

EDUCATION

GAMPT-Scan

User Manual

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ULTRASONIC SOLUTIONS

General Safety Instructions

Before the operation of the $G A^{MPT}$ -Scan and the ultrasonic probes read the following instructions carefully to your own as well as to the operational safety of the device.

- *Pay attention that the device can only be powered by an AC electrical outlet (100 – 250 volts, 50 – 60 Hertz).*
- *The opening slits in the device serve for ventilation and should be kept absolutely free to avoid an overheating of the device.*
- *Never try to input objects into the vents of the device, because it can cause short circuits or electric shocks.*
- *Control the ultrasonic probes before every application. Exchange damaged probes. Never use probes that show cracks.*
- *Remove the ultrasonic probes from the device by pulling at the plug. Never pull at the cable. The same applies to all other cables connected to the device.*
- *To connect to socket „Probe“ use only sensors delivered from company GAMPT mbH. Attention! At the socket can be voltage peaks up to 300V !*
- *The $G A^{MPT}$ -Scan is a lab device, not a medical product! Do not use the ultrasonic probes at persons or other creatures.*

Pay attention to the special operation and safety instructions in the corresponding chapters (marked with arrowhead and cursive written) !

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Technical and software changes reserved. Errors and omissions excepted.

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1. Introduction

The ultrasound echography (also sonography) has developed to one of the most important investigation methods among others in medicine and NDT (non destructive testing). There are unreviewable multitudes of ultrasonic devices for different applications. They all work on the same basic principles of emitting a mechanical wave, whose reflection will be and recorded in an echogram.



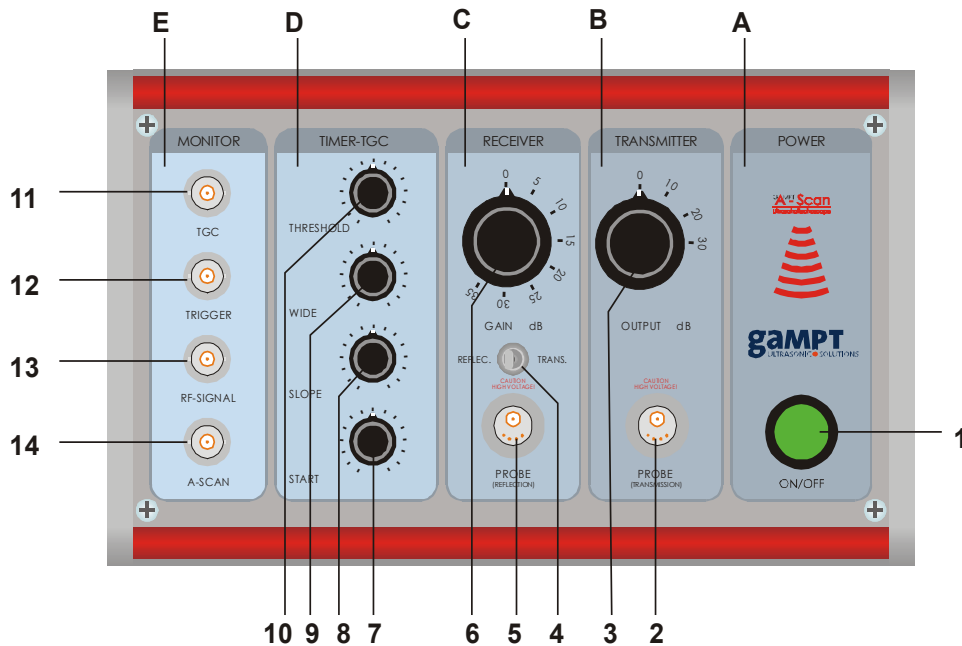
The $G A^{MPT}$ -Scan is a high sensitive ultrasonic measurement system, which can be connected to a PC or simple to an oscilloscope. With the delivered software an extensive signal analysis can be done (HF-signals, amplitude signals, B-mode, M-mode, spectral analysing). The ultrasonic probes will be connected with robust snap-in-connectors. The probe frequency is automatically recognized from the device. With help of the adjustable emitting and receiving power, it is possible to fit the ultrasound signal to nearly each arbitrary investigation object. Thereby the intensity loss of ultrasonic signals from deeper investigation areas can be corrected by a Time Gain Control (TGC). Threshold, start- and endpoint or rise of TGC are free adjustable. The most important signals (Trigger, TGC, HF- and amplitude signal) are available on BNC-sockets. For the setup of lab experiments there is an extensive choice of ultrasonic probes (1, 2 and 4 MHz) and accessories. Thereby the theme area goes from physically basics of ultrasound up to industrial and medical applications. In connection with the scanner system many setups to imaging methods can be build.

2. Components

2.1. Control Elements ^GA^{MPT}-Scan

The ^GA^{MPT}-Scan is an ultrasonic A-scan device with an outlet for pulse echo operation (reflection mode) and an additional outlet and toggle switch for operation with two probes in transmission mode. The device is available as “stand alone” version with a parallel interface for data transfer to the PC. Optional there is also an USB-adapter.

For better understanding device principles the different components are optically departed. (A: power supply, B: transmitter, C: receiver, D: time gain control (TGC), E: BNC outlets to oscilloscope)



- | | |
|---|--|
| <p>A power supply</p> <p>1. on/off</p> <p>B transmitter</p> <p>2. probe connector transmission</p> <p>3. emitting power</p> <p>C receiver</p> <p>4. toggle switch reflection / transmission</p> <p>5. probe connector reflection mode or receiver in transmission mode</p> <p>6. receiver amplifier</p> | <p>D Time Gain Control (TGC)</p> <p>7. start point</p> <p>8. slope</p> <p>9. width</p> <p>10. threshold</p> <p>E outlets oscilloscope</p> <p>11. signal TGC</p> <p>12. signal trigger signal</p> <p>13. signal ASan HF</p> <p>14. signal ASan NF</p> |
|---|--|

The transmission power is controllable in a range from 0-30 dB in steps of 10 dB. For the receiver amplification the range is from 0-35dB with steps of 5 dB. For the TGC start point, rise, width and threshold are continuously adjustable with a gain up to 30 dB. With the BNC outlets different signals can be transferred to an external oscilloscope.

In materials provided there is also a measure and control software for Microsoft windows (see chapter “Software”). With it, it is possible to measure differences in amplitude and time of flight. Additionally the simultaneous visualizing of the HF- and amplitude signals can be done, wherewith in contrast to conventional A-scan devices the waveform character of ultrasonic signals can be demonstrated. In a next diagram form and progression of the TGC are shown.

2.2. Ultrasonic Probes



The ultrasonic probes distinguish oneself by a high sound intensity and short sound pulses. With that they are particularly appropriate for pulse-echo mode. All probes have a robust metal box and are waterproof protected at the sensor surface. The probes are delivered on demand with a special plug for connection to the GAMPT Scan or with a BNC plug for universal use.

