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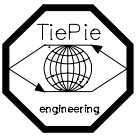
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User manual

WinSoft

Windows software
for

TE6100



TiePie engineering

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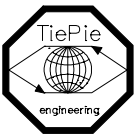
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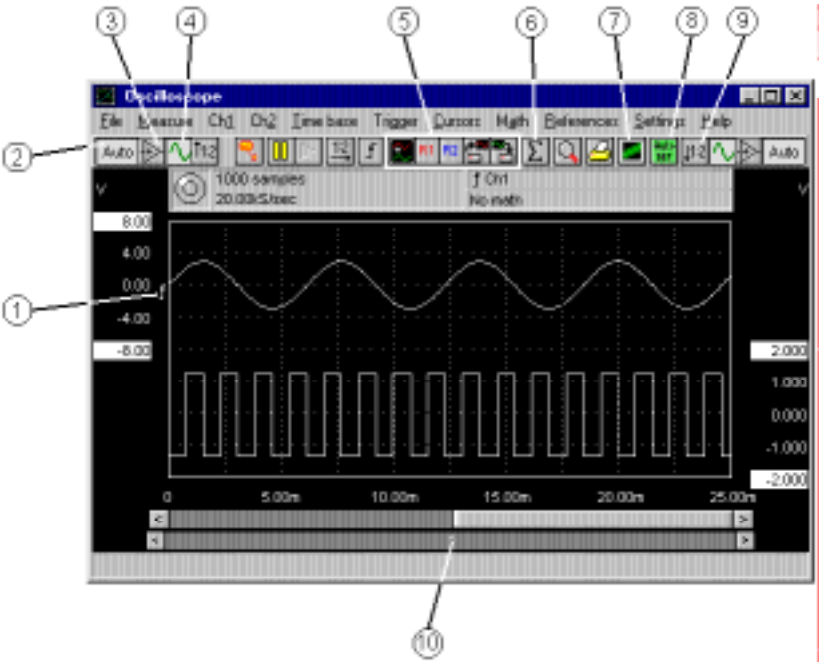
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Introduction

This manual is intended as an add-on for the instrument user manual. The instrument user manual describes the hardware. This manual describes the Windows software.

This manual expects that the reader has a basic knowledge how to control applications running under windows, working with menus in windows applications etc.

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1 Set the trigger level, the trigger hysteresis and the trigger slope by dragging and double clicking. Press the right mouse button and setup the complete trigger system.

2 Toggle auto ranging for channel 1. Press the right mouse button and select an input sensitivity from a menu.

3 Toggle the invert for channel 1

4 Set the signal coupling for channel 1 to AC or DC

5 Copy, show, save and load reference signals

6 Select a math channel

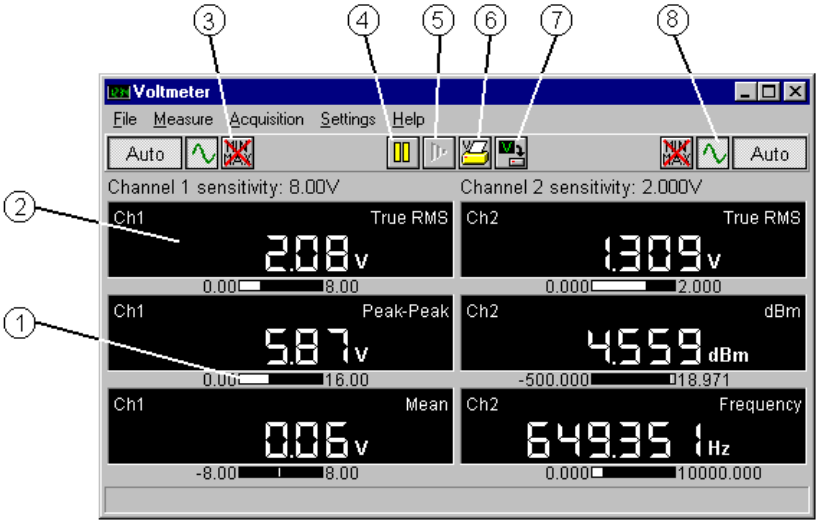
7 Toggle envelope mode

8 With the auto setup the oscilloscope sets itself according the input signal.

9 Switch between a number of pre defined offset and gain settings for channel 2. Press the right mouse button and select the settings from a menu.

10 Adjust the pre trigger point. Press the right mouse button and setup the complete time axis.

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1 The bar graph of display 2 of channel 1, for a quick indication of the signal size.

2 Display 1 of channel 1, press the right mouse button to setup the display.

3 Reset the minimum and maximum values.

4 Stop the measurements with this button.

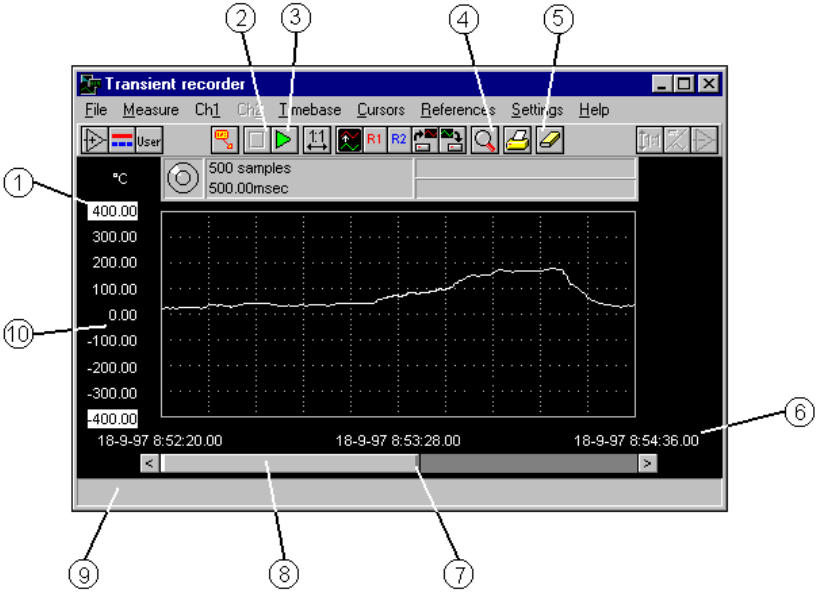
5 Perform a single measurement with this button.

6 Perform a measurement at settable times and send the result to the printer.

7 Perform a measurement at settable times and store the result on disk.

8 Switch the channel 2 signal coupling to AC or DC..

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1 Drag this end of the axis and adjust the gain of channel 1. Press the right mouse button and setup channel 1.

2 With the **Stop** button the transient recorder is stopped.

3 Start a measurement with the transient recorder

4 Zoom in to a specific part of the signal

5 Erase the signal screen.

6 The time axis can display sample times and real time and date. Set this by opening the *Settings* menu. The right mouse buttons allows the complete time base to be set up.

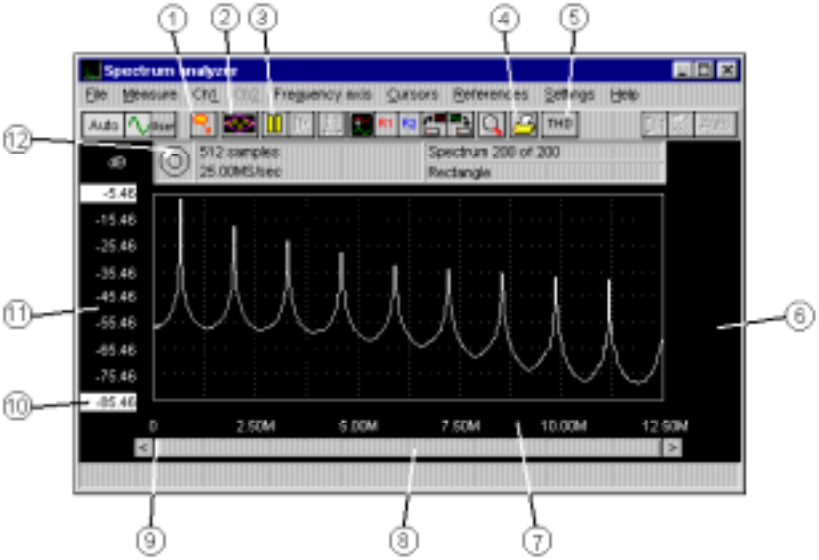
7 Drag this end of the slider and change the horizontal magnification. Press the right mouse button and setup the time base.

8 Drag the slider and adjust the horizontal position of the signal. Press the right mouse button and setup the time base.

9 The hint bar displays explanation of the objects the mouse is placed on.

10 Drag the vertical axis and adjust the vertical position of the signal. Press the right mouse button and setup channel 1.

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1 Press this button to place a comment label in the display

2 Press the **Window** button to seslect a window function for the FFT

3 Stop the continuous measurements

4 Make a hard copy of the current signal

5 Measure the Total Harmonic Distortion

6 Double click here to switch channel 2 on

7 Press the right mouse button to setup the frequency axis

8 Dragging this slider adjusts the horizontal position of the signal. Pressing the right mouse button allows setup of the frequency axis

9 Drag this end of the slider (or the other end) to adjust the horizontal magnification. Press the right mouse button to setup the frequency axis.

10 Drag this label of the axis and adjust the vertical magnification. Press the right mouse button to setup channel 1.

11 Drag the axis and adjust the vertical position of channel 1. Press the right mouse button to setup channel 1.

12 This led indicates whether the input signal is clipped (creates higher harmonics) or not.

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Requirements

To use the Windows software you need:

- an IBM compatible PC/AT with 486 processor or higher (mathematic coprocessor recommended)
- Microsoft Windows 95 or higher
- 4 MB RAM
- 4 MB free harddisk space
- a 3½" high densitiy disk drive
- a mouse or other pointing device

Optional

- a soundcard with wave file playback and/or general midi

Installation guide

After installing the TE6100 card in the rack, Windows will detect a device has been added and come up with a dialog to install drivers for the new device.

Windows suggests to search for drivers for the new device. In the next screen, you can select a specific location, choose that option and select the CDROM drive where you placed the software CD. Then select OK. The proper files will be installed.

When the driver is installed, the software can be installed.

Choose **Start | Run** from the taskbar. Type **R:INSTALL** in the command line text box and choose **Continue.** (R: is used to indicate the CDROM drive, if your CDROM drive has another drive letter, replace R with the appropriate letter)

Now the installation program is started and will ask which language has to be used during the installation. This language will also be set to the default language for the software. Choose **Next** when done.

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Next the destination drive and directory for the software can be selected. Only drives with enough free disk space can be selected. Choose **Next** when done.

If the destination directory already exists, the setup program will ask you whether you want to replace exisiting files. If you choose no, setup returns to the previous step, otherwise setup continues and replaces any existing file in the destination directory.

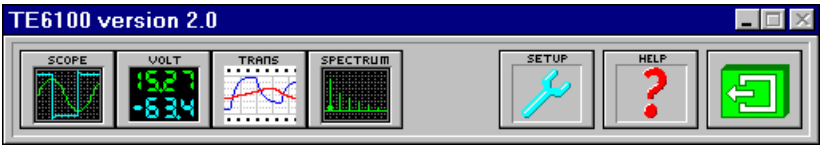
The setup program will now ask you for some default text which will be used on printouts of the instruments. All fields need at least one character. Press **Next** to continue. If some text boxes have no data, pressing the **Next** button will result in a focus on the text box which needs data.

If you have made an error in the destination drive or directory selection or if you have made an error filling out your companies name, address or your name, you could go back by pressing the **Previous** button. Otherwise press the **Next** button to start transfering the program files from the disk to the destination directory. When the program asks you to insert the next disk, please do and press **Ok** to continue, **Cancel** will abort the installation and erase all installed files.

After the installation is done, the readme file will be shown. After reading the file you can Exit the setup program. A program group has been made with icons for the program the readme file and the uninstall program.

Structure of the program

The program is divided into 4 integrated measurement instruments, which are available on the instrument taskbar:



- An oscilloscope
- A true RMS voltmeter
- A transient recorder
- A spectrum analyzer

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If an instrument is not active (instrument button state is up), the instrument can be made active by pressing the left mouse button over the instrument button. If the instrument is active (instrument button state is down) and you press the left mouse button over the instrument button, the instrument will be made inactive and it will hide itself.

If you have 2 or more instruments active, one instrument can be on top of the other. To make the inactive instrument active you can move the currently active window away from the inactive window, so you can select it. However there is a faster way (assuming the taskbar is visible): press the right mouse button over the instrument button.

The other three buttons represent the following:

- The program setup
- The online help
- The exit button

Starting the program

The program can easily be started by using the program group created by the setup program. By double clicking the icon with the same name as the hardware instrument you are using, the program is started.

Now an intro screen will appear with the TiePie logo, the instrument name, the program version number and the copyright notice.

After a few seconds the intro screen disappears and the instrument task bar appears. If in the program setup any instruments are set to be active at power up, these instruments are switched on as well.

Help

For all instruments online help is available by pressing the Help button in the instrument task bar or by pressing the key <F1> in a window.

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Controlling the instruments

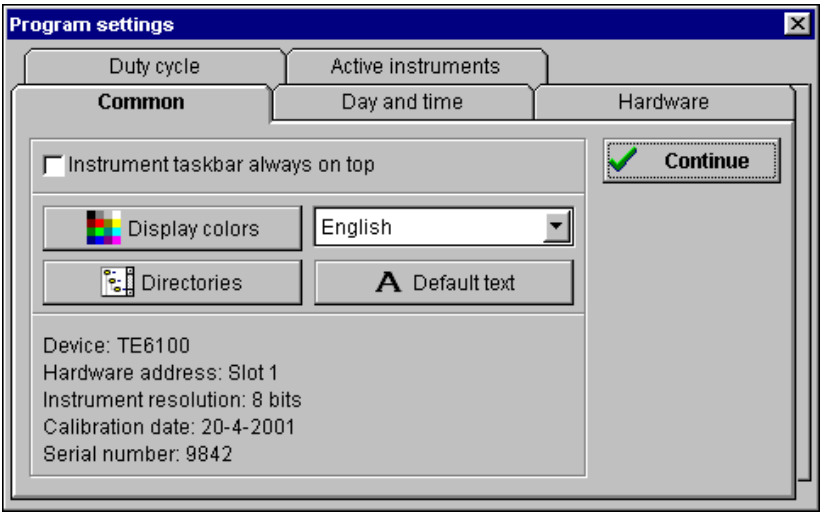
All instruments are controlled by use of the mouse, the keyboard and by menus.

All objects in the instrument windows give acces to the corresponding settings by clicking the right mouse button on the objects. A popup menu will appear in which related settings can be altered.

When the mouse is placed on an object in an instrument window, information about the object is given with "fly over hints" (small rectangles with a few words of text) and some text in the hint bar, at the bottom of the instrument window.

Program setup

Several parts of the program can be set up to your own demands. To change those settings, press the **Setup** button in the instrument task bar. The following dialog will appear:



The dialog contains 5 pages with related settings, the pages can be selected by clicking the tabs. Settings that are made in these pages are saved when the application is closed and restored when the application is star-

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ted again. The positions and sizes of the instrument windows are also saved and restored.

Instrument taskbar always on top

It is possible to let the instrument taskbar appear always on top of the other windows. In that case the instrument taskbar will always be visible . The selection for that is made on the **Common** page, with the **Instrument taskbar always on top** check box.

Setting display colors

The colors of channel 1, channel 2, reference signal 1, reference signal 2, math signal, trigger symbol, timebase, background, grid and cursors can be set to your own preferences. Press the **Display colors** button on the **Common** page and a dialog will appear in which the settings can be made.

Setting the application language

By selecting the language selection pull down on the **Common** page, you can select an other language to be used in the application. The program will instantly switch to the selected language. Also a help file in the selected language will be opened when the Help function is activated.

Setting the location of files

By pressing the **Directories** button on the Common page, it is possible to set the directories for the files the program works with. A popup menu will appear. From this menu you can select a directory which you wish to change. After selecting a directory, an input dialog appears in which you can enter the name for directory.

