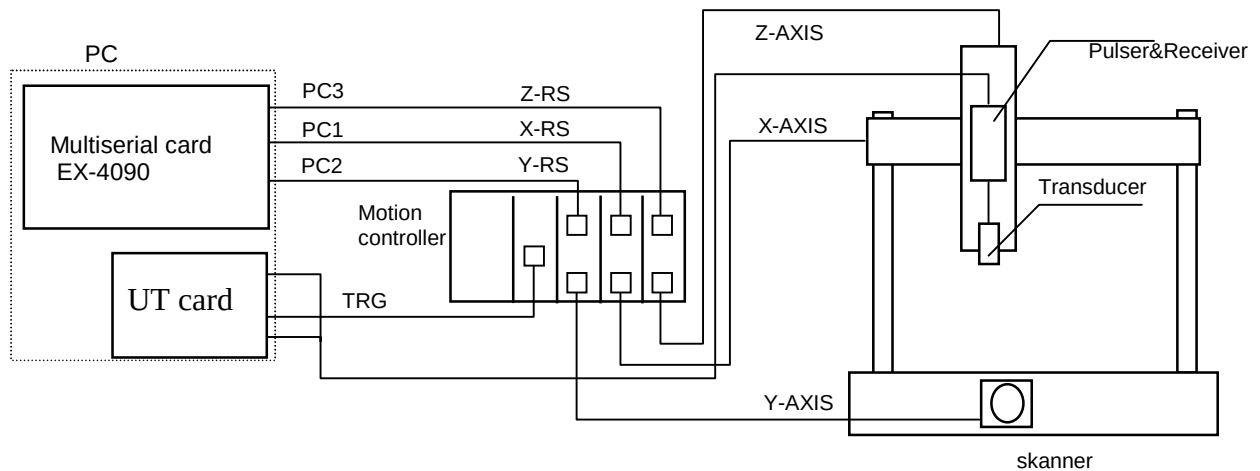


Fig. 1.1 Schematic diagram of the system

1.1 Ultrasonic scanner system contains following elements:

- Positioning mechanism, allowing to move and place the transducer.
- Water containment with support.
- Transducer support.
- Three transducers: two with 100ns pulse length (one focussing with lens) and one with 200ns pulse length.
- Pulser&Receiver OPGUD.
- Motion controller, containing stepper motors controller and delivering trigger (position) information to the measuring electronics (UT card).
- Ultrasonic Testing Card OPKUD 01/100.
- Multiport card with 4 serial ports.

The device needs also a standard PC with Pentium compatible processor.

2.1 System function:

In the standard version the system can make ultrasonic measurements using pulses. It can send a short pulse and receive the answer. Following measurements are for example possible:

- Non-destructive testing of materials and parts;
- Investigation of ultrasonic fields;

It is possible to use the system with burst and continuous wave, but for this purpose it is necessary to use another sender.

In the present version of the controller it is possible to scan along any linear axis. The system can work in continuous mode (allowing very quick measurement during the movement of the axis) and step mode.

2. Installation

The computer you want to install Scanner system in must have two unused ISA expansion slots.

2.1 Installation of Serial RS232 Enhanced Card EX-4090 and OPTEL Testing card OPKUD 1/100.

Both cards are shipped with protective electrostatic cover. When unpacking, touch the board electrostatically shielded packaging with the metal frame of your computer to discharge the accumulated static electricity prior to touching the board.

WARNING : TURN OFF the PC and all accessories connected to the PC whenever installing or removing any peripheral board

1. Turn off the PC and all accessories power.
2. Unplug all power cords and entire cables from the rear of the PC.
3. Remove the PC's cover (see your PC operation Guide if you are not skillful about it)
4. Find a unused ISA expansion slot. Remove the blank expansion slot cover and save the screw for affixing retaining bracket.
5. Grab the upper edge of the installed board. Align the board's retaining bracket with the expansion slot rear panel, and straighten the board's gold finger with the expansion slot, crush the board into the slot.
6. Restore the screw in the expansion slot retaining bracket.
7. Replace the PC's cover and connect the cables you detached in step 2.
8. Turn on the PC and other peripheral devices power.

2.2 Software Installation:

1. To install the Scanner System in PC computer with GA-5SMM mainboard it is necessary to turn off serial and parallel communications ports onboard (in Bios settings –integrated peripherals).