The blue coded 1 MHz probes are suitable especially for large penetration depth because of their high sound intensity. Their employment is recommended particularly for investigations of strong damping materials and for generation of Rayleigh and shear waves, respectively. For that the probes can be utilized either as transmitter or as receiver



The red coded 2 MHz probes are suitable for wide range employment. Because of the higher frequency the axial and lateral resolution power is evidently better compared to the 1 MHz probes. On the other hand the damping of 2 MHz sound in most materials is not yet too large, so that investigations in middle depth can be obtained easily. Especially these probes are suitable for investigations at medical objects and as ultrasonic Doppler probes.

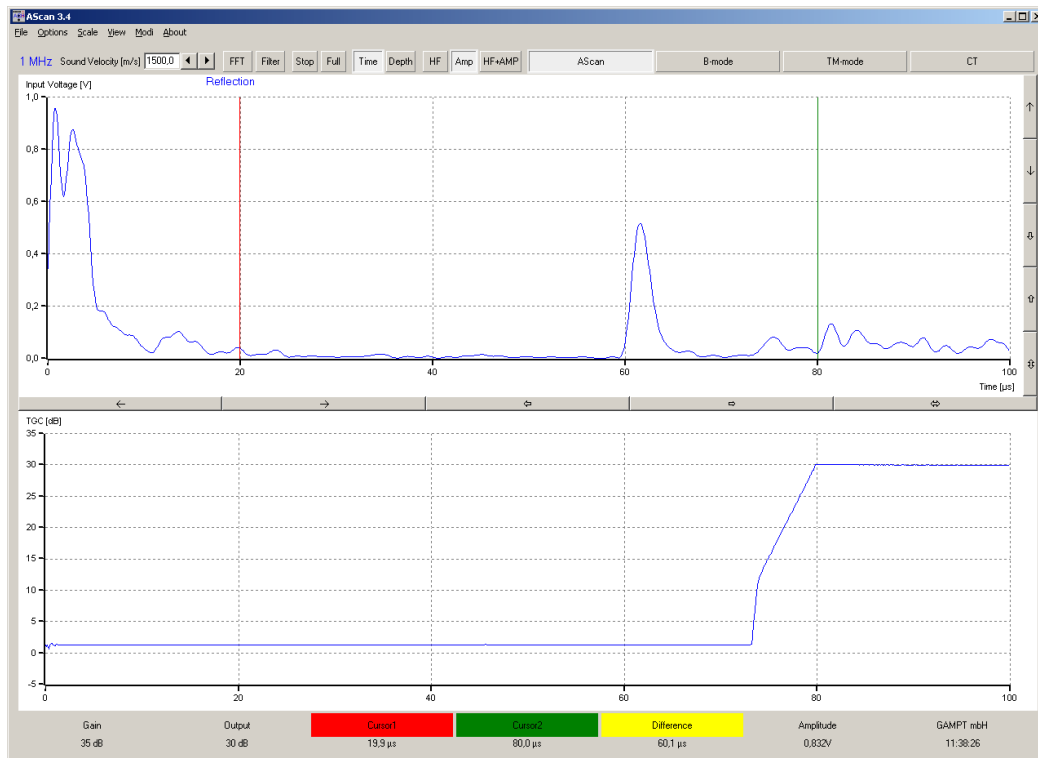


The green 4 MHz probe is distinguished by an extreme short oscillation decay time which results in the highest axial resolution power. This probe is especially then used when very small structures have to be detected. Mainly for investigations in liquids the limited penetration depth of some materials is no problem. The high resolution power and therewith related spectral bandwidth recommend this probe particularly for investigations of thin plates.

3. Software

3.1. Overview

The software AScan serves to record, display and evaluate the data supplied from the $G A^{MPT}$ -Scan. Beside the display of data in diagrams, there are different evaluation and filter functions. Beside the normal measurement mode the program has an offline simulation mode. This simulation will be activated automatically when no device is connected (see also chapter “Data Transfer”).



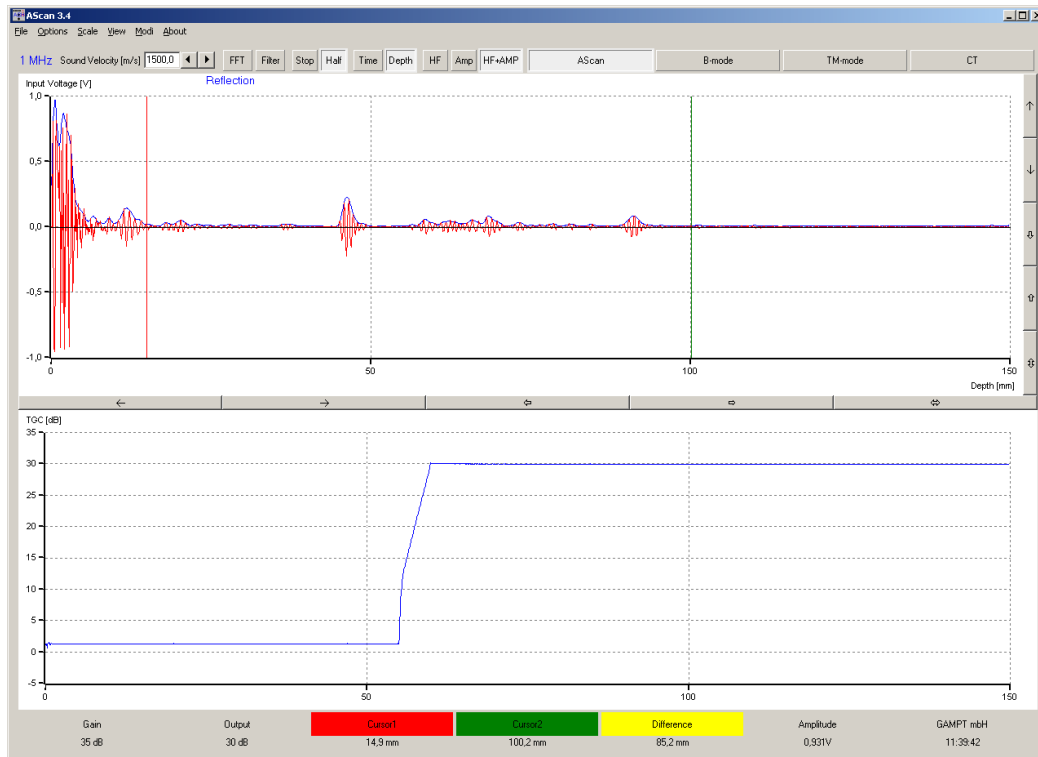
Further software options are:

- switching range area , automatic mode advertisement (transmission, reflection)
- switch between time of flight and measurements depth in dependence of sound velocity
- zoom functions, data export, print
- frequency and cepstrum analysis (FFT) of selectable signal area, frequency filter
- Time Motion mode
- manual guided B-mode imaging
- optional: computer tomography and scanner guided B-mode

After starting the program the measure mode is active and the main screen AScan mode is open. Beginning from here all actions and evaluations can be selected and started.

3.2. Main Screen: AScan - Mode

The main screen is shown in the picture below. In the upper screen part the A-scan signal, the frequency of the connected transducer, the mode (reflection/ transmission) and the actual position of the cursors (red and green line) are displayed. The cursors can be positioned by mouse (move the mouse to the cursor, the mouse pointer will change) or by keyboard (arrow keys: left+ right cursor1, up+ down cursor2).