Default text on the printer output

It is possible to add three lines of text to the application. These lines of text will be placed on every printout. They are placed on the upper left corner of the printout. Enter here e.g. the company address, employee name, telephone number etc.

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To enter the text, click the button **Default text** on the **Common page** and an input dialog will appear.

The three lines of text can be entered here. To switch between the three lines, use the <**Tab**> key or click with the mouse in the requested line.

This text is saved when the application is closed and loaded when the application is started.

Device info

In the lower part of the **Common** page some device info is given. Information that is displayed is:

- The hardware device
- The address where the hardware is found
- The resolution of the hardware

Depending on the hardware device some extra info can be displayed:

- The date of the last calibration
- The serial number

Setting the date and time style

At several places in the program dates and/or times are displayed. The way they are displayed can be set at the **date and time** page. For both the date and the time several styles are available to select from.

Manually adjusting of calibration factors

By selecting the **Adjust cal. values** button at the **Hardware** page, a dialog appears in which the current calibration values of the instrument can be changed.

The dialog has a grid in which for both channels the gain and offset calibration values can be adjusted. On the right are the following buttons:

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Continue	The currently displayed values are set as the calibration values to use. Loading of a calibration file at start-up will be disabled.
Cancel	All changes (including the applied) are ignored and the calibration values which were used prior to pressing the **adjust cal. values** button are restored.
Load values	A file dialog is presented in which a file can be selected with calibration values, which has to be loaded and displayed in the grid.
Save values	A file dialog is presented in which a filename can be typed or selected to which the values currently displayed in the grid can be saved.
Apply	Sets the current grid values as the calibration values to use. A one shot is done so the result is displayed. The apply is not permanent until the **Continue** button is pressed.

Restore factory calibration factors

The TE6100 has a set of calibration factors in EEPROM which are read at power up of the software. If the calibation factors are altered manually, the original values can be restored by pressing the **Restore factory cal.** button.

If loading a calibration file at startup is enabled, this will be disabled by pressing the **Restore factory cal.** button.

Loading a set of calibration values at start up

When a specific set of calibration values is made, it can be stored on disk. To use this file of calibration values at power up, place a check mark in the **Use cal. file** check box at the **Hardware** page. If no file name was selected yet, a file open dialog will appear in which a file with calibration values can be selected. If an illegal file is selected or cancel is pressed the check box will be untagged.

Pressing the **Restore factory cal.** button will override the values from the file.

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When loading calibration values from a file is enabled and a different file has to be loaded, this file can be selected by pressing the **Change cal. file** button at the **Hardware** page. If cancel is pressed or an illegal file is selected, no changes are made to the current selected calibration file.

Selecting the type of duty cycle

The software can use two different types of duty cycle calculation:

- The normal duty cycle setting displays the percentage of which the period is high.
- The inverted duty cycle setting displays the percentage of which the period is low.

Selection can be made on the **Duty cycle** page, by selecting one of the two radio buttons. The pictures next to the radio buttons display the two types in a graphical way.

Active instruments at start up

At the **Active instruments** page a selection can be made which instruments have to be switched on at start up of the software.

Place a check in the check boxes of the instruments that have to be switched on at start up of the software.



Note The Transient recorder can not be activated at the same time as one of the other instruments.

When at least one instrument is selected, it is possible to select a settings file that has to be loaded at start up as well. Each single instrument can have its own settings file.

Selection of the file is done by pressing the **Change file name** button on the **Active instruments** page. In the appearing dialog the file can be selected. The name of the selected file will be displayed in the **Instrument settings file** box.

To clear the file name, press the **Clear** button.

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Note When more than one instrument is selected to be switched on at start up, the settings file ascociated with the instrument with the highest 'priority' will be loaded. The priorities in file loading are: highest: the transient recorder, then the oscilloscope, then the voltmeter and lowest the spectrum analyzer.

Saving instrument settings on disk

When a certain kind of measurement is done often, it is useful to save the instrument setting on disk and restore it each time it is needed. This will avoid each time setting up the instrument in the same way.

To save the instrument setting to disk, enter the *File* menu from the oscilloscope, the transient recorder or the spectrum analyzer and select *Save instrument setting...*. A save dialog will appear in which a drive and directory can be selected and a name for the setting can be entered.

If an invalid file name or a name of an existing file name is entered, a warning will be displayed.

The settings for all instruments are saved in one file. This file has the extension .SET. It is an ASCII file, in a Windows INI format.



Note This file can be edited in any ASCII editor, but it is recommended not to do so, to avoid invalid (combinations of) settings.

Restore instrument settings from disk

When a certain kind of measurement is done often, it is useful to save the instrument setting on disk and restore it each time it is needed. This will avoid each time setting up the instrument in the same way.

To restore instrument settings from disk, enter the *File* menu in the oscilloscope, transient recorder or spectrum analyzer and select the *Restore instrument settings...* item. A restore dialog will appear in which a drive, a directory and a file name can be selected.

After pressing the **OK** button the file is loaded and all instruments are set according the settings in the file.

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Storing measurement data on disk

To save measured data for later examination, it can be stored on disk. This can be done in two ways: by activating the *Write waveform to disk...* item from the *File* menu in the oscilloscope, transient recorder or spectrum analyzer or by clicking the **Write waveform** button ().



Note The voltmeter has a completely different way of storing measurement data to disk. This will be discussed in the chapter voltmeter.

Both ways will bring a save dialog in which the drive, the directory and the filename can be entered. When a name is entered and the OK button is pressed, all waveforms will be saved, together with the settings of the instrument and the references. Three files are written:

a file with the extension **.DAT,** containing the waveform data of both channels and both references
a file with the extension **.GEG**, containing the instrument settings
a file with the extension **.REF**, containing the reference channels settings

The files containing the settings are ASCII files, with a windows INI file structure. The .DAT file can be either binary or in ASCII.

When the file already exists, a warning will be given. When the disk is full, the file will not be written and an error will be put on the screen.

Setting the data file type

The waveform data can be stored in a binary and in an ASCII format.

The binary format is built of records of 8 bytes large. The first two bytes are for channel 1, bytes 3 and 4 are for channel 2, bytes 5 and 6 are for reference 1 and bytes 7 and 8 are for reference 2. The two bytes for each channel form a 16 bits value, where 0 represents -sensitivity and 65535 represents +sensitivity.

The ASCII format exists of one line of information for each sample in the record. Each line exists of:

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the sample number, related to the trigger point (sample number 0)
the sample time, related to the trigger point (t=0)
the voltage value for channel 1
the voltage value for channel 2
the voltage value for reference 1
the voltage value for reference 2

The items are separated by commas.

The ASCII files can simply be imported in other applications, like e.g. spread sheet programs.

Files in ASCII format are much larger than files in binary format, up to 7 times.

To set the file type, enter the *File* menu and select the item *Data file type*. Choose the requested setting from the menu.

Loading saved measurement data from disk

Previously saved waveforms can be read from disk in the oscilloscope, transient recorder and the spectrum analyzer. There are two ways to do this: by activating the *Read waveform from disk* item from the *File* menu or by clicking the **Read waveform** button ().

Both ways will bring up a load dialog in which a drive, directory and file can be selected. When a file is selected and the OK button is pressed, the waveform will be read from disk.

Each waveform consists of three files: a .DAT file, a .GEG file and a .REF file. If one of these files is missing or the waveform data is not compatible, an error is generated.

The data file type in which the data is written will be determined by the software and the correct reading functions are used.

Then the data is read according to the Waveform read method that is set.

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After reading the data, the instrument is set to Pause (not required in the Transient recorder) to avoid the data being replaced by new measured data.



Note Measurement data stored in the voltmeter can be read in the oscilloscope and the transient recorder.
The values of display 1 of channel 1 will be placed in channel 1 of the transient recorder.
The values of display 2 of channel 1 will be placed in Reference 1 of the transient recorder.
The values of display 1 of channel 2 will be placed in channel 2 of the transient recorder.
The values of display 2 of channel 2 will be placed in Reference 2 of the transient recorder.

Setting the Waveform read method

When a waveform is written to disk, all four channels (Ch1, Ch2, Reference 1 and Reference 2) are written to disk.

There are two methods to read waveforms from disk:

Read all signals in file

With this method all signals that were active when the waveform was written are read. If e.g. Ch1 and Reference 2 were active when the waveforms were saved, Ch1 and Reference 2 are read. the data in Ch2 and Reference 1 will remain unchanged. Ch1 and Reference 2 will be switched on and Ch2 and Reference 1 will be switched off.

Only read current displayed signals

With this method only the currently active channels are read from the waveform file. The other channels will remain unchanged and they will remain switched off.

To select the proper waveform read method, enter the *File* menu, select the *Waveform read method* item and select the correct method. When closing the application, the selected method is saved in the application settings file. This file is always read when starting the application.

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Comparing signals using the reference channels

To be able to compare live signals to other signals, the oscilloscope, the transient recorder and the spectrum analyzer have two reference channels, R1 and R2. R1 is a reference channel for channel 1 and R2 is a reference channel for channel 2. These reference channels are filled once and remain unchanged while measuring. The references only change when new data is stored in the references.

Fill the references

To fill the reference channel(s), two ways are available: copying the current displayed signals to the reference channels or read previously saved waveform data from disk.

To copy the current live signals to the reference channels, either press the correspronding button on the speed button tool bar () or select the item *Copy live to refs* from the *References* menu. This will copy the waveform data from the active channel(s) to the corresponding reference channel(s). The settings of the channel(s) will also be copied to a special reference setting. If the reference channel(s) was(were) not yet displayed, it is (they are) switched on as well.

To fill a reference channel with data from disk, see the paragraph on Loading saved measurement data from disk.

The data in the reference channels will remain unchanged until new data is stored in the reference channels. The reference channels are displayed with the same record view offset and record view gain as the live channels. Changing the pre trigger value will not affect the reference channels. When the record length of the live channels is changed to a shorter record after filling the reference channels, less data of the reference channels is displayed, but the data is kept in memory. When the record length is changed to a longer record, the part of the reference channel that was not filled, is filled with zeroes.

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Switching references on or off

Switching a reference channel on or off can be done by selecting the item *Display Refx* from the *Reference* menu, where x stands for 1 or 2. It can also be done by means of a button on the speed button tool bar:  for reference 1 and  for reference 2. When a button appears to be pressed, the corresponding reference is switched on.

Scaling references

When a reference channel is filled, the data remains the same until new data is stored in the reference channel. When the input sensitivity, the software offset or the software gain for the corrsponding channel changes, the reference channel will not change.

It can be useful that when a signal is copied to a reference channel to compare live measurements with that reference channel, that the settings of the reference channel will follow the settings of the live channel. So when e.g. the input sensitivity of the live channel changes, the reference channel is scaled in such a way that the live channel and the reference channel can still be compared on a 1:1 base.

To do that, select the item *Scale references* from the *Reference* menu. Any change of the input sensitivity, the software offset or the software gain of a channel will also be applied to the reference channel. When scaling references is switched on, a check mark is placed in the menu item.

To switch Scaling references off, select the *Scale references* item again.

Update reference comment

When a measurement is taken, three lines of comment text can be added to the measurement. This text is saved to disk together with the waveform data and printed out with the waveform. (See Add comment text to a measurement)

When the reference channels are filled with data from a file and the comment text has to be changed, this can be done using the item *Update*

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comments ... from the *Reference* menu. After activating the item, a dialog appears in which the three lines of text can be entered / changed. When the dialog is closed with the **OK** button, the new text is automatically saved to disk.

Documentation of measurements

In the oscilloscope, the transient recorder and the spectrum analyzer several features are available to document measurement data.

Add comment text to a measurement

For explanation and documentation, each measurement can be supplied with three lines of text.

This text will be saved together with the waveform data when the waveform is written to disk. The text will also appear on a hardcopy printout.

To enter the text, open the *Settings* menu and select the item *Comment...* A dialog appears in which the three lines of text can be typed. To switch between the three lines, use the mouse or the <**Tab**> key.



Note The text remains the same until new text is entered or the lines are cleared. So when text is entered and more than one waveforms is saved or printed, each waveform will have the same comment.

Place a comment label

When documenting a measurement, it can be useful to add some comment to a specific part of the signal. This can be done with the special comment labels.

These comment labels are placed within the signal display at a specific position in relation to the waveform. The comment labels contain text and can have an arrow pointing at a specific point of the waveform. The shape, the colors and the arrow can all be customised to your specific wishes. When printing the measurement, the comment labels are placed

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as well. To place a comment label, press the **comment label** button () or activate the *Add a comment label* item from the *Settings* menu.

The comment label is now placed within the signal display. It can be dragged to any position with the mouse and the arrow can be dragged to any position as well. The comment labels are waveform based, when the record view offset or the record view gain changes, the position of the comment label remains the same in relation to the record.

Edit a comment label

To change the properties of a comment label, place the mouse pointer on the comment label or the arrow of the comment label and press the right mouse button. A menu will pop up in which all properties can be edited.

Comment text...

With this item the text in the comment label can be edited. An input dialog with a text input box appears after activating. Enter the text for the comment label in the input box. Multiple lines can be entered and will appear in the comment label as they appear in the text input box.

Comment shape

With this item the shape of the comment label can be selected. Three choices are available: a rectangular shape, a rectangular shape with rounded corners and an ellipse shape.

Draw arrow

With this item the arrow can be switched on or off. When the arrow is switched on, a check mark is placed in front of the menu item.

Arrow point shape

The arrow point can have different shapes: no point at all, a square, a circle, a triangle and an arrow. When no point is selected, only a line from the comment label to the end point of the arrow is drawn. When the arrow point is selected, a triangle is drawn that is always pointing away from the comment label. When Draw

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arrow is switched off, this item is not available.

Comment colors

With this choice the foreground color and the background color of the comment label and the arrow can be selected. The foreground color is used for the line around the comment label, for the text, for the arrow and for the line around the arrow point. The background color is used to fill the comment label and the arrow point.

Deleting a comment label

To delete a comment label, place the mouse cursor on the comment label to delete and press the right mouse button. A menu will pop up. Select the *Delete comment* item to delete the comment label.

Make a hard copy print out

To save a measurement on paper, a WYSIWYG hardcopy utility is added.

The printout contains all active signals with the settings at the moment of activating the hardcopy function. All relevant information about the signals (sensitivity, offsets, gains, sampling frequency, record length etc.) are placed around the signal display.

A record view indicator is placed in the upper right corner of the printout, indicating which part of the measured record is displayed, where the trigger point is located and where the cursors are located in the record (if switched on).

If cursors are switched on, the cursors are drawn (when in the display) and a table with the cursor readout is drawn.

If comment labels are placed, they are printed in the same way as they appear on the screen.

The hardcopy can be activated in three ways: using the key combination <Ctrl+P>, using the **print** button () or by entering the *File* menu

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and selecting the *Print...* item.

A print dialog appears in which the current selected printer is indicated. To change the selected printer or the settings of the selected printer, press the **Setup** button. A new dialog appears in which another printer can be selected or the settings of the current printer can be changed.



Note In theory all paper sizes are supported, but envelope paper sizes will give unusable results.
Selecting landscape or portrait has no use, since the hardcopy function forces landscape.

When the correct printer is selected and all settings are made, press the **OK** button to leave the dialog. Press the **Cancel** button to leave the dialog without changes.

The check box **Color print out** determines whether a color printout is made or a black and white printout is made. When this box is checked and the printer supports colors, a color printout is made. If the printer does not support colors, different shades of gray are created (by the windows printer driver). If the box is not checked, only black is used.

For easy identifying the signals, the signals can be printed with small markers in each signal, for each signal a different marker. The check box **Print markers** enables this function.

With the **Preview** button a preview of the print out can be viewed on the computer display.

To start printing now, press the **Print** button. A dialog appears, indicating that the hardcopy is generated and sent to the printer.

