# PhysTech

# RH 2030, RH 2035, RH 2010
# van der Pauw and Hall

## Software Manual

## Version 4.1, 2015-01-30

# Contents

# Introduction

This manual is the 3. part of the main Hall documentation set:

1) **Hardware manual H**
2) **Software installation manual I**
3) **Software program manual S** (this manual)
4) **Basics manual B**
5) **Theory manual T**

The Software (program) manual provides information on how to use the Hall system and how to work with the Hall program.

In the following only **user class 4** will be described, except at some marked parts. Features needing a higher user class are not visible or not enabled (grey text) in input dialogs and menus. Sometimes inputs are not visible or not enabled because these depend on the data or evaluation mode. The most general examples are coming from the vdP/Hall program module.

In the most menus and input windows you get **help** information by the F1-key. Then the electronic manual will be opened at the corresponding page. For this you need a PDF viewer, either the Adobe Reader, the Foxit Reader or the Sumatra Portable, or a plug-in for your Web browser.
At some input windows there is a help button. It have the same function as the F1-key. You get help information by the F1-key also if there is no help button!
In some input windows you get by the F1-key different help information depending on the selected input group. For example if there is an input group for interpolation then you get the help text of chapter 2.7.1 if activating this input group and pressing the F1-key.
At many buttons and inputs you get a hint by moving the mouse to this position.

Reference to another chapter of this manual will be denoted only by this chapter, for example 1.1.3. If there is a reference to another manual the type of this manual will be additionally given, for example I3.1 for chapter 3.1 of the software installation manual. The equations, most abbreviated by 'equ.', refers to the Theory Manual. The chapter reference inside this manual is in many cases a hyperlink, that means if you click onto the blue chapter number, the document jumps to this chapter.

All inputs in this manual will be shown in the Windows classic style. The inputs may have another look on your computer, it depends on your Windows Themes, see chapter 2.3.1.

A user without experience in Hall can make easily measurement with the easy program. A quick information for this will be given in chapter 4.1.3.

# 1. Program start, structure and Basics

## 1.1 Program start

### 1.1.1 Main start window

After activating the Hall icon on your desktop the software is coming up with the start window and included there an input window. On the top you see the program name, the program version and date, and the licence number and name.
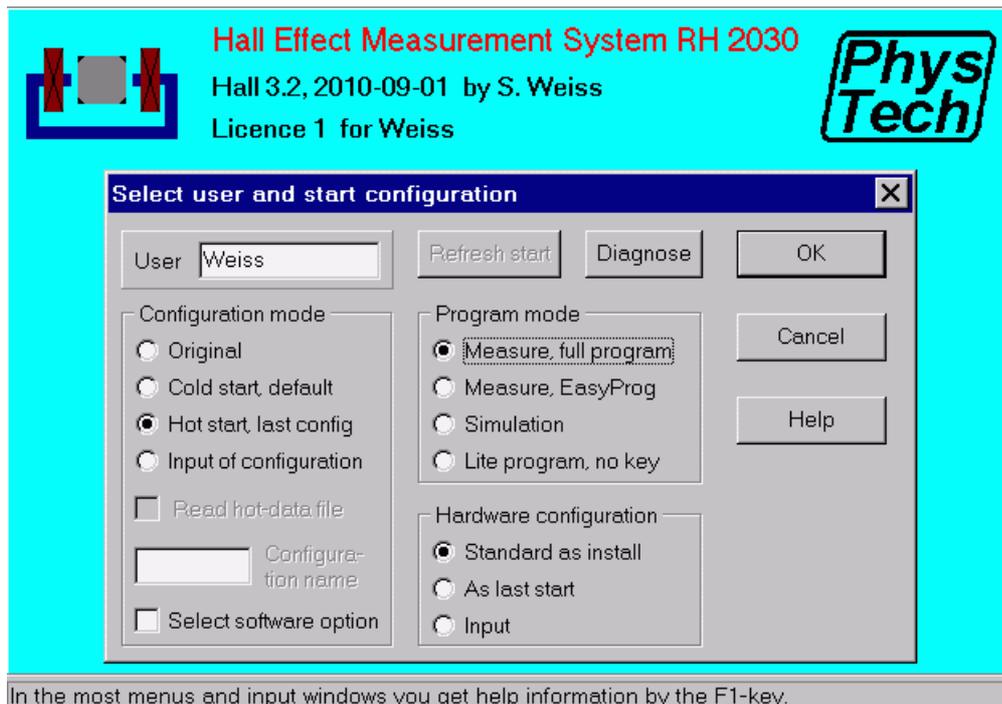


The **input window** defines which initialization (init) files should be loaded (configuration mode), which hardware options should be used, and whether the software should work as a measurement or without the hardware as a simulation and evaluation software. It also defines the data path.

First type in your **user name.** You can type in up to 16 characters. These, without blanks, will also be used for your personal data directory. In the measurement data file and in the database will be only maximal the last 8 characters saved. If you type in no name then as name 'Guest' will be set.

The **Configuration mode** define which user initialization will be loaded. This sets the program, sample and measurement parameters (except reverse bias voltage).
4 possibilities exist:

**Original**      A predefined configuration file set, that can not modified in any case, only init files from the system directory Sys\Init will be read. It should only be used, if the 'Cold start' configuration set is not working properly.

**Cold start**   The cold start files will be used. This mode is the default mode after instal- lation and for a new user. Cold start files can not be automatically created after program start but only manually, see 1.2.1. In most cases the cold start uses the 'Original' files, see 1.1.2.

**Hot start**    This is the standard mode, it is a configuration file set, that can be saved during the closing procedure, to make sure, that a user can work the next day or week with the same configuration as the software has been left.

**Input con-**    A configuration file set, saved under a particular name, allows you to start a
**figuration**    previous saved configuration The name has to be defined in the input box below this flag. It can be saved before during the closing procedure.

**Read hot data file** loads also the last or predefined user changes of parameters which normally should be fixed because they hardware dependent, not used at this time.

**Select software option** gives you an optional second start window, see 1.1.6. Normally this is not necessary. For a new user it will be automatically opened.

At **Program mode** you select the kind of using the program. **Measure** starts the full measurement program with the hardware. All hardware has to be attached and powered. **EasyProg** starts a special measurement program for easy and routine work with restricted options. You can call this module, called routine program, also from the full program. Look in chapter 4.1 for a description.
**Simulation** don't use the hardware, only simulations and evaluations are possible.
**Lite program** works similar as the 'Simulation' but need no protection key, see in the Installation Manual.

By **Hardware configuration** you can select how your hardware will be started. Normally use the 'Standard'. Here the software expects all in the setup program installed hardware options attached to the system. But in some cases there is no need for some options or it is not attached. In that case this input box enables a hardware configuration only for the actual use of the software without modifying the system setup. But only options that has been installed can be switched off, new options can not be activated here. This has to be done using the set up program.

**Standard**    Starts the software with all hardware options as it has been installed.
**Last start**    Starts the software using the hardware configuration of the last start.
**Input**    Opens an additional input window (after 'OK') for a definition of the hardware that shall be used, for example working without cryostat, see chapter 1.1.6. The default input values will be taken from the last start.

The **Refresh** button refresh the main start window if you change the user name.
With **Diagnose** you get an input window for diagnose parameters. It is only necessary if you have start problems, see chapter 1.1.3. At this input window you can also define remote working.

**Note:** You can start only one **instance** of the measurement program. For the lite program you can start some instances on one computer. You can also start the measurement program for making long time measurements and parallel (multitasking) an instance of the lite program for evaluation of your data files. But the lite program must have already created the lite licence. This will be done at the first start of the lite program, see in chapter I1.3 and I7.1 of the installation manual.

**Tip:** If start problems occur, select the cold or original start.

## 1.1.2 Search strategy for user init files

The following give an example of the search strategy for the user init file 'Globals.Cfg' in the standard mode 'Hot start'. We assume that UserX is the personal data directory and the software version is 3.2:

1) UserX\Init\32\Globals.Hot.Cfg
2) UserX\Init\32\Globals.Cold.Cfg
3) Conf\Init\Globals.Cfg
4) Sys\Init\Globals.Cfg

If the file was found in 1 (1 is the highest priority), this file will be load and the search will be canceled. In the other case the file will be searched in 2 and so on. With the mode 'Cold start' the search starts in 2.
At the personal init directory there is also the program version number as sub directory. So you can work with different program versions. After installing a new program number version the old init files will be copied to the new sub directory at first program start if possible.

## 1.1.3 Diagnose and start problems

This input is only necessary if you have start problems or if you want to look which files will be loaded or which commands will be send to the hardware. The diagnose is for checking problems at the hardware communication. All inputs here are only temporary, a new start will deactivate all.You find a log file of the start in the directory Diag\Start. For the measurement program it is 'Start_A.LOG'.

**Start options** are only valid for the program start. With 'Monitor' you get a monitor window on your screen with information about loaded system and user initialization files and commands send to the hardware. 'Delay' gives a 1 s delay after every action, by 'Ignore errors' the start goes on although errors occur.

**Work options** are valid for the whole program and not only at start. With 'Use standard monitors' you get at working a monitor window on your screen, 'No repeat of cmds' do not repeat a command if an error occur.

**Diagnose** is a special work mode to check problems with the hardware communication. Different diagnose work modes D1 to D7 and, sometimes for special customers, S1 to S3 exist. Use these diagnose modes only after authorization from PhysTech. The program saves then automatically or manually some or all communication commands into a report file. After leaving the program you get an information window about the report file name, usually Diag\Report\Diagnose.Zip. Send this report file to PhysTech.

The most used diagnose mode is D1. It reports the commands for the first and last measurement. So, if PhysTech request you for diagnose mode 1, start the program, make one measurement (usually a VdP and Hall measurement), save the measurement, leave the program and send the report file to PhysTech.

Diagnose mode D5 reports only commands of the cryo system (temperature controller). Diagnose mode D7 reports only errors and semi-errors. It can be activated permanently in Set_Conf, see chapter I3.2 and I6.5 of the Installation Manual.

**Start modes** defines how the hardware should be used. 'Normal, program' starts the program with the full hardware. 'Comands, all inits' starts not the standard program but a special monitor program in which you can send commands to the hardware. Here are also the full hardware will be used and initialized. 'Commands, no inits' starts also the monitor program but which no initialization of hardware. 'Commands, cryo init' starts the monitor program and initialized only the cryo system.

If you get start or hardware problems, the program breaks with an error message and asks you for making the report file 'Diag\Report\Rep_Err.Zip'. Please save this file and send it to PhysTech if you have questions to PhysTech. A short description of possible **start errors** will be given in chapter I6 of the Installation Manual, additional expert information in Sys\Doc\Diagnose.Txt.

**Remote server/client** gives you the possibility to use remote working as server or client.
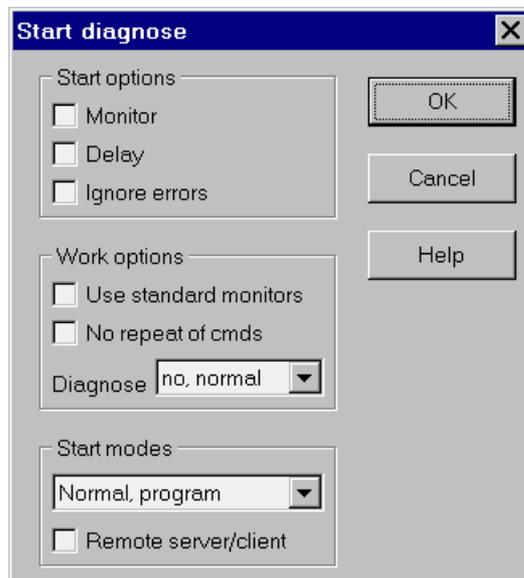
## 1.1.4 Remote working

Here you can define remote working. One use can be to check hardware problems by PhysTech. In this case you start your program as a server and PhysTech will control it as a client. The other use can be making measurements from home via internet. In this case you start the measurement program in your laboratory as a server. At home you start the simulation program as a client, for this you need the simulation hardlock key.

You get the following input window if you start your system as a **server**:
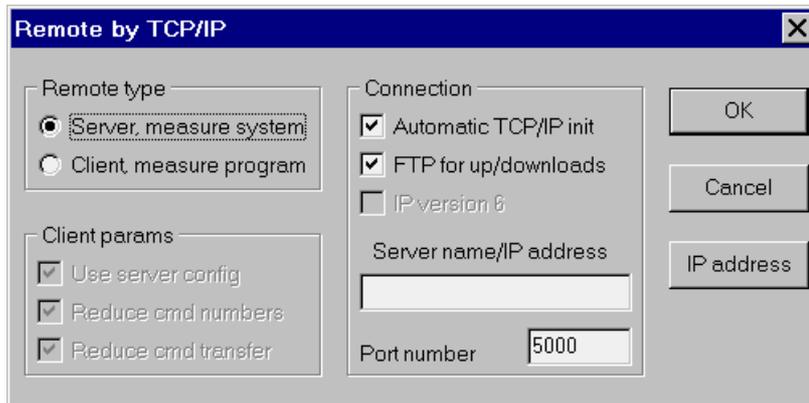


With 'Automatic TCP/IP init' your IP address and port number will be send to a hidden directory of PhysTech server. In this case it is not necessary to inform the client about these parameters. In the other case you must phone or send a mail to the client with these 2 values. With 'FTP for up/downloads' you use FTP instead HTTP. Make sure that FTP is allowed.
For the remote connection you have to input the Server name or your IP address and the . Port number. If you don't know your IP address click onto the 'IP address' button. Make sure that the port is opened, ask your administrator.

For the **client** you get following input window:
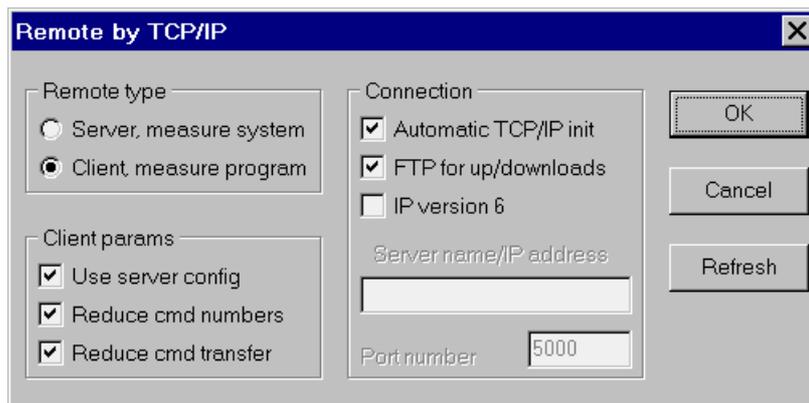


Without 'Automatic TCP/IP init' you must input the Server name or IP address and the Port number. In the other case it will be automatically read from PhysTech server, see at remote server. IP version 6 will not be supported by all providers/servers.

'Use server config' means that the configuration from the server will be copied to the client. By 'Reduce cmd numbers' and 'Reduce cmd transfer' the transfer is faster but for checking problems it can be useful to switch off these options.

The remote **server** will stay in a special window as shown below.

After the server and client were started, you see the actions and the transfer of commands initiated by the client. 'Enter' is the current command from the client, 'Send' the last answer from the server to the client. The send and enter strings will be listed in the memo text field below the buttons. The text field will be cleared after 500 entries. You can initiate a chat by the 'Chat' button.
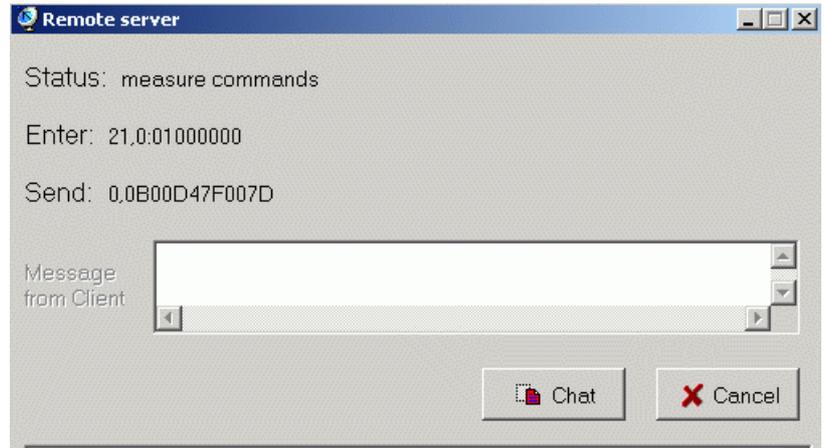
At Windows 2000 and XP you should deactivate a screen saver.

If the server was started, you can start the remote **client** by the 'Start' button. If the connection and the initialization were successful, you get following window for the client:

You start the measurement program by the 'OK' button. After the initialization of the hardware the program goes into a measurement menu as usually.

By the 'Msg' button you can send a message to the server (chat mode). This message has to be input in the top text field. A message received from the server will be shown in the bottom text field.
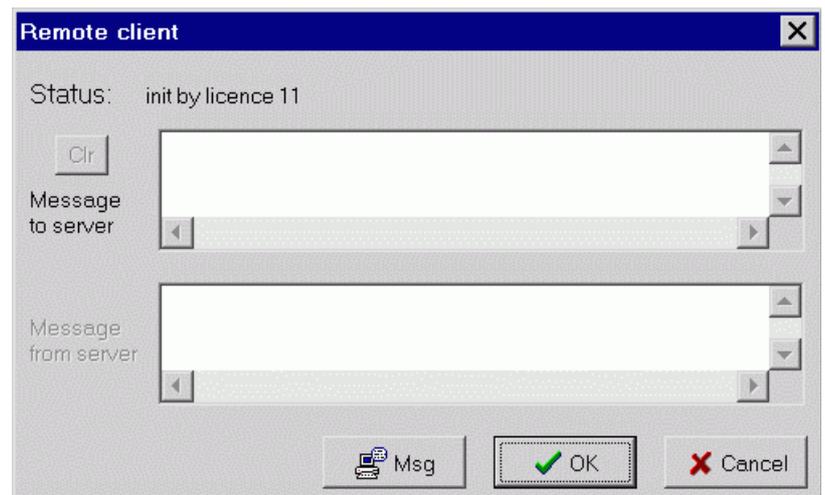
From the client you can call a chat window similar as above in 'Base tools → Utils → Remote program'. There are following **buttons**:

**Break:** Disconnects the remote connection.

**Tools**: There you can switch on or off peripheral hardware components, if available. You can also shut down the remote server by the client.

**Msg:**   Sends a message to the server.

**Close:** Leaves this input window and goes back to the measurement program.

The server must be started before the client. You can start the client some times without new starting of the server.

## 1.1.5 New user

If you start the main program with a
new/unknown user name or if you start
with start option 'Original', you see the
following input:
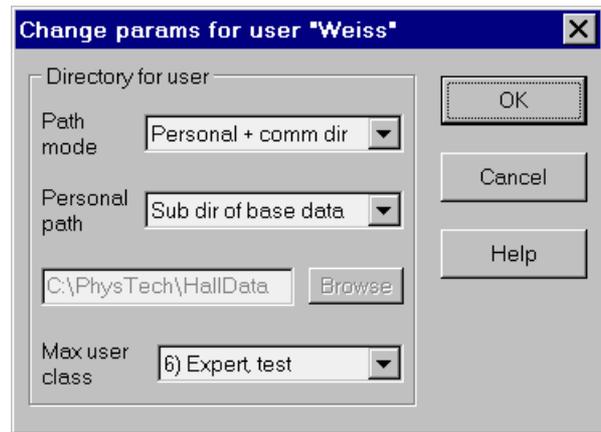
By **Path mode** you define your data path:

| | |
|---|---|
| **Guest directory:** | Your measurement data will be saved to Guest data directory 'HallData\Guest' and the Guest database will be used. |
| **Common data directory:** | The common data directory 'HallData\Data' will be used for measurement data and database. |
| **Personal directory:** | Your personal data directory, for example 'HallData\UserX' will be used for data and database. |
| **Common + Personal directory:** | You may switch between these both data paths, the default one is the common. |
| **Personal + Common directory:** | You may switch between these both data paths, the default one is the personal. |
| **Personal, Common, Input:** | As before, additionally an input of the path is possible. |

With **Personal path** you define your personal data directory:

| | |
|---|---|
| **Sub dir of base data:** | Defines your personal data path as a sub directory of the base data path, for example 'HallData\UserX', see chapter I7.3. |
| **Windows Personal:** | Selects the Windows Personal directory. |
| **Input of dir:** | Here you can define the path by an input. |

The directory for loading **initialization files** will also be defined by the path mode. This directory is a sub directory of the data path. At the first mode above it is 'Guest/Init', at the second 'Data/Init' and at all others a sub directory of your personal data path, for example 'UserX/Init' if UserX is the user name.

**Note:** The Windows guide lines prefer the Windows Personal directory. We prefer that the data path is a sub directory of the base data path. In this case users can read data from other users.

**Max user class** defines the maximal user class which you can use. This is the maximum value for the user. For the most users it is not necessary to change it. The real value can be restricted later in the software. The RH 2035 allows usually only a maximum class of 4.

You can modify these user inputs also in the Help menu in 'Configuration info' by clicking onto the 'User file' button. The user file is in Hall\Work\Users.