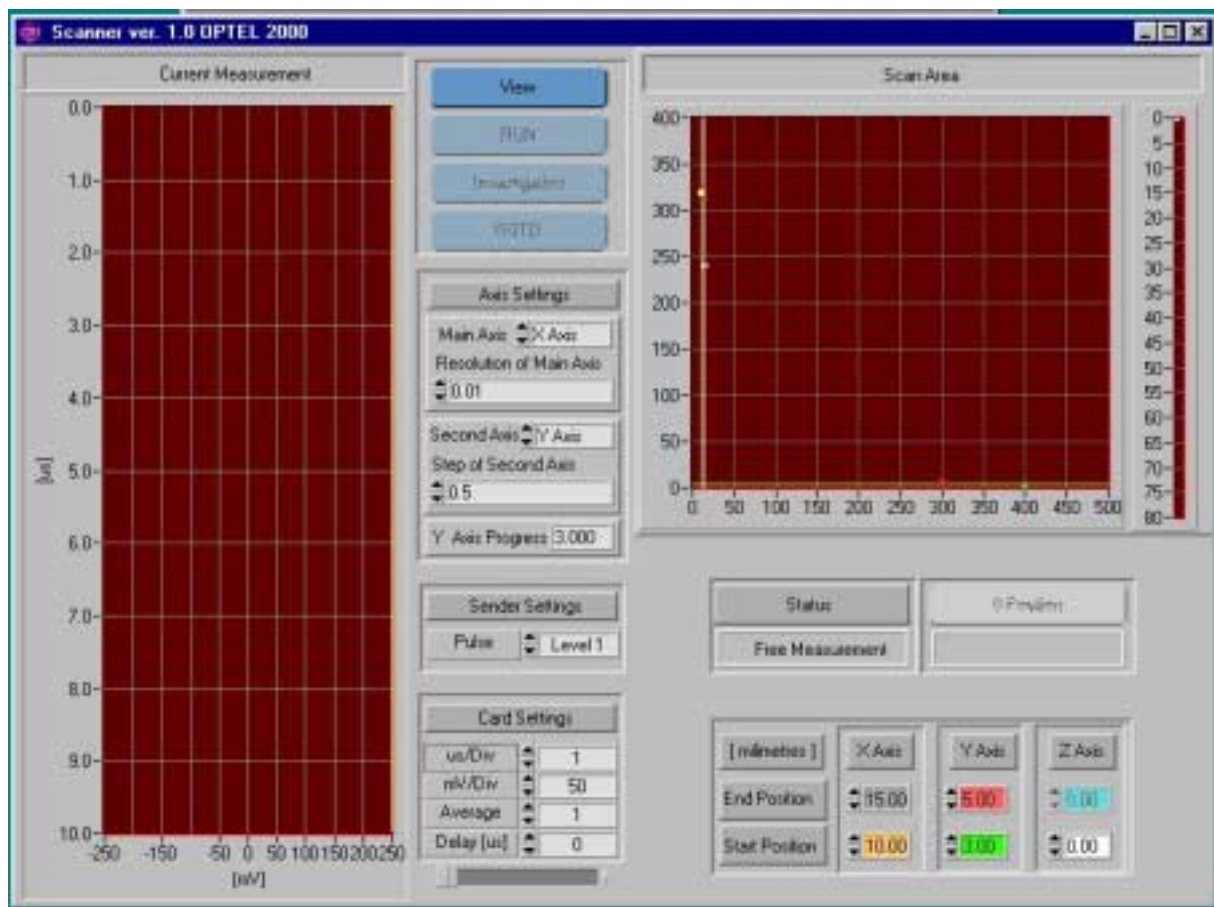
The default settings for EX-4090 board are:

Serial port	Interrupt	I/O Address
com1	04	3F8 – 3FF
com2	03	2F8 – 2FF
com3	10	3E8 – 3EF
com4	11	2E8 – 2EF

1. Resolution of color for video card must be 32 bits.
2. Please copy distribution files: setup.exe, scanner.001 and scanner.002 on hard disk in your computer.
3. Run setup.exe and follow the instruction.

At least 45 MB free space should be on the disk to use full range of measurement axes.

3. Description of the software



3.1 User Interface

Cursors on Scan Area space serve to choose area to be measured (X and Y axes). Z axis sets depth of measuring head in water. It is possible to define scan area in two ways :

- By moving cursors on “scan area” field,
- By filling out numeric boxes in down part of user interface.

These tools are equivalent and cooperate each other. Using second way you will be able to set limits of area to be scan with resolution of 0.01mm easier. If you choose measuring area using numeric input, you should first set the “end position” than “start position” because worth of “end position” must be greater then “start position”. Minimum worth of X Axis is 5.1 mm.

There limits for measuring range of X Axis are:

resolution	max.length of X Axis
0.01 mm	10 mm
0.05 mm	50 mm
0.1 mm	100 mm
0.5 mm	full range

Data from scanning are collected in several files with maximal size of 1000. There are asuch many files as many y-axis jumps is declared. For instance: y start position: 5mm, y end position: 6.5 mm, step of y-axis: 0.5 - creature 4 files.

In this version of the software the depth of measurment is always 500 samples.

3.2 Keys:

Investigation: serves to manually setting of measuring head in any position within area range. It allows you to choose the scan area. You can change all settings too. After return to “normal” mode all settings are saved. It means that full scan routine performs with early choosen settings. There is one exeption: “time base”. Time base is always 1us/div (500 samples) by full scan. 500 samples by 100 MS/s is 5us of depth (approximate 3.3 mm for water).