Ending the program

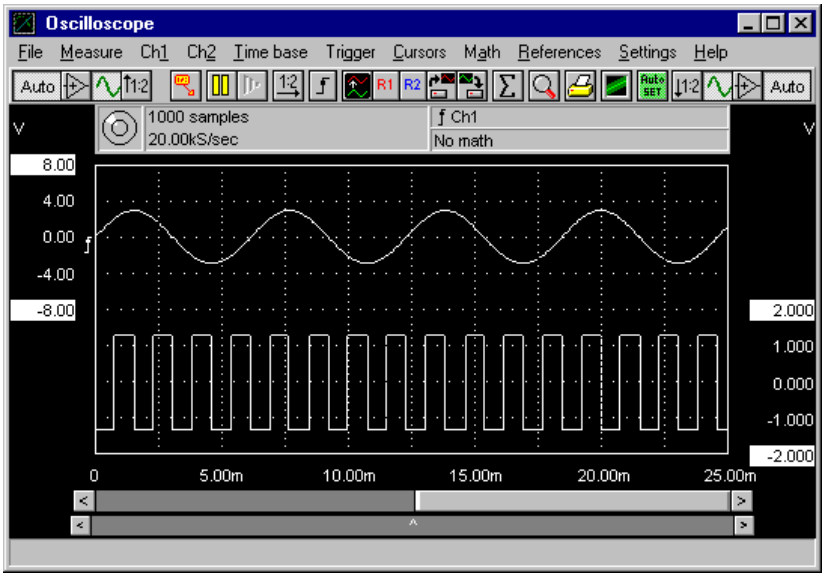
With the right most button in the instrument taskbar the application can be terminated. The application settings and instrument window positions are saved on disk.

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The oscilloscope is an instrument with which electrical voltages varying in time can be displayed. With the oscilloscope time dependent electrical signals can be examined easily.

The oscilloscope has separated voltage inputs, channels, which can be configured individually. It is a digital sampling oscilloscope. That means that the oscilloscope takes samples at fixed times. From each sample the value is determined and the size is displayed at the screen. The screen is filled with all samples. Between two adjacent samples on the screen a line is drawn. The speed at which the samples are taken, is adjustable.

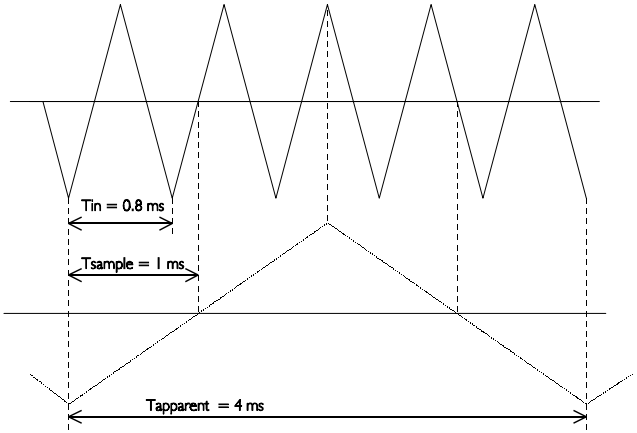
Cursors are available to perform voltage, time or frequency measurements on the displayed signal.



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A disadvantage of digital sampling oscilloscopes is the fact that aliasing can occur.

Aliasing occurs when a too low and therefor wrong sampling frequency is used. The next illustration shows how aliasing occurs.



The input signal is a triangular signal with a frequency of 1.25 kHz (upper most in the illustration). The signal is sampled at a frquency of 1 kHz. The dotted signal is the result of the reconstruction. From that triangular signal the periodical time is 4 ms, which corresponds with an apparent frequency (alias) of 250 Hz (1.25 kHz - 1 kHz).

To avoid aliasing, the sample frequency must be greater than 2 times the maximum frequency of the input signal.

If you have any doubts about the displayed signal, you can set the timebase of the oscilloscope one step faster or slower and check whether the signal at the display changes accordingly. If that does not give any clearance, you can determine the frequency of the input signal with the spectrum analyzer. Therefore you must set the frequency range of the spectrum analyzer to the maximum, to avoid aliasing with the spectrum analyzer. For more information, see the chapter Spectrum Analyzer

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Displaying channels

The oscilloscope has several modes to display the two channels. To select the measure mode, enter the *Measure* menu and select:

Ch1	measure and display only channel 1
Ch2	measure and display only channel 2
Ch1 and Ch2	measure channel 1 and channel 2 simultaneously and display the values of both channels

Note When measure mode Ch1 and Ch2 is selected, the highest sampling frequency will be disabled.

Note When the measure mode Ch1 and Ch2 is selected, displaying math signals becomes available.

When only one channel is measured, the controls of the other channel are disabled or removed from the display.

Envelope mode

When a signal is monitored and a glitch is expected, envelope mode can be switched on to be sure to see the glitch. In envelope mode, for each sample in the record a highest value and a lowest value is stored. Each measurement is checked whether the new value lies between the previous highest and lowest or not. If not, the highest or lowest value is changed to the new value. Then a vertical line is drawn between the lowest and highest value. So a glitch is always captured.

Envelope mode is reset each time when the setting of the instrument changes (sensitivity, offset, record length etc.), when the window size changes and when the pre defined reset number is reached. To set the reset number, enter the *Envelope* menu, which can be found in the *Measure* menu or by clicking the right mouse button on the **Envelope** mode button (). Select the item *Reset envelope after* and a menu with the possible option pops up. When the choice *32 measurements* is selected, envelope mode will be reset after 32 measurements. When the choice *infinite measurements* is selected, envelope mode will not be reset automatically, only by changes in the instrument settings or by a window size change.

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Envelope mode can be switched on by clicking the envelope button, by pressing the <E> key or be selecting the item *Envelope mode* from the *Measure* menu. When envelope mode is switched on, the **Envelope** button stays down.

Envelope mode is switched off by pressing the button again, pressing the <E> key again or by selecting the Envelope mode menu item again.



Note Envelope mode is only a display function. The envelope signal is not stored to disk or printed in a hardcopy operation.

Averaging

When a noisy signal is measured, the influence of the noise can be eliminated by averaging several measurements. The noise component(s) will disappear and the actual signal remains.

Averaging can be switched on by selecting the item *Perform averaging of* from the *Measure* menu. In the next menu a number of measurements can be selected that have to be averaged. The item */ measurement* will switch off averaging. Averaging can also be switched on or off by pressing the **Averaging** button ().

When averaging is set to e.g. 20 measurements and the oscilloscope is set to Pause, presing the One shot button will result in taking 20 measurements which are averaged

Averaging is reset each time when the setting of the instrument hardware changes (sensitivity, coupling, sampling frequency, record length etc.) and when the pre defined reset number is reached.



Note When a number of pre samples is set, averaging will have a large effect on the shape of the signal in the pre samples because this part of the measured record changes much.

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Math mode

The oscilloscope is equipped with a special Math channel. This channel can display the following signals:

Ch1 + Ch2
Ch1 - Ch2
Ch2 - Ch1

These are display added or subtracted signals. This means that the on screen signal sizes are added or subtracted. The position and size of the math signal can be controlled by the software offset and software gain of both channels.

To get a math channel, both channels have to be on. Selecting a math channel is done by selecting a menu item from the *Math* menu. The *Math* menu can be found in the main menu or can be called by clicking the **math** button (Σ).



Hint When the oscilloscope operates in split screen mode and ch1 uses the upper half of the screen and ch2 uses the lower half of the screen, the math channel comes in the center of the screen.

The math channel can be switched off again by selecting the item *No math* from the *Math* menu.

Setting up a channel

The two channels of the oscilloscope are completely configurable. Both channels are identical, each has its own menu item in the main menu. Since the possibilities for both channels are equal, channel 1 is explained here. Where channel 1 is described, the same applies to channel 2.

With the menu item *Ch1* (or *Ch2*) from the main menu a popup menu is called with all settings for a channel.

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Setting the sensitivity of a channel

The input sensitivity of a channel determines how large a certain signal will be displayed, the lower the full scale value, the larger the signal will be displayed. It is also possible to enable an autoranging function.

The sensitivity can be set through the *Sensitivity* menu. The *Sensitivity* menu is called by enabling the *Ch1* menu and then selecting the *Sensitivity* menu. In this menu the input sensitivities are available. Also an Autoranging setting is available. The *Sensitivity* menu can also be entered by clicking the right mouse button over one of the Ch1 or Ch2 controls and readouts.

To switch on Autoranging, a special button is available. When auto ranging is switched on, the button caption is **Auto**, otherwise it holds the current set input sensitivity. Pressing the right mouse button on this button will bring up a menu with all sensitivities.



Note When autoranging is switched on, several measurements might be needed to set the input sensitivity, depending on the input signal.

Another way to set the sensitivity is by using the keyboard. A few keys have been reserved for setting the input sensitivity of the channels. These keys are:

<F5>	Increase Ch1 sensitivity
<F6>	Decrease Ch1 sensitivity
<F7>	Increase Ch2 sensitivity
<F8>	Decrease Ch2 sensitivity

Setting the signal coupling of a channel

The input signal can be coupled directly to the ADC (DC) or through a capacitor to the ADC (AC). In the hardware, a capacitor is switched into (AC) or out of (DC) the signal path.

In COUPLING DC the complete signal (AC+DC) at the input is passed through. In COUPLING AC only the AC component of the input signal is passed through. It is then possible to examine e.g. a ±20 mV ripple on a

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30 V DC voltage, since only the ripple is passed through and the DC voltage not. AC voltages with a frequency lower than ±4 Hz are not coupled correctly.

There are three different ways to set the coupling. Two ways are: by clicking the coupling button or by pressing keys. The third way is through the *Signal coupling* menu.

The *Signal coupling* menu is called by enabling the *Ch1* menu and then selecting the *Signal coupling* menu. In this menu the settings *Coupling AC* and *Coupling DC* can be found. The menu can also be entered by clicking the right mouse button over one of the Ch1 or Ch2 controls and readouts.

In the tool bar for each channel a coupling button is found, the coupling button for Ch1 at the left hand side of the screen, for Ch2 at the right hand side of the screen. The picture at the button indicates the state of the coupling setting. The left button of the two buttons below is indicating AC coupling, the right button is indicating DC coupling.



The current coupling state is displayed in the coupling button.

The keys which can be used to change the signal coupling are:

<A>	sets the coupling of channel 1 to AC
<D>	sets the coupling of channel 1 to DC
<Shift+A>	sets the coupling of channel 2 to AC
<Shift+D>	sets the coupling of channel 2 to DC

Setting the vertical position of a channel

The vertical position of a channel on the screen is adjustable in two ways: a hardware method and a software method.

Using the hardware method, an adjustable DC voltage is added **before** sampling the input signal. As a result the vertical position of the signal at the screen changes. If a measured signal is larger than the selected input

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sensitivity range, the signal will clip at the upper or lower end of the screen. By adding a DC voltage to the signal, the part which is clipped can be brought inside of the screen, without clipping.

This hardware method can be realised by activating the choice *DC hardware offset* from the *Ch I* menu. A dialog box appears in which a voltage level in volts can be entered. This voltage will be added to the input signal. If a voltage has to be subtracted, enter a negative value. The numbers along the vertical axis are adjusted.

Using the software method, the signal is adjusted graphicaly **after** all the samples have been taken. This method only affects the displaying of the signal. If the input signal is clipped, because it is larger than the selected input sensitivity range, and the signal is adjusted, the signal stays clipped. The clipping will show very clearly on the screen. The signal is cut off at the top or bottom. This positioning method is mainly used to move signals which overlap each other on the screen.

The software positioning can be changed by using a menu or by dragging the vertical axes. To adjust the offset by means of a menu, enter the *Ch I* menu and select the choice *Software offset ...* A dialog box appears in which the offset can be entered. The value is in Volts.

The easiest way of adjusting the offset is by dragging the axis. This is done by pressing the left mouse button within the vertical axis, but not over the inverted area (on the top and bottom of the axes) and moving the mouse up or down while keeping the mouse button pressed.

Magnifying or reducing the vertical axis

The measured values can be magnified or reduced by the software, by the Software gain. By doing this, the vertical axes can be made larger or smaller.

This can be used to display two signals of different sizes on the screen, to be compared more easily. For example: Ch I is measuring a 5 Volt signal, Ch2 is measuring a 4 volt signal. Set the gain of Ch I to 0.8 and the gain of Ch2 to 1. Both signals are displayed with the same size.

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Another application is to display two signals in a 'split screen mode'. By setting the gain of the channels to 0.5 and the offset of Ch1 2 divs up and the offset of Ch2 2 divs down, the channels are displayed separately.

The software gain can be changed by using a menu or by dragging the vertical axes. To adjust the software gain through the menu, enter the *Ch1* menu and select the choice *Software gain...* A dialog box appears in which the gain can be entered. The value of the gain has to be between 0.25 and 4, where values smaller than 1 make the signal appear smaller and values larger than 1 make the signal appear larger. To change the software gain by dragging the vertical axis, place the mouse pointer over either the upper most or the lower most label of the vertical axis. These labels are drawn inverted. When the mouse pointer is over one of these labels, press the left mouse button and drag the label upwards or downwards, thereby enlarging or shrinking the axis and the signal.

Inverting a channel

With the software it is possible to invert the signal of a channel. This software invert multiplies all measured values by -1 and adapts the values along the vertical axis accordingly.

There are three ways to invert a signal: by means of a menu, by means the keyboard and by pressing the invert button.

The *Invert* menu is found in the *Ch1* menu. In this menu two choices are available to switch the invert on or off.

A few keys have been reserved to set the invert:

<i>	toggles the invert of channel 1
<Shift+i>	toggles the invert of channel 2

In the tool bar for each channel an **invert** button is found, the invert button for Ch1 at the left hand side of the screen, for Ch2 at the right hand side of the screen. The picture at the button indicates the state of the invert setting. The left button of the two buttons below is indicating Invert On, the right button is indicating Invert Off.



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The channel view button

For controlling the software offset and the software gain some pre defined settings are available by pressing the channel view button.

These settings are:

offset = 0 and gain = 1 (using full screen)
offset = +0.5 input sensitivity and gain = 0.5 (upper half of the screen)
offset = -0.5 input sensitivity and gain = 0.5 (lower half of the screen)
offset and gain have the last value set by the user

These settings are available by pressing the **channel view** button. Each setting has its own picture on the button. The image below displays the above mentioned settings from left to right.



The image at the button indicates the current settings. Each click on the button will select the next state. If the offset or gain are changed by other means and one of the predefined states is obtained, the button will go to that state as well, otherwise user is displayed.

The **channel view** button for channel 1 is found at the left hand side of the display, for channel 2 at the right hand side of the display.

Changing the units of the vertical axis

Along the vertical axis, normally the voltage of the input signal is projected. The unit of measure is then Volt and the numbers along the axis correspond with the size of the input signal.

The oscilloscope allows you to create another definition of the vertical axis.

By means of the choice *Units of measure* from the *Ch 1* menu the units of measure of the vertical axis can be changed.

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After activation, a popup menu with 13 choices appears. The unit that is selected, is displayed at the top of the vertical axis. It is also placed on the paper when printed out. When activating the choice *User defined ...* a dialog box appears, in which a custom unit can be entered, with a maximum length of 5 characters.

The *Units of measure* popup menu can also be called by clicking the right mouse button over the vertical axes.

If you are measuring e.g. with a temperature probe, you can choose *DEGREE C* for the units.

By activating the choice *Units gain...* from the *Ch 1* menu, a multiplication factor can be entered for the units of the vertical axis. A dialog box appears in which the factor can be entered. The numbers along the vertical axis are multiplied by the factor and replaced by the result.

If you are using a 10x probe, you can by means of units gain enter the value 10, to get correct numbers along the vertical axis.

Another application is when measuring with a temperature probe. Suppose the temperature probe gives a voltage change of 1 volt at a temperature change of 5 degrees. By entering the factor 5, the temperature change is displayed directly in the number of degrees.

It is also possible to add an offset to the numbers of the vertical axis. In the dialog box called by activating *Units offset...* from the *Ch 1* menu, an offset can be entered. This offset is added to the numbers along the vertical axis. Nothing is done to the signal.