## 1.1.6 Optional start windows

If a new user starts the program or if you select in the main start window 'Select software option' you get following input:
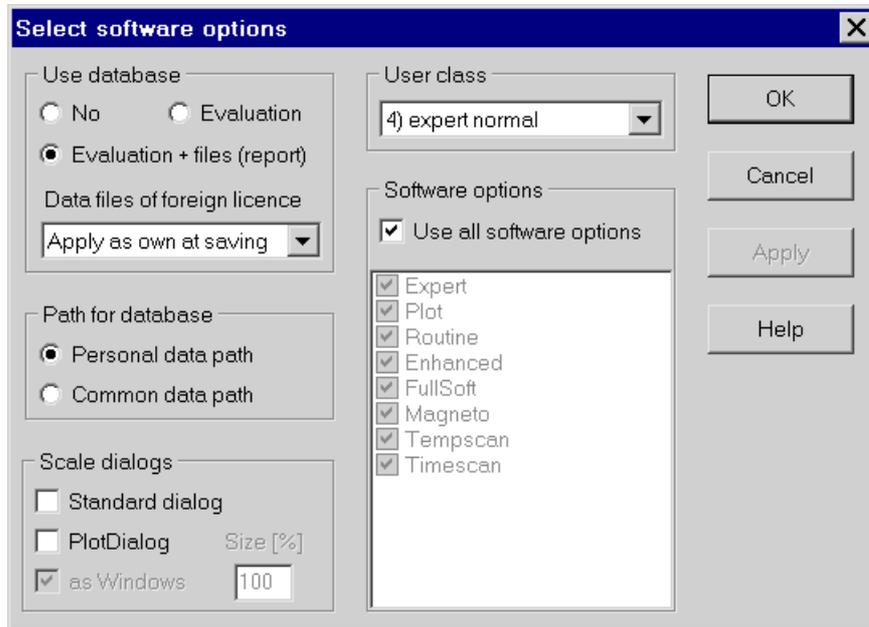


At **Use database** you can define if you want to work with the database. 'Evaluation database' means that only evaluation values will be saved into the evaluation database. Before saving you get a question or you have to call the save dialog.
At 'Evaluation + files (report)' additionally the measurement action, but not the measurement data, will be saved into the file database as a report. If measurement data will be saved then automatically this report will be done.

With **Data files of foreign licence** you define what happens if you read foreign measure data files and want to save the modified file. This input is only important if you get measure data from foreign customers. 'Keep licence, no database' means that the foreign licence will be kept and no entries will be done in your database. At 'Use database' your database will be used for the foreign licence. 'Apply as own at saving' means that at saving this data file the licence number will be set to your licence number.

With **Path for database** you define whether you want to use your Personal or the Common data path for saving your data. **User class** defines your input level, see chapter 2.4.1. With deactivating of 'Use all software options' you can select your **software options** for the start.

By **Scale dialogs** you can scale the standard and the plot dialogs. Either you can define a percentage size or the option as 'Windows'. In the last case the dialogs will be scaled by the Windows display text size (DPI). Especially at high resolutions screens it may be important to increase the scale with an individual percentage value bigger than 100 to avoid too small dialogs. Plot dialogs are dialogs which contain additionally a plot or grid. Look in chapter 2.3.1 for more information, especially for high resolution screens.
After changes in the 'Scale dialogs' input group, the Apply button will be enabled. A click onto this button shows immediately the optional start window in the new size.

If you start the program with the option **Input of hardware configuration** then you get an additional input window.
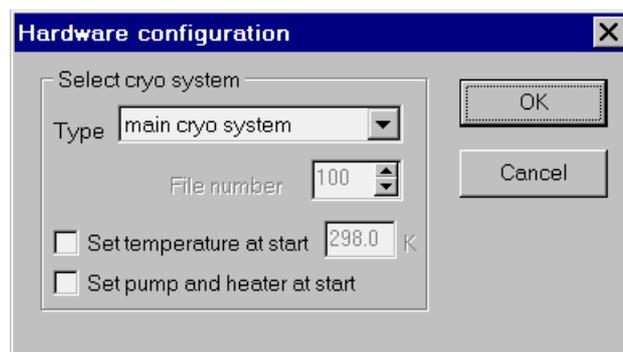
The input of **Select cryo system** defines the cryo system the software should work with. Types are:

| | |
|---|---|
| **main cryo system:** | As installed by the set up program. |
| **alternate cryo system:** | If a second (alternative) cryo system has been installed, it can be selected here. |
| **input of cryo file no.:** | Not for common use. |
| **no cryo, simulation:** | The software is working without a cryo system. The cryostat is simulated. |
| **no cryo, input temp:** | As above, but the cryo system is not simulated. The temperature can be set as a parameter. All measurements except the temperature dependent ones are possible. |

It is also possible to define a new **temperature** at program **start**. At every program start then the set point of the temperature controller will be set to this value.
You can also switch on **pump and heater** at program start if these options are available.

## 1.1.7 First start after installation

After starting the measure program first time after installation you get an information that you should do a calibration because no customer specified calibration file exist.
The electric magnet of the RH 2030 and RH 2010 has to be calibrated, see chapter 4.2.3.
This is not necessary for the permanent magnet of the RH 2035, but you should input the magnet field written on your magnet, see chapter 4.2.2.
The calibration of the magnet field has to be done the first time after the system has been installed, or every time the pole tips gap has been changed. It's normally not necessary to calibrate the magnetic field if the pole tips has not been changed after the last calibration.

You should also do the calibration of the offset voltages once after the system has been installed, see chapter 4.2.4.

All calibration procedures are in the 'Calib' menu of the program module Base Tools.

## 1.1.8 Program exit

Before leaving the program you will be asked for saving your current configuration. Here you define how the configuration files including all modifications done throughout the last working with the software should be saved into init files. By **Hot start** you can start your current configuration next time by selecting the start mode 'Hot start'. It is available as long as it is overwritten. You can also input a name of configuration.
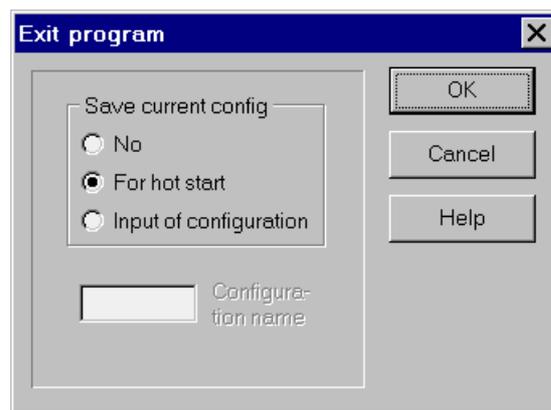
**Tip:** We recommend to save once a 'well' running configuration with your preferred style, face and inputs. Call it for example 'Good'. Then you can start this configuration when the hot start contains too much unfavorable changes.

If you have changed the **material parameters**, not the sample parameters, it is possible that you get a checkbox for confirmation that you want also to save the new material parameters, see in 2.4.2. Here you can save these parameters only for the selected configuration, not for a cold start.

In some cases you get at program exit an additional question for the **cryo system**. This means that the pump or heater was switched off by the program, the set point has still the old value. It could be that this value is very low or very high. If you start the program again some temperature controllers run to the old set point. Some controllers save its set point although you have switched it off. Defining the set point to room temperature the cyro system will not cool or heat at new program start. You can input the value for the 'room temperature' in the general cryo options, see chapter 2.4.6.2.4. By default it is 305K.
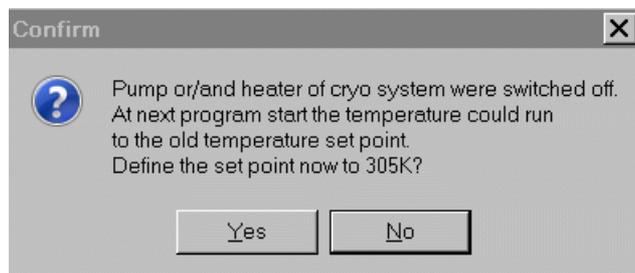
# 1.2 Program structure

## 1.2.1 Main program modules

By starting with 'Original' or 'Cold start' you see the main menu of program modules. These program modules will also called in this manual programs but all these are included in the Hall program, these are not separate programs.
I/V-curves, Magneto, Temp and Time are normally not available with the RH 2035 system using the permanent magnet.
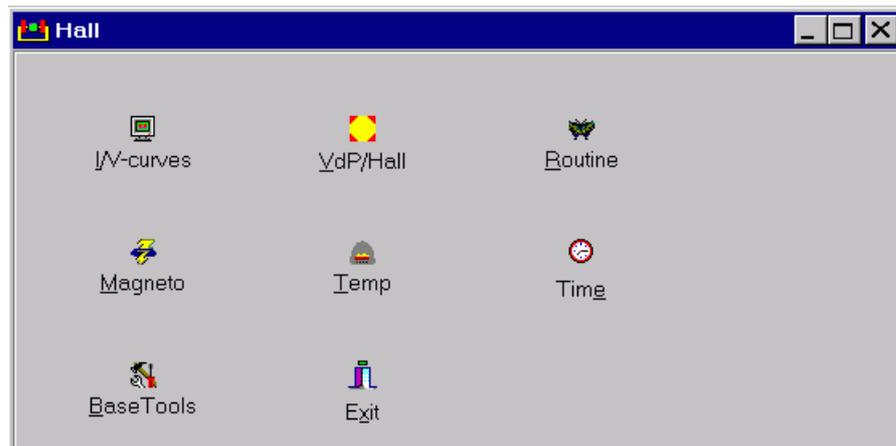


**Base Tools:**

Here you find some tools, for example the calibration of the system and the magnet and a Hall classic measurement procedure. You can switch between measure and simulation program. A direct access is possible to other program tools as presentation plot program, and database. Manually making and saving of single user initialization files are possible (user class 5). Here you can refresh your lite licence for the portable program.

The following 6 program modules are called **measurement modules** or main programs:

**V/I curves:**  2-point and 4-point resistance measurements can be done either for one or two definable contact pairs, or under automatic variation of all contact pairs. This module can especially be used for checking the Ohmic behavior of one or all sample contacts in detail.

**VdP/Hall:**  Van der Pauw, Hall and contact resistance measurements can be done either independent or in combination. This module is meant to be the main measurement module. Contact resistance, sample/layer resistivity, mobility and carrier concentration can be measured and evaluated in combination or independently.

**Routine:**  The easy way to measure sample/layer resistivity, mobility and carrier concentration. The user is guided through all necessary input windows and test measurements.

**Magneto:**  The van der Pauw resistivity can be measured as a function of the magnetic field B.

**Temp:**  Van der Pauw resistivity, Hall resistance and contacts resistance can be measured as a function of temperature. This requires an optional cryostat.

**Time:**  Similar to the temp module, but the time will be variated.

We call the Temp and Time measurement modules also **Tempscan** resp. **Timescan**. The 6 measurement modules are meant to work independent from each other, although results from the static program can be transferred into the global (relevant for all modules) parameter set, especially the sample parameters. All these measurement modules contain also sample characterizing and test measurements (2- and 4-point I/V) to avoid unnecessary moving from one measurement module to another one. Also all global parameters for data evaluation, viewing the data or configuration of the software are available in all these modules. This give a software structure, that is similar for all the measurement modules, except the Routine, and differs only in data relevant tasks.

The Routine module has only restricted options and so another program structure. The other 5 measurement program modules will be explained in the following of chapter 1 and in chapter 3.

## 1.2.2 Menu structure

All measurement program modules, except the Routine, have a similar menu structure. The following picture shows as an example the Hall module:
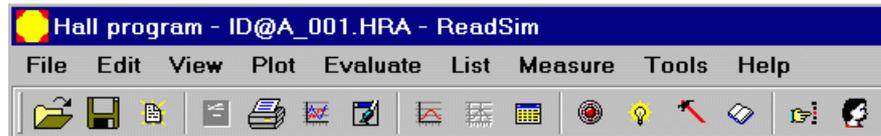


The **top line** gives the program name, the data file name and the mode. 'Read' means that the data was read from a file and not currently measured, 'Sim' denotes that the data are simulated. Under this caption line there is the menu bar. Below the toolbar there is the **main canvas**. The data during the measurement will be shown on this canvas, after measurement or if you open a data file the standard plot resp. evaluation will be placed on this main canvas as shown in 1.3.4.

In the **status line** additional information or hints will be given, see picture in 1.3.4.

**Menus** exist for File, Edit, View, Plot, Evaluate, List, Measure, Tools and Help. The menus Edit, Plot, Evaluate, List and Measure are very program specific, the other are very similar. So you find for the common functions in File, View, Tools and Help a common explanation, chapter 2. There are also the common measurement menu points explained.

The **toolbar** contains symbols for the main important actions:

**Open** a data file.

**Save** a data file.

**Read/View** is a special procedure for reading/exploring data, see 2.2.1.

**Data tasks** for saving and printing data, save evaluation to database.

**Print** the standard plot on a printer.

**Plot program** will be called for the standard plot.

**Refresh** the standard plot**.**

**Last plot** calls again the last menu point in the menu Plot.

**Last evaluation** calls again the last menu point in the menu Evaluation.

**Last list** calls again the last menu point in the menu List.

**Last measurement** calls again the last menu point in the menu Measure.

**New sample** starts the test measurements for a new sample, see chapter 2.1.1.1.

**Check measurement** calls the check measurement tool, see chapter 2.1.1.

**Sample parameters** enables the input of sample parameters, see 2.4.4.

**Temperature** calls the temperature tools, see chapter 2.4.6.

**Last menu point** shows the sub menus of the last menu.

**User button** is a user definable button, see chapter 2.3.4.

Following **shortcuts** exist for these menus:

**F1:**           Help information, opens this manual at the corresponding chapter.
**F2:**           Repeats the last menu action.
**F5:**           Refresh the plot.
**F11:**         Personal hot key 1, see chapter 2.3.4.
**F12:**         Personal hot key 2, see chapter 2.3.4.
**Ctrl+O:**     Open a data file.
**Ctrl+P:**     Print the standard plot or evaluation.
**Ctrl+S:**     Save the current data.
**Alt+F4:**     Close the program.

You can also use the **keyboard** instead the mouse for calling the menu points. For this you have to press Alt+'key' as usual for Windows. If you press the Alt-key, you see which key/character is necessary. The character will be underlined in the menu name. So if you type Alt+F, the file menu opens.

## 1.2.3 Program tools

Depending on the kind of work which you do in the main program modules you can call further common program modules (tools), so different plot programs, list programs and the database. An explanation for these tools will be given in chapter 5.
Program tools have his own sub window with menu bar and toolbar. The plot or list will not shown on the main canvas but on the canvas of the sub window.
A marker, movement by mouse or cursor keys, exist at many sub programs or program tools. In the last part of chapter 5.1.6.5 this marker will be explained.

## 1.2.4 Windows and Personalization

The size of all windows except pure text dialogs can be changed by the mouse. Normally you see this option by the additional minimize and maximize button at the top right of the window. Mixed windows with inputs and plots have also this possibility although there these both buttons are missing.

Inside of some mixed windows there is a so called splitter, moving this splitter changes the size ratio, for example between a data grid and a plot as shown in chapter 2.2.1.1.

At some software parts there are additional separate windows which are not fixed to the main window. You can change the size and position of these windows. If you click on the symbol of such window you get a short menu with additional features. Often there is the entry 'Stay on top'. Activating this flag means that this window has the highest priority for the visibility. This window hides this screen part of all other program windows.

The size of main and plot windows will be automatically scaled, usually this is sufficient. Chapter 2.3.1 and 2.3.5 describe how to change the style and size of these windows.

The dialog (input) windows have by default a fix size, but these can be scaled, see '**Scale dialogs**' in chapters 1.1.6 and 2.3.1. This can be important at high resolutions screens because the dialog windows may be too small by default for such screens. If this scale option is not activated, the Windows display text size (100%, 125%, ...) has only an influence on the menu size but not on the size of dialog text or dialog buttons of the Hall program.
If the size of the toolbar buttons is too small, you can enlarge the buttons. Look in chapter 2.3.1 for more tips for high resolution screens.

You can define personal shortcuts at the most menus, see chapter 2.3.4.

Usually the current **configuration** will be saved for the next hot start, see chapter 1.1.7. But sometimes it can be helpful to make a cold start with the default configuration. Then you would lose your personal styles, sizes and shortcuts. Therefor it is possible to save only these parameters for a cold start. This will be described in chapter 2.3.4.
You should save once your complete 'well' running configuration, see chapter 1.1.7.

## 1.2.5 Parameter guide

The Hall program allows the input of a lot of user defined parameters. These are parameters for the measurement, evaluation, plot, sample, view and so on.

Some parameters are only valid for the selected action or for a group of actions. We call these **local parameters**. Usually you get after calling a menu action an input window. It contains the main parameters for the selected action. Most of them are local parameters. So before a measurement you can input the corresponding measurement parameters, before a plot you can define it view.

Other parameters are **global**, these are valid for the whole program, for example the material parameters. Most of the global parameters are in the menus 'View' and 'Tools'. The following lists the main menu entries for the global parameters (in brackets the menu and chapter of manual):

- **Form and panel styles** (View, 2.3.1): Defines the main face of the program.
- **Default plot parameters** (View, 2.3.2): Will be used for the initialization of a plot.
- **Global plot parameters** (View, 2.3.3): These will be used for all plots.
- **New size** (View, 2.3.5): Defines the window size of the program.
- **Program params** (Tools, 2.4.2): Defines the global physical, evaluation, simulation and material (2.4.3) parameters.
- **Sample parameters** (Tools, 2.4.4): These are *global* for the physical used sample in all measurement program modules or *local* for the current module after reading data. Here you can call the database parameters (2.4.5).

Some global parameters have to be input at a selected action, for example the sensitivity before a measurement.
In some cases a global and a local value for a parameter exist. For example, the magnet field will be varied in the Magneto program module. This local input has higher priority than the global value and will be used for the measurement.

## 1.2.6 Base Tools

Here you find some general tools. Most of them are also available in the measurement program modules and will be explained there. The most important menu here is the 'Calib' menu with the calibration of the system and the magnet.

The **toolbar** contains buttons for following actions: User class, Simulation mode, Edit and Presentation plot program, Database, System calibration, Field calibration, Temperature, User button.

The **File** menu enables the movement between the main program modules.

In the **View** menu you can set the kind of style, the window size, and personal short cuts as explained in chapter 2.3.

In the **Conf** menu you can define the user class and switch between measure and simulation program. At user class 5 there is the feature for manual making and saving single user initialization files.

The **Calib** menu contains the 'System calibration', the 'Field calibration' and the calibration of the 'Offset voltage', see chapter 4.2.

The **Utils** menu enables a direct access to other program tools as Edit data program, Edit plot program, Presentation plot program and database. Setting of the temperature, calling the monitor and refreshing the licence for the lite or portable program are here available. When using the remote client, a chat window can be opened.

When using an electric magnet, the **Measure** menu enables a Field test and a Hall classic measurement at user class 5.

The **field test** should be done with the reference sample in similar way as the field calibration. You get as result a plot calculated magnet field versus defined magnet field. At the first 2 test modes ('Standard' and 'Avoid remanence') the measurement goes from the biggest negative field (Fmin) over zero field to the maximum positive field (Fmax) and then back to Fmin. This is not the same field order as at the calibration. The 2. mode deletes the remanence when necessary. The test mode '+- max field' makes first a measurement at Fmin, Fmax, Fmin/2 and Fmax/2 without deleting the remanence. Then this order will be repeated with deleting the remanence.

'Hall classic' measures the voltage for one current at different fields, no complete V/I curves will be measured. You get a voltage or R=V/I versus field curve. If activating 'Differential', the voltage will be measured at the positive and negative current. Then the resistance can be calculated by these 2 points which avoids an error by a voltage offset. A hardware compensation of the voltage is possible.
The parameter *Direction* defines the variation of the field. At 'input' the measurement will be done from start field to the field F.
'0..-,0..+' measures first from 0 to -F, then from 0 to +F.
'-..0..+..0..-' goes from -F over 0 to +F and then over 0 back to -F. Additional directions are '0..-..0..+..0' and '0..-..0..+..0..-'.
Activating 'Avoid remanence' deletes a remanence if necessary. The field should be switched off after a measurement or after leaving the Hall classic procedure. The other inputs are similar as for a V/I curve.

# 1.3 Program Basics

## 1.3.1 Measurements and data files

The Hall program contains procedures for the measurement and for the evaluation. You can save the measurement data and read the data files. For the evaluation it is not a difference whether the data come directly from the measurement or from a read data file. The sample and measurement parameters will be saved into the header of the data file. So if you read a data file, it could be that the program works with other sample parameters as your physical sample in the cryo system. Before reading file data the parameters of the current physical sample will be stored internally. If you then want to make a new measurement the program ask you for using the parameters of the read file:
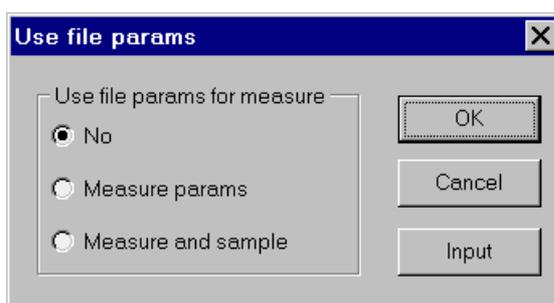


**No:** The parameters of the read file will not be used, the parameters of the physical sample will be restored. This is the normal mode.
**Measure params:** Only the parameters of the measurement will be taken over, these are the current start/stop and so on. Use this option if you want to make a measurement under the same condition as the read file.
**Measure and sample:** Additionally the sample parameters as sample type, thickness and so on will be taken over, see 2.4.4 for sample parameters. This mode gives the possibility to shorten the input time for a measurement of the same or similar sample.

With the **Input** button you can input the sample parameters before starting the measurement. If you don't use the sample parameters of the read file the parameters of the current physical sample will be first restored and then you can make the input.

If you have loaded file data and leave the measurement module and goes to another one then the parameters for the physical sample will be restored without question.

If you have changed sample parameters or other data of a loaded file then these changes were made only in the memory but not in the file itself. For permanent changes you have to save the file again.

**Note:** At a hot start all measurement parameters of the last start will be loaded.

## 1.3.2 Data savings

In the tempscan and timescan measurement module the measure data will be always saved into the file(s) at every temperature at which a measurement will be done. In the other measurement module the measure data will be normally not automatically saved in a file. After the measurement you get the following question for saving data:
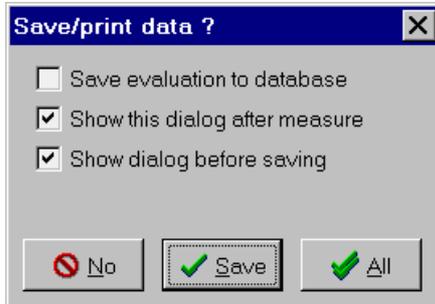
|  |  |
|---|---|
|  | **No:** The data will not be saved into a file. |
|  | **Save:** You get the standard Windows dialog for saving data. |
|  | **All:** Opens the data task dialog for saving and printing data and saving evaluation into the database, see chapter 2.2.3. |

You see the question for 'Save evaluation to database' only in some cases, for example after measurements of VdP/Hall curves.
You can deactivate the question for saving data by 'Show this dialog after measure'. In the data tasks menu of the File menu you can it activate again.
The program shows the dialog in the face above only at the first saving after program start.
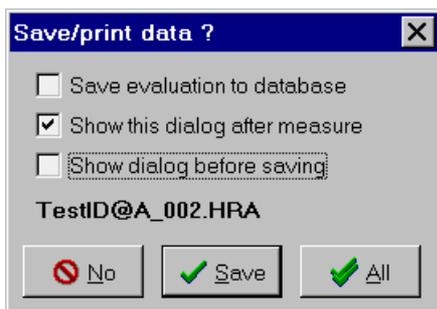
If you have already saved a file you get a similar window. Now you have the additional question for **'Show dialog before saving'**. If you deactivate this option and confirm with 'OK', the program does not open the standard Windows dialog for saving data but save the data directly into the file. You see the automatic generated file name in the line below this option.