The scale of x-axis can be changed from time scale (time of flight measure) to depth scale. [Buttons: **Time** or **Depth** , alternative menu **Scale**]. For the depth scale calculation the sound velocity is needed. This value is to be edited in the respective input field (default 1500 m/s for water). The Up/Down button pair left beside the diagram serves for the amplitude resolution (upper pair) and moving the zero line (bottom pair).

The permanent refreshing of the A-scan line can be interrupted by the **Stop** button (freeze) and continued with **Start**. With the buttons **Half** / **Full** the measurement range (maximal time of flight or depth) can be switched between 100 μ s or 200 μ s).

For the display of the measured values in the A-scan line it can be selected if only amplitude (red), only HF-data (blue) or both should be shown. The selection is done with the buttons **Amp**, **HF** or **HF+Amp**. (alternative menu **View**).

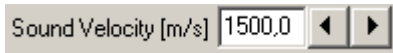
In the bottom diagram the Time Gain Control with all parameters (start point, rise, width and threshold) is shown. Whereas emitting output power and receiving amplifier always impact to all measurement values, the TGC effects only a selectable time range. The gain works only in this time range. Thereby the slope can be changed in position, width and rise. With it it is possible to emphasize especially interesting areas and also to suppress disturbing signals.

- *Pay attention not to compare quantitative values from TGC amplified range with other ones. This is especially valid for amplitude measurement.*

In the bottom screen area there are some status information. Among others there are the time of flight values / depth values of the selected cursor positions, in yellow the difference between the red and green cursor is shown. On left side the adjusted receiving amplification (gain) and emitting output power are displayed.. Right there is the amplitude voltage value at the position of the mouse pointer (middle of the cross)



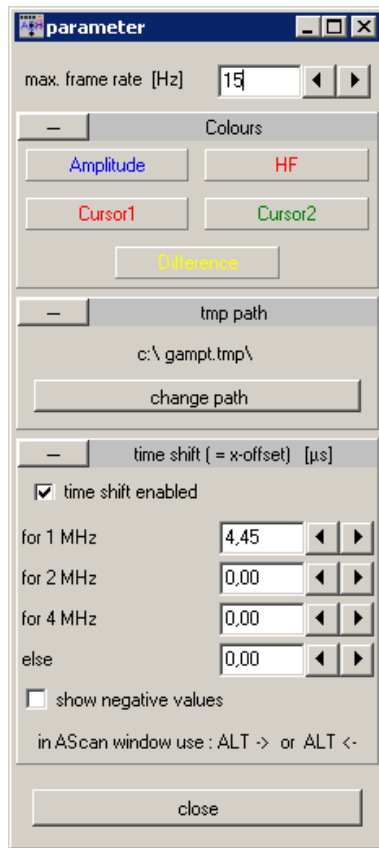
Between the diagrams there is a button panel with different arrows. These arrow buttons serve the zoom function on the x-axis. The first two move the axis one division to left and right, the next two zoom in and out. The double one at least performs an auto scale of the x-axis. This stays active until another arrow is selected or the measurement range has been changed. The arrows beside the diagram work analogue for y-axis.



To input values into the program there are fields like sound velocity top left. The values can be edited directly or varied by using the mouse and the arrow buttons. Alternatively it can be changed with the keys up/down (with page up/down the increment value increase tenfold). When a limit is reached it will be signed by red coloured value. Then the limit value is valid.


3.3. Menu Options

3.3.1. Parameter



The **max. frame rate** impact how often data are transferred from the echoscope and displayed in the diagrams. The here given value is only a reference point. Keep in mind that data transfer and evaluation need a certain time. With a too high value the effective frame rate can be lower, the program will work as fast as possible. Whereas it can be that other programs are slowed down.

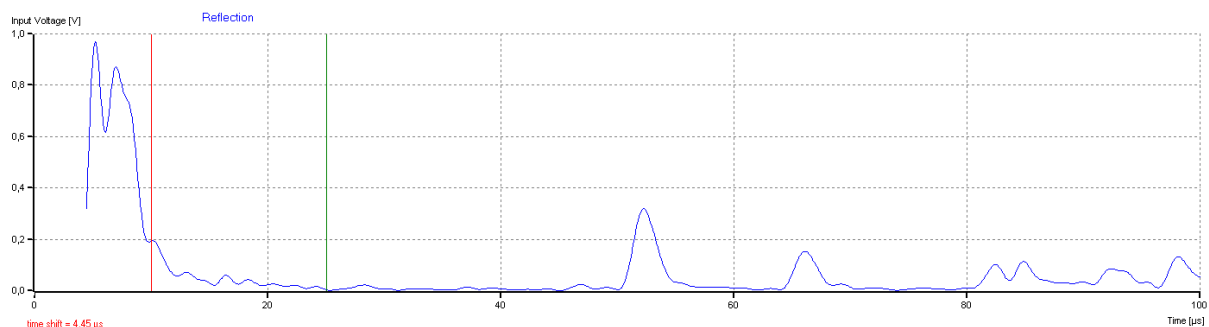
- *The here adjusted value has no impact, when a measure was started in B-, TM- or CT mode. In the imaging measurements the effective frame rate can be higher than before because different queries are not necessary. (see also **pixelwidth** in chapter "TM mode")*

In the **Colours** area the diagram lines or cursors can be adapted. A mouse click to the  beside **Colours** will reduce the area.

tmp path : During the program operation changed values (i.e. sound velocity, frame rate ...) and also different data will be stored. Normally this will be done into the installation path of the program. With good reason not all students have write access to the program directories. So they could not write the data. In this case the data will be written into the **tmp path** directory. While the program is running it works with these data. With a restart of the program the initial data will be overwritten with the original values stored by an administrator in the installation path. The tmp path value take affect only when the user has no write access to the installation path.

The **time shift** executes a displacement of the shown data on x-axis. That can be more comfortable for some absolute time measurements (i.e. to compensate a time delay line). For each know transducer frequency a time shift value can be edited.