An application for this is the temperature measurement. Suppose the output voltage of the temperature probe at 0°C is +10 Volt. By entering a units offset of -10, the zero level of the axis is changed in a way that the absolute temperature is directly readable.

Mouse sensitivity for the vertical axis

For dragging the vertical axis, the mouse sensitivity can be adjusted from course to fine, from 1 step per division to 25 steps per division.

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When a mouse sensitivity of 1 step per division is selected, each mouse movement will make the software offset become one division larger or smaller. When the software gain is adjusted, it will result in a two division smaller or larger signal size (one division at the top and one division at the bottom of the signal).

When the mouse sensitivity is set to 25 steps per division each mouse movement will result in an offset change of 1/25th division or a signal size change of 2/25th division.

The mouse sensitivity can be set by selecting the item *Mouse sensitivity vertical axis* from the *Ch1* menu.

Setting up the time axis

Along the horizontal axis of an oscilloscope the measuring time is projected. The measuring time is determined by the number of samples that is measured and the sample frequency

Setting the sample frequency

The sample frequency determines the speed with which the instrument will take samples of the input signal(s).

The sample frequency can be set in two ways: using the menu of by means of special function keys.

To change the sample frequency using the menu, enter the *Time base* menu and select the *Sample frequency* item. A new menu will appear with all possible sample frequency settings. Together with the sample frequency the maximum total measure time with the current record length and a pre trigger value of 0% is given. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

The last item in the menu is a user defined setting. Activating this item will bring up a dialog box in which a self defined sample frequency (within the instrument hardware limitations) can be entered. Due to the way the sample frequency is generated in the hardware, not all frequencies can

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be generated. If an invalid sample frequency is entered, the closest valid sample frequency will be generated.

The following keys can be used to change the sample frequency:

<F3>	Set the sample frequency one step slower
<F4>	Set the sample frequency one step faster



Note Because the record length, the number of post samples and the record viewing gain are free settable, it is very difficult to set the time base in a certain number of sec/div. Therefor the sampling frequency is set.

Setting the record length

The oscilloscope takes a number of samples to display the input signal. This number of samples is called the Record length. To change the record length, two ways are available: by means of a menu or by means of function keys.

To change the record length using the menu, enter the *Time base* menu and select the *Record length* item. Another menu will pop up, containing the available record lengths and an item for a *user defined* record length. Selecting this item will bring up a dialog box in which a self defined record length (within the instrument hardware limits) can be entered. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

For changing the record length the following function keys are available:

<F11>	Select a shorter record length
<F12>	Select a longer record length

Selecting another record length will change the total measure time, but the pre trigger value will keep the same value.

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Setting the pre trigger value

The oscilloscope is equipped with a trigger system. This trigger system monitors the input signal(s) and determines, based on the settings of the trigger system and the input signal, when measuring and displaying the signal(s) has to start.

The moment of trigger, the trigger point, can be placed at any position in the record with measured data. This will result in a certain number of samples before the trigger point (pre samples) and a number of samples after the trigger point (post samples). Pre and post samples together form the record length. The position of the trigger point is referred to as the pre trigger value, indicating how many pre samples are recorded in the total record. Usually (and default) this number is given in a percentage of the record length, but it can be given in a number of samples or in a time value as well.

To change the pre trigger value, two ways are possible: by a menu or with the special trigger position scroll bar, which is located below the signal display.



This special scroll bar represents the complete record and the slider (**^**) represents the trigger point. In the above picture, the trigger point is set to 25%. To change the trigger point, place your mouse pointer over the arrow (the mouse pointer will change shape), press the left mouse button and drag the slider to the position you want it to have. When one of the small buttons at the left hand side or the right hand side of the scroll bar are clicked, the pre trigger value will change by 1%.
When the mouse is clicked within the scroll bar, but not on the slider, the pre trigger value will increase or decrease by 5%, depending on whether the mouse is clicked to the right or to the left of the slider. When the mouse button remains pressed, an auto repeat function will be activated.

To change the pre trigger value by using the menu, enter the *Time base* menu and select the *Pre trigger value* item. this will bring up a menu with 5 pre trigger value options and a *user defined* option.
The pre trigger value options are default given in a percentage, but can

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be given in a number of samples or in time. To do that, first the user defined option has to be selected. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

When the user defined option is selected, a dialog box appears. In this dialog box can be selected in what unit the pre trigger value has to be entered (percentage, samples or time) and what the pre trigger value has to be. When the dialog box is closed using the OK button, the entered value is accepted and the selected unit will be used the next time the pre trigger value menu is called.

Mouse sensitivity pre trigger position adjustment

For adjusting the pre trigger value by dragging the slider of the pre trigger position scroll bar, the mouse sensitivity can be adjusted from course to fine, from 4 steps per screen to 100 steps per screen.

When a mouse sensitivity of 4 steps per screen is selected, the pre trigger position scroll bar is divided in 4 positions. Each mouse movement will adjust the pre trigger value to the next position in the direction the mouse is moved. So the available pre trigger positions are 0%, 25%, 50%, 75% and 100%.

When a mouse sensitivity of 10 steps per screen is selected, the available pre trigger positions are 0%, 10%, 20%, 30%, ..., 90% and 100%.

When the mouse sensitivity is set to 100 steps per screen each mouse movement will result in a pre trigger value change of 1%.



Note The mouse sensitivity does not affect adjusting the pre trigger value by clicking the buttons of the scroll bar or by clicking in the scrollbar outside the slider.

To set the Mouse sensitivity, enter the *Time base* menu and select *Mouse sensitivity pre trigger position adjustment*. In the menu that pops up, the choices are available.

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Magnifying the horizontal axis

The software supports a wide range of record lengths which can all been viewed completely. A special displaying algorithm guarantees that whenever the record length is larger than the display size, no amplitude information will be lost.

To take a closer look at a smaller part of the record, that part can be magnified to fill the screen. This is done with the record view gain, which is completely variable between 1.0 (full record view) and a value depending on the instrument window width (about 40 - about 80).

Adjusting the record view gain can be done through a menu and by means of the special record view scroll bar.

To change the record view gain by means of a menu, enter the *Time base* menu and select the *Record view gain* item. This will bring up a dialog box in which the requested record view gain can be entered. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

Setting the horizontal position of the signal(s)

When a record view gain > 1 is selected, only a part of the record is visible. To view a certain part of the record, a record view offset can be applied.

Applying a record view offset can be done by means of the special record view scroll bar and by means of a menu.

To use the menu, enter the *Time base* menu and select the *Record view offset* item. A dialog box will appear in which the record view offset can be entered, in seconds. When the trigger position is not equal to 0, a negative value will make pre samples visible, a positive value will make post samples visible. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

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When the record view gain is equal to 1.0, the *Record view offset* item is not available in the menu.

The record view scroll bar

For an easy way of adjusting the record view gain and the record view offset, the oscilloscope is equipped with a special record view scroll bar, located under the signal display.



The dark gray part of the scroll bar represents the measured record, the slider (light gray) represents the visible part of the record. The red lines represent the position of the cursors. If the cursors are not switched on, no red lines are visible.

To change the record view gain, place the mouse pointer on the left hand side or the right hand side of the slider (the mouse pointer will change shape), click the left mouse button and drag the side of the slider to the position you want. Simultaneously the record view gain will be adjusted and the signal in the display changes accordingly.



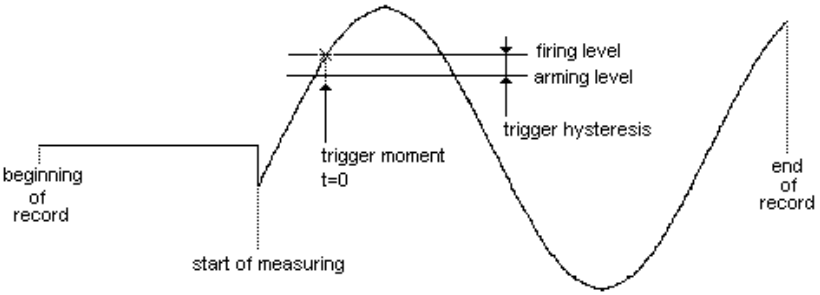
Note The minimum slider width is 10 display pixels and the scroll bar width is dependent of the window size, so the maximum gain is limited to (scroll bar width in pixels / 10). With a large window, the record view gain can be set to a larger value than with a small window size.

To change the record view offset, place the mouse pointer anywhere on the slider, except on the left hand side or the right hand side. The mouse pointer will not change shape. Press the left mouse button and drag the slider to the position you want. The record view offset will be adjusted and the signal in the display changes accordingly.

When the small buttons are clicked, the record view offset is increased or decreased by 1 sample. When the mouse is clicked within the scroll bar but outside the slider, the record view offset is increased or decreased by 5 samples, depending on which side of the scroll bar is clicked. When the mouse button is kept pressed, an auto repeat function is activated.

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To be able to examine a signal, the moment of displaying the signal has to be adjustable. Therefore an oscilloscope is equipped with a triggering system. This functions as follows:



The input signal is compared with two levels in the trigger system: the arming level and the firing level. When the input signal passes the arming level, the trigger system is armed. If the input signal passes the firing level, the trigger system becomes active and 'fires' a pulse. This pulse is used to start the display of the signal.

The arming level and the firing level are coupled to each other by the trigger hysteresis and their level is determined by the trigger level. The firing level corresponds to the trigger level. The trigger hysteresis defines at which signal size change can be triggered, the change has to be that large that both levels are passed. With a small trigger hysteresis it is possible to trigger on small signals. If a signal contains a lot of noise, a small trigger hysteresis causes triggering on the noise, instead of the original signal, which gives an unstable display. A trigger hysteresis larger than the noise level is then necessary.

In the illustration a signal and the two levels are displayed. In this case it is triggered on the rising slope of the signal. The signal passes the two levels from low to high. When triggering on the falling slope of a signal, the two levels are swapped. Then the signal has to pass the two levels from high to low, to generate a trigger.

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Selecting the trigger source

The trigger system can have different sources to determine when measuring has to start. These sources are:

Ch1	Trigger on channel 1
Ch2	Trigger on channel 2
External	Trigger on the external trigger input
Ch1 AND Ch2	Trigger on channel 1 and channel 2; the signals on both channels have to meet their trigger settings
Ch1 OR Ch2	Trigger on channel 1 or channel 2; only one of signals has to meet its trigger setting.



Note The items Ch1 AND Ch2 and Ch1 OR Ch2 are only available when both channels are measured.

To change the trigger source, enter the *Trigger* menu and select the *Source* item. In this menu a source can be selected. The trigger menu can be found in the main menu and can be called by clicking the **trigger** button () or by pressing the right mouse button when the mouse is over one of the trigger controls or readouts.

Selecting the trigger mode

The trigger system has several trigger modes:

Rising slope	trigger on the rising slope of a signal
Falling slope	trigger on the falling slope of a signal
TV Line	trigger on the line sync pulse in a video signal
TV Frame odd	trigger on the odd frame sync pulse of a video signal
TV Frame even	trigger on the even frame sync pulse of a video signal



Note For the TV trigger modes, the TE6100 has special hardware. This hardware does not require any level or hysteresis adjusting, so the level and hysteresis items in the trigger menu are disabled when a TV trigger mode is selected. TV trigger can not be selected when the trigger source is set to external.

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To change the trigger mode, enter the *Trigger* menu and select the *Trigger mode* item. A menu will popup and a trigger mode selection can be made.

Another way to change the trigger mode is by using the trigger symbol. Double clicking the left mouse button on the trigger symbol will change the trigger mode from:

Falling slope	to	Rising slope
Rising slope	to	Falling slope
TV Line	to	TV Frame odd
TV Frame odd	to	TV Frame even
TV Frame even	to	TV Line

Setting the trigger level

Adjusting a trigger level can be done is several ways: by means of a menu or by using the special trigger symbol.

To change a trigger level by means of a menu, enter the *Trigger* menu and select the *Level Ch1 ...* or *Level Ch2 ...* item. An input dialog appears in which the trigger level can be entered, in volts.

In this dialog, also a check box for selecting **auto level triggering** is found. When auto level triggering is selected, the trigger level will be set to a value that lies in the middle between the highest and the lowest value of the previous measurement. This can be very useful with continuously changing signals. When auto level triggering is selected, the trigger symbol will show that with a letter **A** in the symbol. The level can no longer be adjusted with the symbol.



Note When a trigger source External is selected, or a TV trigger mode is selected, the trigger level adjustment is disabled.

Setting the trigger hysteresis

Adjusting a trigger hysteresis can be done in several ways: by means of a menu or by using the special trigger symbol.

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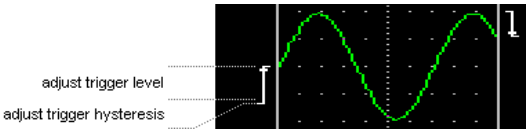
To change a trigger hysteresis by means of a menu, enter the *Trigger* menu and select the *Hysteresis Ch1 ...* or *Hysteresis Ch2 ...* item. An input dialog appears in which the trigger hysteresis can be entered, in volts.

When **auto level triggering** is selected, the trigger symbol will show that with a letter **A** in the symbol. The hysteresis can still be adjusted with the symbol.

Note When a trigger source External is selected, or a TV trigger mode is selected, the trigger hysteresis adjustment is disabled.

The trigger symbol

The oscilloscope is equipped with a special trigger symbol, that is used to adjust the trigger level, the trigger hysteresis and the trigger mode. The WYSIWYG trigger symbol is found at the left hand side or the right hand side of the signal display, depending on the trigger source.



In the above picture, the trigger mode of the left hand symbol is set to Rising slope and the trigger mode of the right hand symbol is set to Falling slope.

In TV trigger mode, the trigger symbol identifies the trigger mode using a few characters:

T	T	T
V	V	V
L	F	F
	o	e

To adjust the trigger level using the trigger symbol, place the mouse pointer on the trigger symbol, in the area that is marked adjust trigger level in the above picture. The mouse pointer will change to a ↕ symbol.

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Press the left mouse button and drag the trigger symbol to the correct position, while keeping the left mouse button pressed. While dragging, the trigger level is adjusted according the position of the trigger symbol on the screen. When the mouse button is released, trigger level adjustment stops and the normal mouse pointer shape is returned.

To adjust the trigger hysteresis using the trigger symbol, place the mouse pointer on the trigger symbol, in the area that is marked adjust trigger hysteresis in the above picture. The mouse pointer will change to a ⇳ symbol. Press the left mouse button and drag the hysteresis level of the trigger symbol to the correct position, while keeping the left mouse button pressed. While dragging, the trigger hysteresis is adjusted according the size of the trigger symbol. When the mouse button is released, trigger hysteresis adjustment stops and the normal mouse pointer shape is returned.

To adjust the trigger mode using the trigger symbol, place the mouse pointer on the trigger symbol and double click the left mouse button. The trigger mode will change from:

Falling slope	to	Rising slope
Rising slope	to	Falling slope
TV Line	to	TV Frame odd
TV Frame odd	to	TV Frame even
TV Frame even	to	TV Line

The trigger time out

When the input signal does not meet the trigger conditions, no new measurement data will be displayed and the last displayed signal will remain on the screen. This can be very inconvenient with unknown signals, since it is not known how the trigger system has to be set. To provide in that case for a representation of the input signal on the screen, a trigger time out setting is available.

With the time out setting it is determined how long the delay will be for a trigger pulse. If that time expires, a trigger pulse is forced by the software and the available data will be displayed. This will not result in a stable display, but it will give an impression how the trigger has to be set.

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To set the trigger time out, enter the *Trigger* menu and select the *Time out ...* item. An input dialog will come up in which the time out time can be entered, in seconds.

When a time of zero is entered, there will be no trigger time out, but no triggering as well. As soon as a signal is displayed, the instrument will be set up for a new measurement and immediately a trigger pulse is generated, without waiting for a trigger. This can be useful when e.g. a slowly changing DC level has to be monitored, on which can't be triggered.