## 1.3.3 Data file extensions

The Hall measurement data are binary data. The extension for the Windows file system is HAL. Additionally to this Windows extension the files have a second extension, we call it data extension. In the sample below, 'TestID@A_001.HRA.HAL', it is HRA.

The first character of this extension denotes the **data type.** Different data type files were used in the different program modules and have different data formats:
**C**      : Timescan data file
**E**      : Seebeck Tempscan data file
**F**      : Data file of presentation plot program
**H**      : Data file of Hall module
**M**      : Data file of Magneto module
**S**      : Seebeck data file
**T**      : Tempscan data file
**V**      : I/V-curves of I/V module

The second character of this data extension denotes the kind of measurement. The meaning depends on the first character.
The third character is normally user definable, by default it is an 'A'.

## 1.3.4 Text header in plots, abbreviations
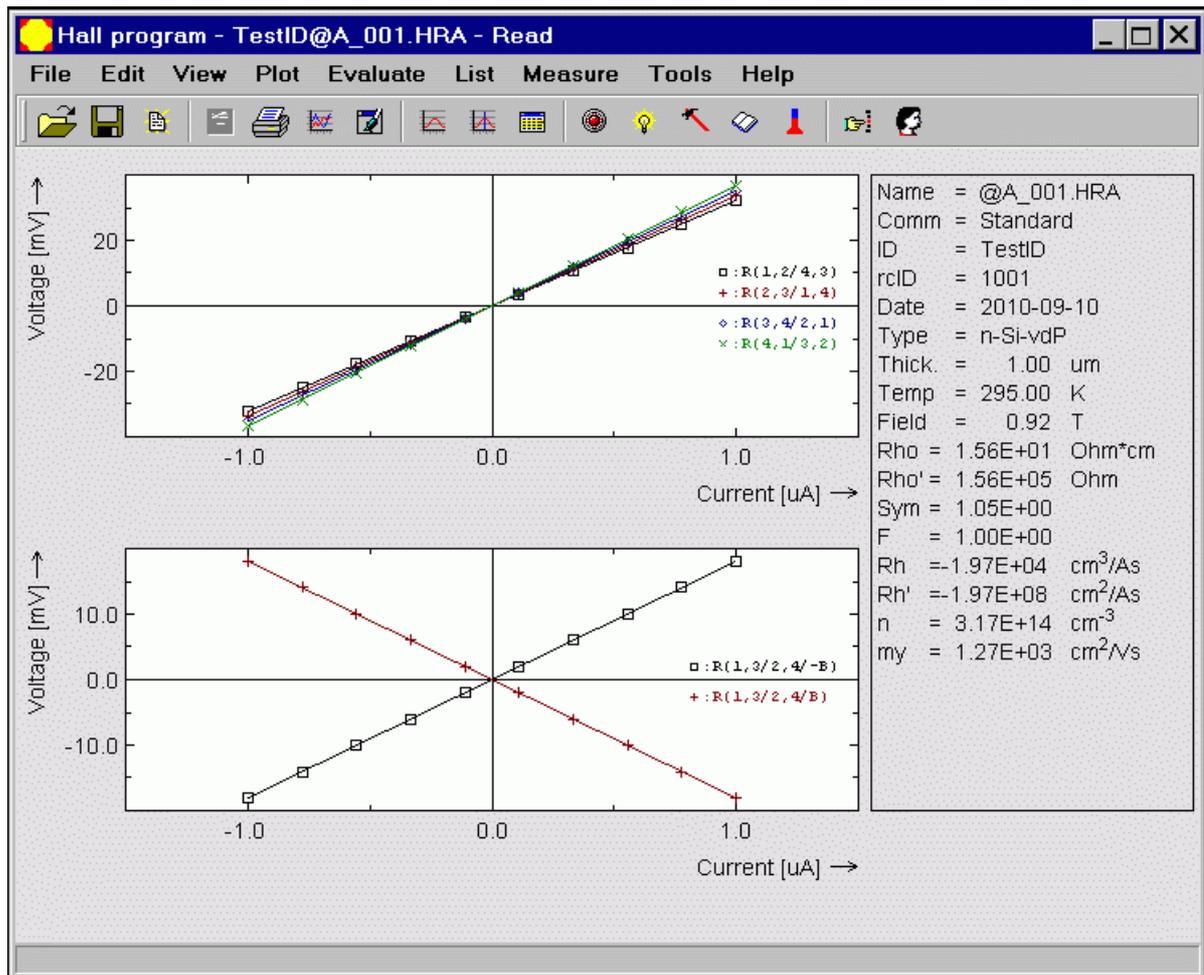


The file name is TestID@A_001.HRA.HAL in the example above. At the right side of the plot you see the plot text header. The following data values are in all plots:

**Name**       : Base file name without ID and data extension HAL.
**Comm**       : Comment
**ID**         : Sample identification, see in 2.4.4
**rcID**       : Record ID in the file data base
**Date**       : Date of measurement
**Type**       : Type of doping (n- or p-type), material name, sample type
**Thick.**     : Thickness of layer = D

There are further values depending of the kind of plot and measurement. The following give a list of these **abbreviations**:

**Cont.**      : Contact of sample/matrix (I+,I-/U+,U-)
**F**          : Correction factor
**Field**      : Field of the magnet
**my**         : Carrier mobility
**Ns**         : Carrier concentration
**n**          : Carrier concentration, n-type
**p**          : Carrier concentration, p-type

| | |
|---|---|
| **n,p(Rho)** | : n resp. p calculated from measured Rho and my of material table |
| **n\*,p\*** | : same as n,p(Rho) |
| **n~,p~** | : n resp. p. corrected by Debye |
| **Rh** | : Hall coefficient |
| **Rh'** | : Rh/D |
| **Rho** | : Sample/layer resistivity |
| **Rho'** | : Rho/D |
| **R(1,2)** | : 2-point contact resistance R(+,-) |
| **R(1,2/4,3)** | : 4-point contact resistance R(I+,I-,U+,U-) |
| **Sym** | : Symmetry factor |
| **Temp, T** | : Temperature, if 2 sensors then sensor 2 (sample) |
| **TempC, TC** | : Temperature of control sensor 1 |
| **TempD, TD** | : Temperature difference after – before measurement |
| **TempV, TV** | : Temperature difference sensor 2 (sample) – 1 (control) |

## 1.3.5 Data dimensions

The data saved in the binary and ASCII files and in the program memory have always the same base dimension, for example V for the voltage. The axis numbers on the plot or the values at the text header can be shown as technical dimensions if this base dimension, for example nV, uV, mV, kV and so on. Complex dimensions are composed by the base dimensions.

Following **base dimensions** will be used:

| | |
|---|---|
| **Area** | : cm^2 |
| **Charge** | : C |
| **Concentration** | : cm^-3 |
| **Current** | : A |
| **Energy** | : eV |
| **Frequency** | : Hz |
| **Length** | : cm |
| **Magnet field** | : T |
| **Resistance** | : Ohm |
| **Temperature** | : K |
| **Time** | : s |
| **Voltage** | : V |

## 1.3.6 Temperature measurement

Depending on your cryosystem 1 or 2 temperature sensors will be used:

- **1 sensor:**   The same sensor will be used for the temperature control and for the measuring of the sample temperature.
- **2 sensors:** Usually sensor 1 is for the temperature control (setting of temperature), sensor 2 is for the measuring of the sample temperature. It is possible that sensor 1 and 2 will be denoted as sensor A and B on your cryosystem. Sensor 2 will only be used for the measurement plot and evaluation, the temperature of sensor 1 will be used at waiting for (constant) temperature and so on. That means sensor 1 defines when the measurement starts, sensor 2 gives the sample temperature at this measurement.

The temperature will be measured before and after a measurement (VdP, Hall …). The shown temperature (plot) is the **average** of both, called Temp. This average and the value 'before' will be saved into the data file. Then the difference 'after – before', called TempD or TD, can be calculated.

If using **2 sensors** then the temperatures 'average', 'before' and 'after' come from the sample sensor 2. The average temperature will further be called 'Temp'. Additionally the temperature of the control sensor 1 will be measured before and after a measurement. The average of these both values will be called TempC and will also be saved. The difference 'sensor 2 - sensor 1' will be called TempV or TV. Sensor 1 or 2 means the average temperatures of sensor 1 or 2.

Before the start of a measurement with setting temperature you see the window of **Wait for temperature**. The current temperature will be permanently shown until achieving the set point 'SetTemp'. Depending on the 'cryo times' (chapter 2.4.6.2) parameters and the waiting time the measurement may start earlier.

At using two temperature sensors both temperatures will be shown. 'Temp' is here the temperature of the control sensor 1, 'TempS' is the temperature of the sample sensor 2. Both temperatures are here not averaged. The control sensor 1 will be used to check the achieving of the temperature set point.

By clicking on the button '**Start now**' the measurement starts without waiting for the start temperature.

At the **Parameters** you can activate some flags:
If activating **Only manual start** then the program don't start when achieving the temperature set point. Only a manual start by the 'Start now' button is possible.



If activating **Show plot** or **Show 2. sensor**, if enabled, the window increases and shows at the bottom a plot with the up to 100 last temperatures measurements versus time, made here at waiting for the temperature. 'Show 2. sensor' means here sample sensor 2. If you activate these both flags then the curves of the control sensor 1 (black) and of the sample sensor 2 (red) will be shown.

**Note:** 'Temp' denotes always the standard temperature', independently if it comes from sensor 1 or 2.
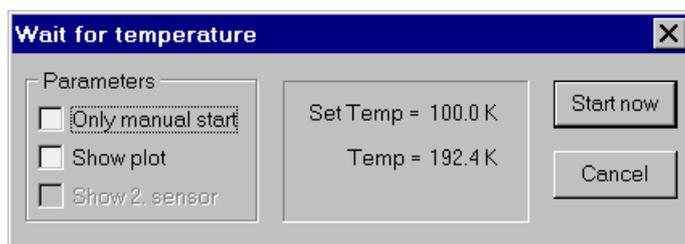
If the temperature measurement and its repetition was not successful then the temperature will be set between 1.1 and 1.4 K. The reason for this problem can be a communication error or no connection of the sensor.

Normally the Hall system comes without a cryosystem. In this case there is no setting of the temperature possible.

## 1.3.7 During the measurement

During the measurement the menus are not enabled and a new toolbar is visible. At the right side of this toolbar are in most cases a progress bar and further information, for example at a tempscan the current temperature.
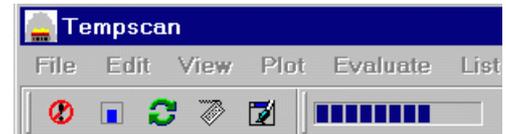
Not all options of the **toolbar** exist for all measurement modules:

**Break** the measurement after confirmation by the user.

Hide the standard window and show only the **progress window**.

Make a **measurement** if the program is in the temperature waiting loop.

**Input** (change) of parameters.

**Refresh** the plot.

If you click onto the break button you get the following question and buttons for the **break** of measurement, but not all buttons are enabled at all measurement modules.

**Break meas:** Break the measurement immediately, it can be that the last measure point is not valid and will not be overtaken in the data array.

**End meas:** Break the measurement after the current measurement block/record is finished, so that this gives a correct end of the measurement.

**Break prog:** This function will interrupt the program. Use it only if the normal break doesn't work and after program problems like access violation. After this interrupt the program doesn't work accurately. Close the program and start it again after this function.

**Cancel:** Close the break window and go back to the measurement.
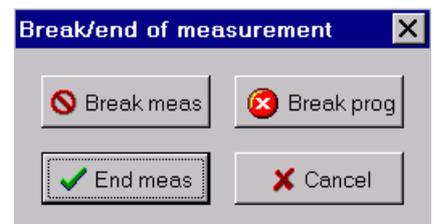
The **Progress window** hides the standard window and shows a small window with a progress bar and the current temperature. Use this option if you need your screen for other programs. Then you can watch the progress of the measurement, but you need only a small place on the screen.
If you close this window by the Windows close button (right top) you go back to the measurement with the full standard window. If you minimize the progress window then you see it only in the task bar. You can break the measurement by the Break button.
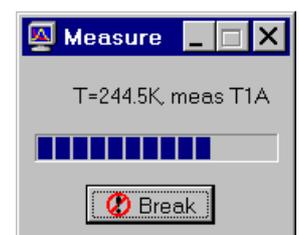
## 1.3.8 Miscellaneous

At many input fields you have to put in **numbers**. Only a range within of a minimum and maximum value is possible. If the input is smaller/bigger than the minimum/maximum, the minimum/maximum value will be applied. Sometimes you get a warning at the closing of the input window when an input is out of the valid range. Then you get a separate input window with the chance of a new input. This is especially important to avoid too high voltages or currents on the sample or to avoid too long measurement times. This warning can be disabled by a special flag.

The Hall program forbids Windows to go into the **sleep mode** after some time of inactivity of user interaction. This avoids that Windows suspends the Hall program during long measurements which would yield to communication errors after wake-up. The display standby mode will not be changed.

# 2. Common functions

All measurement program modules, except the Routine, have a similar menu structure. So you find in all the same or very similar menus for File, View, Tools and Help. In the following these common functions and the common measurement menu points will be explained.
Chapter 2.6 explains common functions from the other menus Edit, List, Plot and Evaluate.
Chapter 2.7 don't describe menu functions but only parts of input windows which will be used in some input windows.

# 2.1 Measurement menu

The measurement menu of all measurement program modules contains specific and 2 common measurement routines.

**New sample** should be used if you change the sample in the sample holder. It calls also the same procedure as 'Test of contact' in the Contact measurements menu.

## 2.1.1 Contact measurements
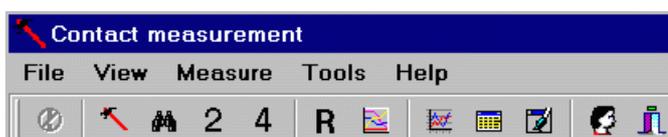
This measurement tool contains test measurements (V/I curves) and a procedure for searching the best current. In most cases it is not necessary to go to the V/I-curve program module because you can do here the most important V/I measurements and save its data. So you avoid unnecessary moving from one measurement module to another one.

The **toolbar** contains symbols for the main important actions:

**Break** the current measurement.

**Test of contact** checks whether the sample is well contacted.

**Search** best current.

All **2-point** V/I curves will be measured.

All 4-**point** V/I curves will be measured.

Show **R=(Vn-Vp)/(In-Ip)** instead V/I curves.

Show **all** curves **in one** plot.

**Plot program** will be called for the selected plot.

**List** data.

**Refresh** the last plot.

**User button** is a user definable button, see chapter 2.3.4.

**Close** the check measurement tool, go back to the measurement program module.

## 2.1.1.1 Test of contact

This procedure is a check of the ohmic behavior of the contacts. It is also a test whether the sample is well contacted by the probes and it search the best current.

Three **test modes** can be selected, all using the 2-point resistance measurement (current and voltage at the same contact pair).
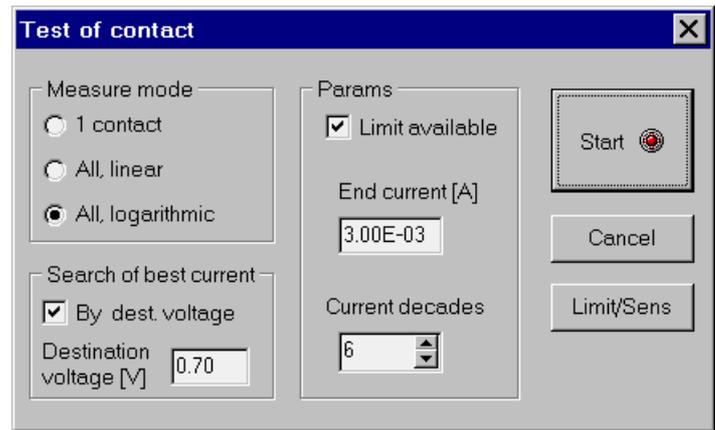
**1 contact:** One definable contact pair (e.g. 1,2) resistance will be continuously in time measured at one definable current (e.g. 1.00E-5A). This is very useful for preparing one contact that failed during the test (all logarithmic) or to check recovery times (high resistivity material) either for setting the current or the magnetic field, or to control the drying of the silver paste (it´s conducting only in dry condition).

**all linear:** All contact pair resistances are measured in a row at 6 different currents starting from the negative defined value (e.g. -1.00E-5 A) to the positive one (e.g. 1.00E-5A). This test is the best for a ´known´ sample. ´Known´ means a sample where the current range is known from measurements of similar samples (material, type, concentration, thickness). Also high resistivity material (I<1.00E-9 A) should be tested using this routine.

**all logarithmic:** All contact pair resistances are measured in a row at different currents, starting from 1.00E-9 to 1.00E-2 measuring in both polarities. This routine is meant to be the standard contact test routine. It definitely has to be used for unknown standard samples and for low resistivity material.

By activating a flag the global voltage and/or power **limit** will be available also for the test measurements.
The button **Limit/sense** opens a new input window. It will be explained in chapter 3.2.1.2.
**Start** will start the selected contact test

For this 1. test mode you have to input the contact pair and the current, for the 2. only the current. The field is normally zero.

At the 3. test mode you can input the **end** current and the numbers of current **decades**. The search of the best current can be done by the input of a **destination voltage**. It will be used after the end current was reached for a more detailed search. The meaning of destination voltage will be described in chapter 3.2.1.1.

### 2.1.1.1.1 One contact

After starting this test measurement, the measurement parameters are set and the voltage over the selected contact pair is continuously measured. The measurement parameter and results, voltage and resistance, are displayed, the resistance versus time plot is shown and will automatically be actualized. A measurement result for a good sample is shown below. The measured resistance should be nearly constant with time.
This kind of contact test is meant to be an additional test for 2 selected contacts.
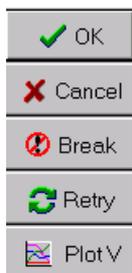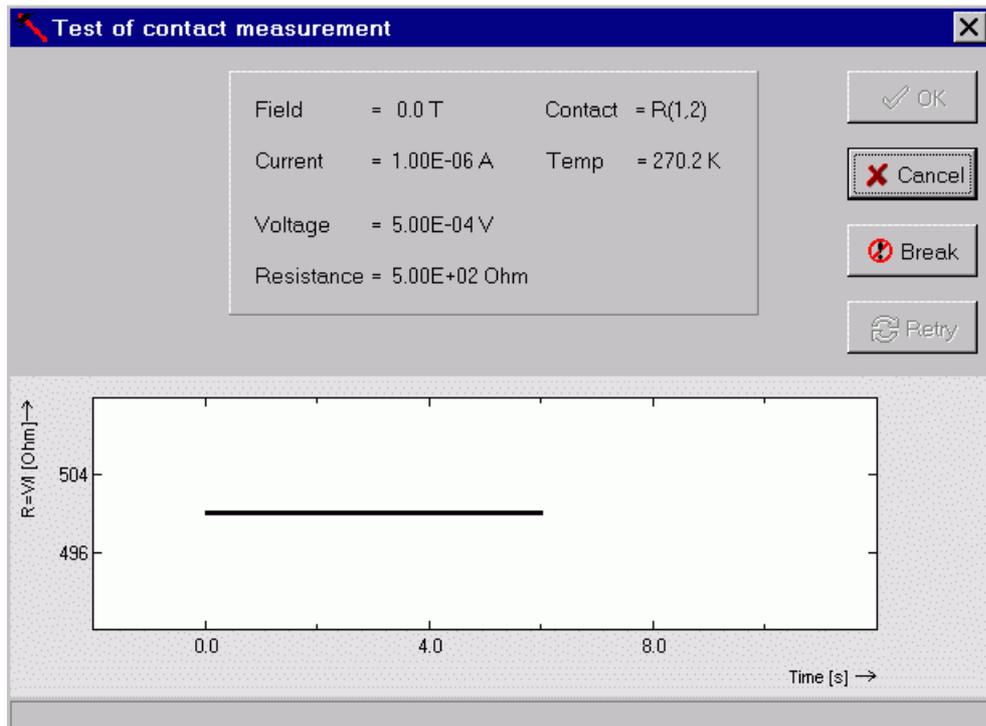


OK continues the program, depending test mode and test start.

Cancel breaks and leaves the contact test, goes back to the menu.

Break stops the measurement.

Retry goes back to the 'test of contact' main input window.

Plot V resp. R shows the voltage resp. the resistance.

If you have breaked the measurement, you can copy the shown curve resp. grid data as ASCII data into the clipboard by Ctrl-C.