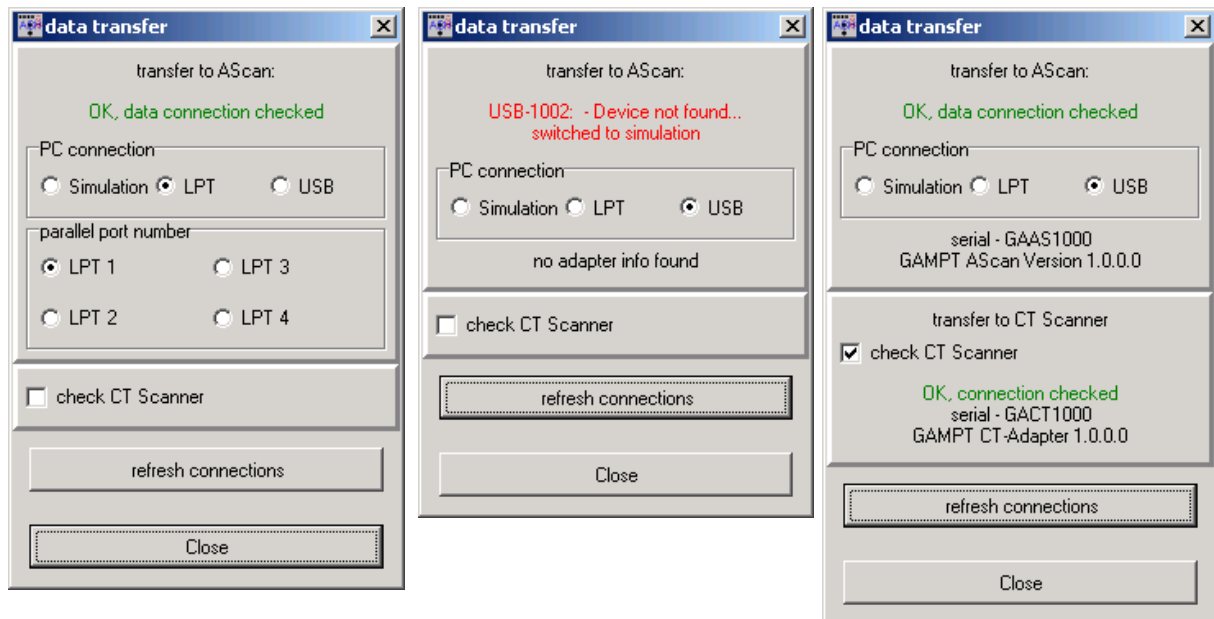
- *For exact measurements we recommend always to measure relative by using both cursors.*
- *That is why the time shift is deactivated by default.*



Is the time shift nevertheless activated it will be shown in the main screen under the diagram as red coloured value. The starting point of the diagram line is displaced by the given value (in the picture above 4.45 µs). With help of the keys ALT + arrows (right/left) the time shift for the actual frequency can be changed without the parameter window. (Caution! not possible for all overloaded windows)

3.3.2. Data Transfer

The program has to know where the data come from. For this we have to adjust the data transfer. The $G A^{MPT}$ -Scan can be connected via parallel port interface (LPT) as well as via USB port. The respective choice can be given in the program form *“Data Transfer”*. You will find under the menu *Options* the item *Data Transfer*.



The program will check the connection and when it is successful the result will be given in green letters. When there is no connection the software shows an error message in red letters with the probable reason. In this case the program will switch automatically to the simulation mode. In simulation mode the data will be generated in the computer, this mode also works without a $G A^{MPT}$ -Scan, it can also be used for demonstration. The program will stay in simulation mode until the next successful data transfer check.

- *The program saves the actual data transfer choice, so it is not necessary to edit them every time starting the program. But doing so it will also remember the simulation mode, a notice about that will be given.*

If the choice “check CT scanner” is activated also the connection to the scanner will be checked. The choice should only be activated when there is a scanner.

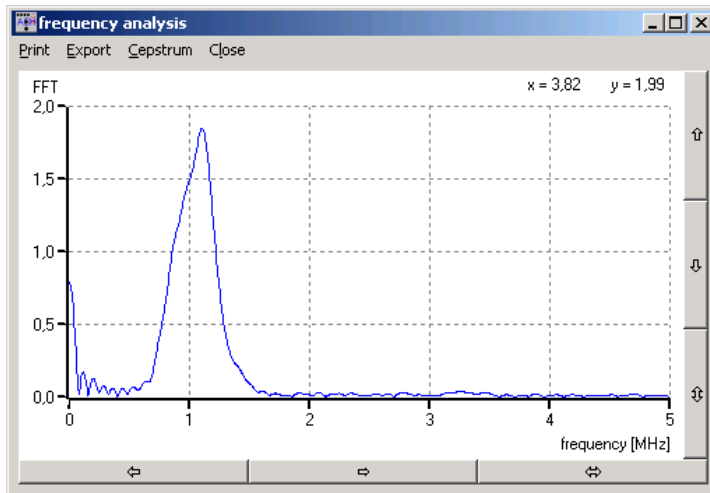
- *When an USB- adapter is recognized his answerback will be checked and shown. Pay attention to use only adapter that are suited to the devices. A scanner adapter works only with the scanner and not with the AScan device and reversely.*

When no connection could be established, it is recommended to go on step by step, especially by using USB adapter:

- o first switch off the devices, take off all data cable and adapter
 - o now connect the adapter without device, USB adapter should be recognized right now
 - o connect device and switch on, refresh connection
 - o when there is a scanner do the same steps with it
- *By use of USB- adapter it can be, that other USB devices are influenced. Especially via the AScan adapter a lot of data will be transferred, so a great part of the USB bandwidth is used.*

3.4. Frequency Analysis

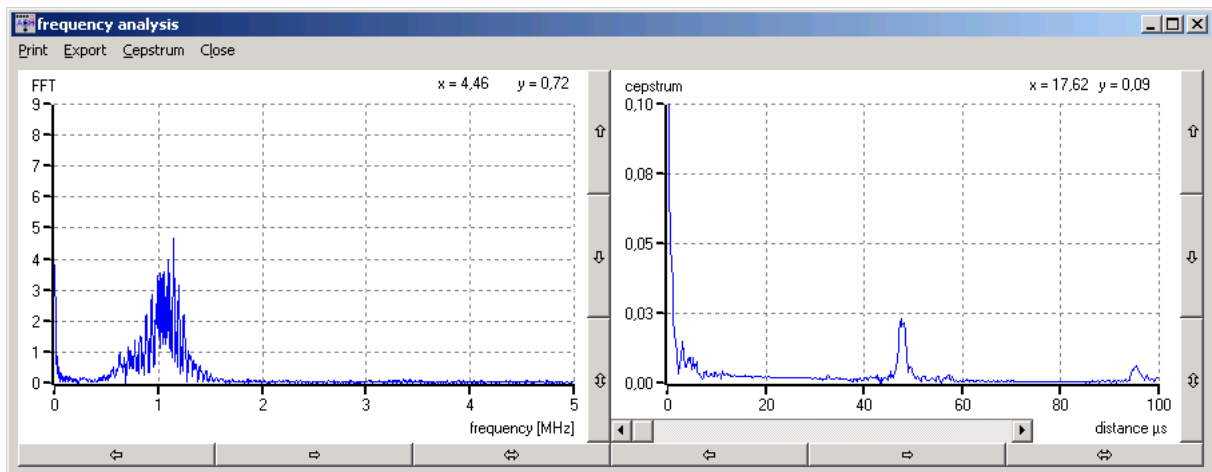
3.4.1. Fast Fourier Transformation



Behind the button **FFT** there is the frequency analysis evaluation. For this the spectrum of the scan line is calculated with help of a F(ast) F(ourier) T(ransformation). For the spectrum calculation only the values between the red and green cursor are used. With it you get an information about the occurring frequencies in the measurement signal. Moving the mouse in the new diagram shows the calculated values at mouse position in the right upper corner.

With the menu item *Cepstrum* in the FFT-window a second diagram will be activated.