In the dialog also a check box for an infinite time out is available. When this box is checked, the software will keep waiting for the input signal to meet the trigger settings, without ever forcing a trigger pulse. This can be very useful in one shot measurements and with auto disk measuring.

Performing measurements

When the oscilloscope is completely set up, measurements can be performed.

By default the oscilloscope is always measuring and displaying. Changes that are made in the settings can be made while measuring and will be executed while measuring, so the effects are immediately visible.

Stopping the measurements

To avoid a new screen of measurement data replacing an old screen, measuring and displaying of data can be stopped. This can be done in several ways: by pressing the **Pause** button (), by pressing the <S> key or by activating the item *Stop continuous measuring* from the *Measure* menu.
When measuring is stopped, the latest measured data will remain on the screen. The **Pause** button changes to a **Play** button () and the **One shot** button () becomes available.

The measured signal can now be examined.

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To perform a single measurement, press the **One shot** button, press the <O> key or activate the *Perform a single measurement* item from the *Measure* menu.

Continuous measuring can be started again by pressing the **Play** button, the <S> key or the item *Start continuous measuring* from the *Measure* menu. The **One shot** button will be disabled again.

Perform Auto disk measurements

The oscilloscope can store measurement data automatically on disk. This is very useful when e.g. an interference glitch has to be measured. Suppose that at unpredictable times a glitch occurs. By using the auto disk measurements, the oscilloscope will wait for the glitch to occur. When the glitch occurs, it is measured and the data is stored on disk. The time and date of the measurement are stored as well.

To activate the auto disk function, first set up the oscilloscope to the appropriate settings (input sensitivity, sample frequency, record length etc.) Then, enter the *Measure* menu and select the *Auto disk* item. A special auto disk dialog will appear. In this dialog, a target disk, a target directory and a name for the files can be selected. For the file name, only 5 characters can be entered, three characters will be added by the software for a file serial number. At the bottom of the dialog a bar graph is displaying the available disk space on the selected drive.

The trigger system of the oscilloscope has a time out function. When the input signal does not meet the trigger conditions within a certain time, a trigger is forced. This is used to see an unknown signal. This feature can be unwanted in the auto disk function, therefor a **Time out infinite** check mark is available to set the time out to infinite. Then the oscilloscope will keep waiting for the input signal to meet the trigger conditions.

When all is set, press the **Start** button to start the auto disk measurements. The **Cancel** button will change to a **Stop** button and measuring takes place.

The auto disk measurements stop when the **Stop** button is pressed or when the disk is full.

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Note In the root of a disk only 128 files can be stored. A RAM drive has a user definable number of entries (default 64) and can store no more files than there are entries available. The auto disk function will stop with a disk full error when this number of files are written. However, DOS or Windows might still report a certain amount of free space on the disk. To be able to store more files, create a directory on the disk and store the files in that directory. A directory can contain many more files.

Note The auto disk function can store only 999 files, due to the three characters that are used for creating the file serial number.

Auto setup

When an unknown signal is connected to the oscilloscope, the easiest way to setup the oscilloscope is by using the Auto setup function.

The Auto setup function is activated by selecting the item *Auto setup* from the *Measure* menu or by pressing the **Auto setup** button ().

This function sets the sensitivity for both channels to auto ranging, so the optimal signal size is obtained. Also the trigger level of the channel that is the trigger source is set to auto level, to insure there is always a trigger.

Then the time base is set in a way that the signal at the channel that is triggered on, is displayed with 2 to 6 periods.

The auto setup function does nothing to the signal coupling, the measure mode (ch1, ch2 or ch1 and ch2) or the trigger source.

Zooming

When a certain part of the screen has to be enlarged to full screen, the zoom function is the easiest way to do that.

The zoom function is activated by pressing the **zoom** button (). This button stays down until the zoom function is finished.

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When the zoom function is activated, a rectangular area in the signal display can be selected with the mouse. Place the mouse at one of the corners of the rectangle, press the left mouse button, keep it pressed and drag the mouse to the opposite corner of the rectangle. While dragging, a dashed rectangle is drawn. When the rectangle has the correct size, release the mouse button. The zooming function will finish and the software offset and gain of both channels and the record view offset and gain are adjusted to the values that result in viewing the selected part of the screen.

To undo the last zoom operation, press the **zoom** button with the right mouse button. A menu will appear which enables you to undo the last zoom operation. A history of 10 zoom operations is stored and can be undone.

Performing cursor measurements

To perform measurements on the measured data, two pairs of cursors are available. Each cursor pair exists of a horizontal and a vertical cursor that can be placed anywhere inside or outside the signal display. Where the two cursors cross each other, a link is made. For the left cursor this link is pink, for the right cursor this link is black.

Switching on cursors

To switch on cursors, enter the *Cursors* menu and select the *Large cursors* item or the *Small cursors* item. Large cursors are drawn from the left to the right hand side of the signal display or from the top to the bottom of the signal display. Small cursors only form a small cross. The *Cursors* menu can be found in the main menu or can be called by clicking the right mouse button in the signal display. When the cursors are switched on, a special cursor readout window appears as well.

The cursors are wavefom based. This means that the cursor position is related to the wavefom. If the record view offset or record view gain is changed, the cursor position will remain at the same position in the waveform. If the input sensitivity, the software offset or software gain is changed, the cursor will stay at the same voltage level. Because of this,

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cursors can get off screen. In the record view scroll bar two red lines are drawn to indicate the position of the cursors in the record.

To position a cursor, bring the mouse pointer on the cursor to position. The mouse pointer will change shape:

- position a horizontal cursor
- position a vertical cursor
- position a cursor pair



Hint To position an off screen cursor, bring the mouse pointer to the edge of the signal display at which the cursor exceeds. The mouse pointer will change shape.

Now press the left mouse button and drag the cursor to the correct position. When that is reached, release the left mouse button. The original mouse pointer shape is restored.

Setting up the cursor measurements

With the cursors it is possible to measure the input signal(s) in several ways. To set up the cursor measurements, press the settings button at the cursor readout window (the right most button at the left top of the window caption) A menu appears, containing the following options. The menu can also be called by pressing the right mouse button over the table.

Voltmeter measurements

All measurements which can be selected in the voltmeter measurements submenu are also available in the voltmeter. The only difference between the measurements is that the voltmeter uses the previous two measurement values and the current measured values which are added together and meaned before the value is displayed. For a complete description of the measurements, see the chapter on the voltmeter.

Time

Rise time left: the rise time of the signal at the position of the left cursor is determined. The rise time is determined by finding the closest zero crossing ((max + min) / 2) relative to the cursor positi-

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on. Next the 10% and 90% values are calculated. Now, the 10% and 90% points are searched left and right of the zero crossing point. By using the number of samples between the 10% and 90% points, the rise time is calculated.

Rise time right: the rise time at the position of the right cursor is determined.

Sample time left: using the left cursor position, the time on which the selected sample is taken will be displayed.

Sample time right: using the right cursor position, the time on which the selected sample is taken will be displayed.

Sample time difference: the difference between the right and the left cursor sample time is determined.

Cursor frequency: using the number of samples between the left and the right cursor, the frequency is calculated. The calculation is done using the following formula: (number of samples between cursors / total number of samples) * sample frequency. To determine a correct frequency always select one period or multiply the frequency by the number of selected periods for greater precision.

Voltage

Voltage left: the voltage of the left cursor will be displayed.

Voltage right: the voltage of the right cursor will be displayed.

Voltage difference: the difference between the voltage of the left and the voltage of the right cursor is calculated. Selecting the min and max of the signal, the top-top value is calculated.

Slew rate

Slew rate left: the slew rate of the signal at the position of the left cursor is determined. The slew rate is the voltage level which a signal drops or gains per millisecond.

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Slew rate right: the slew rate of the signal at the position of the right cursor is determined.

Phase difference

These measurements are only available when both channels are switched on. They measure the phase angle difference between the signals on channel 1 and channel 2. When the software can not detect a complete period of the signal on both channels or when the frequency of the two signals are different, no phase difference is determined.

Degrees: The angle is presented in degrees
Radials: The angle is presented in radials
cos(): The cosine value of the angle is presented

Set impedance value

The dBm and power measurements require a reference resistance. The value of the resistance can be set using this menu item. The value has to be entered in Ohm and is default 600.

Automatic correct points

By selecting this option, the automatic correction of the cursors to the nearest zero crossing is enabled or disabled. The right cursor is positioned one or more periods from the left cursor. To determine a frequency or duty cycle, position the right cursor at the end of the second period or further for correct results.

Automatic tracking cursors

If this option is enabled, the voltage levels of the cursors are automatically set to the voltage levels of the sample numbers which correspond to the left and right cursor.

Calculate values

If this option is disabled, no new calculations will be done until the option is enabled.

Show measurement name
Show measured value
Show measurement unit

To reduce the space used by the window on the screen, the measurement name, value and/or unit can be hidden. This results in the disapearance of the corresponding column which results in a smaller window.

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Display font

By selecting this option, the font which is used to display the strings and values can be changed. The font settings which can be changed are: font name, font style, font size and the font color.

Background color

By selecting this option, the background color can be altered. Some font colors (e.g. light green) are not showing up very good on a white background. Change the background color to e.g. black for a better result.

Selecting the active channel

The cursors can only calculate values for one channel.

The buttons in the left top of the window caption bar can be used to select the channel from which data is used to calculate the selected measurements.

There are two ways to change between channels, pressing the buttons with the mouse or by using the corresponding number on the keyboard.

Showing or hiding the cursor readout

The left button of the two in the right top corner of the window caption bar can be used to hide (▲) or show (▼) the grid with measured data. When hiding the data, the height of the window equals the height of the window caption bar.

Switching off cursors

To switch off cursors, enter the *Cursors* menu and select the *No cursors* item. The *Cursors* menu can be found in the main menu or can be called by clicking the right mouse button in the signal display.
When the cursors are switched off, the cursor readout window disappear as well.

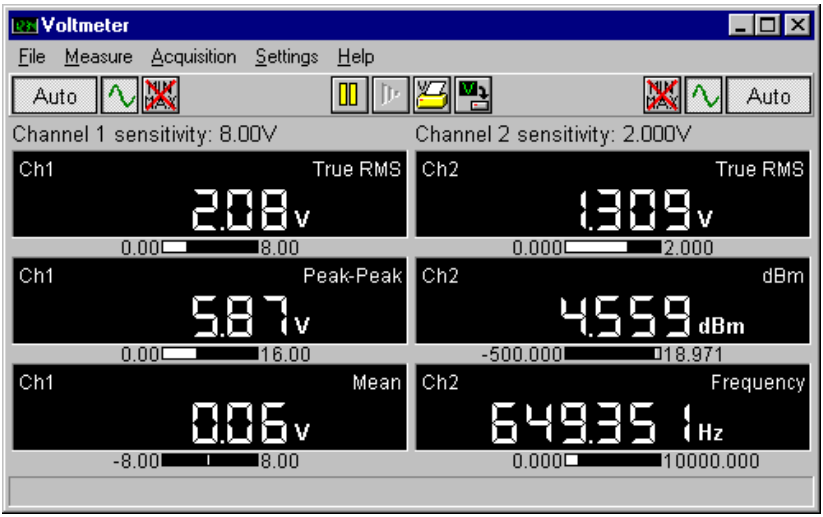
The cursors can also be switched off by clicking the **close** button (⊠) in the cursor readout window

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If from the input signals only the size is important and not the time information or frequency components, a voltmeter is a suitable instrument to measure with. The software is equipped with a two channel digital voltmeter. The voltmeter functions as follows:

- A measurement is performed (minimal 200 samples).
- The measured data is processed, e.g. for calculating the RMS value or the mean value. Eleven different operations are available.
- The calculated values are displayed, e.g. add CH1 and CH2 and display on channel one. Sixteen different display methods are available.

For each channel the voltmeter has up to three displays to present the measured and calculated values. The value displayed in a display is fully configurable. Also for each display a bar graph is available, to give a quick overview of the signal size in relation to the input range.



Of all four instruments, the voltmeter has the lowest settings priority. This means that if for example the oscilloscope is active, the record length,

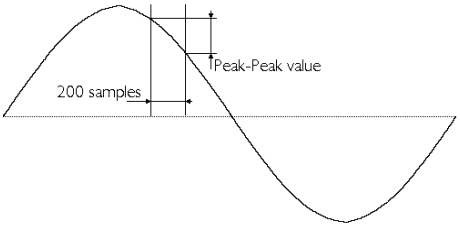
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presamples and post samples of the oscilloscope are used in the voltmeter. The voltmeter only uses post samples to perform the calculations. If less than 200 post samples are available, no calculations are done and a message is displayed. The only setting that can be changed by the voltmeter when the oscilloscope or spectrum analyzer is active, is the sample frequency.

The measure system of the voltmeter

The voltmeter takes 200 samples of the input signal with a certain sample frequency. These 200 samples are used to perform several calculations.

The voltmeter has a limited frequency range in which the measurements are performed correctly. If the periodical time of the input signal is much larger than the measuring time, a wrong value is measured. See the next illustration.



If the time in which the 200 samples are taken is too long in relation to the periodical time of the input signal, **aliasing** can occur (see also the chapter about the oscilloscope).

Setting the frequency range

To avoid errors like the ones mentioned above, the frequency range of the voltmeter has to be set properly. The sampling frequency is then changed. By activating the choice *Frequency range* from the *Settings* menu, a popup menu appears, in which several frequencies are available. The frequencies indicate the center frequency of a frequency range in which the voltmeter measures properly. The size of the frequency range is determined from $0.2 \times f_{center}$ .. $5 \times f_{center}$.

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When *Auto freq.* is chosen, the voltmeter determines the best frequency setting by itself. For each measurement the frequency has to be determined, resulting in a longer time before updating the displays.



Note The Auto frequency setting overrides the sample frequency setting in the oscilloscope and the spectrum analyzer. This will result in a less usable display in those instruments.

To avoid this, the choice *Scope freq.* is available in the menu. The voltmeter will use the same sample frequency as the oscilloscope or spectrum analyzer.

Displaying channels

The voltmeter has several modes to display the two channels. To select the measure mode, enter the *Settings* menu and select *Channels*. Use the **Measure channel** option to enable or disable measuring from a channel. Measuring takes place from at least one channel.

When only one channel is measured, the controls of the other channel are disabled or removed from the display.

Setting up a channel

The channels of the voltmeter can be setup in several ways. Both channels have the same settings, so only channel 1 is discussed here.

Setting the input range

In the voltmeter, the input range or sensitivity can be set through the channels settings dialog.

The channels setting dialog is called by selecting the *Channels* option from the *Settings* menu. In this dialog, the input sensitvities are available, as well as an autoranging setting.

To switch on Autoranging for the Voltmeter, a special button is available. When auto ranging is switched on, the button caption is Auto, otherwise

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it holds the current set input sensitivity. Pressing the right mouse button on this button will bring up a menu with all sensitivities.

When the input signal is larger than the selected input range, '-------' is displayed.



Note When Autoranging is switched on, several measurements might be needed to set the input sensitivity properly, depending on the input signal.

Another way to set the sensitivity is by using the keyboard. A few keys have been reserved for setting the input sensitivity of the channels. These keys are:

<F5>	Increase Ch1 sensitivity
<F6>	Decrease Ch1 sensitivity
<F7>	Increase Ch2 sensitivity
<F8>	Decrease Ch2 sensitivity

Setting the input coupling

The input signal can be coupled directly to the ADC (DC) or through a capacitor to the ADC (AC). In the hardware, a capacitor is switched into (AC) or out of (DC) the signal path.

In COUPLING DC the complete signal (AC+DC) at the input is passed through. In COUPLING AC only the AC component of the input signal is passed through. It is then possible to examine e.g. a ±20 mV ripple on a 30 V DC voltage, since only the ripple is passed through and the DC voltage not. AC voltages with a frequency lower than ±4 Hz are not coupled correctly.

There are three different ways to set the coupling. Two ways are: by clicking the coupling button or by pressing keys. The third way is through the channel settings dialog. The channels setting dialog is called by selecting the *Channels* option from the *Settings* menu. In this dialog, the signal coupling setting is available.