### 2.1.1.1.2 All linear

This test routine can be used, if the sample is remeasured or the measurement current range should be the same as for other similar samples for comparison, or for **high resistivity material**. All 2-point contact configurations are automatically measured in the predefined current range. The measured contact resistances are listed and plotted for 6 different currents. The contacts are OK and the desired current range is OK (due to the contacts, see ´define measurement current´) if for each contact configuration (rows) the resistances do not vary with the current for more than app. 0.5 %. If it differs more, the current range may be too low. If some resistances could not be measured (gives ----) the measured voltage is too high (>10V) therefore the current range could be too high. If a complete row can not be measured, one contact may be bad. Normally, if one contact is bad, three contacts pairs (rows) can not be measured, because every of the 4 sample contacts are used for 3 contacts pairs. Using this combination, it should be easy to find the bad one. Look at the hardware manual for the definition of the contact pair numbers.
Good contacts should look like this below (simulated data), but normally the data points in the diagram overlap.
Break is available during the measurement and stops it. The buttons have the same meaning as explained before.
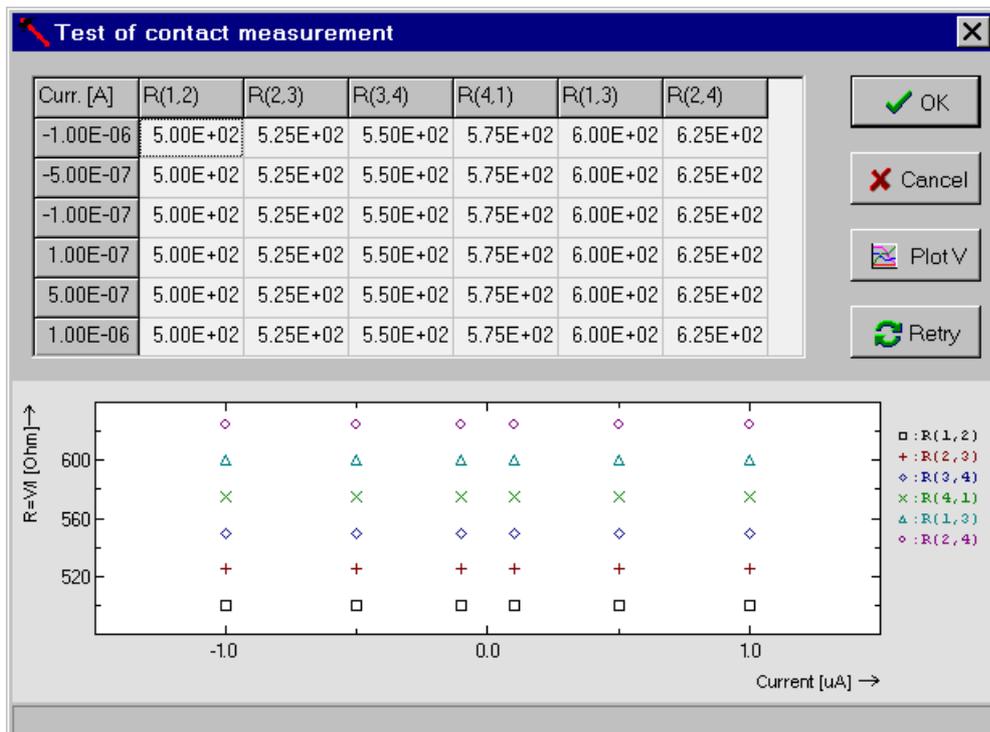
### 2.1.1.1.3 All logarithmic

The standard contact test. Again all contact configurations are measured in a row, but this time for a large current range (+/- 3E-9 to +/- 3E-3). Again the resistances for each contact pair are listed and shown in a diagram. It should always be used for **standard and low resistivity material**. Real data do not look like that below. Normally at low currents the resistances can not be measured accurate because the voltage is too low. Therefor at low currents the displayed resistances are very noisy and differ a lot. Coming to higher currents the data smooth down, the resistances become a stable value. That current from which the resistance data become stable is the low limit for the useable current range for vdP and Hall measurements. At very high currents (typical >1E-3A) on some **standard material** (and all high resistivity material) the voltage becomes too high (>10V) and the resistance can not be measured any more. This limits the usable current range at the high current side. From this behavior the suitable and best measurement current range can be determined.
The buttons have the same meaning as explained before, except the OK button.
If a contact is bad (see chapter before) then contact the sample again and repeat the test.
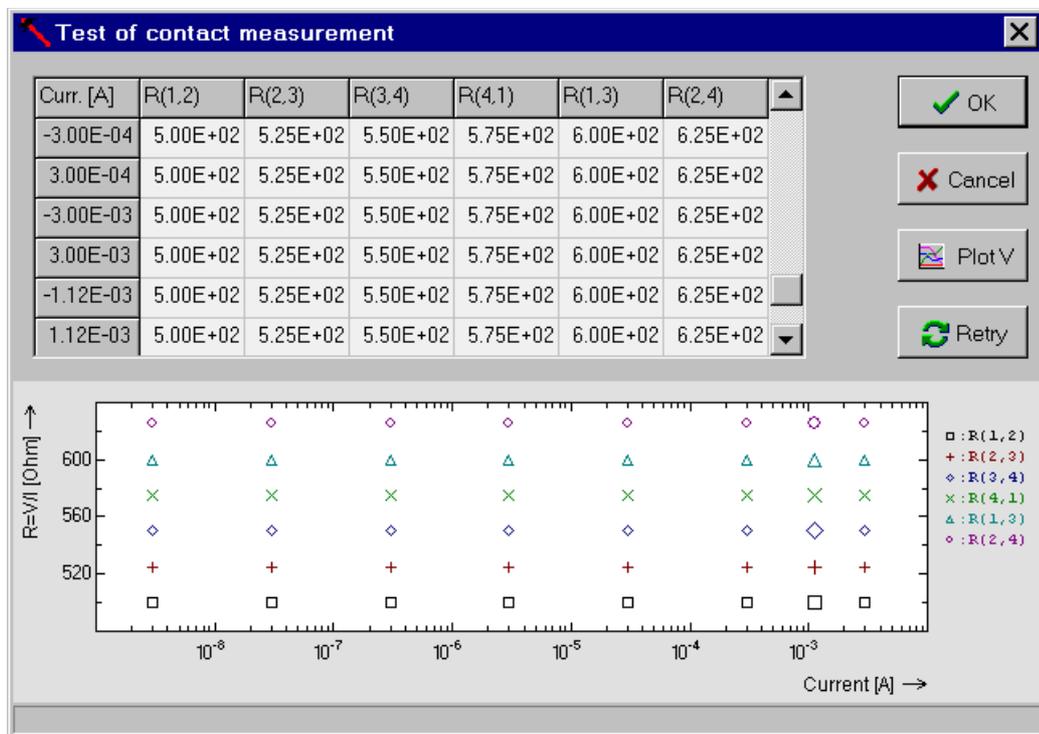


The software is suggesting a value after 'OK' is used. It is selected by looking at that current where the 2-point measurements above become stable. It gives approximately the lowest current value for a good vdP and Hall measurement. **Yes** (right picture) means, that the displayed value will be used as a **proposal** in the vdP and Hall measurement parameter input window. It can be changed there. The decision at which current the final measurements shall be done is not done here. Therefore it's always useful to overtake this value.
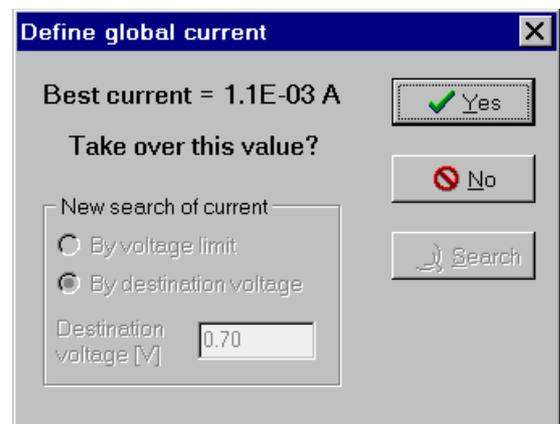
For **standard material** this current value **fits quite well**. This is due to that fact, that for this application the Hall voltage and the 4-point van der Pauw voltage at the same current are of a similar order. For **low resistivity material**, this is normally **not** the case. The Hall voltage is much smaller. Therefore the **current should be selected as high as possible**. That means the user has to look at the high current results in the data above, and to keep in mind which current still works (Normally for this application up to 1.0E-2 A).

In the example above the search of the best current was already done by the input of a destination voltage, see chapter 2.1.1.1. Therefore this search is here not possible. Without this option you can do here at this window the search by a destination voltage by the **Search** button.

### 2.1.1.2 Menu

The menu of contact measurements have some more possibilities as the toolbar.
In the **file** menu you can save I/V curves, go the plot or list program.

In the **measurement** sub menu are:

| | |
|---|---|
| **Test of contact:** | As described above. |
| **Best current:** | Start directly the logarithmic test of contact. |
| **One, 2-point:** | Measurement of one 2-point I/V curve. You have to input the contact pair and the current, for the current see chapter 3.2.1.1. |
| **All, 2-point:** | All 6 2-point V/I curves will be measured, see chapter 3.1.1. |
| **All, 4-point:** | All 6 4-point V/I curves will be measured, see chapter 3.1.1. |
| **Test voltage:** | Simple voltage versus time measurements at a fix current. Can be helpful to check drifts of the sample. Needs user class 5. |
| **Set current off:** | If keeping the current after measurement, here you can switch it off. |

In the **View** menu you can select the y-axis of the plot, either the voltage or a resistance:

| | |
|---|---|
| **V versus I:** | The standard V/I curve. |
| **R=V/I:** | The resistance will be formed by a simple division. |
| **R=(Vn-Vp)/(In-Ip):** | The resistance will be formed by the slope between 2 points, the negative and the corresponding positive current point will be used. |
| **R=dV/dI:** | The resistance will be formed by the deviation. |

It is possible to show **all** curves **in one** plot.

### 2.1.2 New sample

First the 'Test of contact' input window will be opened. There is additionally the GoOn button. This skips the test and goes to the next input window.
You should select 'All logarithmic' as measurement mode and start the contact test.
After applying the best current by the' OK' or 'Search' button the input window for the sample parameters will be opened. After this the database input window will be opened at first use.

# 2.2 File menu

The file menu covers all the data handling and enables the movement between the main program modules.

**Open** and **Save** open the windows standard procedures for reading and saving data. In 'View → Form and panel styles' you can select the new Vista dialogs, see chapter 2.3.1.

The open and save routines know the data that can be handled by the actual module, so e.g. tempscan data will not be read in using the V/I module.

**Overwrite** saves the current data by keeping file name and date.

**Programs** enables the movement from the actual main program module to another one (Base tools, V/I program, vdP/Hall, Routine, Magneto, Tempscan, Timescan).

**Exit** opens the program closing procedure.

## 2.2.1 Read/View

This special procedure gives much more features before or during the reading of the data, for example a list of favorites, a preview, a data grid with measurement parameters, an explorer and a file or database search. It gives you also a help to find a special or 'lost' file or measurement easier and to find out the differences of various measurements.

### 2.2.1.1 Main window
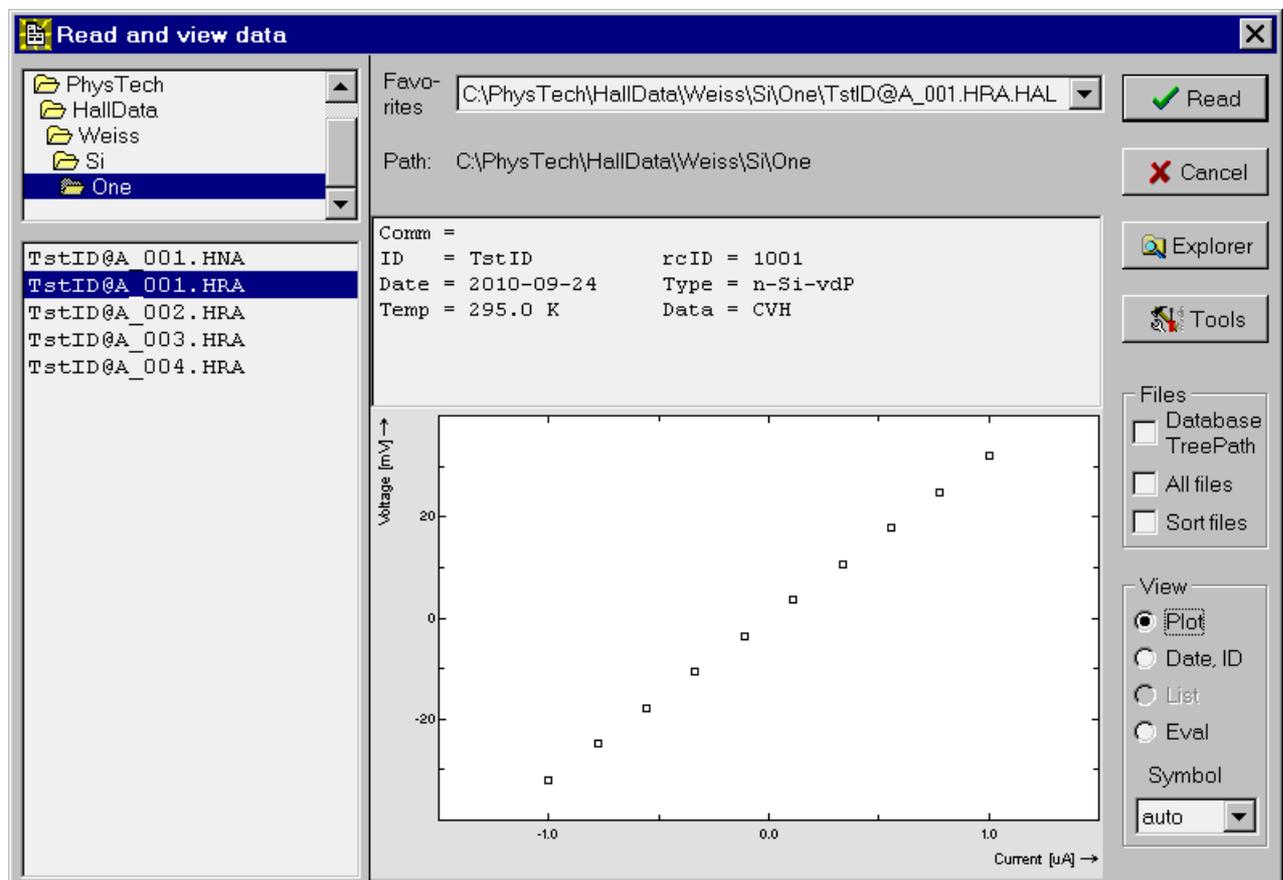
The main window opens a file read program with a special explorer. Using this explorer the measurement data can be displayed in several ways before it´s read in. It enables an easier searching for a particular measurement.

On the top a list of previous read in file including paths (**Favorites**) can be shown to find data used in former sessions.

On the left side, the **data path** (top) and a **list of files** of that folder are displayed. The button **Read** or a double click on the marked file opens the marked file.

The main window size shows a plot of one file or a data list of all files. On the right there are buttons and parameter inputs.


In the **Files** input box there are some options:

Activating **Database TreePath** shows only those directories which are used in the file database. The view is as an explorer, see picture above with selection of 'date and ID'. In the other case all directories will be shown in the folder view as in the picture with selection of 'plot'.

By the flag **All files** all data files without the restriction to the valid ones for the particular measurement/evaluation main program (like tempscan or V/I module) will be shown.

**Sort** files by name is also an option.


The graph of marked file can be shown using the **Plot** option of the **View** box on the right, see picture above. This box defines the kind of data that is shown. The plot shows the main curve of the marked data file. Above the plot there is a text field with some important sample and measurement parameters.

The files can be marked using the mouse or the cursor keys for an easy data scrolling. Several plot symbols can be defined in the **Symbol** input.


If activating 'Plot' and not 'All files' then a **multi selection** of files is possible. This means you can mark up to 6 files in the file list box. The marked files will be shown together in one plot if possible, because all curves must have the same x- and y-axis. Above the plot there is a small list with important parameters of each shown file, there is on the right a color explanation for each curve. The multi selection must be done with the Shift or Ctrl key, as defined by Windows. The Shift key (in conjunction with the left mouse button or arrow keys) is used to select a contiguous sequence of list items. The Ctrl key is used to select non-contiguous list items. Reselecting a selected list item will deselect it.

Above the plot or in the grid view (see below) there is a text field called **Data type**. It gives a short information about the data files. It depends on the type of data (I/V, VdP/Hall, …). The following list contains only the important entries:

**I/V files:**
`C21:` One I/V curve of 2-point measurement.
`C41:` One I/V curve of 4-point measurement.
`C26:` All 6 I/V curves of 2-point measurement.
`C46:` All 6 I/V curves of 4-point measurement.
`CF1:` 1 I/V curve of inline sample measurement.
`CF2:` Dual I/V curves of inline sample measurement.

**VdP/Hall files:**
`-V-:` Only VdP measurements.
`--H:` Only Hall measurements, 2 field points.
`--B:` Only Hall measurements, many field points.
`-VH:` VdP and Hall measurements, 2 field points.
`-VH:` VdP and Hall measurements, many field points.
`CV-:` All 6 2-point and vdP measurements.
`CVH:` All 6 2-point, vdP and Hall measurements, 2 field points.
`CVB:` All 6 2-point, vdP and Hall measurements, many field points.

**Magneto files:**
`V--:` All 4 curves for magneto resistance.

**Tempscan, Timescan:**
`-V-:` Only VdP measurements.
`--H:` Only Hall measurements, 2 field points.
`--B:` Only Hall measurements, many field points.
`-VH:` VdP and Hall measurements, 2 field points.
`-VH:` VdP and Hall measurements, many field points.
`CV-:` All 6 2-point and vdP measurements.
`CVH:` All 6 2-point, vdP and Hall measurements, 2 field points.
`CVB:` All 6 2-point, vdP and Hall measurements, many field points.
`C--:` One or all I/V curves of 2-point measurement.
`-F-:` Inline sample measurement.
`E--:` Seebeck tempscan, separate measured.
`S--:` Seebeck tempscan, measured together with standard tempscan.

**Seebeck files:**
`O1-:` 1 V/I point, 1 temperature difference.
`O2-:` 1 V/I point, many temperature differences.
`R1-:` V/I curve, 1 temperature difference.
`R2-:` V/I curve, many temperature differences.

**4. or 5. character** at Hall and tempscan files:
`F:` Many fields; `D:` Drift correction measurement; `*:` Compensation done/measured

Selecting **Date and ID** in the view box, a sample data list directly correlated to the files list is shown. The grid contains sample ID, measurement date, doping type, material name and data type:
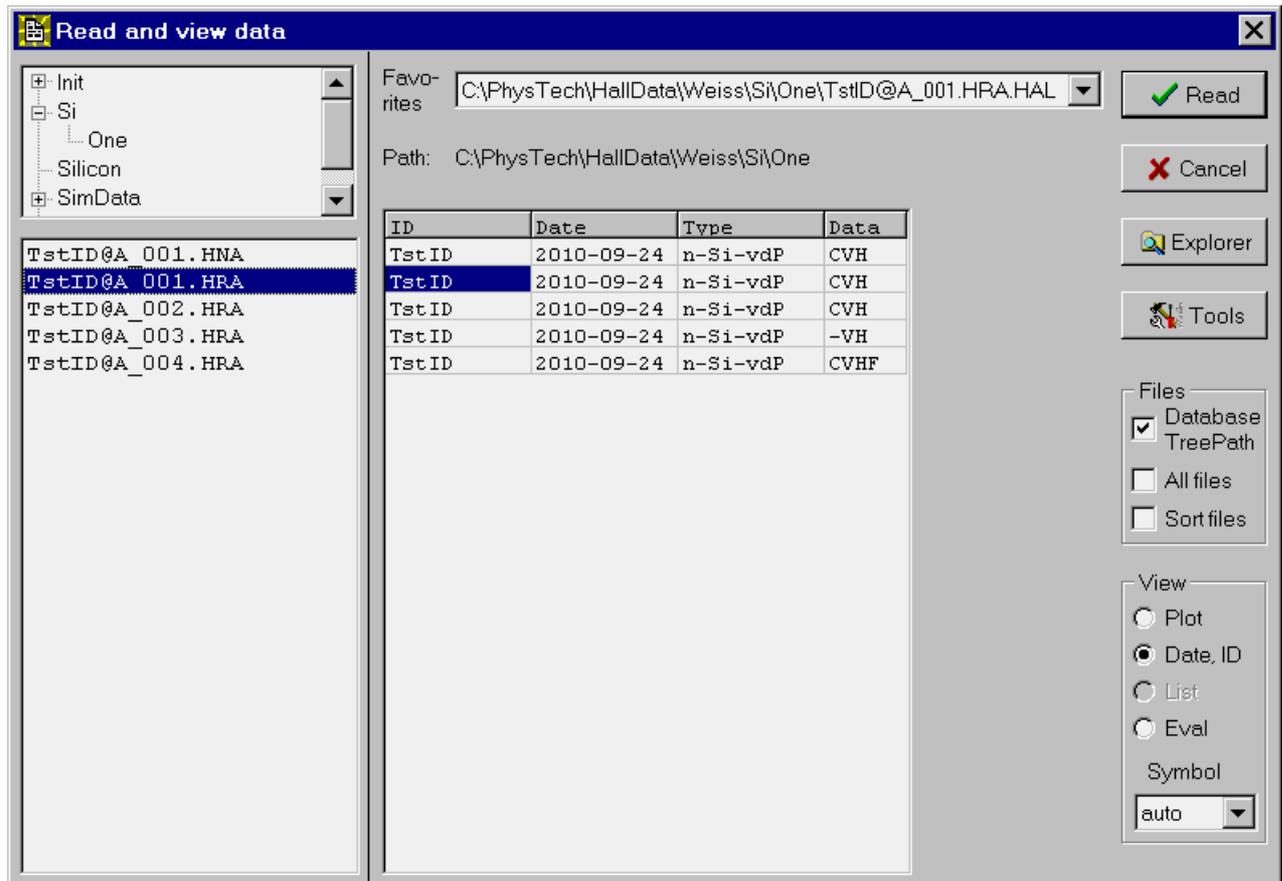


Selecting **List** in the view box gives a list of some measurement parameters used for the measurement files on the left. The List view is not always possible. 'All files' must not be activated.
Selecting **Eval** in the view box lists some evaluation values but is only in some modules available.

| Rho | Rh | Conc. | My |
|---|---|---|---|
| 4.80E-01 | -2.29E+04 | 2.73E+14 | 4.76E+04 |
| 1.56E+01 | -1.97E+04 | 3.17E+14 | 1.27E+03 |
| 1.56E+01 | -1.97E+04 | 3.17E+14 | 1.27E+03 |
| 1.56E+01 | -1.97E+04 | 3.17E+14 | 1.27E+03 |
| 1.56E+01 | -1.97E+04 | 3.17E+14 | 1.27E+03 |

**Tip:** You can change the total size of the Read/View window by the mouse, you can also change the ratio of the left (file list) and right (plot or grid) size. For the last one go with the mouse cursor to the splitter between these two parts.