In “Investigation” mode you can set the position and after “**Go to**” is depressed, the head goes to wanted position. It is possibly to watch measured signal in all the time even while the head is moving. This is why it is comfortable to define area to scan.

Run.

Run starts full scan routine. The question “Are you sure to run?” appears because of big size of measurement data and time to complete data. For example : measurement range X within 10mm-20mm with resolution 0.01mm takes about 10s, by 100 steps along Y axis it takes about 1000s.

Each “Run” starts with positioning routine except that neither limits of field nor resolution of scanning have been changed.

Remember! In this issue you can not stop full scan routine.

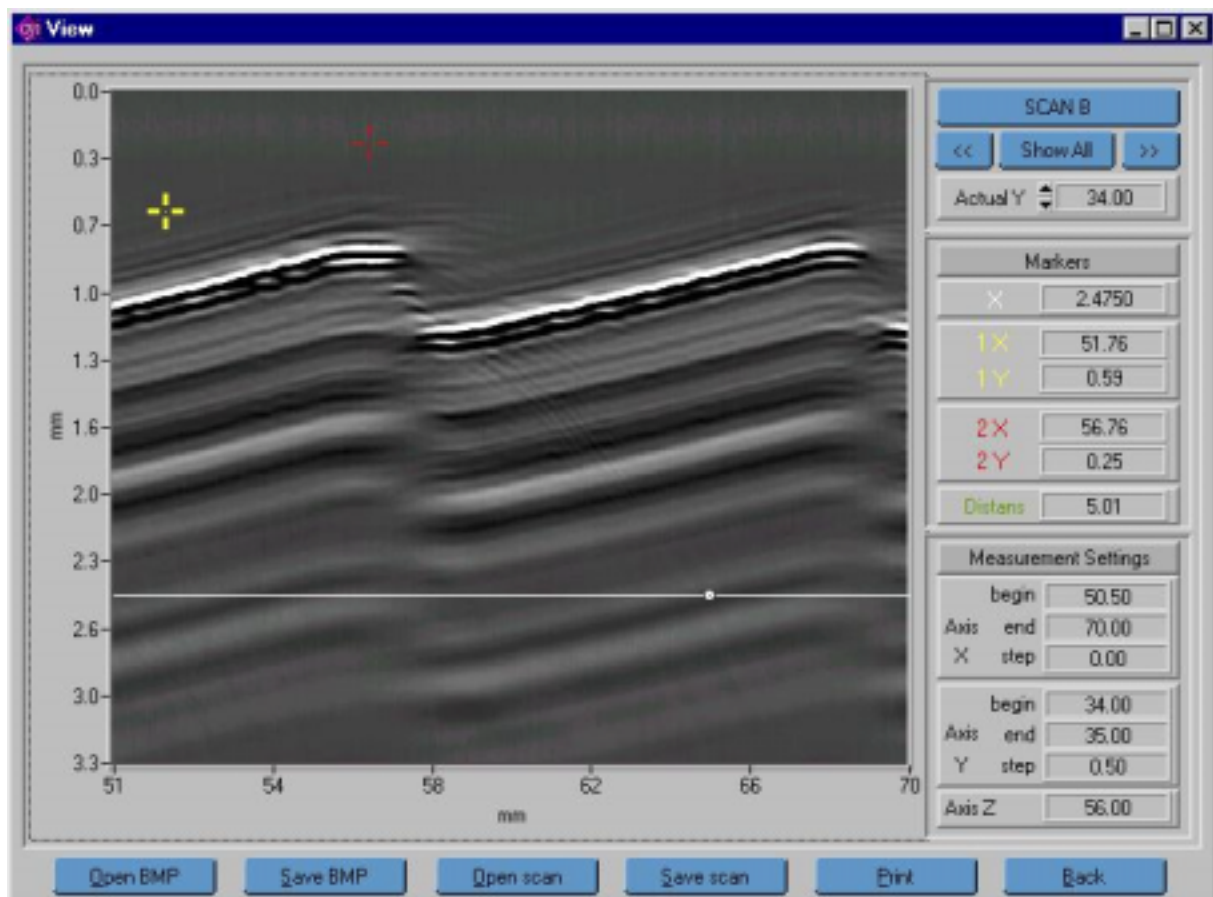
0 position:

causes positioning of measuring head on the reference (“0”) position.

View:

After full scan routine is ended you can view results of. A window with scan B appears and it is possibility to watch all “slides” along y-axis (in turn). Two markers (small crosses) show distance within scanned space. Third marker (white horizontally line) shows level of C-scan. Image of C-scan appears after “**C-scan**” button is

depressed. By using arrows you can watch succeeding pictures deep along the time within range 1 – 500 samples.