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In the tool bar for each channel a coupling button is found, the coupling button for Ch1 at the left hand side of the screen, for Ch2 at the right hand side of the screen. The picture at the button indicates the state of the coupling setting. The left button of the two buttons below is indicating AC coupling, the right button is indicating DC coupling.



The current coupling state is displayed in the coupling button.

The keys which can be used to change the signal coupling are:

<A>	sets the coupling of channel 1 to AC
<D>	sets the coupling of channel 1 to DC
<Shift+A>	sets the coupling of channel 2 to AC
<Shift+D>	sets the coupling of channel 2 to DC

Setting a DC hardware offset

The signal offset is adjustable in two ways: a hardware method and a (per display) software method.

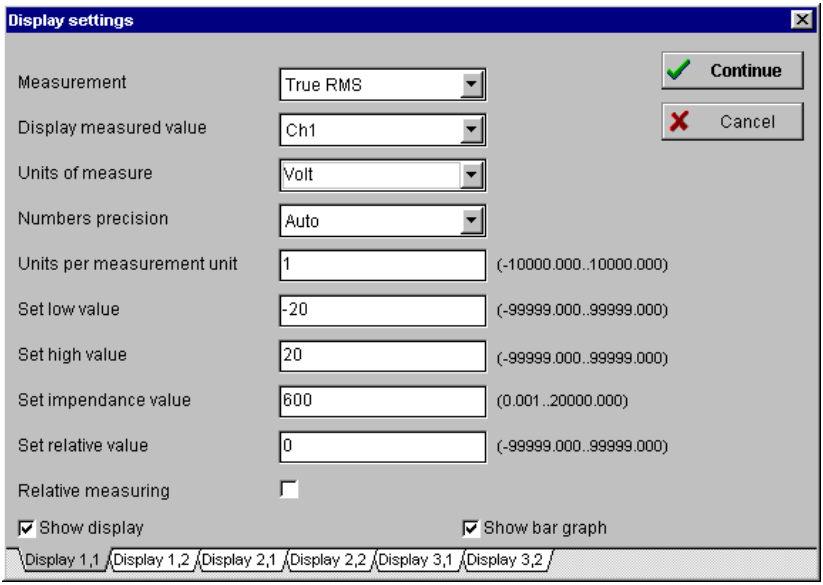
Using the hardware method, an adjustable DC voltage is added before sampling the input signal. The hardware method can be realised by selecting the *Channels* option from the *Settings* menu. Type the offset in the DC hardware offset edit box. This voltage will be added to the input signal. If a voltage has to be subtracted, enter a negative value.

Configuring the displays

The voltmeter can display the measured values in several different ways, in up to six displays. Below the display, a bargraph is showing the value in the display in a graphic format.

By activating the choice *Displays* from the *Settings* menu, a dialog appears in which the settings of all the displays can be changed. This method works always, even if the display and bargraph for which the settings are changed are invisible.

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These settings can also be done by placing the mouse cursor over a display and pressing the right mouse button. A popup menu appears with all settings for that display. This method only works if the display or bar-graph is visible.

All settings applied to a display are also applied to the corresponding bargraph.

The following explanations expect that the **Display settings** dialog is displayed and active.

Switching displays on and off

A display can be made visible by placing a checkmark in front of the **Show display** string. If a display is turned on, while the matching channel is not measured, the display will not be showed.

If all six displays are visible, the layout is as following:

- The left hand side displays belong to channel 1.
- The right hand side displays belong to channel 2.

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Switching bargraphs on and off

Each display has a bargraph that can be switched on or off independantly from the displays. The bargraphs can be switched on or off by tagging or untagging the *Show bargraph* option.

Processing the measured value

The software can process the measured value in 11 different ways. By activating the **Measurement** selector, the following calculations can be set:

TRUE RMS: The true RMS value of the input signal is calculated. The true RMS value (Root Mean Square) is the value of a random voltage, corresponding to a DC voltage, dissipating the same power in a resistance in the same amount of time. So an AC voltage of 1 volt RMS corresponds to a DC voltage of 1 volt. (Most -cheap- voltmeters only display, when measuring AC voltage, the correct value when the input signal is a true sine wave and usually in a limited frequency range. This instrument always displays the correct value.)

Peak-peak: The peak-peak value of the input signal is determined. The peak-peak value of a DC voltage is zero. The peak-peak value of a true sine wave with a RMS value of 1 volt is 2.828 volt.

Mean: The mean value of the input signal is determined. The mean value of a varying voltage corresponds with the value of a DC voltage across the same load. The mean value of a 1 volt DC voltage is 1 volt. The mean value of a true sine wave AC voltage is 0.

Max: The maximum of the input signal is determined. The maximum value of a 1 volt DC voltage is 1 volt. The maximum value of a 1 volt AC sine wave voltage is 1.414 volt. This is determined from the 200 samples.

Min: The minimum of the input signal is determined. The minimum value of a 1 volt DC voltage is 1 volt. The minimum value of a 1 volt AC sine wave is -1.414 volt. Determined from the 200 samples.

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dBm: The value of the input signal is converted to dB. This is done using the formula:

$$dBm = 10 * \log \frac{1000 * value^2}{reference\ resistance}$$

'value' is the RMS value of the input signal. The reference resistance can be set using the edit box set impendance value.

Power: The value of the input signal is converted to a power, using the formula:

$$POWER = \frac{value^2}{reference\ resistance}$$

'value' is the RMS value of the input signal. The reference resistance can be set using the edit box Set impendance value.

Crest: The value of the input signal is converted to a crest factor, using the formula:

$$CREST = \frac{peak\ value}{RMS-value}$$

'peak value' is the highest voltage of the input signal with respect to the zero level.

Frequency: The frequency of the input signal is determined. Frequencies lower than 0.5 Hz, are displayed as 0 Hz. The frequency can be determined for one channel at a time. If the frequency is determined for channel 1, the frequency of channel 2 can't be determined.

Duty cycle: The duty cycle of the input signal is determined. The duty cycle indicates how much of a signal is low/high (depending on the duty cycle setting) in relation to the periodic time of the signal. The number is given in percent.

Moment. value: Displays the voltage level of the first post sample.



Note If a frequency or duty cycle measurement is set, the voltmeter is slower on all displays, because for determination of the frequency or duty cycle more measurements have to be done.

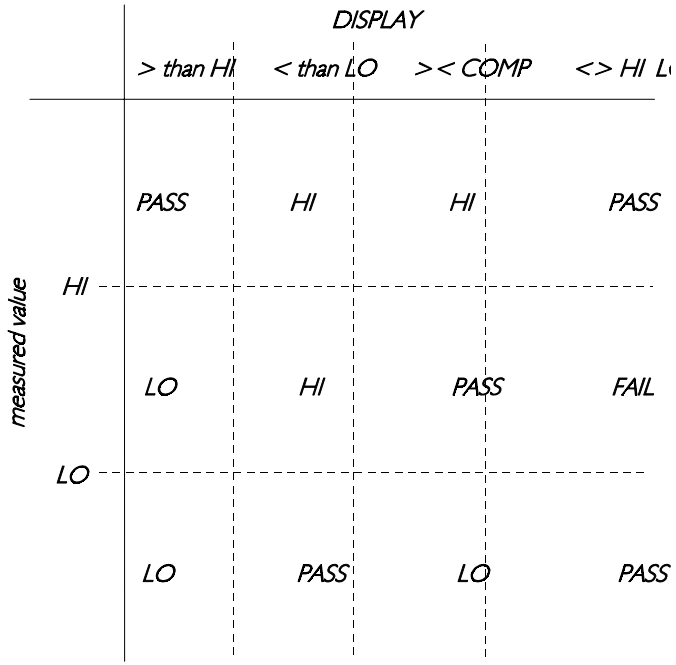
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Displaying the calculated value

For displaying the measured and calculated values, 16 methods are available. Activate the **Display measured value** selector to set the following possibilities:

CH1:	The measured value of Ch1 is displayed.
CH2:	The measured value of Ch2 is displayed.
CH1*CH2:	The values of Ch1 and Ch2 are multiplied and the result is displayed.
CH1/CH2:	The value of Ch1 is divided by the value of Ch2. The result is displayed.
CH2/CH1:	The value of Ch2 is divided by the value of Ch1. The result is displayed.
CH1-CH2:	The value of Ch2 is subtracted from the value of Ch1. The result is displayed.
CH2-CH1:	The value of Ch1 is subtracted from the value of Ch2. The result is displayed.
CH1+CH2:	The values of Ch1 and Ch2 are added and the sum is displayed.
> then HI:	The value is compared to the high value. If the value is higher than the high value, then PASS is displayed, else LO is displayed.
< then LO:	The value is compared to the low value. If the value is lower than the low value, then PASS is displayed, else HI is displayed.
>< COMP:	The value is compared to the high value and the low value. If the value is higher than the high value, HI is displayed. If the value is lower than the low value, LO is displayed. If the value is lower than or equal to the high value and higher than or equal to the low value, PASS is displayed.
<> HI LO:	The value is compared to the high value and the low value. If the measured value is higher than the high value, PASS is displayed. If the value is lower than the low value, PASS is displayed. If the value is lower than or equal to the high value and higher than or equal to the low value, FAIL is displayed.

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MAX: The maximum measured value ever is displayed.

MIN: The minimum measured value ever is displayed.

LOG(1/2): The result of the calculation

$$20 * \log \frac{measured\ value\ CH1}{measured\ value\ CH2}$$

is displayed.

LOG(2/1): The result of the calculation

$$20 * \log \frac{measured\ value\ CH2}{measured\ value\ CH1}$$

is displayed.

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Change the units of measure

Normally, every type of measurement has its own unit. The voltmeter allows you to change this unit for each display separately. There are twelve predefined values and a user defined value.

The selection can be made with the **Units of measure** pulldown. The unit which is selected, is displayed in the display. To select a user defined unit of measure, just type a string with a maximum length of five characters .

Change the units per measurement unit

Using the edit box **Units per measurement unit,** the number of units per selected unit can be set. In the edit box, the multiplication factor can be entered. The measured value is multiplied by the factor and displayed.

This can be used if e.g. a 1:10 probe is used. To correct the reading, enter a value 10 in the edit box.

Relative measurements

The voltmeter can take absolute measurements and relative measurements. When measuring absolute, the measurements are related to the 0 level (ground). When measuring relative, the measurements are related to a settable value. This value is subtracted from the measured value by the software. This means that before displaying the value in the display, the relative value is substracted from the calculated value.

The value can be set by entering a value in the **Set relative value** edit box. The value has to be entered in volts.

To enable relative measurements, a checkmark has to be placed after **Relative measuring.** Relative measuring is then enabled.

Relative measurements can be used with e.g. a temperature measurement. Suppose the output voltage of a temperature probe at 0 degrees Celcius equals + 10 volt. By entering a relative value of 10 volt, the absolute temperature is directly readable.

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Comparison measurements

For displaying the measured and calculated values, 16 methods are available (See: displaying the measured value). Four of those methods are comparison measurements:

> then HI
< then LO
>< COMP
<> LO HI

These measurements require a high and a low value. By entering a value in the **Set high value** or **Set low value** edit boxes, the high and low levels can be set.



Note For easy entering of low and high values, the software does not check whether the high value is larger than the low value. So it is possible to enter a low value which is larger than the high value. Measurements using these values will give useless results.

Setting the reference impedance

The dBm and power measurements require a reference resistance. The value of the resistance can be set using the **Set impedance value** edit box. The value has to be entered in Ohm. The default value is 600.

Setting the number of digits after the decimal separator

With every calculation done on a measurement, a default number of digits after the separator is set (auto setting). This number corresponds with the significant number of figures determined by thge hardware. The number of digits after the separator can be changed using the **Number precision** selector.



Note The displays have a maximum number of 6 digits. When the value in the display is that large that digits before the decimal separator can't be displayed, an arrow pointing to the left is displayed left from the first digit. The displayed digits are correct though.

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Sound settings

With comparison measurements, for each value a sound signal can be set. When this is done, the set limits are indicated audibly.

By activating the choice *Sounds* from the *Settings* menu, a dialog appears from which for each display value a sound signal can be set. For each display value can be chosen from: No sound, 100 Hz, 200 Hz, 500 Hz, 1 kHz, 2 kHz, 5 kHz and 10 kHz.
With the choice *No sound*, no sound signal is generated with the selected display value.

If you are using the PC speaker or a WAV device, it is only possible to make one sound at a time. This means that the sound which is played first, is repeated until the condition is invalid. As soon as the condition is invalid, the sound for the next condition can be played.



Note If your computer is equipped with a digital playback soundcard (a soundcard which can play WAV files), you can also play the sounds through your soundcard. Select the sound device pull down after which you can select wav device from the list. If this option is missing and you have a soundcard, you should install drivers for the soundcard or you dont have a digital playback soundcard.

If the computer is equipped with a soundcard, it is also possible to select the MIDI device option. The MIDI device uses the instrument settings as defined in the General MIDI standard. When using MIDI, it is possible to play all four sounds (LO, HI, FAIL and PASS) at one time.

Resetting the minimum and maximum values

When displaying the measured values, the maximum value ever and/or the minimum value ever can be displayed. These values are kept until the software is closed.
To reset the minimum and maximum values, for each channel a **reset** button is available in the speedbar () and through the settings, channel menu. By pressing this button, the maximum value is set to the lo-

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west possible measured value. The minimum value is set to the maximum measured value possible.

Performing measurements



Hint Use the frequency meter to determine the frequency of the input signal.

When the device voltmeter is switched on, and the measurement proces is not in one shot mode, measurements take place. The measured values are displayed continuously. If the oscilloscope is active, the trigger conditions also apply to the voltmeter.

Start and stop measuring

The measuring can be halted by pressing the **pause** button () or <S> key. The **oneshot** button () next to the **pause** button becomes available (<O> key), and the **pause** button changes to a **play** button ().

The measuring can also be halted by selecting the *Stop continuous measuring* option from the *Measure* menu. The option *Perform a single measurement* becomes available and the *Stop continuous measuring* option changes to *Start continuous measuring*.

Averaging

Normally the voltmeter adds the two previous measured values with the current measured value and divides it by three. In this way, very small changes do not show up which results in a more stable values.

To switch averaging on or off, enter the *Settings* menu and select the *Mean values* option. The check mark in front of the menu item indicates whether averaging is on or off.

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Fast measuring

By selecting the option *Fast measuring* from the *Settings* menu, fast measuring is enabled or disabled. Before the fast measuring option can be enabled, you have to set a frequency range other than scope or auto.

When enabling the fast measuring option, the trigger timeout is set to zero, the record length and post samples are set to 200 and the averaging is disabled.

One shot measurements

A single measurement can be performed by pressing the **oneshot** button or by selecting the *Perform single measurement* option from the *measure* menu.



Note One measurement consists of three succesive measurements (except if fast measuring is selected or mean values is disabled, these take one measurement), from which the measured values are averaged. Between the measurements the display is updated. If the voltmeter has to perform an autoranging action or has to change the sample frequency during an oneshot, measurements are taken until all changes to the range and the frequency have been done. Then three measurements are taken with the final settings.

Continuous measuring can be switched on by activating the **play** button or pressing the <S> key.

Storing measurement values on disk or paper

The voltmeter can store measurements on disk or print them. This is done in a completely different way than the other instruments.

The voltmeter can be set to measure (acquire) at fixed times. The measured value will then be stored on disk or sent to the printer.

The time at which measurements are taken is not 100% guaranteed. The reason for this is the Windows environment which is not a real-time

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multitasking system. Because of this there is no guarantee that the time between two measurements is the set interval. If this occurs, close all windows programs except the voltmeter and then try again.

Setting the time between two measurements

By activating the choice *Time* from the *Acquisition* menu, the time between two measurements can be set. A dialog box appears in which the time in seconds can be entered.



Note When a time shorter than 0.5 seconds is entered, the acquisition speed is determined by the changes of the displays.