### 2.2.1.2 Data Explorer

The Explorer button opens an additional data explorer similar to the Windows explorer and similar to use. Files can be listed, plotted or deleted, folders created or removed, database records deleted. The current data path will be shown in the status line. The list shows all files which matches the **Mask**, independently if they can be read in the current program module. After you have changed the mask you must press the 'enter' key to refresh the list.
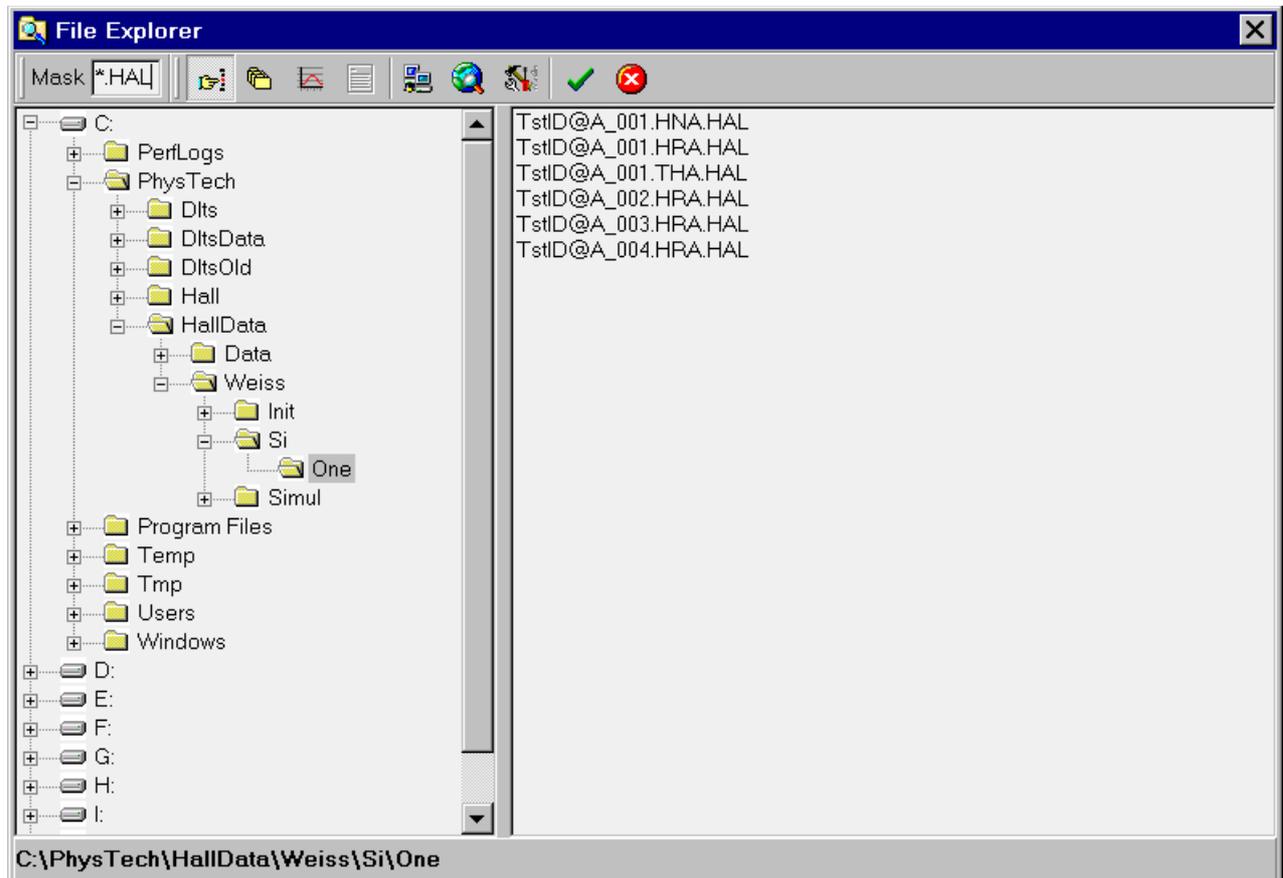


|  | |
|---|---|
| 🖮 | **Search files** gives on the right side a file list of the marked directory. |
| 🔍 | **Extended file search** restrict the search by sample and measurement parameters. |
| 📑 | Include in the list also the files of all **sub directories** of marked directory. |
| 📈 | Show at the right bottom a **plot** of the marked file, see picture below. |
| 📄 | Show at the left bottom a **memo** of measurement parameters for the plotted file. |
| 🖥 | Opens the Windows **network** dialog. |
| 🔎 | **Find a path** either by a path or a file mask. |
| 🛠 | **File tools** for create/remove directory, delete files and delete records in database. |
| ✔ | **Okay** apply the file if possible, in the other case the path. |
| ⊗ | **Cancel**, goes back to the ReadView window without apply. |

The next picture shows the data explorer with activated plot and memo field. Plot and memo are only visible if one file was marked. The file search will be restricted by the 'Mask'. The file names must match this mask, Windows wildcards '?' and '*' are valid for it.
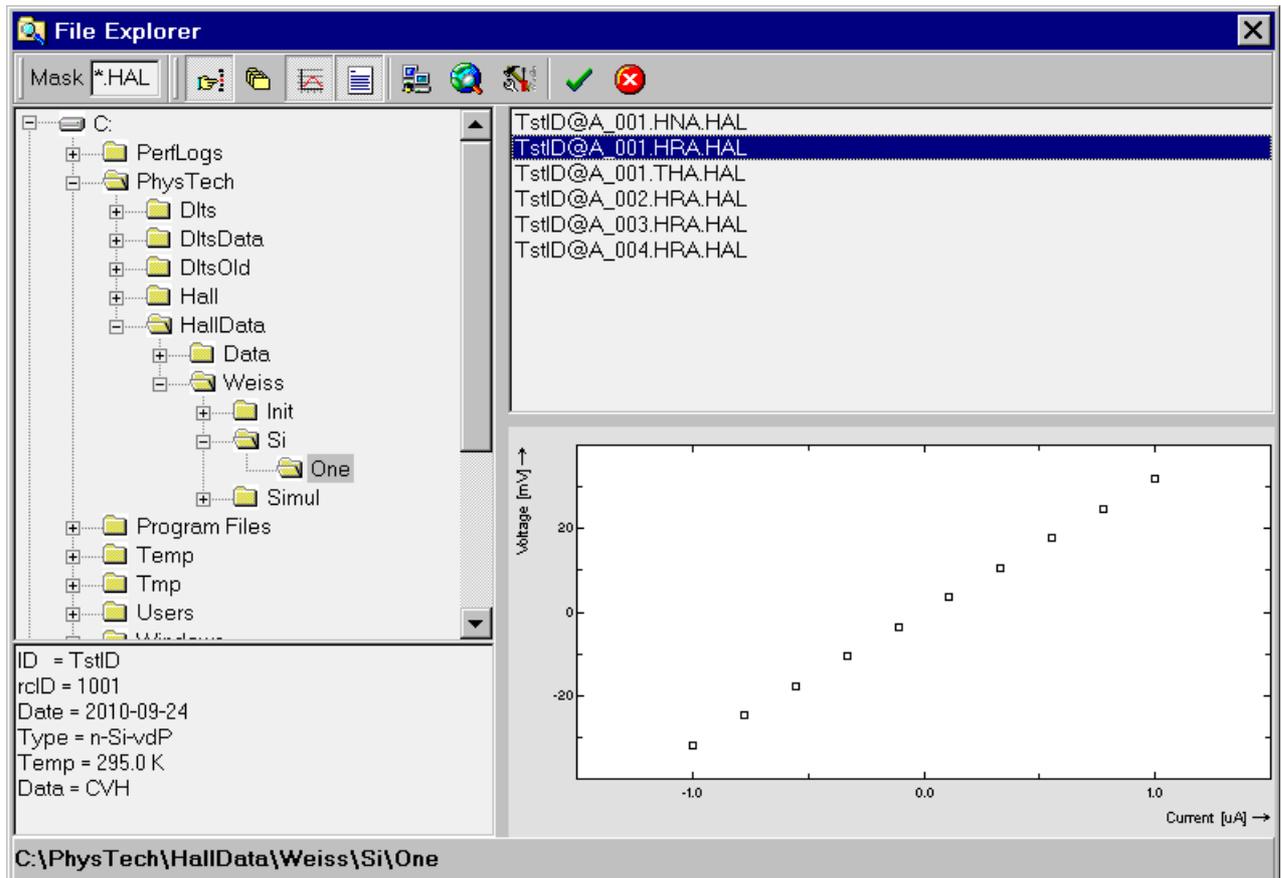


In **File tools** you can create or remove an empty directory. You can delete the selected file (file list on the right side) or all files of the current directory (explorer view on the left) or all files of the current directory and of all its sub directories. In all cases you must confirm the action. If deleting files you can activate the option to delete additionally the corresponding records in the file and/or evaluation database.
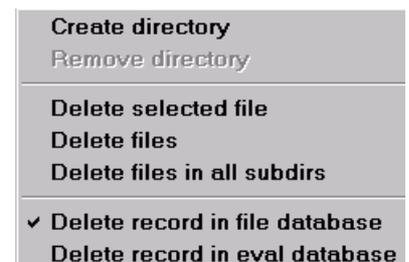


**Find and apply path** is a tool to find a path either by a path or a file mask. It lists all sub directories of the selected directory (called here base directory) which matches the path resp. file mask. The selected directory will be applied as new current (base) directory by clicking onto the 'OK' button.
This tool can also be used to find the location of a special file. To search a special file by the ID use the database search of the next chapter.

The data explorer allows also an **extended file search** by special sample or measurement criterion. All files of the marked directory, and if the button is activated, and its sub directories will be checked. The 'Mask' is further valid. If all search criteria are fulfilled then the file will be listed.

For this option click onto the 'Extended file search' button. Then the following input window opens. If leaving by 'OK' then the extended file search is activated and remains until you deactivate it. For the deactivation click again onto this button and leave the input window by 'Cancel'.

Each criterion can be activated or deactivated by a flag. If activated then an input defines which condition the file must fulfill.

Selections for following **criteria** exist:
- Sample type
- Material name
- Doping type
- Many fields at Hall measurements
- DataStr
- Special mode

Following Special modes are available:
Nothing, Search by MeasStr or HeadStr.



DataStr and Search by MeasStr or HeadStr is only for special cases. These strings of a data file will be listed in 'List → File header' at user class 6, an explanation of these strings will be given in Hall\Sys\Doc\Data.Txt. The input strings must match these strings. Wildcard characters are '?' and '*' as in the Windows file search.

**Tip:** The extended file search shall help to find files of special sample or/and measurement parameters. So it can be important to compare new results with old ones. For searching in all directories mark the data directory. This search need not the database. Use the database search of the next chapter for searching a special file by its ID.

## 2.2.1.3 Tools

By the Tools button in the main Read/View window you get additional tools for the data handling.



**Browse** is for the defining of the current data path.
**Find file** search for data files in the file database.
**Database** calls the database program module.
**Sample apply** is for changing sample parameters of many files.
**PresPlot** applies the current plot into the presentation plot program.



**Browse** opens the following input window for defining the actual data path.
The path can directly be defined by keyboard input. Drive and higher folders can be selected by browsing through the file structure as known from windows. Drive and folders are automatically shown in the input line at the top. With the button 'Network' you get the Windows network dialog, 'Explorer' opens the Windows explorer.

**Find file** (at the Tools button) search for data files in the file database using search masks for the sample ID and RecID. Base directory is the directory of the used database.



Only files which match the **Sample ID** mask and the **RecID** mask will be listed. The RecID is a file specific record ID in the database. Sample ID and RecID are definite for a record in the file database.
Wildcard characters are '**?**' and '**\***' as in the Windows file search.

By **Valid files** as search mode only files usable in the actual program module are shown, by **All files** as search mode all files independent of actual program module are shown.

**Find** looks for all files fitting to the masks.
**Okay** apply/read the selected file.
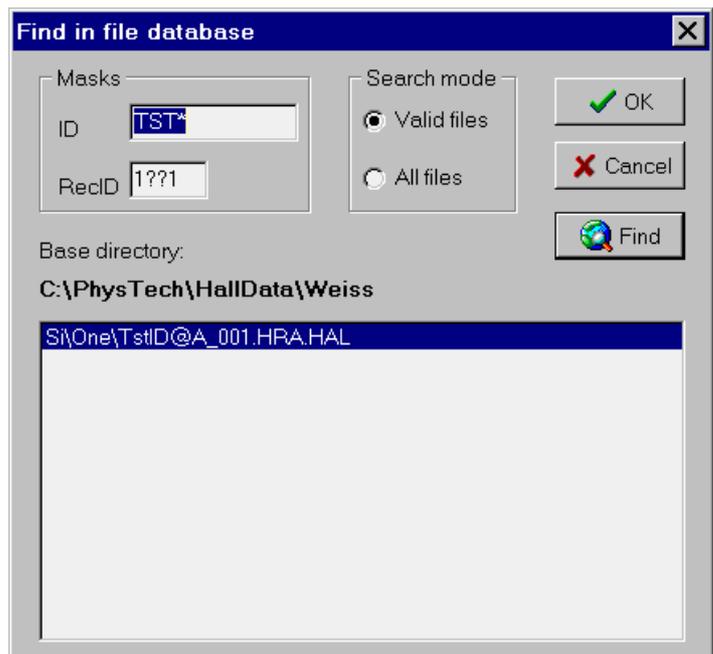
The entry '**Sample apply**' by clicking onto the 'Tools' button is for changing sample parameters for many files. It can be helpful if you have for example typed in the wrong sample thickness. The header of all files which names match a given or computed mask will be restored, the file dates will be kept. Only selected sample parameters will be restored, an evaluation will here not be automatically done. This function needs user class 5 and is only enabled after reading data from a file but not after a measurement.

The current file name will be shown in the status line. For the examples above we take ID@A_001.HRA. Three **file search modes** exist:

**Mask input:** You have to input a directory and a file mask for the search. Wildcard characters are '?' and '*'. The software appends always the data extension 'HAL'.

**Same ID:** Only files with the same sample ID and part in the file name will be applied. The software sets the mask, for example 'ID@A_*.???.HAL'.

**Same no:** Only files with the same sample ID, part and number in the file name will be applied, for example 'ID@A_001.???.HAL'. If the file name comes from a 'set of temp variation', see chapter 2.4.5, then this will be taken into account. So ID@A_00T001.HRA yields to the mask 'ID@A_00T???.???HAL'.

If activating '**With sub directories**' then files in all sub directories will be searched by the same given mask. This flag is only visible at mode 1.
The flag '**With sub data directory**' is visible at mode 2 and 3, all files in the sub data directories will here also be restored. For example, the data directories are 'ID@A_*' for mode 2 and ID@A_001 for mode 3.
'**Same 3. extension character**' means that only files will be searched which 3. data extension character is the same as in the current file name, for example 'A'.

Independently of the mask only files with the same **sample ID** and sample part in the file header will be searched! All file names found by the search will be listed before changing the file headers. There you can cancel this operation.

By the '**Sample**' button you can check and change the current sample parameters. The selected sample parameters will be applied and stored in the sample header of each file.

The **base sample parameters** 'Type and material will be applied always.

**Additional apply parameters** are:
- Sample thickness
- Ns(Rho) calculation
- Special calculations (Debye...)
- Comment
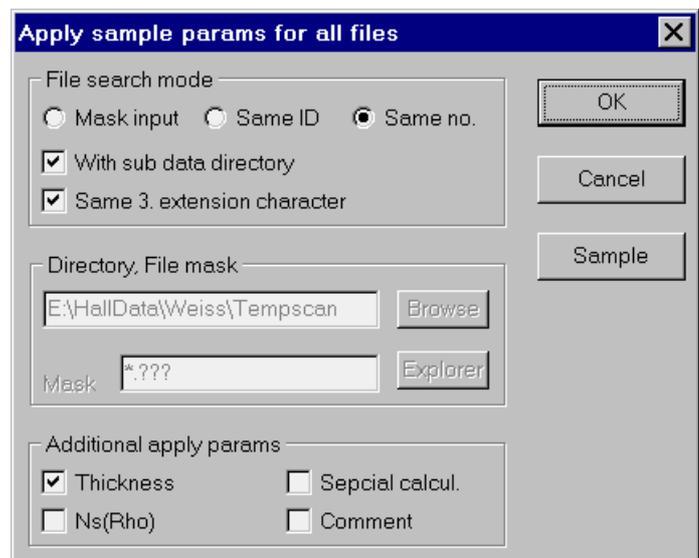
## 2.2.2 Read special

The Read special procedure enables some features for the reading of data, a main application is the combination of current (already loaded) data with new ones.
Not all possibilities shown in the input below exist in every measurement module.

The **Read mode** define how the new data should combined with the old current data. Old data refers to data in the memory (already loaded), new refers to data that will be read in by the new input of file name.
**New data** use only the new one and makes no combination with the old one.
**Old + new, Old – new, New – old** add or subtract the data, this will done data point for data point.
**Append** the new data to the old ones, either all new data or only those data which x-values don't exist at the old one (no overlap).



**Tip:** If appending data and one overlap range has bad data points then read first the file with the good data and then the file with the bad overlap range. If you select 'Append, no overlap' then the bad data over the overlap range of the second file will not be included in the new data arrays.

At the **Mode for same x-points** you define which data regarding to the x-axis will be used at addition or subtracting data. That means that the program search which data point of the new data belongs to a corresponding point at the old data.

| | |
|---|---|
| **Only same x-values:** | Only data points which x-data are the same at old and new data will be used. |
| **Absolute difference:** | Data points of old and new data can combined which absolute difference is smaller than a given maximum. |
| **Percentage difference:** | Data points of old and new data can combined which percentage difference is smaller than a given maximum. |
| **Interpolate new x-data:** | The new data will be interpolated to the old (reference) x-axis data. This is the favored mode for tempscan data. |

**Note:** Normally it is not a problem to measure 2 V/I curves with same current points. But is is not possible to measure 2 tempscan files with the same temperature axis. If you measure file 1 and then file 2 the temperature will drift a little bit. With the mode 'Interpolate new x-data' you make from file 2 data with the x-axis from file 1. For example, if the first data point of file 1 is 100.0 K and the first point from file 2 100.1 K, then the program interpolate all y-data of the first point of file 2 to 100.0 K.

At **Parameters** you can **sort**, **interpolate** and **smooth** (approximate) the data.

## 2.2.3 Data tasks (All)

Several tasks, so saving and printing the data and saving evaluation values into the database, can here done. Not all inputs are possible for all measurement modules. At the question for saving data after the measurement you can call this window by the button **All**.

The **Actions** inputs define what happens after clicking 'OK'. The data can be **printed** and **saved.** If evaluation exist, it can be saved into the **evaluation** database. If the evaluation gives a sample parameter likes Ns, it can be applied as sample parameter and for the simulation. If the file was already saved, then you get the checkbox 'Override measure data' instead 'Save measure data'. If the evaluation was already saved in the database, you get the question, whether you want to delete the existing record.
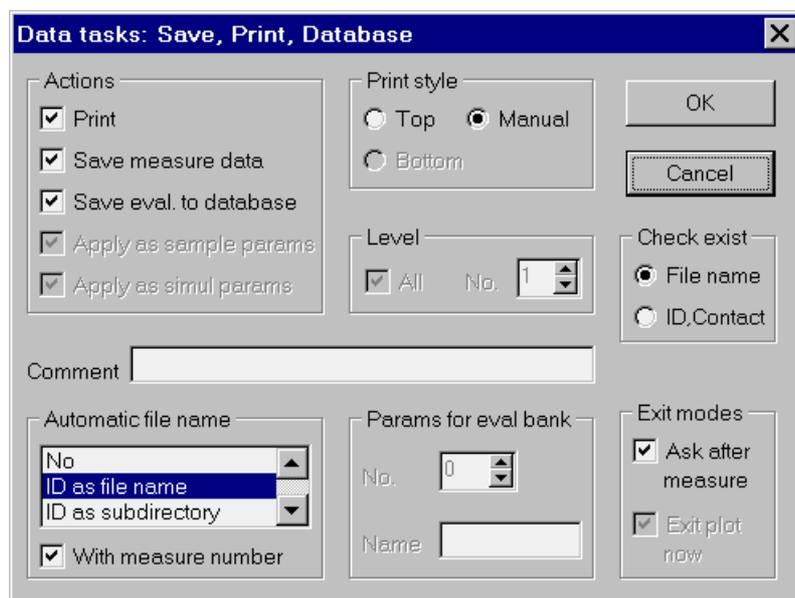
If saving Arrhenius data in the evaluation database a selection of **level** is possible. At some evaluations and deactivating 'All levels' you can define a **number** and **name** of evaluation. The name is only for searching in the database. The number is only for an easier comparison of results in the database. So you can at the database restrict your search of results by selection of an evaluation number.

'**Apply as sample params**' applies the results into the sample parameter set.
'**Apply as simul params**' applies the results as simulation parameters. When 'all levels' is activated, the number of levels will also be defined.

Input of **comment** for the data header is here also possible.
**Automatic file name** will be explained in chapter 2.4.5.
**Print style** defines the position of the plot on the paper (top, bottom, manual).

**Check exist** search if the new **file name** or the **ID and contact** already exist in the database.

By **Ask after measure** (Exit modes) you activate the automatic question for saving data after measurement at V/I, vdP/Hall and magneto module, see chapter 1.3.2.

**Tip:** Applying into the evaluation database and as sample or simulation parameter is often also possible at an evaluation plot, see chapter 5.1.5.3.

## 2.2.4 Print

This menu opens a special print dialog. The 'Other parameters' button opens a second window with further (not so important) inputs, the 'Setup' button the Window printer setup.