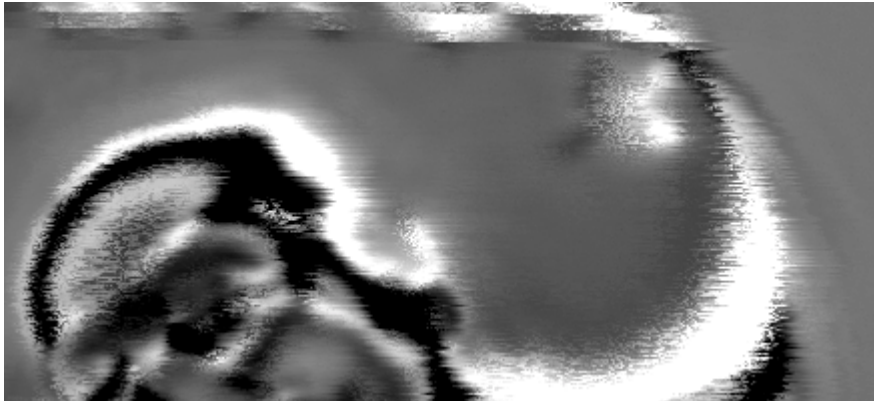


“Show all” key initializes automatic “slide show” of all early collected B-scans (or C-scans) one after the other. We don’t recommend to use this function to view of C-scan due to long time it takes.

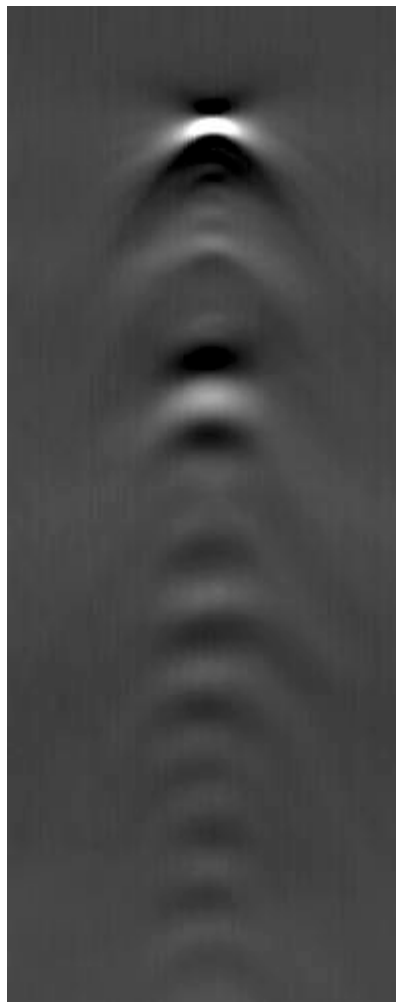
There is possibility to save results of process in user-named directory on your disk or save single slide as bitmap file.

4. Examples of pictures (measurements) made with the system

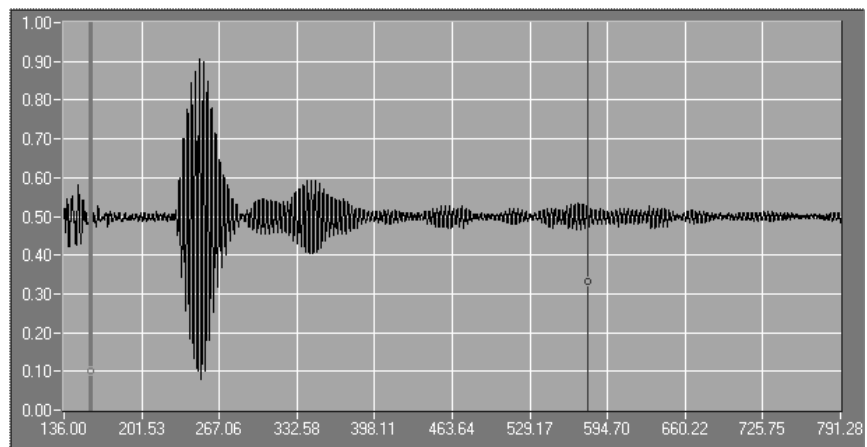
C-scan (part of the coin):



A-scan:



Waveform (oscilloscope display):



5. Ultrasonic Testing Card OPKUD-01/100

OPKUD-01/100 is particularly well suited for ultrasonic measurements as well as other kinds of measurements which employ mechanical scanning elements or multiplexed channels (the card is capable of controlling such devices). Together with the pulser&receiver unit OPGUD-01 and an ultrasonic probe it could be used as complete ultrasonic testing device. OPKUD-01/100 is a short (8-bit) ISA card and can be installed in a standard PC computer.