Setting the hysteresis

With an acquisition time smaller than 0.5 seconds, the acquisition speed is determined by the changes in the displays. It can occur that the input signal has a value just between two displayable values. In that case the display will constantly change between the two values. To avoid a constant storage to disk or printer in that case, a hysteresis can be set. Only when the input value change exceeds the hysteresis value, the input value will be stored.

By activating the item *Hysteresis* from the *Acquisition* menu, a dialog appears in which the hysteresis can be entered. The hysteresis is entered as a percentage of the last measured value. With each new measurement, the size of the hysteresis in volts is recalculated.

The hysteresis can only be set with an acquisition time smaller than 0.5 seconds.

Start an acquisition

By activating the choice *Write data* from the *Acquire* menu, a menu is shown with which a selection can be made to write to disk or printer.

The choice *Disk* will cause the measurement data to be stored on disk. After activating the choice, a save dialog appears in which the drive, direc-

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tory and name of the file can be typed. If the typed file already exists, an overwrite prompt will appear. The measuring will start after this. At fixed times a measurement is taken and stored on disk. Measuring can be aborted by pressing the cancel button.



Note The file generated by this function can be read in the Transient recorder, to get a graphical representation of the data.
display 1 of Ch1 is placed in Ch1
display 2 of Ch1 is placed in Ref1
display 1 of Ch2 is placed in Ch2
display 2 of Ch2 is placed in Ref2

The choice *Printer* will cause the measurement data to be written to the printer. After activating the choice, a print dialog appears from which a printer can be selected. A dialog will appear in which the title of the job can be typed. Now measuring starts. At fixed times a measurement is taken and sent to the printer. Measuring can be aborted by pressing the Cancel button.

The printing and writing can also be activated by pressing the following buttons on the speedbar:



In both modes, the measurement values are preceded by a block of information. In that block is indicated how the channels are set and how the high, low and relative levels are set. Each measurement is preceded by the time and date of the measurement.

If a measured value is larger than the selected input range, '-------' is displayed. This will also be stored on disk or sent to the printer.

The date/time format can be set through the program settings dialog.

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For measuring slowly changing signals (e.g. the temperature change in a room) the transient recorder is the most suitable instrument.

The transient recorder is a two channel, direct registering measuring instrument, displaying the changes of the input signal graphically on the screen or on paper.

The transient recorder measures at settable, fixed times and processes the measured value if necessary. The number of measurements to be taken is also settable.



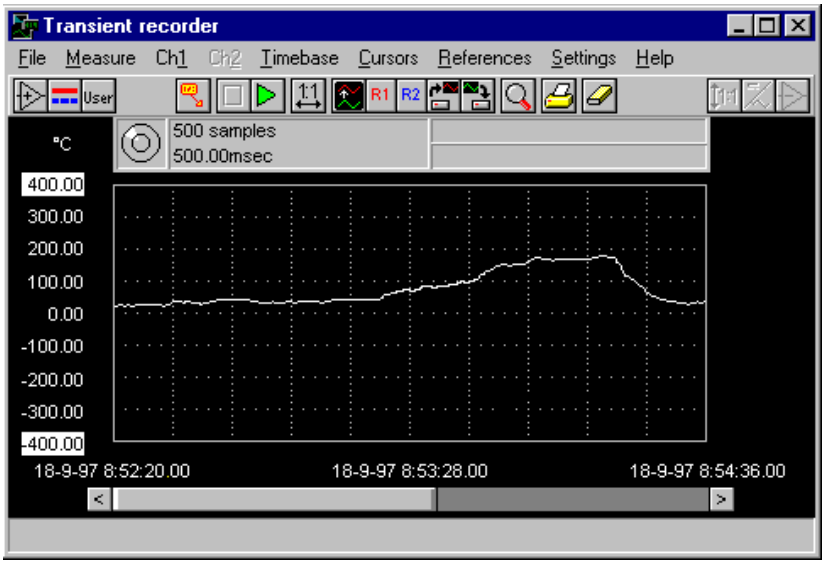
Note The transient recorder displays each measured sample immediately, the oscilloscope first takes all samples and then displays the complete record.

The transient recorder measures the input signals at adjustable times. The time between two measurements is adjustable from 0.01 second to 500 seconds. The number of samples is also adjustable from 1 to 32760. The maximum measuring time is 500 sec x 32760 samples = 16380000 seconds (189.6 days).



Note Due to the different way of measuring the input signals, the transient recorder can not be used together with the oscilloscope, voltmeter or spectrum analyzer.

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The transient recorder measuring system

Before measuring with the transient recorder, the channels and the time base have to be set up completely.

When all settings (input sensitivity, coupling, number of samples, sample speed etc) are made, the transient recorder can be started. All settings will be applied to the hardware and the hardware begins to measure. The hardware will continue measuring until the predefined number of samples is measured or when the user interrupts the measurement. Each measured sample will be stored in the board memory of the hardware.

When the measurement is running, the software will constantly monitor whether a new sample is measured. If a new sample is measured, it is obtained from the hardware acquisition memory and displayed on the display. This will continue until the measurement is ready.

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Note At certain sample speeds and/or relatively slow computers, it might occur that the software can't keep up with the hardware, in other words, the software misses samples the hardware has measured **and stored.** This is only a minor problem. The software detects that it has missed samples and will warn the user by lighting up a red LED in the display and displaying a warning message in the hint bar.
The missed sample in the record is filled with the value of the previous sample.
Trying to reload the missed sample(s) would take so much time, that again samples would be missed.

When the total measurement is ready, the software will reload the complete measured record from the hardware acquisition memory and display it.

Hint There are a few things to make the software keep up with the hardware longer:

- make the transient recorder window as small as possible
- Select Scan mode instead of Roll mode
- Do not show references while measuring
- close all other applications (especially applications in DOS windows)
- Set the Windows video driver to display up to 256 colors instead of True color or High color

Displaying channels

The two channels can be measured in several different ways:

Ch1	only channel 1 is measured and displayed
Ch2	only channel 2 is measured and displayed
Ch1 and Ch2	channel 1 and channel 2 are measured and displayed simultaneously

Selecting which way to measure the channels can be done using the *Measure* menu.

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When only one channel is measured, the controls of the other channel are disabled or removed from the display.

Setting up a channel

Setting up a channel in the transient recorder is done in the same way as in the oscilloscope. The only difference is that in the transient recorder no auto ranging for the input sensitivity is available.

For information on setting up a channel, see chapter 2, the oscilloscope.

Setting up the time axis

The time base in the transient recorder is almost the same as in the oscilloscope. However, the transient recorder has no pre trigger setting.
Therefor only the items that differ from the oscilloscope time base settings are discussed here.

Setting up the sample speed

The transient recorder measures a number of samples with a certain time between two samples. This results in a total measure time of (number of samples x time between two samples).

To setup the timing characteristics of the transient recorder measurement, open the Transient recorder measurement speed dialog. The dialog can be opened by activating the choice *Sampling speed...* from the *Time base* menu.

In the upper part of the dialog a selection has to be made how the timing characteristics of the transient recorder measurement have to be set. There are three possible ways:

- Enter the number of samples and the time between to measurements. The total measuring time is determined by the dialog.
- Enter the number of samples and the total measuring time. The time between two samples is determined by the dialog.
- Enter the time between two samples and the total measuring time. The number of samples is determined by the dialog.

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When a selection is made, the selected items can be entered in the input boxes in the lower part of the dialog. Under the input boxes, the determined value of the third parameter is displayed. When an invalid combination is made, the text in the input box that causes the invalid combination turns into red. When this is ignored, the value is clipped to the nearest valid value.

When the parameters are set properly the **OK** button can be clicked to apply the values and return to the transient recorder.



Note The timing in the hardware is generated by a cristal oscillator and two programmable integer dividers. This system can't generate all frequencies, but comes close. When the **OK** button is clicked, the software will determine the division values for both dividers, in such a way that the generated frequency approaches the requested frequency as close as possible. A lot of divider combinations have to be checked for that. While determining the correct divison factors, an hour glass is displayed

Setting the record length

The transient recorder takes a number of samples to display the input signal. This number of samples is called the Record length. To change the record length, three ways are available: using the record length menu, using the sample speed dialog or by means of function keys.

To change the record length using the menu, enter the *Time base* menu and select the *Record length* item. Another menu will pop up, containing the available record lengths and an item for a user defined record length. Selecting this item will bring up a dialog box in which a self defined record length (within the instrument hardware limits) can be entered. The *Time base* menu can also be entered by pressing the right mouse button over one of the time base controls or read outs.

For changing the record length the following function keys are available:

<F11>	Select a shorter record length
<F12>	Select a longer record length

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For the third way to change the record length, see setting up the sampling speed.

Setting the horizontal axis type

The Transient recorder can measure for a very long time. In that case it can be useful to have real time and date values along the time axis instead of the number of seconds since the starting moment.

This can be selected by opening the *Settings* menu and select the *Horizontal axis type* item. Now you can select between *Date / Time* and *Sample times*.

Perform measurements

Before measuring with the transient recorder, the channels and the time base have to be set up completely.

The channels do not have auto ranging, so the sensitivity has to be set manually. Since the Transient recorder usually measures slow signals, the input coupling should be set to DC, otherwise the input capacitor will block the signal.

Start measuring

When all settings are made, the transient recorder can be started. This can be done in three ways:

- Clicking the **Play** button ()
- Pressing the <**S**> key
- Enter the *Measure* menu and select the *Start measuring* item

When the measurement is started, all controlls except the Stop controls are disabled.

Stop measuring

When the predefined number of samples is reached, the Transient recorder will stop measuring. It is also possible to stop the Transient recor-

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der manually, e.g. when the event to measure is measured, or the instrument settings are wrong (coupling, sensitivity etc). This can be done in three ways:

- Clicking the **Stop** button ()
- Pressing the <S> key
- Enter the *Measure* menu and select the *Stop measuring* item

When the measurement is stopped, all controlls are enabled again.

Scroll mode

While measuring, the transient recorder displays the measured signal on a 1:1 base, meaning that for each sample 1 display pixel is used. When the number of measured samples is larger than the available number of pixels in the display, the record view offset has to be changed in such a way that the latest samples will be visible.

There are two ways to do this:

Scan mode: When the display is full, the record view offset will change a full screen, so the new samples will start filling the display from the left hand side of the display again.

Roll mode: When the display is full, the record view offset will change with one sample, making space for one new sample. Each new sample causes a change in the record view offset.

Roll mode looks nicer than Scan mode, but is also slower, so the Transient recorder will sooner miss samples in Roll mode than in Scan mode.

To set the scroll mode, enter the *Measure* menu, select the item *Scroll mode* and choose between the two possibilities.

Comparing signals using the reference channels

To make the transient recorder keep up with the measuring hardware longer, references can be switched off while measuring. To do this, open the *References* menu and select the *Show references while measuring* item.

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When the item *Show references while measuring* is checked, switched on references are shown while the Transient recorder measures. If the item is not checked, the references are switched off when the measurement is started and switched on again when the Transient recorder is ready.

Performing cursor measurements

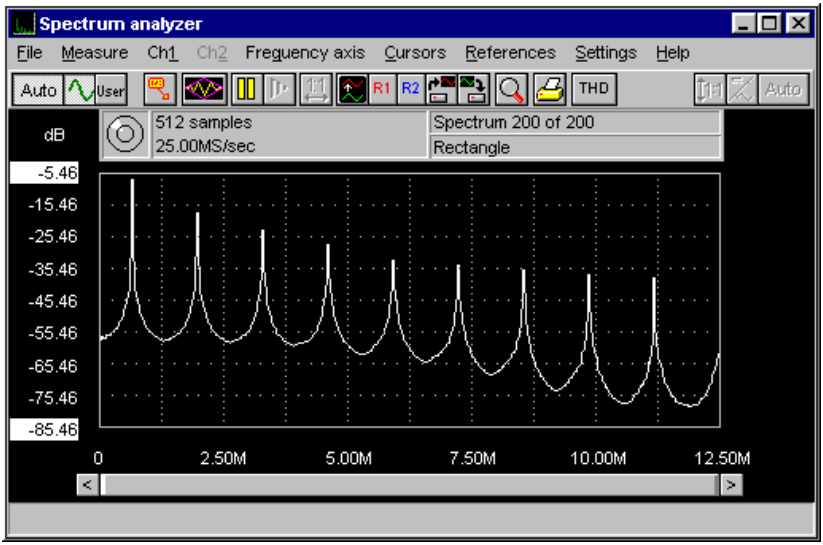
Like in the oscilloscope, the transient recorder has a set of cursors to perform measurements on the displayed signals.

The cursors in the transient recorder work exactly like the oscilloscope, so refer to chapter 2, the oscilloscope, for an explanation on how to work with the cursors.

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The common way to examine electrical signals is in the time domain, using an oscilloscope. The time domain is used to determine amplitude, time and phase information, which is necessary to describe the behaviour of an electrical system.

Not all electrical systems can be characterised in the time domain. Circuits like filters, amplifiers, oscillators, mixers, modulators and detectors can be characterised best by their frequency behaviour. That frequency behaviour is best obtained by observing the electrical signals in the frequency domain. To display the frequency domain, an instrument is needed that can distinguish different frequencies from each other and measure the signal size at the different frequencies. An instrument that can display the frequency domain is the spectrum analyzer. It graphically displays voltage as a function of frequency.



In the time domain all frequency components of a signal are seen summed together. In the frequency domain, complex signals (signals compo-

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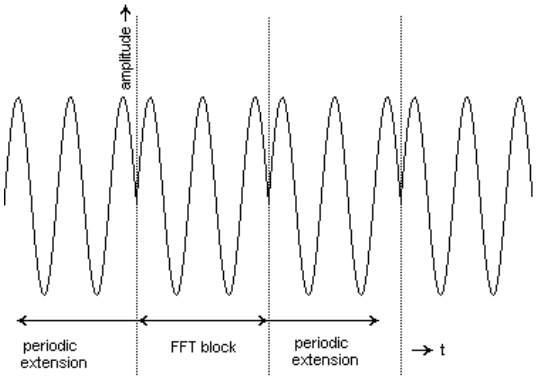
sed of more than one frequency) are separated into their frequency components, where the voltage of each component is displayed.

The frequency domain contains information which is not available in the time domain. Therefore the spectrum analyzer has certain advantages compared with an oscilloscope.

- With a spectrum analyzer small harmonic distortions on a signal can be displayed better than on an oscilloscope. A sine wave may look good in the time domain, however in the frequency domain the harmonic distortion is visible.
- A noise signal may look fully random in the time domain, in the frequency domain it can appear that one frequency is dominantly present.
- In the frequency domain it is very simple to determine carrier frequency, modulation frequency, modulation level and modulation distortion from a modulated signal (AM or FM).

Description of FFT

The spectrum analyzer is using the Fast Fourier Transform (FFT) principle. For this transform, a number of samples are taken with a previously set sample speed. The number of samples has to be a power of 2, e.g. 512 , 1024 or 2048. With these samples, here called FFT-block, the spectrum is calculated. Therefore the FFT places an infinite number of FFT-blocks behind each other, in the positive and negative direction. Each FFT-block forms 1 period of the created periodic signal.

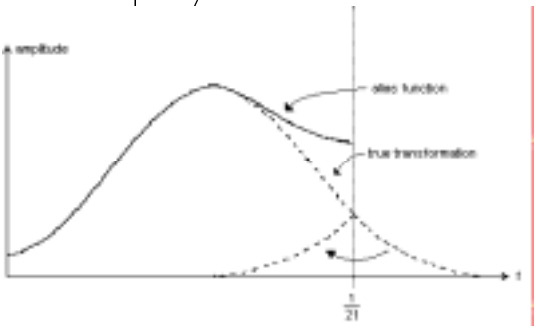


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From the signal obtained like this, the spectrum is calculated. The FFT calculation results in a number of spectral components which is half the number of samples in the FFT block (e.g. 256, 512, 1024). These spectral components together form the frequency spectrum of the input signal.
The spectrum analyzer displays an amplitude spectrum, which means that a 2 volt peak-peak sine wave is displayed with a 1 volt spectral component.