3.4.2. Cepstrum



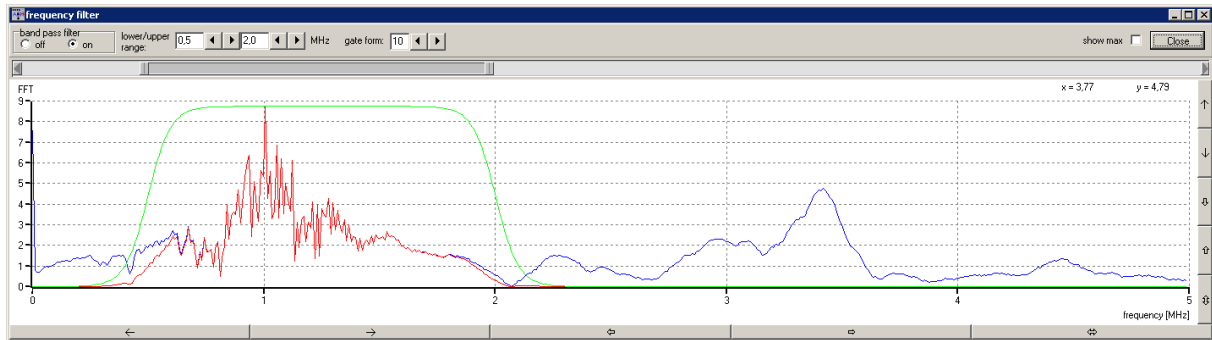
In this second diagram there is once more FFT now with the spectrum data as initial values. With it you get information if there are specified repeating intervals in the spectrum. Such information can be very helpful for evaluation of multiple reflections, i.e. at thin plates.

With the bottom moving bar in the Cepstrum diagram a band pass filter can be adjusted. This one will calculate a back transformation from the Cepstrum- to the FFT-diagram and will be shown as red line (i.e. to smooth the FFT).

The menu *Print* send the form to a printer, with *Export* either the FFT or the cepstrum data will be written to an ASCII (text)-file.

3.4.3. Frequency Filter

When select the button **Filter** in the main screen a new window will be open. With this a frequency band pass filter can be performed, which can affect the data shown in the upper diagram in main screen:



At first the calculated spectrum is displayed as blue line.

- *In contrast to the previous frequency analysis all data of the A-scan line are used for spectrum calculation and not only these between the cursors.*

A range in spectrum is selectable with help of the moving bar above the diagram. The border values of this range are shown as MHz values at the top. The filter can now be activated/deactivated with the choice **off/on**.

When the filter is activated all values outside the range are set to zero, the red line is valid. With help of an inverse FFT this filtered spectrum will be back calculated and the result is shown in the upper diagram of the main screen.

With this filter you can eliminate i.e. disturbing signals with high frequencies. Such or similar filter system are often used in measurement devices.

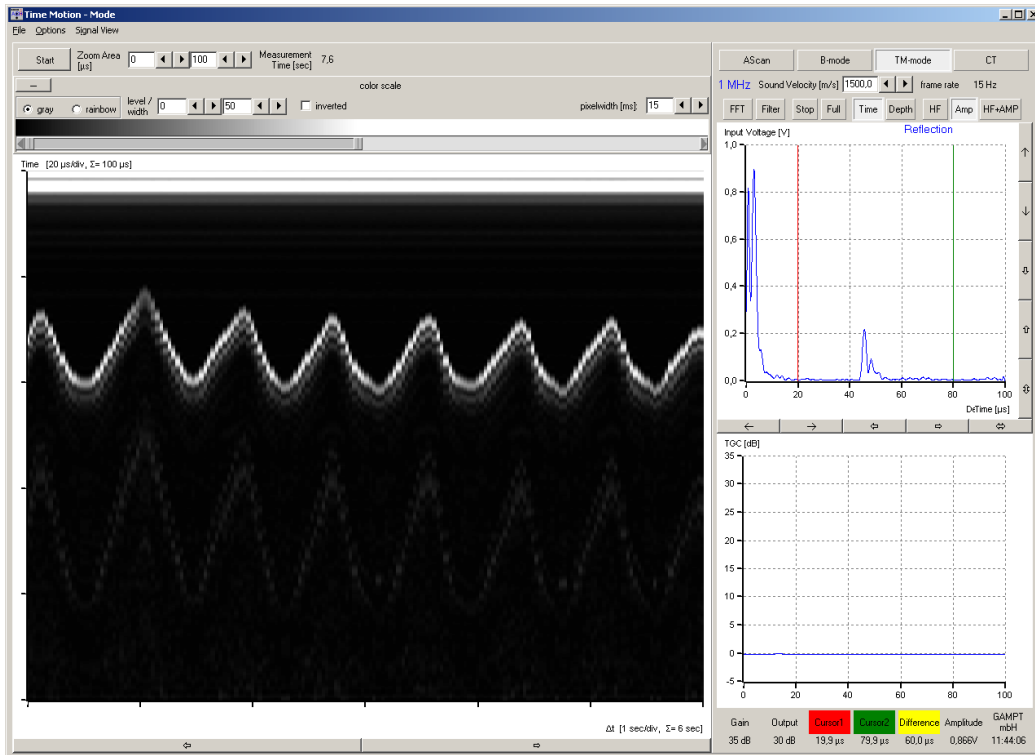
- *To show the frequency filter is activated the button **Filter** in the main screen is coloured red.*
- *The frequency filter affects the shown measurement signal in the main screen. With wrong or senseless parameters of the filter no or not analyzable measurement signal might be shown.*
- *The frequency filter works before the other evaluation on the 'original' signal. That means, when a frequency range was filtered here this range will not be shown i.e. in the FFT-evaluation. This is also valid for the imaging methods (B-, TM- and CT mode)*

3.5. Imaging Methods

With the G^A ^{MPT}-Scan not only the one dimensional display of the data in diagrams can be done, it is also possible to generate two dimensional images. In this chapter 3 imaging methods with the G^A ^{MPT}-Scan are presented.

3.5.1. T(ime) M(otion) Mode

The picture below shows the Time Motion Mode form. On the right side there is a down scaled main screen. Here the respective buttons and functions are also available. With the menu item **Signal View** this display can be deactivated or hidden (by deactivating / hiding the measure display or decrease shown window size the computer reserve calculation time. This can, especially for slower computers, increase the image quality).



With the button **Start** the measure is started. The button display change to **Stop**, the measure is running until this button is pressed.

➤ *All other buttons are inactive during the measurement*

The duration of the measure is documented as measurement time in the upper area. During a measure the actual measured A-scan line is converted to gray scaled values and in the left diagram shown as vertical bar. The y-axis represent the time of flight or depth, the x-axis is a measure for the measurement time. In the Time Motion picture the last time section is shown, the picture above shows the last 6 sec of the measure.