5.1. Technical data

A/D converter:

Resolution:	8 bits
Sampling frequency	100 or 50 MHz [*]

Analog parameters:

Input channels:	1
Input amplifier gain:	1/10 (switched attenuator), x1, x2, x5, x10, x20,x50, x100*
Bandwidth:	0,1 - 25MHz
Input voltage	AC, max. 10V p-p
Input impedance	50 Ohm, 10pF

Data buffer	256, 512, 1K or 32K bytes [*]
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Triggering:

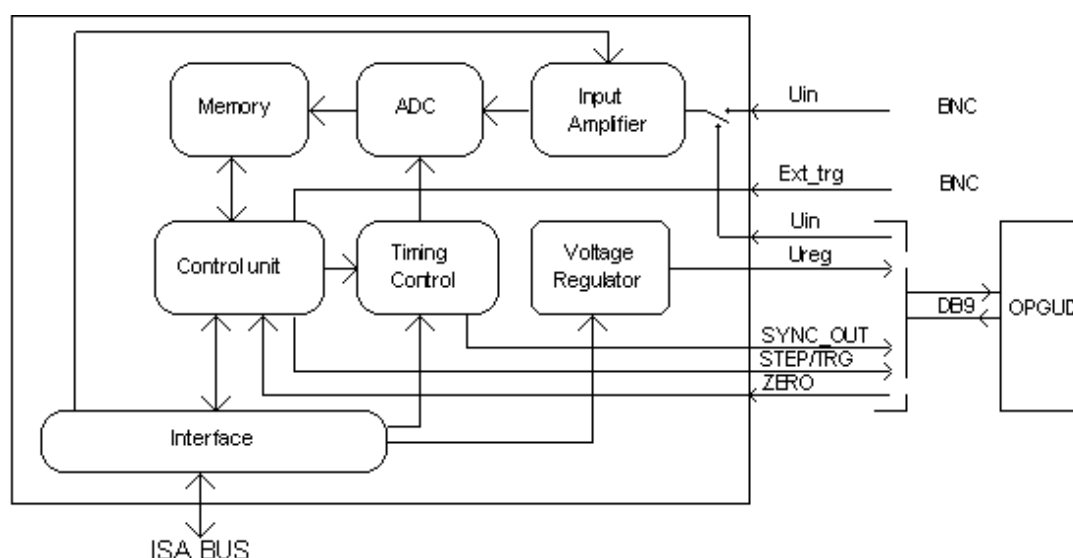
Source: internal (software) or external (TTL Signal) *

Post-trigger: 0 – 255 μ s *

Ext. trigger frequency: max. 2kHz

* *software selected*

5.2 Block diagram of the card:



5.3. Signals on external connectors:

DB9:

- U_{in} - measured input signal;
- SYNC_OUT- pulse generator control;
- STEP/TRG - step motor control or external trigger input (software selected);
- ZERO (TTL-input signal) - position marker (e.g. generated by an optical or mechanical sensor).
- Ureg (out) - software controlled voltage (2-10V, 8 steps) used for pulse amplitude control of the OPGUD pulser&receiver units;

BNC:

- U_{in} - measured input signal;
- EXT_TRG external trigger;

5.4. Characteristics of the card:

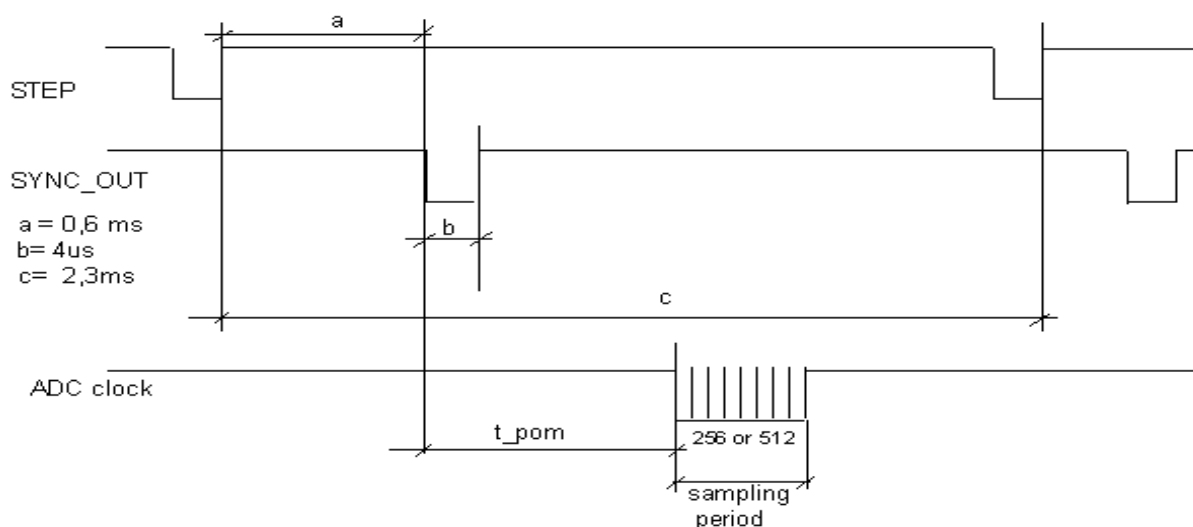
It can work in two modes:

- Automatic: The measurement is controlled with the software and the sync_out signal triggers the measured unit (scan A and B)
- Classical oscilloscope: measurement is controlled by the external trigger signal.