The **page initialization** for the printer is normally 'automatic'. This means depending on the style the initialization will be set. So if Top as style is set then the start initialization, at Bottom style the end initialization and at other styles both initializations will be done. At selecting Top or Bottom the style will be set to Bottom resp. Top after printing. The other possibilities are initialization only at start or end, always start and end (full page) or nothing. The paper will be 'really' printed only after the end initialization.
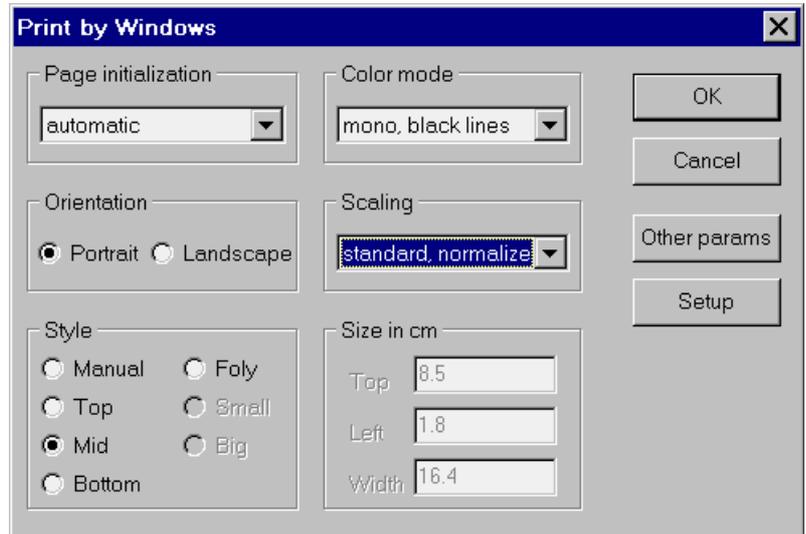
With **Style** you define the size and the position of the plot on the paper page. At Manual the inputs of the Size group will be applied.

As **color mode** there are monochrome with black (lines, symbols, text), 256 grey scales, color without background and color with background color as used on the screen.

**Scaling** defines the scaling of the plot on the paper in comparison to the screen:

**as screen:** Same scaling as screen, normally not used.
**aspect as screen:** The paper print has the same aspect (y/x) ratio as on the screen.
**Search correct font**: As above, but the font will be adapted.
**Standard, normalized:** The standard aspect ratio will be used for the paper print, independent from the used aspect ratio on the screen. This is the standard scaling.

If data were interpolated then there is an additional input group called **Print data**:

**Original:** Only the original data (not interpolated) will be printed.
**Interpolation:** Only the interpolated data will be printed with the selected symbol.
**As screen:** The data will be printed as shown on the screen, normally the original data with symbols, the interpolated data by lines.

**Note:** Before printing new data the data should be saved to disk. In the other case you don't get the file name at the paper page.

# 2.3 View menu

In the view menu you can set the kind of style, the window size, default and global plot parameters and personal short cuts.



**Refresh** plots the standard plot again on the main window. **Params for standard plot** doesn't exist in all measurement modules.

## 2.3.1 Form and panel styles

**Form styles** defines the main form style. The standard plot will be shown on the canvas of the measurement program, see picture in 1.3.4. If you select a plot or evaluation, the program opens one of the plot programs by a new form. This form (window) has as the main form a caption line, a menu, toolbar, canvas and status line. The form style define how the old (main) form is visible. There are 3 possibilities:
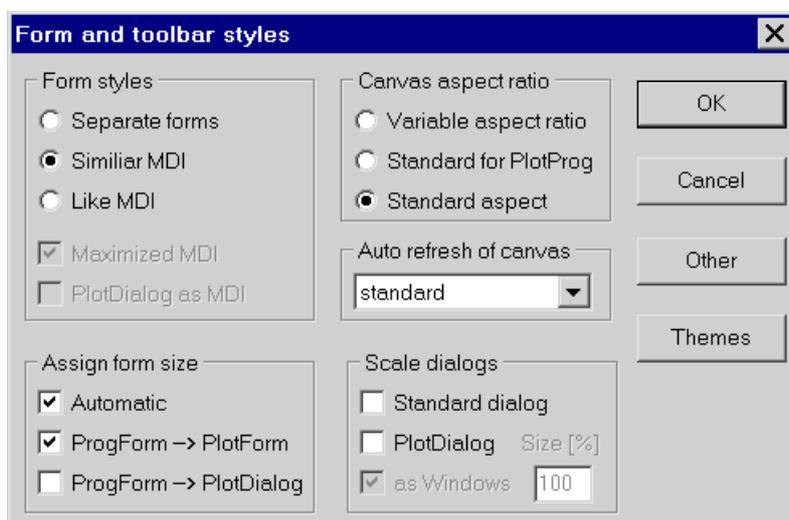


**Separate forms:** Only the current (new) form is visible. If you close this form you don't leave the program but show the old form.



**Similar MDI:** From the old form is only the caption visible, the old form is de-activated but not hidden. The current (new) form will be placed under the old caption line.



**Like MDI:** The current (new) form is a child of the main window of the measurement program.
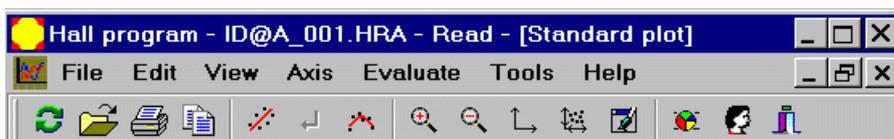


The software use for this the **M**ultiple **D**ocument **I**nterface of Windows, but only one child window is possible. By **Maximized MDI** will the child always maximized. If activating **PlotDialog as MDI** dialogs with plots inside will also be shown as a child window.

**Note:** The Windows guide lines would prefer the third mode. Our preferential mode is the second one (Similar MDI). It is much faster.

At **Assign form size** you can define how a change of the form size will be overtaken from other program modules:

- **Automatic:** If you change the size of the main program this change will be applied for other programs, except the plot programs. There are an additional option.
- **ProgForm → PlotForm:** If you change the size of one of the main programs, then this size will overtaken for the plot programs.
- **ProgForm → PlotDialog:** If you change the size of the main programs, this size will be overtaken for dialogs with plots, for example the ReadView window in 2.2.1.

**Canvas aspect ratio** defines the ratio of the used y/x canvas points for plots on the screen, see chapter 2.3.5.

**Auto refresh of canvas** defines when the canvas should be refreshed after an action.

By **Scale dialogs** you can scale the standard and the plot dialogs. Either you can define a percentage size or the option as 'Windows'. In the last case the dialogs will be scaled by the Windows display text size. Especially at high resolutions screens it may be important to increase the scale with an individual percentage value bigger than 100 to avoid too small dialogs. Plot dialogs are dialogs which contain additionally a plot or grid.
If this scale option is not activated, the Windows display text size (100%, 125%, ...) has only an influence on the menu size but not on the size of dialog text or dialog buttons. Sometimes the enlarging yields to a too 'long' text, a text string may be cut by a text box, a wordwrap may be wrong. Try then different scales for the best result.

The **Other** button opens a new input window. Changes here will only directly applied when leaving also the main input window (previous page) by 'OK'.

You can define the style and options of the **toolbar**. If the size of the toolbar buttons is too small, you can enlarge the buttons by a percentage input of the size. The activation of 'Show captions' enlarges also the button size.

You can select the **font** of the form and dialogs. 'As developed' uses the new Microsoft Sans Serif, 'as Windows' uses Tahoma for Windows 2000 and XP, Sergoe UI for Windows Vista and Seven.
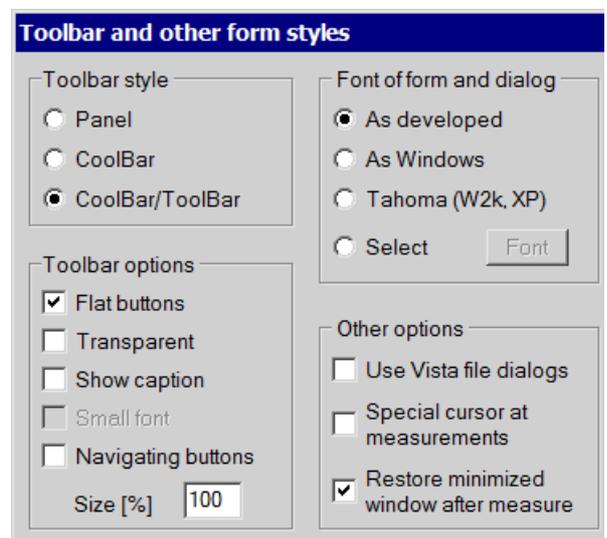
By **Use Vista file dialogs** the new Windows standard file dialogs will be used under Windows Vista, Seven and 8.X.

**Special cursor at meas** means that during the measurement a special form of the cursor, the hour glass, will be shown.

If you have minimized your form (window) during the measurement and the option **Restore minimized window after measure** is activated, then the software restores the old form size automatically after the measurement is finished.

Clicking onto the **Themes** button opens an input for the Windows themes. These are customizations of the graphical user interface and include visual styles. You can choose the theme in the Windows control board. All themed applications have a similar appearance.

If activating '**Disable visual styles**', the Hall program doesn't use themes. The look and feel is then as Windows Classic, independently from the selected Windows themes except the caption line, menu and boarder.
By '**Disable desktop composition**' the windows will not be animated when minimizing and maximizing, the Aero design will be switched off for the Hall program.
Both flags have no meaning at Windows 8.X. There you can switch off these only in the Windows system properties.

A change of these flags will be visible after a program restart because it changes the registry. These are not available for the Portable Program. You find these flags also by a right mouse click onto the DLTS program and selecting there 'Properties → Compatibility'. Further possibilities are in 'Visual effects' of the Windows system properties.

'**Deactivate desktop composition**' has the same effect as the flag above but it will immediately be done without the registry. It is not valid at a cold start or for other DLTS users.

**Windows styles** defines the colors and styles of the buttons and other control elements. The default is 'Windows', colors and styles will here be used as selected in the Windows themes. The change of the Windows style will be active after leaving the 'Form and toolbar styles' input window. The new rendering of some control elements may be not perfect. So a wordwrap of the checkbox label will not be shown.

All inputs in this manual will be shown in the Windows classic style. An example gives the left picture. The default themes depends on the operating system. It is 'Aero' for Windows 7, as shown in the right example.
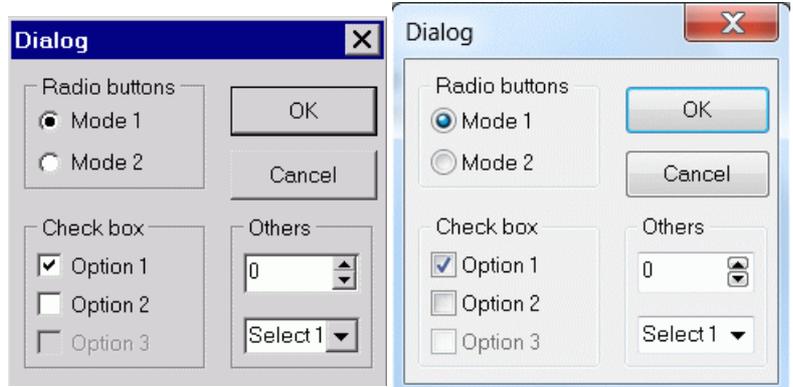
Tips for screens with a **high resolution** (big DPI value):
- Select in the Windows **Display** (from control panel) a text size of 125%, 150% or higher. It enlarges the menu and caption size.
- Activate the **scaling** of the standard and plot dialogs, see previous page. The scaling size can be defined by an input or by the Windows display property.
- Enlarge the **toolbar** buttons by an individual input if necessary, see previous page.
- The **plot** size will usually automatically be scaled. If the aspect ratio is not optimal, change the line and column numbers, see chapter 2.3.5.
- By default the maximum **canvas** size is limited to 1840x1196 pixels (see chapter 2.3.3.7), which is enough for a 2560x1600 screen.

**Tip:** You can save your settings for a cold start in 'Personal shortcuts', see chapter 2.3.4.

## 2.3.2 Default plot parameters

The default plot parameters will be used for the initialization of a plot. In the plot program you can change these parameters, but these changes are only local, after leaving the plot program and start a new plot the default parameters will be used. An exception are the global plot parameters, see chapter 2.3.3.

### 2.3.2.1 Symbols input sheet

There are default symbols for different kind of plots. These default symbols will be used only at standard plots with one curve. 'Measure' symbol will be used for example at the test of contact, 'Static' at V/I curves , 'Transient' for transient plots, 'Evaluation' for all plots which show evaluation values, for example the Arrhenius plot. 'Standard' is the default symbol for other curves not listed above, for example for the tempscan.
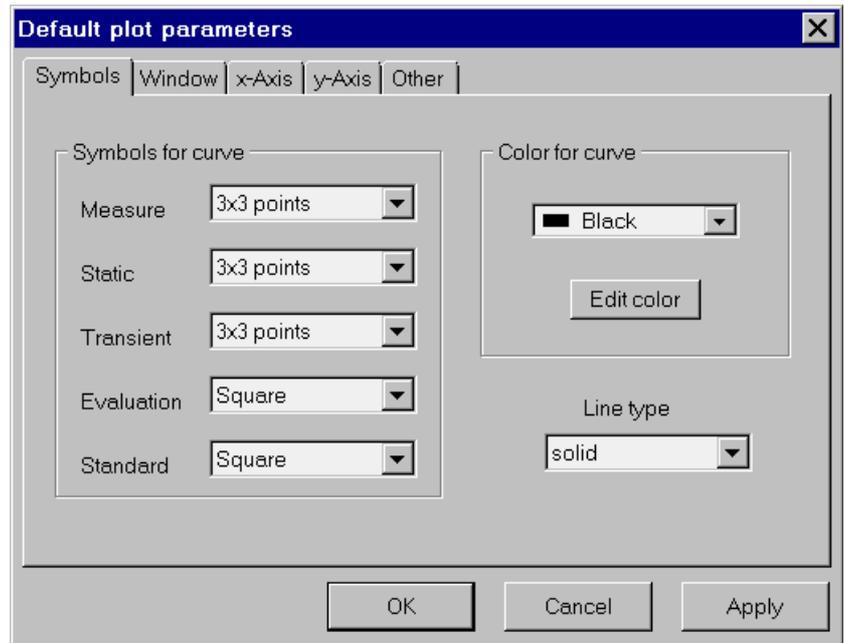


### 2.3.2.2 Window input sheet

At **Styles** you can define the number of intervals for the x- and y-axis. Maximum place for decimal format determine when the software change form the decimal to the exponential format.
**Axis numbers for plots** defines when at the axis the number will be printed. It can be done at every tick or every 2. tick. At start/end means that there is at the first/last tick a number. At 2. tick automatic means that the start will be set by the software.
The mode exist separately for big plots which use the full canvas and for small plots which use only a part of the canvas, for an example two plots one below the other.
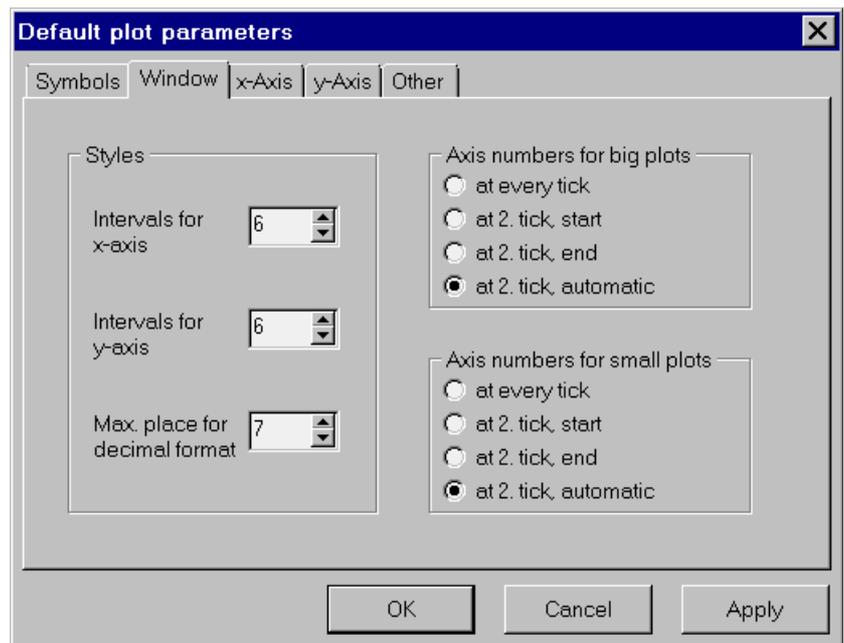
## 2.3.2.3 x/y-Axis input sheet

The window around the plot will be defined by **Axis line and numbers.** If selecting bottom and top for x-axis and left and right for y-axis then there is a full window around the plot and on the bottom and left axis line there is the numbers and axis text.
You can also select the kind of **axis ticks**. Left and right means that the ticks are inside of the left and right axis line.

**Text position** defines the position of the axis text. Top means that the y-axis ends at the top line.
The **arrow type** behind the axis text is only a text string or a graphic arrow.

For the y-axis there is also the input of the **Maximum place for y-axis numbers**. This means that software reserves the place for the selected numbers. This shift the left axis line and change the size of the plot. This can be important if you compare different plots on a paper.
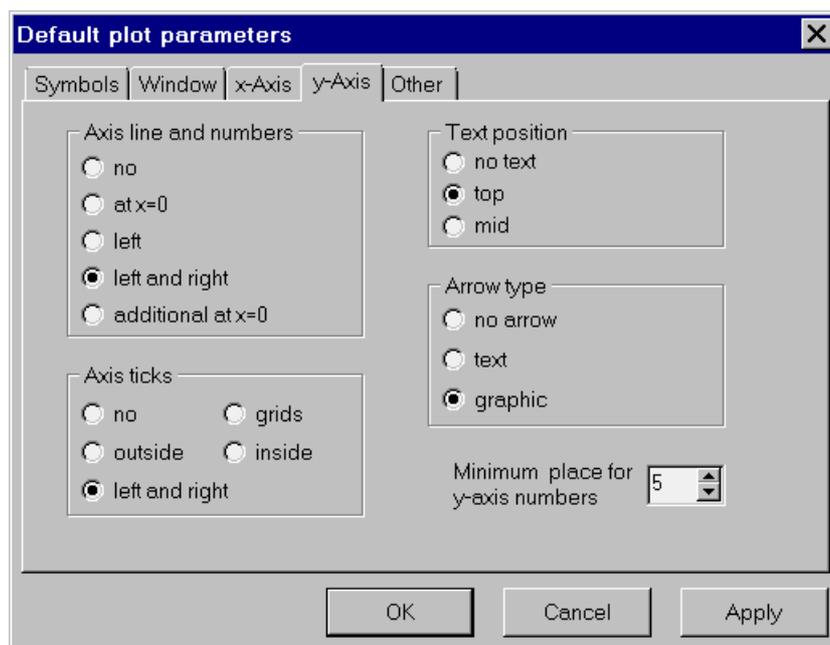
## 2.3.2.4 Other input sheet

Here you define the header position at big (full) plots. The first mode prints the file name and comment of the text header above the plot window, others will be printed at the right outside of the plot window.
Automatic means that if there is enough place on the right mode 2 will be used, in the other case mode 1.

The axis for V/I plots can be separately defined, either as global or a cross or cross and boarder.
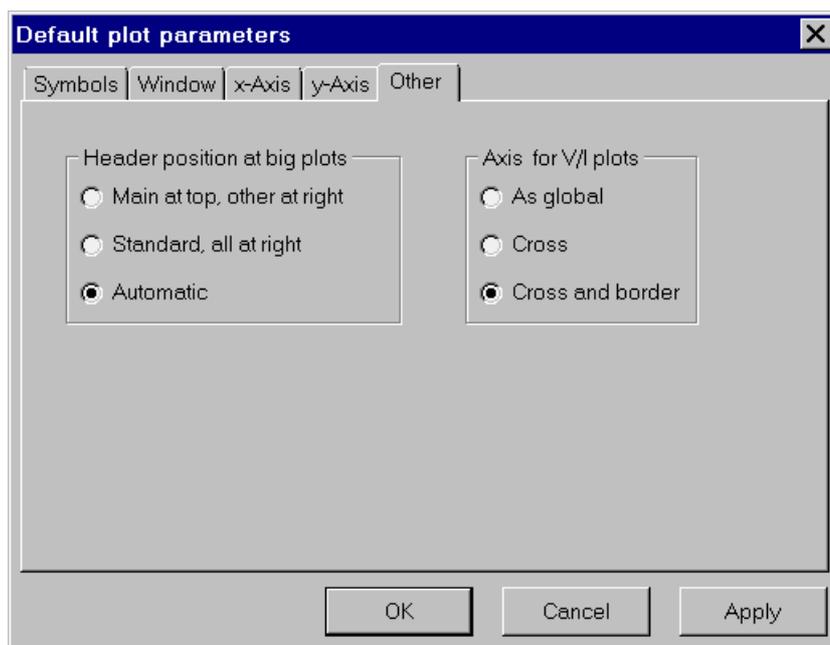
## 2.3.3 Global plot parameters

The global plot parameters are valid for the whole program and can only changed here.