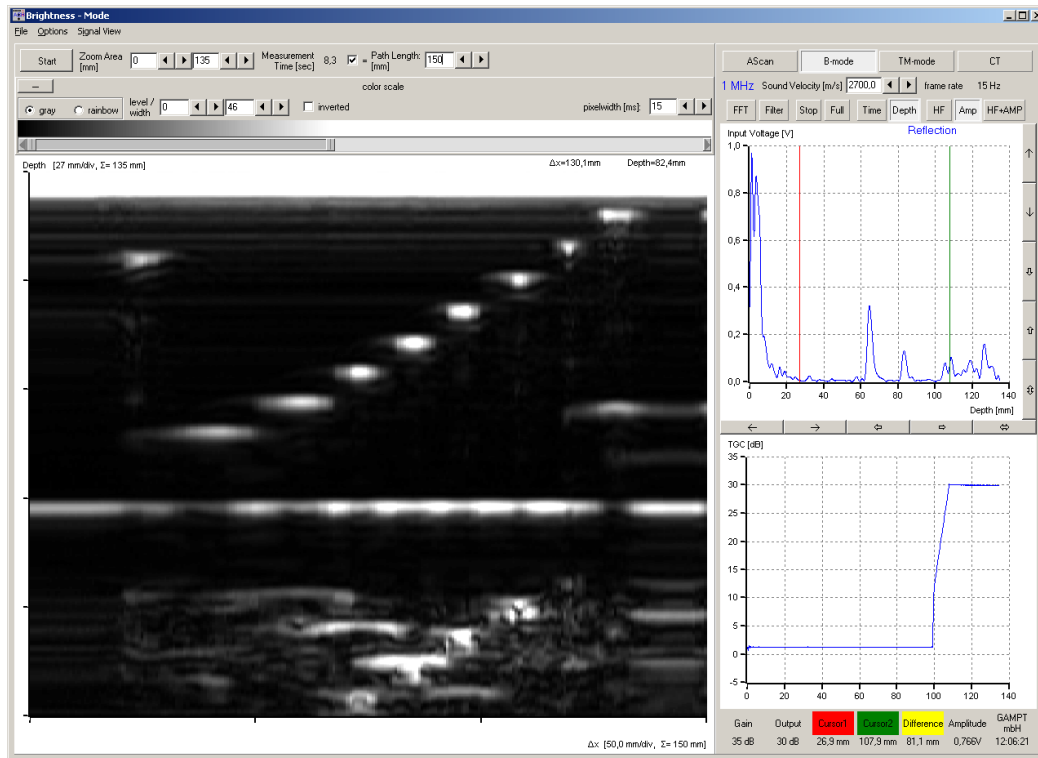
When the measure is finished the picture can be evaluated. Moving the mouse over the picture shows the actual x-y-coordinates above the diagram. The width of the time section can be changed with the arrows under the picture.

With help of the input fields **Zoom Area** it is possible to zoom the picture in y- direction. In the area **color scale** the appearance of the picture can be changed. It is possible to change from gray scale to rainbow coloured display, the contrast can be changed with the moving bar or with the input fields **level/width**

The value **pixelwidth** affects the with of each vertical scan line in the image. Smaller pixelwidth values go to a better x-resolution, but it needs more calculation time. A meaningful value can be estimated with the frame rate value shown in the right AScan window during (!) the measurement.

3.5.2. B(rightness)- Mode

Display and function of the B-mode imaging are similar to the TM-mode.



In the picture above the acrylic test block was measured. For this the probe was put on the surface and constantly moved from one side of the block to the other. The block has a width of 150mm, the measure continued 8,3 sec. In the B-Mode there is a way to assign the measurement time with local coordinates or distances. For this activate the check mark beside measurement time and edit the path length which was measured. Now times on x-axis can be converted into distances.

- *Precondition for this converting from times to distances is, that the scan is done with steady speed. Also start and stop time has to correspond with the passing way. At evaluations with the mouse pointer there can be little differences.*

Both in TM-Mode and B-Mode on y-axis of the image the time of flight is shown. If you switch to depth scale in the down scaled main screen display this will also change the scale in image. For correct image display the correct sound velocity of the sounded material has to be chosen.

- *When there was a scanner connected and recognized from the program (see chapter „Data Transfer“) the B-Mode scan can also be done with it. In this case it is not necessary to convert time to local coordinates, this will be done by the scanner. (for scanner control see chapter „Computer Tomography“)*

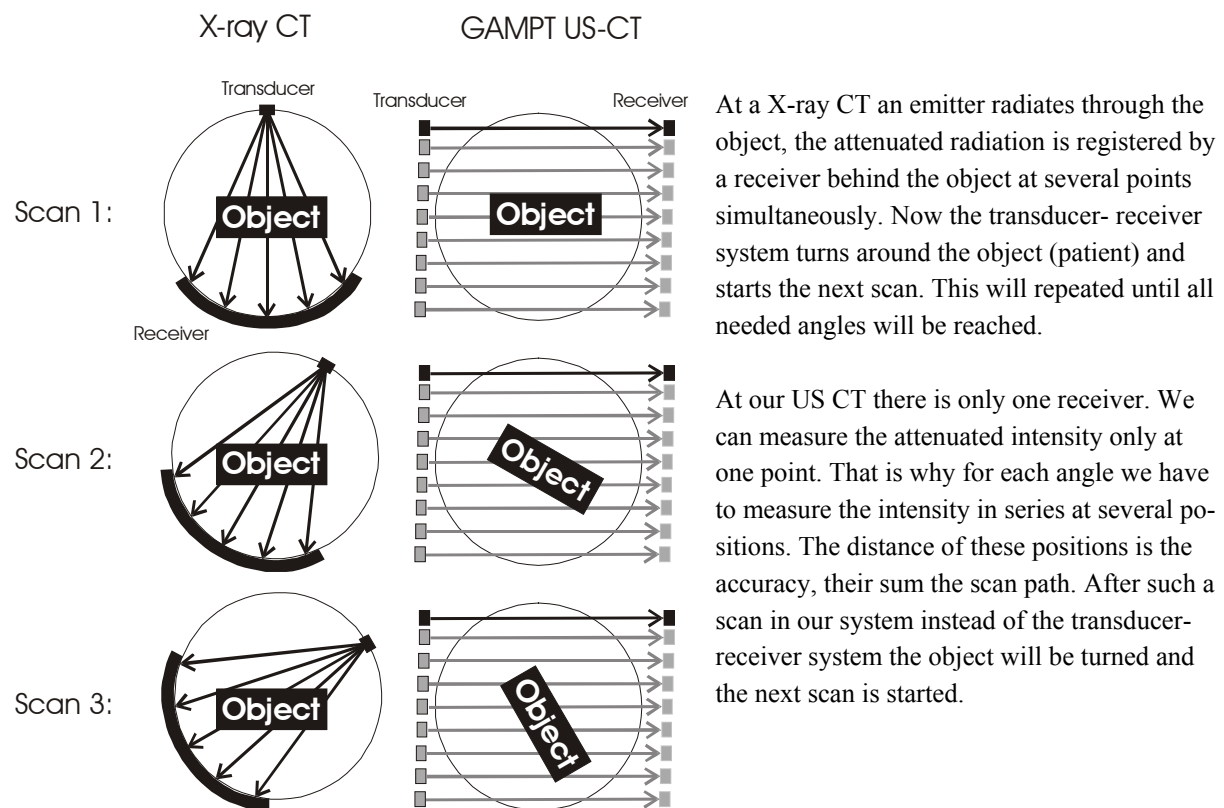
The TGC can be very helpful to emphasize strong attenuated signals from deeper areas. But with wrong adjusted TGC there can also be a image falsification. For this the image above can serve as example. The acrylic block has a height of 80 mm (= depth, because measured from above). All signals from deeper depth (behind the ground echo) are multiple echoes emphasized by TGC.