One of the most important features of the card is a precise synchronization between the transmitter trigger signal T_NAD and the moment when the sampling of the input signal starts.

This time (t_{pom}) is software programmable in the range of 0 - 255 μ s with a resolution of 1 μ s and has stability within the range of 1ns. It is particularly important in the case of scanning devices, since it allows to achieve a very small time skew between different positions (channels). 1ns would correspond to a clock frequency of 1GHz which is much higher than the actual frequency used.

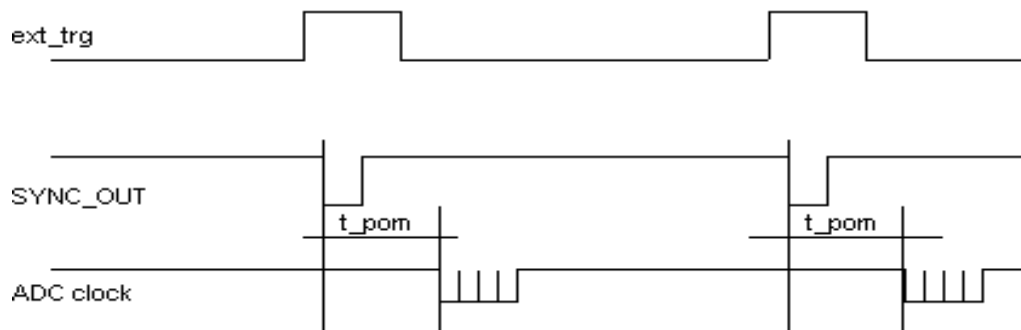
5.5. Automatic measurement mode



The card in its standard version can operate with a moving measurement head (rotating or moving linearly) as well as with a multiplexer circuit switching measurement channels. It can control a step motor (through a driver unit).

- ZERO is a marker of the reference position of the measurement head;
- STEP is a signal controlling the step motor driver unit or the multiplexer;
- T_NAD triggers the transmitter circuit, it is synchronized with the STEP signal in such a way that
- a pulse on the STEP signal is followed by a delayed pulse on the T_NAD signal as shown in a figure below.
- The delay is introduced in order to eliminate potential interference from the step motor.

5.6. Oscilloscope mode (this is the normal working mode in the OPSCAN device)



In this mode, for each EXT_TRG pulse, a single T_NAD pulse is generated (the STEP signal is not generated). This permits a precise synchronization with the clock signal generated on the card and therefore guarantees good repeatability of measurement results. In the case when the measurement circuit cannot be triggered, the repeatability of measurement results corresponds only to the clock resolution (12ns).

5.7. Additional notices:

In the current version of the card, there is no analogue trigger input and this function is implemented in software.

The card is programmed through the I/O operations. The STATUS and ZERO signals can be checked by reading the status register. The STATUS signal can also generate an interrupt.

Thanks to the feature which allows the I/O base address change, a number of our cards can work in a single computer.

All the control signals generated by the card can be modified according to specific customer requirements. For instance, a number of T_NAD pulses can be generated between consecutive STEP pulses, the frequency of the STEP pulses can be modified etc.

It is also possible to change following parameters: sampling frequency, bandwidth and amplification of the input circuit, the size of the input memory.

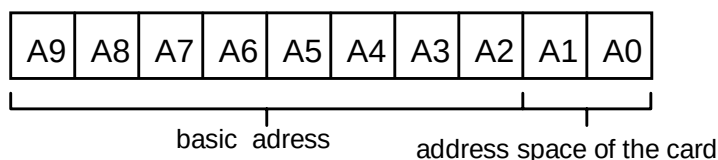
Included with the card is software which operates in both the automatic and oscilloscope mode. It also has a spectrum analysis function.

5.8. How to control the card from the PC:

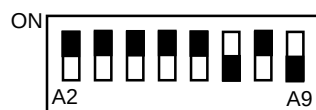
Address:

It is possible to use any I/O adres, possible in the PC. The used address can be chosen with the dip-switch J1. The card uses 4 succeeding addresses, the basis one must be chosen in the way, that the following addresses don't cause conflicts with other computer resources.

10 bits from the I/O space of the PC

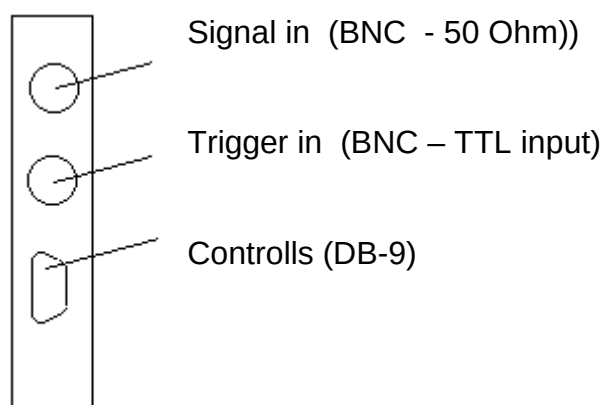


Example: Address 280 is chosen:



'ON' means logical '0' 'OFF' - '1'.