### 2.3.3.1 Colors input sheet

**Colors** for special kind of curves and for plots with many curves can here be defined. Plot inside is the background color of the plot inside the window. Plot background is the color of the canvas.
This plot **background** can be separately used for the form (not used size by the canvas) of the main, the standard plot and the pre-sentation program. In the other case it will be defined by Windows.
3 modes are possible for the color of an **interpolation** curve. 'As curve' means that original data and interpolation have the same color. The software select the color at 'Automatic'. Extra color takes the user defined color for interpolation.
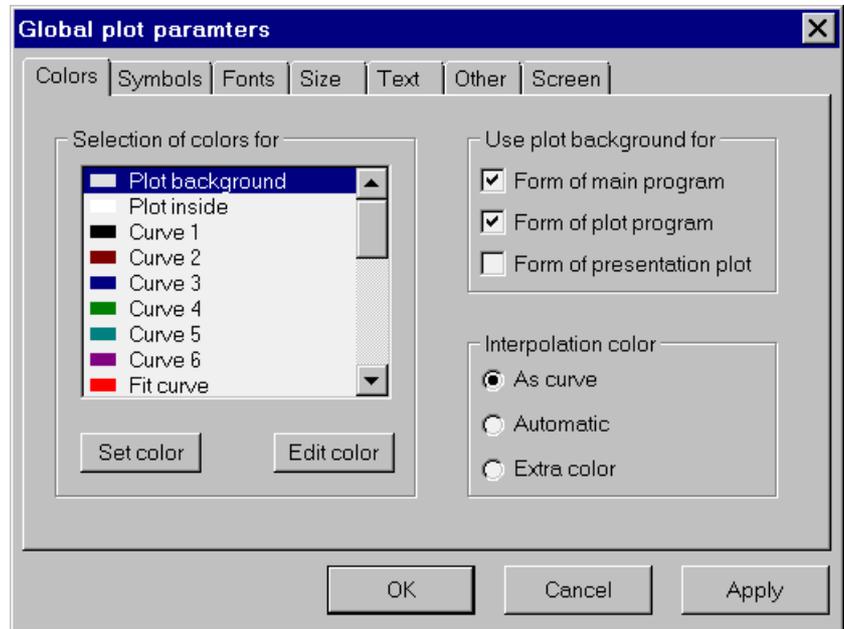
### 2.3.3.2 Symbols input sheet

Here you can define the symbols for curve 1 to 6 at plot with many curves and the symbols for special curves.
**Fit** means if you fit a given curve by a simulation or calculation. **Compare** will be used for the curve which will be compared with another one. The **Difference** of 2 curves have his own symbol. You can also define the symbol for the **Interpolation** curve. **Mark** means if you mark a special point, **Special** is for special applications.
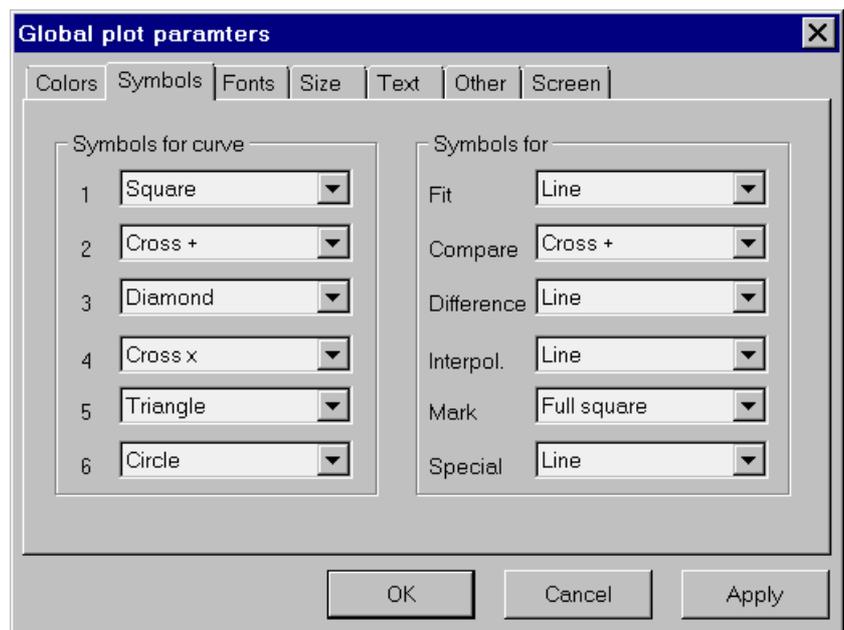
## 2.3.3.3 Fonts input sheet

Here you can select the font of the plots. **Header font** is the font for the text header at plots, normally at the right side. Data font will be used for data inside the plot, for example Arrhenius evaluation list. Symbol font will be used for symbol explanation. Axis font exists for the axis text and numbers. Presentation font will be used in the presentation plot program. In some cases a special small font will be used.

The 'Font' button opens the Windows font dialog. The inputs by the 'Raster' button will be explained in 2.3.5.
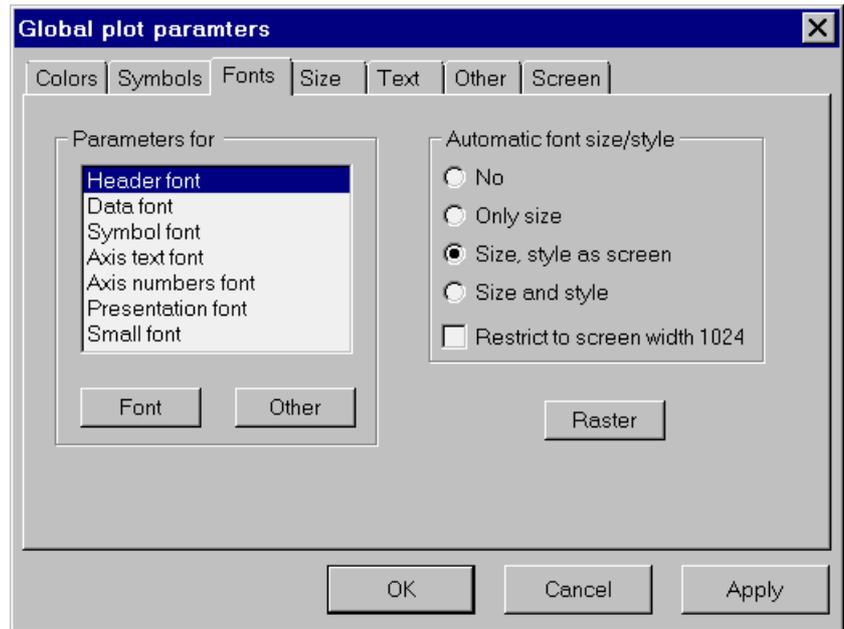
**Automatic font size/style** defines whether the size and style of the selected font will be changed at other screen resolutions as the default 120 dpi. Change of style means that at too small sizes the small font will be used.

The **used font size** is not the defined size. It will be corrected by the used x-pixels of the current window in respect to the virtual x-pixels of a virtual raster window size. The virtual x-pixels size will be defined in the inputs of the Raster button, see chapter 2.3.5. So the default virtual raster font has the size 11 and 10 x-pixels per character. With 92 columns you get a virtual x-pixels size of 920.

You can **restrict** the automatic font size on the screen to screen width 1024. This means if you have more than 1024 x-pixels on the screen the used font size will not be bigger as for 1024 x-pixels.

By the **Other** button you get the other inputs for the font.

You can define the **relative cell size** for the normal character, for characters which used at an exponent or index text, and the offset for exponent or index character.

You can select a box around the text and the background color of a character.

**Tab pos available** means after which character the software can set a tabulator and starts a new position. This is useful at proportional fonts for list of data with text and values.
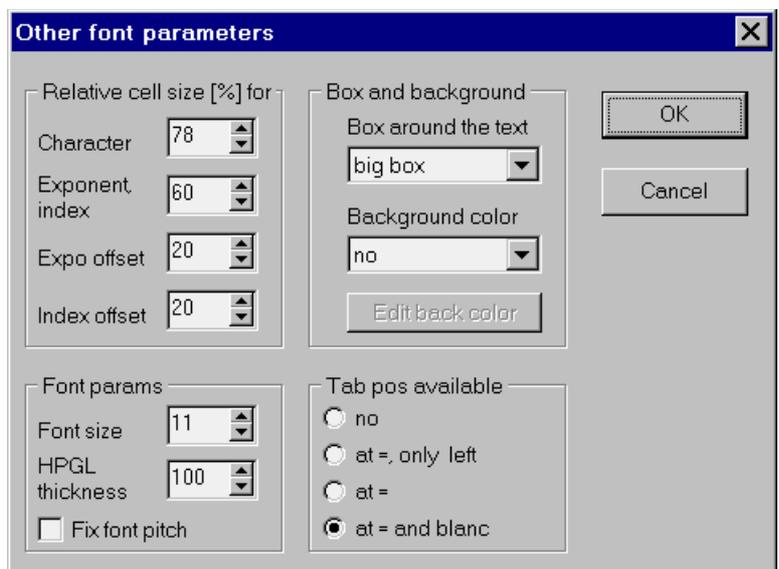
## 2.3.3.4 Size input sheet

Here you can define the **line thickness**. The standard value is 100.

You can define the **size** of the axis ticks and the plot symbols. The size will be given as percentage scale of the plot window. The symbol size exist separately for big plots which use the full canvas and for small plots which use only a part of the canvas, for an example two plots one below the other.
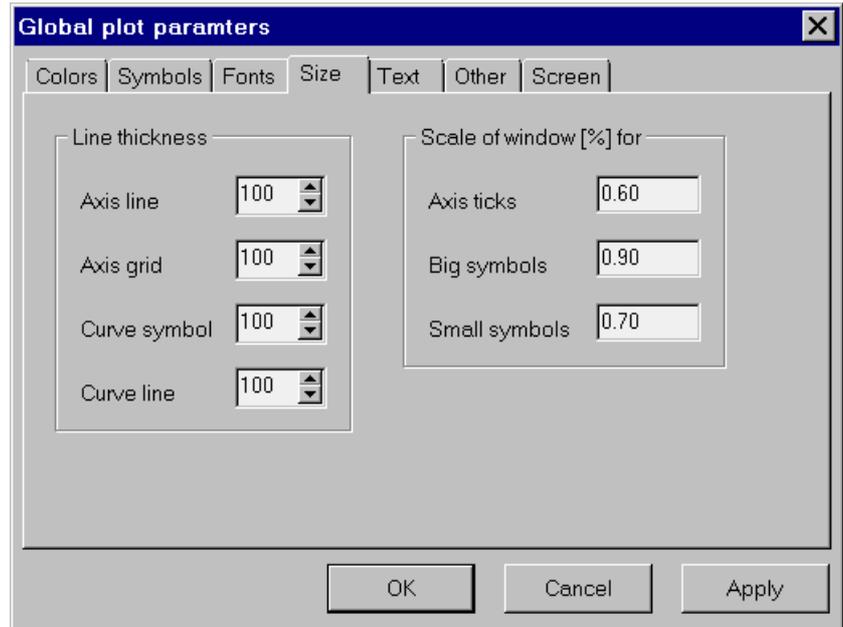
## 2.3.3.5 Text input sheet

**Print header** defines which data will be shown in the plot header, possibilities are **no** use of header, **comment** only, **main data**, **all data** and a **anonymous** mode (no name, ID, date).

**Styles for header** enable an optimization of the header look, especially for pictures with 3 plots and a quarter header at the right top.

As **style for the regression text box** there a horizontal list with and without the evaluation dimension and a vertical list. 'Automatic' sets one of these types, normally the horizontal with dimension. Different colors for the different lines (horizontal), a data grid and a boarder around the box are options.

At other params you can activate the **symbol explanation**. So if you have a plot with some curves you get in the plot an explanation of these curves.
Normally the evaluation data in the header text will be shown with 2 digits, for example 1.12E15. By activating **3 digits for header eval text** 3 digits will be shown, for example 1.123E15.
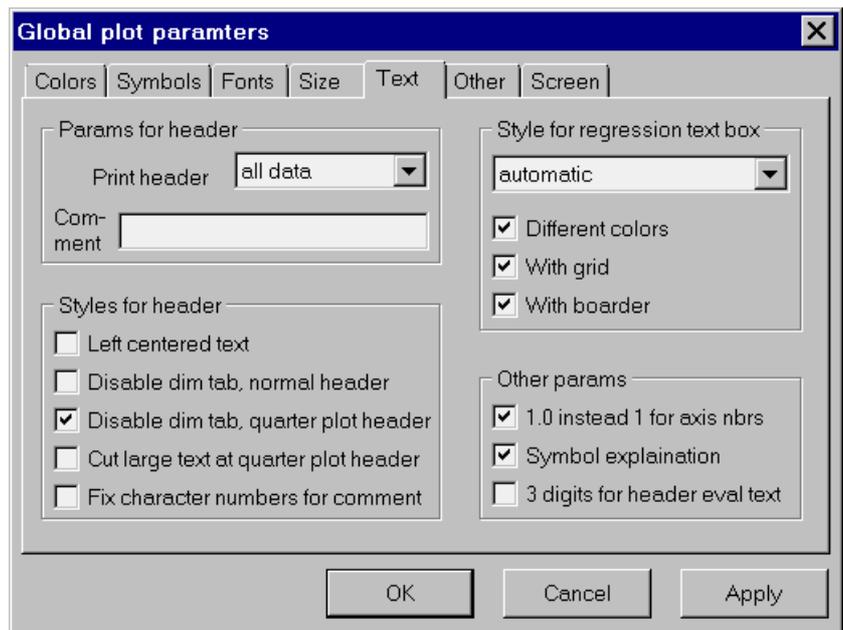
## 2.3.3.6 Other input sheet

For the **linear regression** there are some options. For the automatic search of linear regression can the used minimum range and the search method be selected. Preference to a big range width or to a very good correlation value are possible. The standard search is a compromise of both. The minimum range for the linear regression over V/I curves must be separately defined. For 30% you can select only negative, only positive or both voltages.
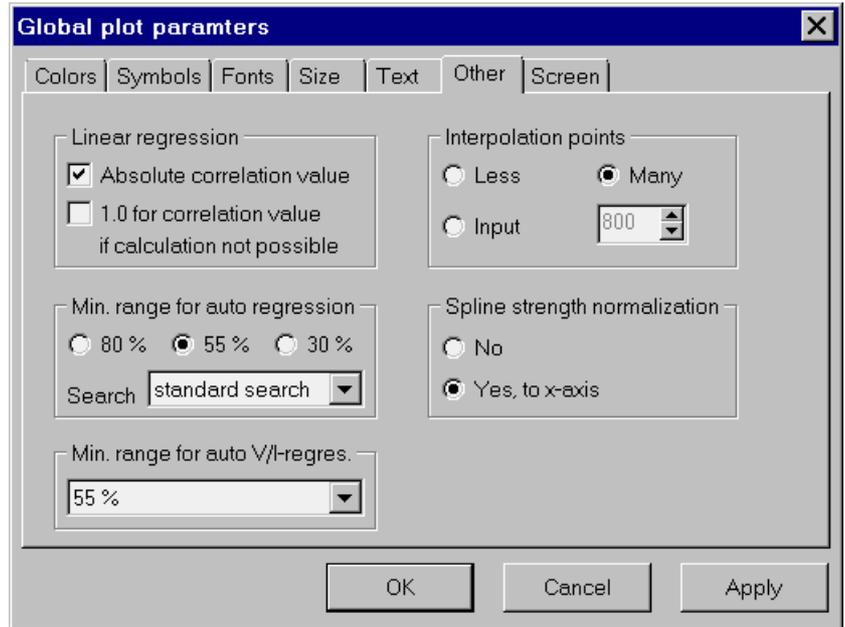
The points of a plot **interpolation** curve can be selected. Less use two times, many four times more points as the original. The minimum interpolation points in both cases is 501. The **spline strength** can be normalized in respect to the x-axis data.

## 2.3.3.7 Screen input sheet

The following inputs are only valid for the plots on the screen, not at printing on a paper.

The **font mode** determines whether the defined fonts will be used or special ones. The **color mode** defines whether the curves are in color or only in black and whether the plots on the screen have a background color.
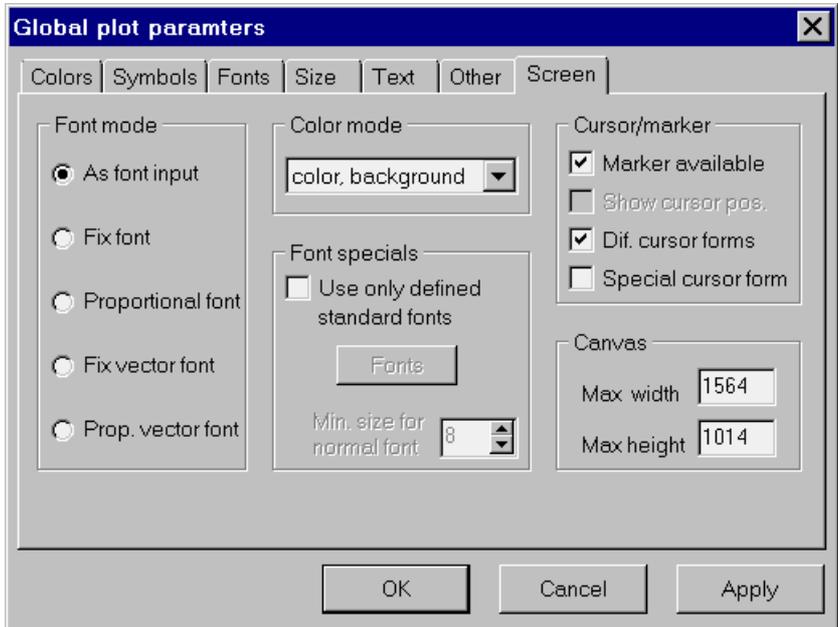
There are some options for the **cursor** resp. **marker**:
'Marker available' means that you can the regression start and end position not only set by the mouse cursor but also by an additional marker (vertical line).
'Different cursor forms' means that, for example at the regression, not only the standard mouse cursor will be used but different cursors which are specific for the current action.

You can restrict the width and the height of the **canvas**. Memory must be reserved for the maximum size. If the maximum values are too small then the full screen size is not possible for the plot canvas.

## 2.3.4 Personal shortcuts

Here you can define your two personal short-
cut keys F11 and F12 and your personal but-
ton. These definitions are specific for every
program module. If you press F11 in the pro-
gram module, the defined action will be done.
You can select all the actions which are pos-
sible from the menu or from the toolbar.

By the '**Save file**' button you can save your
personalization of program style, face and
size and your shortcuts for a cold start. These
are all parameters described in chapter 2.3.1,
2.3.4 and 2.3.5.
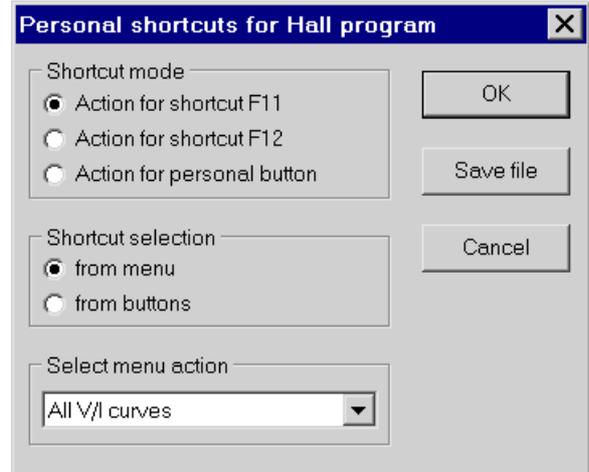
Usually the current configuration will be saved for the next hot start, see chapter 1.1.7. But
sometimes it can be helpful to make a cold start with the default configuration. Then you
would lose your personal styles, sizes and shortcuts. If you have saved here these para-
meters, these will be kept also at a cold start. Look in chapter 1.1.2 for the search strategy
of initialization files.

## 2.3.5 New size

Here you can define a new form (window) size of the program on the screen after leaving these inputs. Form size means here the total size of the program window, including caption, menu bar, toolbar, canvas for plot, not used size and status line. Canvas size means only the size of the canvas on which the plots will be shown, see picture in 1.3.4.
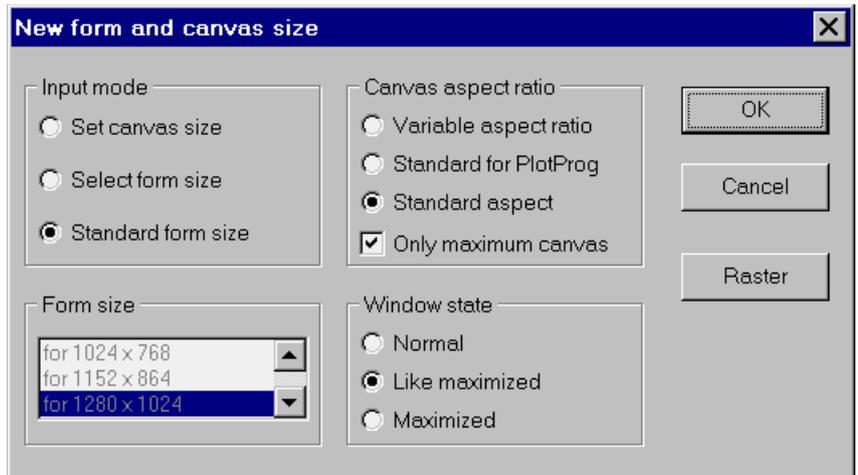
3 input modes are possible:
- **Set canvas size:** The canvas size will be set by the current form size.
- **Select form size:** You can define manually the form size (pixels) by the next input. There means 'for 1280x1024' that 1280 horizontal and 1024 vertical pixels are necessary. This mode can be helpful to use not the total screen size but keep the standard aspect ratio.
- **Standard form size:** The software defines automatically the form size from the screen size/resolution.

At mode 1 and 3 you can define the **Canvas aspect ratio** (y/x points) on the screen:
- **Variable aspect ratio:** The canvas uses the total free size of the form. This has the advantage that there is no unused size in the form, but depending on the form aspect the plots may look not nice because unfavorable height to width ratio.
- **Standard for PlotProg:** A standard definition of the aspect ratio, see below, will be used only for the plot programs, in the other case the aspect ratio is variable.
- **Standard aspect:** A standard definition will be always used, see input window of 'Raster'. The advantage of this mode is that you have always the same aspect and nice plots, but it is possible that you lose space on the screen.

At the standard aspect is the use of the maximum canvas size possible.
The **window state** defines if the window size is as normal defined or maximized. In the first case the biggest used size by the standard aspect will be set. 'Like maximized' means that is not really maximized by Windows but use also the total screen size.

By the button **Raster** the inputs for a virtual text raster of the canvas is possible. This raster will be used for tabulators if text will be printed onto the canvas. You can select the font for this raster and the font size. 'As header' means that the font for the right text header will be used. The number of lines and columns of this virtual font define the standard aspect ratio for the canvas resp. plot. 'Plot right text cols' means the columns of the right text header at a single standard plot.
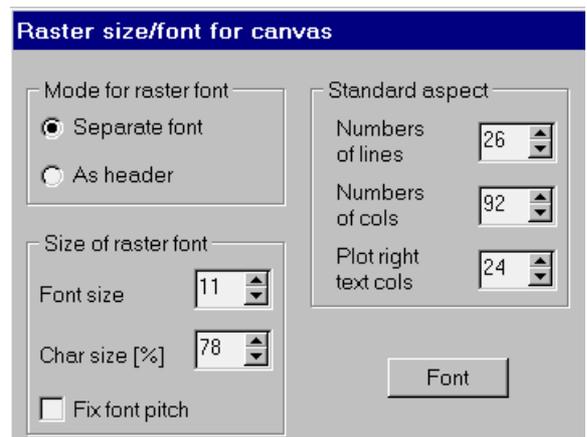
# 2.4 Tools menu

The Tools menu enables a selection of different input menus for setting up the software (not the installation).