Aliasing

Like the oscilloscope, the spectrum analyzer needs a high enough sampling frequency to avoid aliasing. The result of aliasing when using FFT is that the frequency curve is folded back on itself.

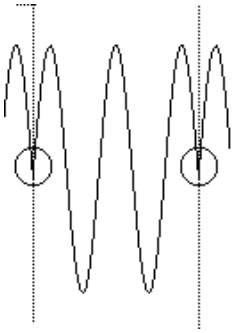


The original signal is sampled at a sample time t. The critical frequency (Nyquist frequency) is (1/2t) Hz.

Windowing

FFT treats the FFT-block like it is one period of a periodic signal. If the sampled signal is not periodic, harmonic distortion can arise, since the periodic waveform, 'created by the FFT', can have sharp discontinuities. See also the following illustration. These discontinuities are also called calculation errors.

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This means that because of the calculation errors extra frequency components are generated around the true frequency. Because of this 'smearing' the amplitude of the true frequency decreases, since the area under the curve remains the same.

The smearing, caused by the calculation errors, can be decreased by placing a window on the FFT-block samples, in such a way that the ends of the FFT-block are smoothly tapered to zero and discontinuities do not occur when the FFT treats the windowed block as one period of a periodic signal. Each sample of the FFT-block is therefore multiplied by a factor, whose size is dependent on the position of the sample in the FFT-block.

The software supports six different windows:

rectangular	(all data is not changed)
Hanning	(sinusoidal)
Hamming	(sinusoidal)
Bartlett	(sinusoidal)
Blackman	(triangular)
Parzen	(triangular)

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Displaying channels

The spectrum analyzer has several modes to display the two channels. To select the measure mode, enter the *Measure* menu and setlect:

Ch1	measure and display only channel 1
Ch2	measure and display only channel 2
Ch1 and Ch2	measure channel 1 and channel 2 simultaneously and display the values of both channels



Note When measure mode Ch1 and Ch2 is selected, the highest frequency range will be disabled.

When only one channel is measured, the controls of the other channel are disabled or removed from the display.

Setting up a channel

The two channels of the spectrum analyzer are completely configurable. Both channels are identical, each has its own menu item in the main menu. The possibilities of the vertical axes in the spectrum analyzer are the same as in the oscilloscope, so only the differences are discussed here. Since the possibilities for both channels are equal, channel 1 is explained here.

Setting the input sensitivity

The input sensitivity of a channel determines how large a certain signal will be displayed, the lower the full scale value, the larger the signal will be displayed. It is possible to enable an autoranging function.



Note The vertical axis in the spectrum analyzer has a range that is twice the input sensitivity. This is done because the frequency components of which a signal is built, can have a larger amplitude than the input sensitivity. So if an input sensitivity of 8 Volt full scale is selected, the axis will have values from 0 to 16 Volt full scale.

The sensitivity can be set through the *Sensitivity* menu. The *Sensitivity* menu is called by enabling the *Ch1* menu and then selecting the *Sensitivity* menu. In this menu the input sensitivities are available. In the spectrum

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analyzer also an *Autoranging* setting is available. The *Sensitivity* menu can also be entered by clicking the right mouse button over one of the Ch1 or Ch2 controls and readouts.

To switch on Autoranging, a special button is available. When autoranging is switched on, the button caption is **Auto,** otherwise it holds the current set input sensitivity. Pressing the right mouse button on this button will bring up a menu with all sensitivities.



Note When Autoranging is switched on, several measurements might be needed to set the input sensitivity properly, depending on the input signal.

Another way to set the sensitivity is by using the keyboard. A few keys have been reserved for setting the input sensitivity of the channels. These keys are:

<F5>	Increase Ch1 sensitivity
<F6>	Decrease Ch1 sensitivity
<F7>	Increase Ch2 sensitivity
<F8>	Decrease Ch2 sensitivity

Logarithmic or linear vertical axis

The vertical axis of the spectrum analyzer can be set to linear or to logarithmic.

When set to linear, the normal axis is used, running from 0 to 2 x Sensitivity. When set to logarithmic, the position on the linear axis that is marked Sensitivity will get the value

$$\text{Value} = 20 \times {}^{10}\log \text{Sensitivity}$$

The rest of the labels will get a value that is related to this value and differ from it with 10 dB per division (when Software gain is set to 1). The measured data will be transformed to logarithmic data as well.

Selecting the axis type can be done by entering the *Ch1* menu, chosing the *Axis type* menu and selecting the axis type.

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The axis type can also be set by the keyboard using the following keys:

<L>	toggle the Ch1 axis between Linear and Logarithmic
<Shift+L>	toggle the Ch2 axis between Linear and Logarithmic



Note Due to 'smearing' errors, caused by discontinuities (See Windowing) and (within specifications) distortion in the Analog to Digital Converter non-existing frequency components will show up when a logarithmic axis is selected. These components are all outside the dynamic range of the measurement system.

To avoid confusion with these non-existing frequency components, the logarithmic graph can be clipped on the theoretical dynamic range of the measurement system. This is done by selecting the *Vertical log axis range* item from the *Settings* menu and chosing either *Not clipped* or *Clipped conform hardware specs*.

Setting up the frequency range

Along the horizontal axis of the screen, the frequency of the measured spectrum is projected.

Magnifying the frequency axis and horizontally positioning the signal is done in the same way as in the oscilloscope and is therefor not discussed here.

Setting up the frequency axis type

The frequency axis can be set up in four different modes:

Linear	the frequency axis runs from 0 to the maximum frequency and has a linear division.
Logarithmic	the frequency axis runs from the minimum frequency to the maximum frequency and has a logarithmic division.
Octaves	the frequency axis runs from 22.1 Hz to 22.6 kHz and is divided in 10 octaves. The center frequencies,

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the lower limits and the higher limits of the octaves are:

f_{center}	f_{lo}	f_{hi}
31.25 Hz	22.1 Hz	44.2 Hz
62.5 Hz	44.2 Hz	88.4 Hz
125 Hz	88.4 Hz	176.8 Hz
250 Hz	176.8 Hz	353.5 Hz
500 Hz	353.5 Hz	707.1 Hz
1 kHz	707.1 Hz	1.414 kHz
2 kHz	1.414 kHz	2.828 kHz
4 kHz	2.828 kHz	5.656 kHz
8 kHz	5.656 kHz	11.314 kHz
16 kHz	11.314 kHz	22.627 kHz

Each octave is displayed with the same width on the display.
This mode requires that the sampling frequency is about 44 kHz and the record length is at least 1024 spectral components. When this display mode is switched on, the sampling frequency can no longer be set and the record length can only be set to a few lengths.

Third octaves

the frequency axis runs from 17.54 Hz to 22.6 kHz and is divided in 31 thirds of octaves. The center frequencies, the lower limits and the higher limits of the octaves are:

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fcenter	flo	fhi
19.68 Hz	17.54 Hz	22.09 Hz
24.80 Hz	22.09 Hz	17.84 Hz
31.25 Hz	27.84 Hz	35.1 Hz
39.4 Hz	35.1 Hz	44.2 Hz
49.6 Hz	44.2 Hz	55.7 Hz
62.5 Hz	55.7 Hz	70.2 Hz
78.7 Hz	70.2 Hz	88.4 Hz
99.2 Hz	88.4 Hz	111 Hz
125 Hz	111 Hz	140 Hz
157 Hz	140 Hz	177 Hz
198 Hz	177 Hz	223 Hz
250 Hz	223 Hz	280 Hz
315 Hz	280 Hz	354 Hz
397 Hz	354 Hz	445 Hz
500 Hz	445 Hz	561 Hz
630 Hz	561 Hz	707 Hz
794 Hz	707 Hz	891 Hz
1.00 kHz	891 Hz	1.12 kHz
1.26 kHz	1.12 kHz	1.41 kHz
1.59 kHz	1.41 kHz	1.78 kHz
2.00 kHz	1.78 kHz	2.24 kHz
2.52 kHz	2.24 kHz	2.82 kHz
3.17 kHz	2.82 kHz	3.56 kHz
4.00 kHz	3.56 kHz	4.49 kHz
5.04 kHz	4.49 kHz	5.66 kHz
6.35 kHz	5.66 kHz	7.13 kHz
8.00 kHz	7.13 kHz	8.98 kHz
10.1 kHz	8.98 kHz	11.3 kHz
12.7 kHz	11.3 kHz	14.3 kHz
16.0 kHz	14.3 kHz	17.9 kHz
20.2 kHz	17.9 kHz	22.6 kHz

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Each third octave is displayed with the same width on the display.
This mode requires that the sampling frequency is about 44 kHz and the record length is at least 4096 spectral components. When this display mode is switched on, the sampling frequency and the record length can no longer be set.



Note When the spectrum analyzer is set to Hold and the frequency axis is set to octaves or third octaves, the signal will not match with the axis and the grid until a new measurement is taken.

Setting the frequency range

The frequency range can be set in two ways: using the menu of by means of special function keys.
The frequency range is determined fully on the sample frequency: the frequency range is half of the sample frequency.

To change the Frequency range using the menu, enter the *Frequency axis* menu and select the *Frequency range* item. A new menu will appear with all possible frequency range settings. The Frequency axis menu can also be entered by pressing the right mouse button over one of the frequency axis controls or read outs.

The last item in the menu is a user defined setting. Activating this item will bring up a dialog box in which a self defined frequency range (within the instrument hardware limitations) can be entered. Due to the way the sample frequency is generated in the hardware, not all frequencies and thus not all frequency ranges can be generated. If an invalid frequency range is entered, the closest valid frequency range will be generated.

The following keys can be used to change the frequency range:

<F3>	Set the frequency range one step smaller
<F4>	Set the frequency range one step larger

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Setting the spectrum record length

The spectrum analyzer takes a number of samples to determine the frequency spectrum of the input signal. This number has to be a power of 2. After the FFT calculation, a spectrum with half of that number spectral components is obtained. This number of spectral components is called the Record length.

To change the record length, two ways are available: by means of a menu or by means of function keys.

To change the record length using the menu, enter the *Frequency axis* menu and select the *Record length* item. Another menu will pop up, containing the available record lengths. The Frequency axis menu can also be entered by pressing the right mouse button over one of the frequency axis controls or read outs.

For changing the record length the following function keys are available:

<F11>	Select a shorter record length
<F12>	Select a longer record length



Note Calculating a spectrum is time consuming. The time need for calculating a spectrum is strongly dependent on the calculating power of the computer and of the selected record length.

Setting up the FFT

FFT window function

To reduce 'smearing' errors (See Windowing), a windowing function can be selected.

To select a windowing function, press the **Window** button () or select the item *FFT window function...* from the *Settings* menu. A dialog will appear in which the requested window can be selected. A graphic display will show effect of the windowing function on the sampled signal.

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The available window types are:

rectangular	(all data is not changed)
Hanning	(sinusoidal)
Hamming	(sinusoidal)
Bartlett	(sinusoidal)
Blackman	(triangular)
Parzen	(triangular)

Performing measurements

When all settings are made, measurements can be made.

Start and stop measuring

To avoid a new screen of measurement data replacing an old screen, measuring an displaying of data can be stopped. This can be done in several ways: by pressing the **Pause** button (), by pressing the <S> key of by activating the item *Stop continuous measuring* from the *Measure* menu.
When measuring is stopped, the latest measured data will remain on the screen. The **Pause** button changes to a **Play** button () and the **One shot** button () becomes available.

The measured signal can now be examined.

Single measurements

To perform a single measurement, press the **One shot** button, press the <O> key of activate the *Perform a single measurement* item from the *Measure* menu. When in the Spectrum analyzer averaging is selected, there will be performed as many measurements as there are set for the averaging and then measuring will stop.

Continuous measuring can be started again by pressing the **Play** button, the <S> key or the item *Start continuous measuring* from the *Measure* menu. The **One shot** button will be disabled again.

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Averaging

When a noisy signal is measured, the influence of the noise can be eliminated by averaging several spectra. The noise component(s) will disappear and the actual signal remains.

Averaging can be switched on by selecting the item *Perform averaging of* from the *Measure* menu. In the next menu a number of measurements can be selected that have to be averaged. The item */ measurement* will switch off averaging.

When averaging is set to e.g. 20 measurements and the spectrum analyzer is set to Pause, presing the One shot button will result in taking 20 measurements which are averaged

Measuring maximum values

The spectrum analyzer can be set to measure and display only the maximum values of the spectral components. After a number of measurements the highest value of each spectral component is displayed then.

To enable measuring maximum values, enter the *Measure* menu and select the choice *Measure max values*. A check mark in front of the menu item indicates whether measuring maximum values is switched on or off.



Note The display of maximum values is resetted when the instrument setting changes



Hint This mode can be useful when the frequency response characteristic of a device needs to be determined. Apply a frequency sweeped signal and switch on Measure max values and the characteristic will be created.

Measure the Total Harmonic Distortion of a signal

With the spectrum analyzer it is possible to measure the Total Harmonic Distortion of a signal.

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The THD is defined as:

$$20 \times {}^{10}\log \frac{\sqrt{(V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2 + V_7^2 + V_8^2 + V_9^2 + \ldots + V_n^2)}}{V_1}$$

where V_1 is the RMS amplitude of the base frequency of the input signal, V_2 .. V_n are the RMS amplitudes of each higher harmonic.

To measure the THD, enter the *Measure* menu and select the *Total Harmonic Distortion* item or by pressing the **THD** button (THD). The software will determine the base frequency of the signal by assuming that the spectral component with the largest amplitude is the base frequency. Then the amplitudes of all higher harmonics (up to 100) in the measured record are determined and the THD is determined.

In the THD output window the base frequency of the signal is given, the harmonic distortion in dB is given and a table with the amplitudes of all used harmonics is given. This is done for all active channels.

The number of harmonics that is used for the calculation depends on the base frequency. If the base frequency is low, more harmonics are found than when the base frequency is high. The calulation routine will use up to 100 harmonics or up to a user defined number. This user defined number can be set by entering the *Measure* menu and selecting the item *Max. number of harmonics to use*. A new menu will pop up with the possible numbers.

Performing cursor measurements

Like in the oscilloscope, the spectrum analyzer has a set of cursors to perform measurements on the displayed signals.

The cursors in the spectrum analyzer work almost like in the oscilloscope, so only the differences are discussed here. Refer to chapter 2, the oscilloscope, for more explanation on how to work with the cursors.

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Setting up the cursor measurements

With the cursors it is possible to measure the input signal(s) in several ways. To set up the cursor measurements, press the settings button at the cursor readout window (the right most button at the left top of the window caption) A menu appears, containing the following options. The menu can also be called by pressing the right mouse button over the table.

Time

Frequency left	the frequency at the position of the left cursor is determined.
Frequency right	the frequency at the position of the right cursor is determined.
Frequency difference	the frequency difference between the left and right cursor is determined.

Voltage

Voltage left:	the voltage of the left cursor will be displayed.
Voltage right:	the voltage of the right cursor will be displayed.
Voltage difference:	the difference between the voltage of the left and the voltage of the right cursor is calculated. Selecting the min and max of the signal, the top-top value is calculated.

Distortion

The Total Harmonic Distortion of the input signal is determined. Up to 100 harmonics are used for the calculation

Automatic tracking cursors

If this option is enabled, the voltage levels of the cursors are automatically set to the voltage levels of the sample numbers which correspond to the left and right cursor.

Calculate values

If this option is disabled, no new calculations will be done until the option is enabled.

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Show measurement name
Show measured value
Show measurement unit

To reduce the space used by the window on the screen, the measurement name, value and/or unit can be hidden. This results in the disapearance of the corresponding column which results in a smaller window.

Display font

By selecting this option, the font which is used to display the strings and values can be changed. The font settings which can be changed are: font name, font style, font size and the font color.

Background color

By selecting this option, the background color can be changed. Some font colors like e.g. light green are not showing up very good on a white background. Change the background color to, e.g. black for a better result.

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