5.9. Connectors:



DB-9 Connector:

Description	Function	Number of pin
Trigger output	SYNC_OUT	1
Control signal output	S/T	2
Index signal input	ZERO	3
Scanner power supply	POWER	4
Vcc	+12V	5
Signal input	Uin	6
Pulser control voltage	VREG	7
Mass connector	Masse	8 - 9

6. Description of the OPGUD Pulser&Receiver circuit

6.1 The small box contains a step function pulser, receiver, transmitter/receiver switch and an input amplifier (40 dB). The box should be connected with the oscilloscope card using a DB9 and BNC cable (included).

6.2 The transmitter is triggered by the Trigger signal from the card (positive TTL logic).

6.3 Transmitter operation:

The rising edge of the Trig_Inp signal (intern) initiates the transducer charging process which takes 3 μ s. After this time, a transistor switch which discharges the transducer is turned on. The amount of time needed for the transducer to be discharged depends on the transducer used – it can be in the range of about 20-40ns (see Fig. 1).

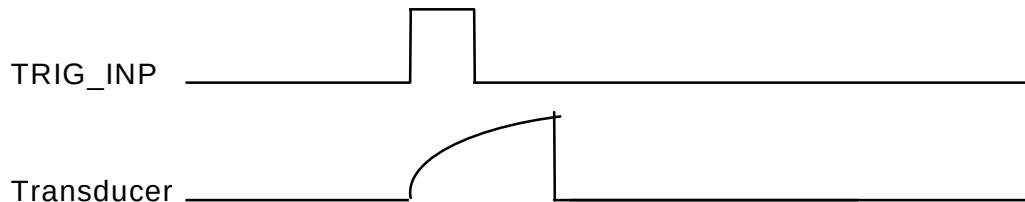


Fig. 6.1 Pulser circuit waveforms.

Attention:

Transducers with a parallel matching inductance should not be used, since they do not allow the transducer to be pre-charged (the inductance causes a short-circuit).

The receiver can (and should) be optimized for each transducer (proper inductance is necessary for good receiving signal).

We have tested the pulser with many transducers and have received good results. The user of this pulser must remember, that it has very low impedance (< 1 Ohm). This causes, that the pulse answer of each transducer is his real pulse answer. Transducer with very low impedance (high capacity) can be used.

The pulser produces positive pulse.

7. Information about transducers used in the system.

As a result of our biometric project a new class of ultrasound transducers has been created, for which a patent application has been submitted. Unlike classical designs, our transducers do not require damping and do not use bonded elements.

Fig. 7.1 shows a transducer element without housing. We can deliver the transducers in any type of housing or without it. Fig 7.2 shows a pulse generated by our transducer (a hydrophone made of PVDF film has been used for the measurement). The signal received in the transceiver mode is depended on the transducer used. We have optimized (and can deliver) three types of transducers, with medium frequencies of about 21, 11 and 5MHz (and pulse length of about 40, 100 and 200ns). The signals produced by them in send&receive mode are shown on the pictures 7.3, 7.4 and 7.5. The difference between the two signals results from the fact that our transducer works differently as a transmitter and as a receiver.

This property is also exhibited by other types of transducers, though the differences are usually much smaller.

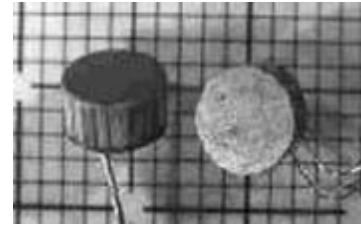


Figure 7.1

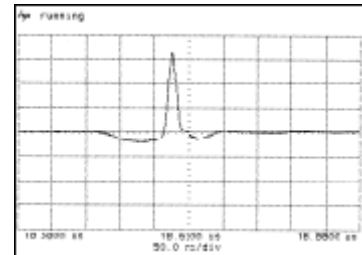


Figure 7.2.

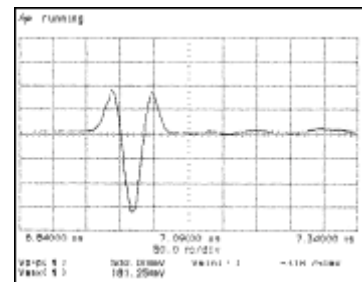


Figure 7.3.