3.5.3. Computer Tomography

3.5.3.1. Basics

- Surely this chapter is interesting also for users which have no scanner. However the here described measurements can be done only with a scanner and the corresponding control unit.
- In the offline simulation mode the program works also without a connected scanner system.

The following illustration should demonstrate the difference between a 'standard' X-ray CT and the GAMPT ultrasonic CT:



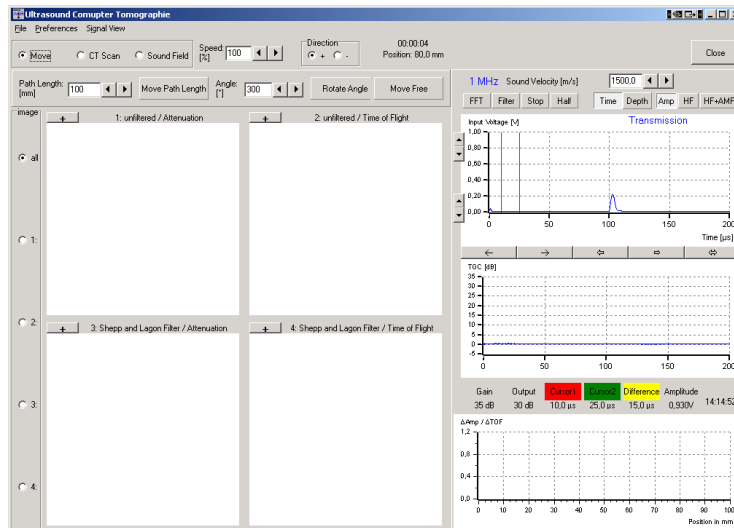
First of all be sure that beside the connection to the $GAMPT$ -Scan also the communication with the scanner works right. (menu item: **Preferences -> Data Transfer**, see also chapter „Data Transfer“)

- It is pointed out that it is possible to work with activated TGC at CT-measurements, but that it can cause unpredictable results. The used CT-algorithm cannot handle different amplification during a measure. It is highly recommended to deactivate the TGC during CT-measurements.

3.5.3.2. Scanner Control

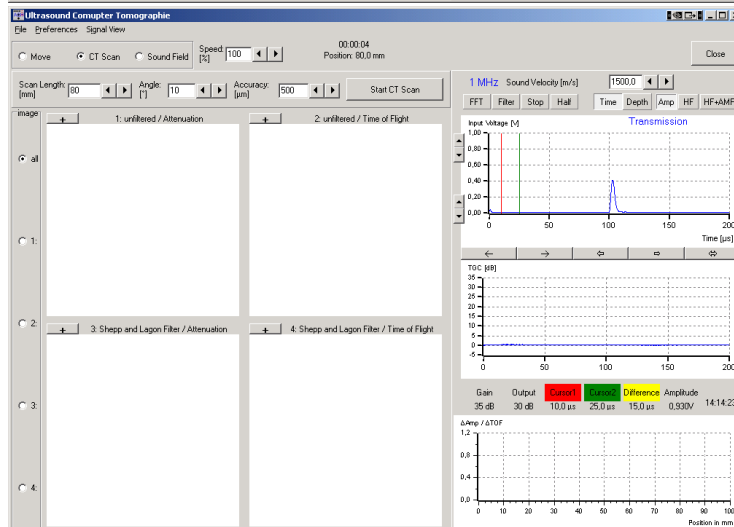
The construction of the form is similar to the B-Mode and TM-Mode. On right side there is the down scaled main screen. Below there is an additional diagram in which during measure the alteration of amplitude signal (red) and time of flight (blue) is shown.

The choice area left above (*Move*, *CT Scan* and *Sound Field*) serves to select an action, respectively to the selected choice the display will change. With *Direction* and *Speed* the movement of the scanner can be controlled (speed is given in percent, whereas 100% is the maximal possible speed).



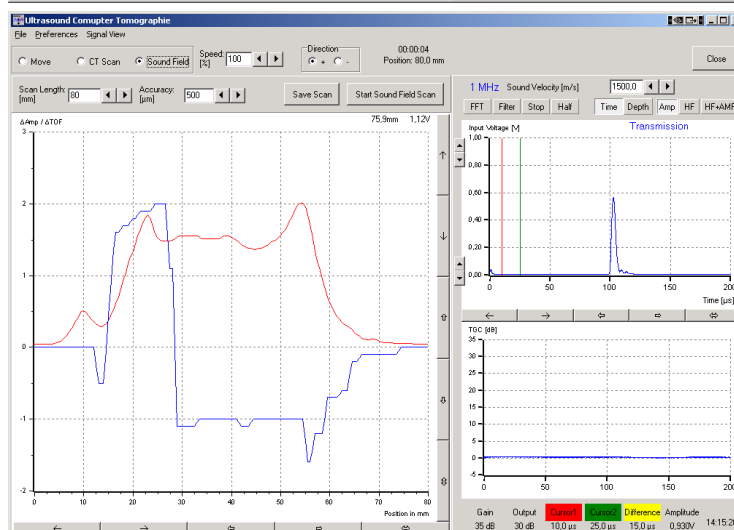
Move:

With it the sledge of CT scanner can be positioned. By pressing **Move Free** the sledge goes into the selected direction until the button is pressed again. With **Move Path Length** the sledge will move by the value given in the input field beside, the button **Rotate Angle** works analogously.



CT Scan:

With *Scan Length* determine the width of the measurement field. It should be always a value, which guarantees, that the object is completely in the field. With *Accuracy* the distance between two measurement points is determined. The number of points per scan is given by $\text{scanlength} / \text{accuracy}$. *Angle* defines how much the object is turning after each scan. The scans will be repeated until 360° is reached or overstepped. **Start CT Scan** starts the measure.



Sound Field:

With it a single scan can be measured. Starting from the actual position *Scan Length* will be moved in steps determined by *Accuracy*. The alteration of amplitude signal (red) and time of flight (blue) are displayed in the diagram. With **Save Scan** the values can be exported into a text file (ASCII-file). By using a hydrophone this mode can be used to measure the sound field of an ultrasonic transducer in lateral or vertical direction.

To get a steady motion of the scanner, it does not stop at each measure point. When the scanner reaches the next measure point the data will be measured ‘on the fly’. When the speed is too high for the selected accuracy, it can be that the scanner reaches the next position before the computer evaluation is ready with the last one. In this case the values are interpolated and as a warning the actual position is shown as red value. (deactivating or hiding the signal view in the down scaled main screen save computer calculation time, it can be helpful for older or slower computer, see menu *SignalView*).