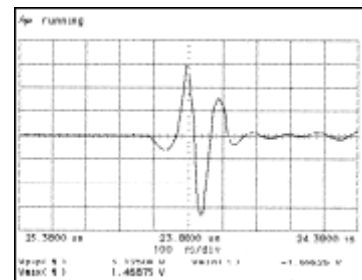


Figure 7.4

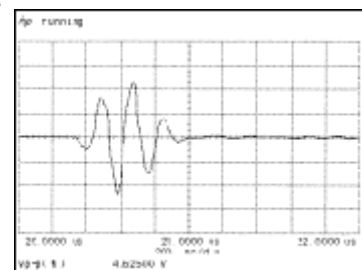


Figure 7.5

Transducer technical data

- **Bandwidth:** 3-25 MHz (maximal 3dB bandwidth for a single transducer, different frequency ranges are also available).
- **Minimal length of a pulse:** 20 ns (40 ns if the same transducer is used for both generating and receiving the pulse).
- **Pulse amplitude** is around two times higher than for classical, attenuated piezoceramic transducers.
- **Sensitivity** is comparable to classical transducers (it is likely to be improved in the future).
- **Minimal diameter:** ca 1mm
- **Maximal diameter:** limited only by the available ceramics
- **Minimal thickness of the transducer:** ca 1.3 mm, standard width is 2mm. The element is the actual transducer, it can be placed in a case or mounted to another object.
- **Temperature range:** Dependent upon the type of

ceramics used (it is possible to use special types of ceramics; typically standard ceramics gives satisfactory results) the transducer can be designed in such a way that the only limiting factor for the temperature range is the ceramics used. Our transducers will not get permanently damaged even if their temperature raises above the Curie point. Once they cool down they become operational again, provided that our pulse generator is used. We have proved construction, that can work continuously at 200°C.

- **Maximal supply voltage:** pulses of up to 700 V peak value. Any type of pulse generator can be used.
- **Electrical impedance** is equivalent to the impedance of a capacitor with comparable capacitance (ca 1.5 nF for the transducer with the diameter of 4 mm). The impedance module is around 20 Ohm for 10 MHz.
- **Tolerance of the pulse shape.** Assuming the same ceramics, differences between different transducers are less than 5 % of the amplitude.

Acoustic impedance matching can be achieved by introducing an intermediate layer. This increases the strength of the pulse and sensitivity but it limits the bandwidth as well. We are not able to create a layer which matches the impedance of water in the entire bandwidth of the transducer.

9. Motion control unit / Electrical system parameters

Control unit of the **OPSCAN** system contains power supply, three stepper motor control units (one for each axis) and trigger control circuit. It has following features:

- Each stepper motor control unit has its own microprocessor and can be connected with PC via RS232 interface (2400bd, 8 Bit, 1 startbit, 1 stopbit, no parity);
- Simple commands are necessary to control this devices;
- Necessary power supply and consumption: 5V/ 1A and 35V/ 1,5A;
- Controls 2-Phase stepper motors, bipolar, max. frequency 65535 Hz;
- Microsteps (up to 8) are possible;
- Max. working space: 16777215 steps;
- Can use the information from two end position switches;
- Is able to use the signals from incremental encoders and can perform with them following functions:
 - o Compute present position of each axis using 24-bit counter. This worth can be transferred to the computer;
 - o Generates trigger pulses between two programmed positions (can divide or multiply the incoming pulses to achieve larger or smaller amount of pulses).

The features of the controll unit allow to make measurements during the movement of the axis with higher precison than allowed by the stepper motors.

Size of the unit: (L/W/H): 500x280x18; weight: about 5kg

Electrical system parameters

Power supply: 110 or 220V AC 50 Hz (depending on the version)

Power consumption: 60W

10. Mechanical system parameters

The scanner uses linear units with ballscrew and stepper motors.

X – axis (horizontal) –	travelling distance/ pitch 300mm /4mm
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(has two linear units coupled together with belt)

Y – axis (horizontal):	400mm/4mm
Z – axis (vertical):	300mm/4mm

(Another travelling distances and pitches are possible.)

Mechanical accuracy of the position repetition is better than 0.01 mm.

For precise triggering of the measurements each axis contains a rotary incremental encoder with 500 pulses/rotation, the highest achievable electronic resolution is thus 0.002mm. This can be achieved during continuous measurement, but is mostly theoretical resolution - it cannot be guaranteed, that the mechanical stability of the system is high enough.

The system uses switches on both end positions of each axis for security and zero index of encoder for indicating the start position with high accuracy. Motor power units are integrated in the housing of each axis.

The cork in the middle of the bottom of water container can be removed (power should be used) and the hole can be used for any purpose.

The water containment is made from plexiglass, support from steel and linear axis mostly from aluminium (ball screws from stainless steel). Transducer support is made from stainless steel.

The device can be positioned (levelled) using bolts placed on the end of each leg.

Dimensions:

Length:	920mm
Width:	750mm
Height:	1690mm

Inner size of the water containment: L=600, W=415, H=400
Cubic content: approx. 100l

Weight: approximately 100 kg

With another travelling distances of the axes, the dimensions of the system will change.

11. Picture of the system



and control unit