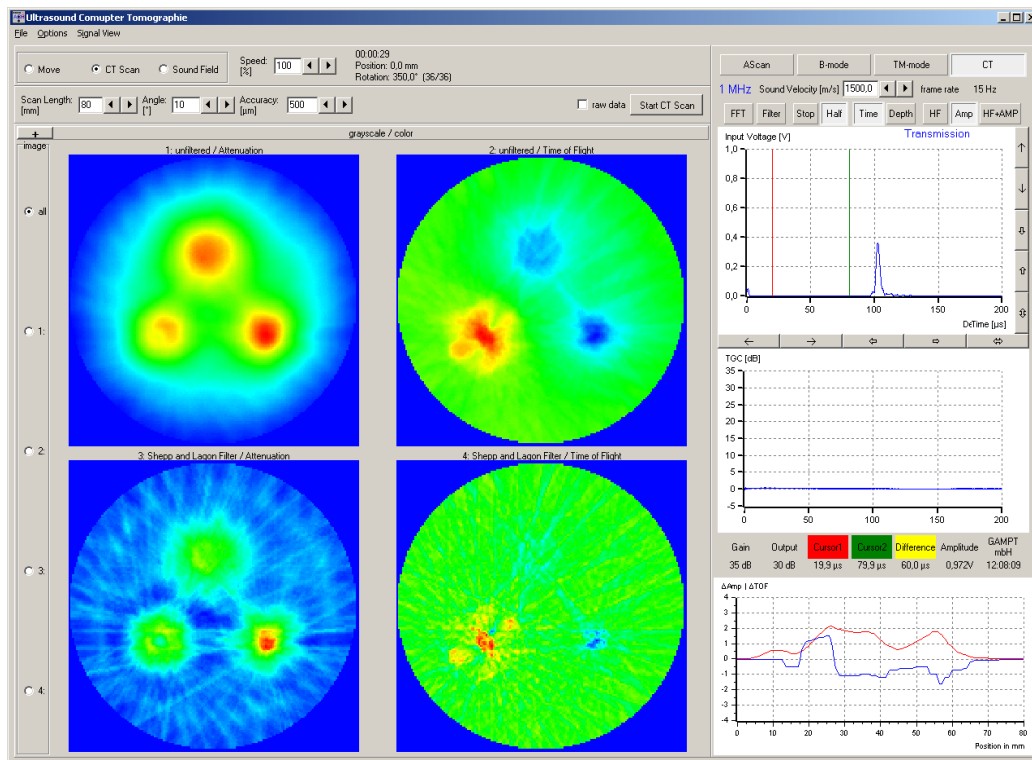
- In simulation mode the values for Path Length, Angle and Accuracy are overwritten by the program and not selectable by the user.

3.5.3.3. Operation Measurement

A measurement is always started in the middle of the object. Are the values for *Scan Length*, *Angle* and *Accuracy* adjusted and the measure was started with **Start CT Scan**, the program demands to move the scanner to the middle of the object. When this not happened until now in the *Move*-mode, the user can do it by using the switches and knobs at the scanner control unit. After this the scanner is moving by $\frac{\text{scan length}}{2}$ in position and starts the first scan.

The respective alteration of amplitude and time of flight in comparison with the first measure point are shown in the diagram right below. The actual position is shown as vertical line. At the same time the position, angle and duration of measure are displayed as values in the upper screen part. With the buttons **Break** / **Continue** a measure can be interrupted, **Cancel** stops the measure.

When a scan for an angle was finished, the measured data will be converted to gray scale values (or rainbow color) and respectively to the angle included into the images on left side. This will repeat after each angle, so the image generation can be observed step by step.



Four images are displayed. The upper two show attenuation and time of flight unfiltered. On the lower two a mathematical filter function was used to increase the contours. In dependence of the basic image an increase of image quality can be reached. By comparison of attenuation and time image additional information about the object can be received.

Through choice all four or only one image can be displayed. A mouse click on above the images direct to the colour scaling explained in B-mode. All four images or the maximised image can be changed.

If the measure is finished the images can be saved by the menu item **File -> Save Images** or the whole form can be printed with **File -> Print Form**.

Recommended parameters for the GAMPT-CT-Phantom:

frequency: 1 MHz
path length: 80 mm,
accuracy: 500 μm
angle : $\leq 15^\circ$

3.5.3.4. CT Data Export

Beside the button **Start CT Scan** there is the choice **raw data**. When this is activated, during the next measure the ΔAmp - und ΔTOF - data (see diagram right down) will be stored. These data serve as basic for image calculation with the CT- algorithm.

When after a measure the images will be saved with menu **File -> Save Images**, then also the raw data of the measure will be saved into ASCII-files using similar names like the images. In the ASCII files each row correspond to a CT scan line, in first column the angle followed by the ΔAmp - or ΔTOF - data for the different positions.

4. Technical Details

A-Scan:

Frequency range:	1 MHz to 5 MHz
Measuring mode:	switchable between pulse echo and transmission modes
Transmitted signal:	Dirac pulse ($<1\mu\text{s}$, 10 V - 300 V)
Transmitter power:	0-30 dB, in 10 dB steps
Gain:	0-35 dB, in 5 dB steps
TGC:	continuously adjustable threshold, rise time and duration, up to 30 dB gain
Connections:	TGC signal, trigger, NF signal, HF signal all via BNC sockets
Computer port:	Sub D-25 socket for LPT, optional USB-adapter
Sampling rate:	10 MHz per channel
Dimensions:	256 x 257 x 156 mm
Main voltage:	100 V - 250 V wide range power supply
Power consumption:	ca. 20 VA

Ultrasound Transducer:

Frequencies:	1 MHz, 2 MHz, 4 MHz
Dimensions:	65 mm x 27 mm \varnothing

CT-Scanner:

Computer port:	control unit via USB
Scan path:	max. 350mm
Lateral accuracy:	1mm
Angle accuracy:	1°

5. Bibliography

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6. Experiments

In the following there is a list with suggestions for experiments, which can be realized with the G^A ^{MPT}-Scan and the respective accessories. You find a description of the setup and experiment in the “**experimental manuals**” of the company GAMPT.

Physical Basics:

- PHY01 Ultrasonic echography (A-scan)
- PHY02 Velocity of ultrasound in solid state material
- PHY03 Attenuation of ultrasound in solid state material
- PHY04 Attenuation of ultrasound in liquids
- PHY05 Spectral investigations
- PHY06 Frequency dependence of resolution power
- PHY07 Shear waves in solid state materials
- PHY08 Ultrasonic B-scan
- PHY09 Ultrasound computer tomography
- PHY10 Characteristic of sound field
- PHY16 Mechanical scan methods
- PHY20 Determination of the focus zone

Industrial Applications:

- IND01 Non Destructive Testing (NDT)
- IND02 Rayleigh waves
- IND03 Level measurement
- IND06 Angle beam measurement
- IND07 Time of flight diffraction technique (TOFD)
- IND08 Detection of discontinuities

Medical Applications:

- MED01 Ultrasonic TM-mode
- MED02 Ultrasonic investigation with the breast dummy
- MED04 Ultrasonic investigation with the eye dummy