 **User class** is a value that enables or disables software parts, evaluations or measurements, due to a selected level. The working with the software might become easier if only the needed options are shown.
At user class 5 you find in Tools a calculator, especially for semi-conductor equations.

**Program Parameters** changes physical models for corrections and simulation parameters. Inputs depend on the user class. There is also the button for access of **Material parameters**.

**Sample parameters** opens the input window of all necessary values to describe and define the sample. Here you define also the **use of the database**.

**Temperature** enables the direct working with the temperature controller. Temperature reading, changing of the temperature, setting of the PID parameters and sending of commands to the controller are supported (depending from the kind of the controller).

**Monitor** allows to monitor the measurement and to define a WebView.

## 2.4.1 User class

User class does not mean a classification of the user. It is a value defining how to work with the Hall software and so far with the complete Hall system. For standard and routine measurements, not needing a user with a particular physical background, or not wanting to think about different physical models for the actual sample the user class 3 (**basic**) is introduced. All inputs concerning measurements, evaluations, plots, etc. based on standard Hall approximation are possible.
Higher user classes enable more features, at lower classes these features are not visible or the input is not possible (grey text). The Hall software provides a great many options to provide the most detailed analysis available in systems of its type. To avoid excessive complexity you are advised initially to use class 3.
For enhanced measurements, evaluations, plots etc, the **expert** classes are introduced. It enables also evaluations with a change of the standard emission / Hall model or special measurements / evaluations needing a physical background for using it (direct capture cross section measurements / evaluations etc.). Level 4 is the last ´checked´ level, meaning that all inputs and evaluations are checked for data mismatch or conflicts. Fatal errors should not appear. User class 5 (**extend**) give you additional features, especially for evaluations and simulations, user class 6 is only for testing and hardware diagnose. Above level 4 it´s due to the user to check the data with the selected evaluation. A conflict might cause an error with a rebooting of the software.
In this manual only **user class 4** will be described, except at some marked parts.
The input of the user class will be restricted by the maximum user class, see chapter 1.1.5.
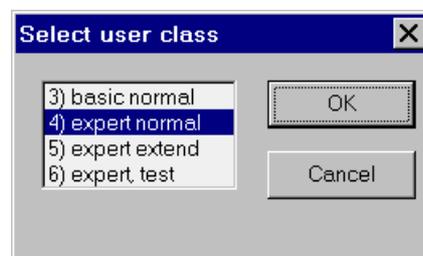
## 2.4.2 Program parameters

Here are material and simulation parameters. The parameters for the Arrhenius plot are normally not necessary for the Hall program.

### 2.4.2.1 Physics input sheet

These inputs define the physical model used calculating the Arrhenius plot y-axis. Specially the temperature correction of the time constants is defined here. Materials opens an input sheet for changing and adding the material parameters for the used semiconductors. The inputs depend on the used input mode and the user class. The below shown input mode selections is valid up to user class 4. User class 5 and higher enables you more features, at user class 4 these features are not visible or the input is not possible.
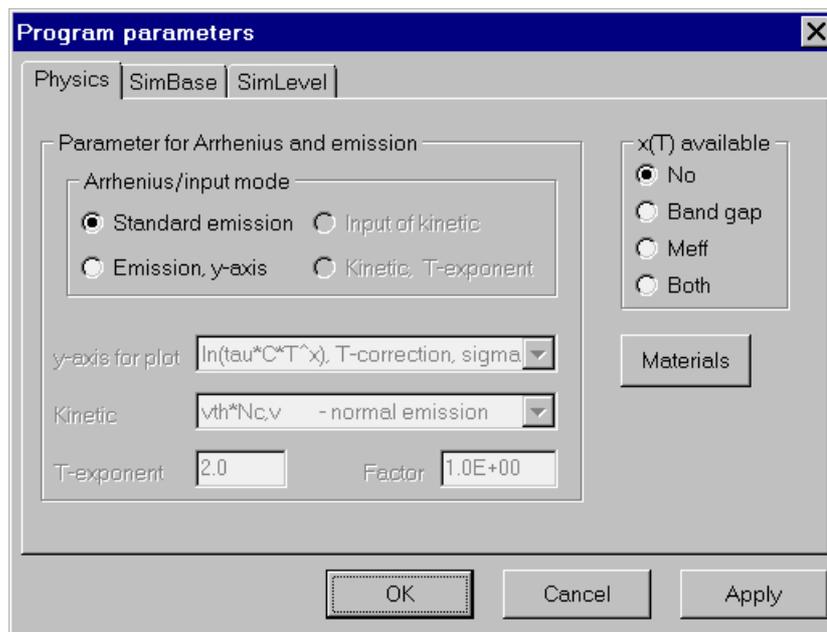


The **Arrhenius/input mode** defines the evaluation and the y-axis of the Arrhenius-plot. The Hall software don't use normally the Arrhenius plot, except in the tempscan program. Starting from Standard emission process (Hall Theory Manual) with emission time constant tau, effective density of states Nc resp. Nv and the thermal velocity vth we get the Arrhenius plot by ln(tau(T)*Nc(T)*vth(T)) versus 1000/T. To get the correct energy from the slope and the correct capture cross section from the intercept of this curve, we have to eliminate the temperature dependence in the argument of the logarithm. This is meant with the so called temperature correction of the Arrhenius plot. For the standard emission process (**S**chockley **R**ead **H**all) we get with vth ~ $T^{-0,5}$ and Nc,v ~ $T^{-3/2}$ as y-axis:

$$y(tau) = \ln(tau*C*(T/300)^2), \text{ with } C=vth(300K)*Nc,v(300K)$$

This is known as $T^2$ correction. In general it will be called **T-correction**, we get an exponent as a temperature correction (2 for the SRH mechanism above) and a constant consisting of the values of the corrected parameters at 300K (vth(300) and Nc(300) in the SRH model). Only for this standard model a correct energy and capture cross section can be evaluated.
In some cases this model is not valid. Therefore is the possibility to change these correction values. This should only be done if the user knows exactly what kind of emission model is valid.

The **Standard emission** uses the so standard SRH $T^2$ correction and have as y-axis for the Arrhenius plot ln(tau*vth*Nc). The capture cross section sigma is calculated from the T-corrected intercept.

**Emission, y-axis** enables some small selections for the y-axis and for evaluation:

**ln(tau*C*T^x), T-correction,sigma:** Similar to the standard emission, the y-axis is ln(tau*vth*Nc), the y-axis text is ln(tau*C*T^2).

**ln(tau*(T/300)^x), T-correction,sigma:** The y-axis is ln(tau*(T/300)^2). No effective mass is used for the y-axis, for the calculation of sigma ln(tau*vth*Nc) will be used.

**ln(tau*(T/300)^x), T-correction, y0=intercept [s]:** Same as above, but the intercept is shown as y0 and not as a capture cross section sigma.

**ln(tau), y0=intercept [s]:** No temperature correction is used. The slope is given as an energy, the intercept as y0 including all parameters, means without any correction.

**ln(tau), T^0 for kinetic, y0=intercept [s]:** As above no temperature correction is used, but the intercept is calculated with respect to the values at T=300K.

The input mode **Input of kinetic** enables the selection of different emission process models (kinetics) and from that the use of different exponents x for the T-correction of the slope and factors for the correction of the intercept. This button is only available with user class 5 and a change from normal emission (SRH mechanism) to the other models should only be done if exactly known, that the selected model is valid for the sample.
Several emission models for use in the temperature correction of the Arrhenius plot can be selected now using the input window **Kinetic**.
The input mode **Kinetic, T-exponent** enables additionally the direct input of the temperature correction exponent x.

The small selection window **x(T) available** on the right side of the Physics input window enables an additional correction for the temperature dependent values of the time constant axis in the Arrhenius plot. At Hall normally this correction will not be used:

**No:** No additional corrections are available (standard).
**Band gap:** The temperature dependence of the band gap is available.
**meff:** The temperature dependence of the effective electron resp. hole mass is available. This effective mass will be used in the effective density of states Nc resp. Nv and in the thermal velocity vth for electrons resp. holes.
**Both:** Enable band gap and meff correction.

The input above enables only this option, a use of it is not always given. This input comes from the material file and will not be automatically saved at leaving the program, for more details look in chapter 2.4.3 For this use the temperature dependence must be defined additionally in the initialization file MatTemp.Cfg. You can plot the temperature depending values in the semi-conductor calculator.

## 2.4.2.2 SimBase input sheet

The two input sheets SimBase and SimLevel define the parameters and values of the Hall program uses for **simulations**. Nearly all measurements that are possible with this Hall system can be simulated and the data can be used for all evaluations in the same way as the measured data.
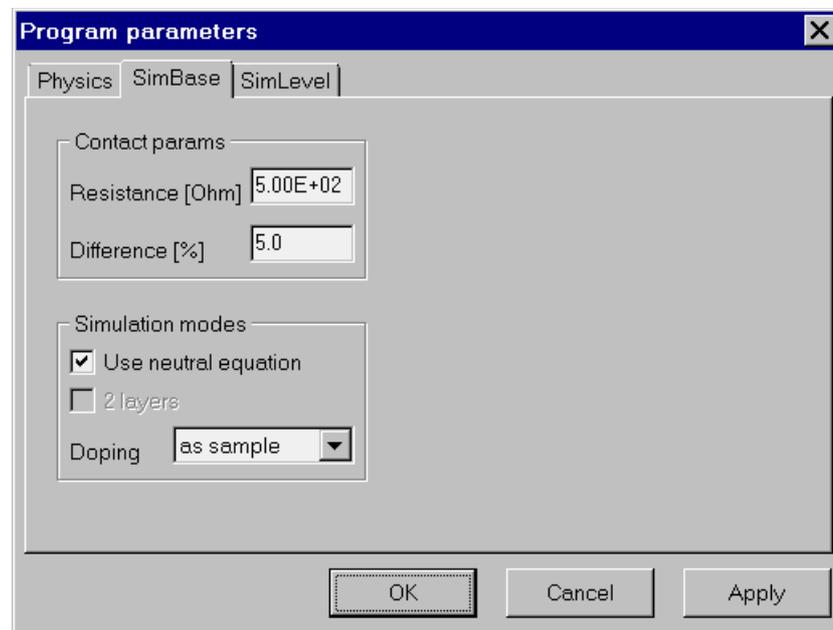


The **resistance for** the 2-point measurements can be defined. A percentage **difference** for the different contact pairs can be input.

The 4-point resistance can be calculated by the **neutral equation**. In the other case the given 2-point resistance will be taken.

The **doping** type for simulations can be select. The last 2 modes are only available at user class 5:

| | |
|---|---|
| **as sample:** | The doping type for simulation will be applied from the doping type of sample parameters. A new simulation and evaluation can give a new sample doping type and therefore a new simulation doping type! |
| **n-type:** | The simulation will be done for a n-type sample. Only electrons will be used for the neutral equation. |
| **p-type:** | The simulation will be done for a p-type sample. Only holes will be used for the neutral equation. |
| **n-type, n and p:** | The simulation will be done for a n-type sample, the energies are EC-ET. Electrons and holes will be used for the neutral equation. |
| **p-type, n and p:** | The simulation will be done for a p-type sample, the energies are ET-EV. Electrons and holes will be used for the neutral equation. |

A **2 layers** simulation is possible at user class 5. Then you get at the right side an input group with the parameters of the seconds layer: Doping type, concentration, factor and exponent of mobility, thickness.

### 2.4.2.3 SimLevel input sheet

Opens an input window defining the base level (called level 0) and trap levels that shall be used in the simulations. Up to 9 different trap levels can be defined for the simulation in **last level.**
For each level values for the concentration **Conc.** [cm$^{-3}$], the **activation energy** [eV], the **entropy** factor the type (acceptor or donator) can be input.
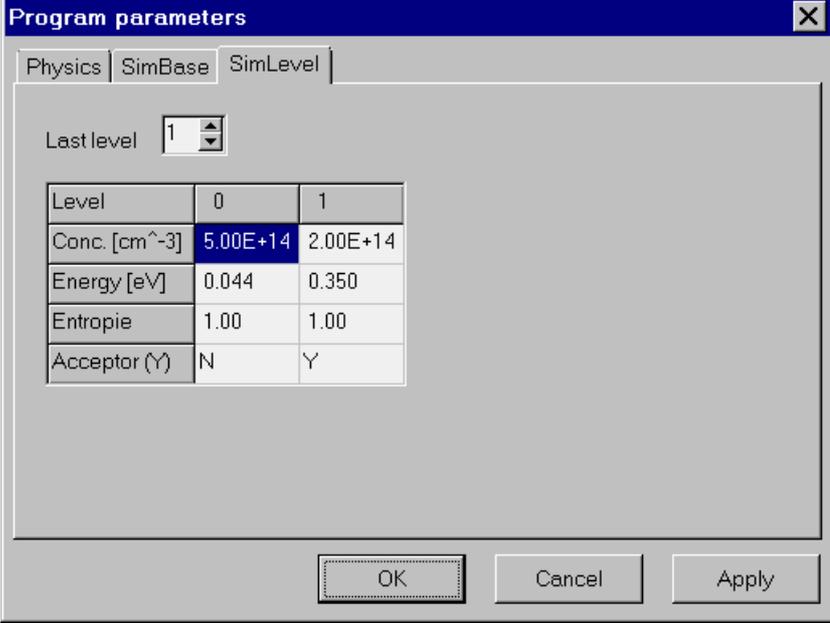


The activation energies are energy differences from the majorities band, at n-type sample this is EC-ET, at p-type ET-EV.

## 2.4.3 Material parameters

One button of the Physics input sheet leads to the inputs of the material parameters partly used in the Hall software. Several semiconductor materials are still predefined, but of course here are not all defined. Therefore the user has to define it here, by changing the values of still defined materials or by introducing a new parameter set and name of a semiconductor material. Not all parameters are used in the Hall software, some are not used at all. The standard combined **vdP/Hall** measurement and its evaluation uses **no material parameter**. Only the optional calculation of n(Rho) needs the mobility.

| Number | 1 | 2 | |
|---|---|---|---|
| Name | Si | GaAs | In |
| Bandgap [eV] | 1.120E+00 | 1.424E+00 | 1 |
| Rel. epsilon semi conductor | 1.190E+01 | 1.310E+01 | 1 |
| Rel. epsilon oxid | 4.100E+00 | 4.100E+00 | 4 |
| Eff. mass factor (n) | 1.080E+00 | 6.800E-02 | 7 |
| Eff. mass factor (p) | 5.580E-01 | 5.000E-01 | 4 |
| Richardson* [A/(cm^2*K^2)] (n) | 1.200E+02 | 1.200E+02 | 1 |
| Richardson* [A/(cm^2*K^2)] (p) | 1.200E+02 | 1.200E+02 | 1 |
| Mobility factor [cm^2/(Vs)] (n) | 1.300E+03 | 8.000E+03 | 4 |
| Mobility factor [cm^2/(Vs)] (p) | 3.800E+02 | 4.000E+02 | 2 |
| Mobility exponent (n) | -2.700E+00 | -2.700E+00 | -2 |
| Mobility exponent (p) | -2.500E+00 | -2.500E+00 | -2 |
| Shallow doping energy [eV] (n) | 2.500E-02 | 2.500E-02 | 2 |
| Shallow doping energy [eV] (p) | 4.000E-02 | 4.000E-02 | 4 |
| Name of shallow doping (n) | P | X | X |
| Name of shallow doping (p) | B | X | X |
| Degeneracy of conductance band | 1 | 1 | |
| x(T)(1:gap, 2:m-eff, 3:both) | 3 | 0 | |

Material parameters — Material numbers: 7 — Save data / OK / Cancel

In the following the material parameters itself and it's use in the software are explained.

**Number** is the number of the data row. The last number is given and can be changed at the right scroll bar input window. The increase of the material numbers add a column for adding a new material parameters set. The name of this column is empty, the other data is predefined by the first (1) data set, normally Silicon.

**Name** defines the name of the material like Si, GaAs, etc. The name is a part of the sample parameter set and saved in any data. After loading the data the material parameters are searched by this name. If a saved material name is not found in a materials parameter set a '*' is added to the name (e.g. Si* or GaAs*) to show that no materials parameters are available and that of the first entry (normally Silicon) is used. If using different material parameter sets (see save data) it is important to use always the same name for the same material (e.g. for SiC either always SiC or H3SiC or H6SiC for the different materials).

**Band gap** defines the band gap of the semiconductor material.

**Rel. epsilon semiconductor** defines the relative dielectric constant of the semiconductor. Normally it will not be used in the Hall Software except for the optional Debye correction.

**Rel. epsilon oxide** defines the relative dielectric constant of the main oxide used for the particular semiconductor material, not used in the Hall Software.

**Eff. mass factor (n/p)** gives the relation between effective electron (resp. hole) mass and electron mass m_0, used for effective density of states and thermal velocity. Therefore these values have influence to the capture cross section calculated by the intercept of the Arrhenius plot.

**Richardson\* (n/p)** defines the Richardson constant for diodes in n/p-type material, not used in the Hall Software.

**Mobility factor (n/p)** defines the mobility of electron (resp. hole) at 300K., will be used for the optional Ns(Rho) calculation.

**Mobility exponent (n/p)** defines the temperature dependance of the mobility of electrons resp. holes. $My(T) = my(T=300)*(T/300)^{exponent}$, used for the optional n(Rho) calculation.

**Shallow doping energy (n/p)** gives the energy level of the main dopand material for donors (electrons) resp. acceptors (holes), not used in the Hall Software.

**Degeneracy of the conductance** band is by default 1 for all predefined materials except of 4H-SiC. For silicon 6 could bet nearer at the physics but our default value is here also 1 because compatibility.

**x(T)** enables the **temperature depending** use of band gap (1), effective mass (2) or both (3) of this material, (0) disables it. But it will only be used when additionally selected 'x(T) available' at the Physics input sheet, see chapter 2.4.2.1. When using temperature depending parameters then a table must exist for this material in the file MatTemp.Cfg.


**Summary:** The default material file contains for the predefined materials correct values only for epsilon of the semiconductor and for the effective masses. The other parameters could be dummy values, but are not so important except the mobility. The mobility will be used by the Hall program only when calculating Ns from Rho, see next chapter. No parameters will be used by the standard vdP/Hall evaluation. For silicon all default parameters should be okay except the degeneracy.

By leaving this input sheet by **'OK'** all modifications are saved in the internal program memory, so that these changes are valid until you leave the program. At the program exit (chapter 1.1.8) you get then an additional question for saving the material parameters into an initialization file. There you can save these parameters only for the selected configuration, not for a cold start.

Leaving the material input sheet by the **Save data** button leads to the input shown on the right.
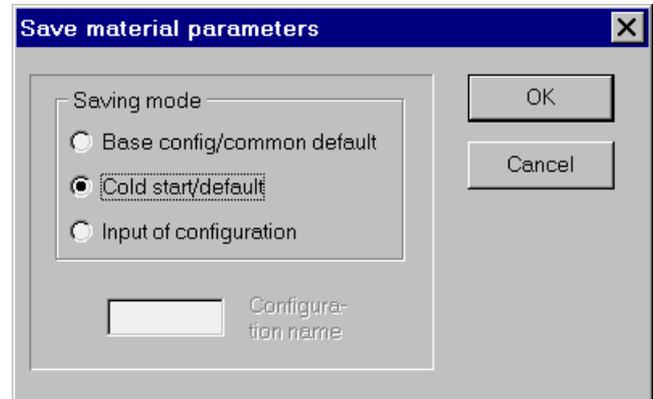
Three different **Saving modes** can be selected. This is necessary for defining for which users or which samples the new material file should be valid. This is sometimes not an easy decision, because several groups working with the Hall system may have different parameters for the same sample material or work with completely different materials and do not want to have other ones in their material list. On the other hand is the working with different material parameters lists quite dangerous, because the same measurement may give different results if analyzed with different material parameters. Therefore the saving of the materials parameters list has to be thought about very accurate. For search strategy and priorities of init files at the program start see chapter 1.1.2.

**Base config/common default** saves the parameters in Hall\Conf\Init\Materials.Cfg, for loading this has the priority 3. It will be loaded at any cold start or if the material parameter file doesn't exist at higher priorities. A hot start file does not exist normally, except you have made changes and have confirmed the saving at the program exit. The changed and saved materials parameters file does not exchange our original one, this is saved in the Hall\Sys\Init directory which have the lowest priority 4. This input mode is the best if some users are working with the Hall system and all users want to use the same material parameters. For this mode user class 5 is necessary.
Depending on your Windows access rights it could be that you need administrator rights for changing files in Hall\Conf, see chapter I4.

**Cold start /default** saves the materials parameters file to the personal user init path in HallData\UserX\Init\32\Material.Cold.Cfg, which has the priority 2. In this example the user name is UserX and the program version is 3.2. For only one user working with the system, we recommend this saving mode.

**Input of configuration** enables to input of a configuration name. If this name is 'Test' then the material parameters will be saved in HallData\UserX\Init\32\Material.Test.Cfg, which have the highest priority 1. But this file will only be loaded if you start at program start your configuration 'Test'. This mode is for our opinion the best way to work with several materials parameters files.

## 2.4.4 Sample parameters

The **sample parameters** are one of the more important parameter sets and have to be defined for every sample before a measurement is done or saved. This parameter set is saved with any measurement data in the file header.

The sample parameters are **global** for the physical used sample in all measurement program modules or **local** for the current module if you have data load from a file. If you see the caption 'Sample parameters' at the input window then they are valid for the sample. If there is the caption 'Sample parameters for the read file' they are only valid for the data of the current file, but the file itself will not be changed. Changes then will not automatically be applied for the physical sample, before a new measurement the software ask for applying, see chapter 1.3.1.
If you change the sample parameters after the measurement and the data was already saved then you have to save the data again to apply the changes also in the file.



**Type** gives the type of the sample, normally it is vdP-Hall. Depending on your hardware and software options the barshape type can be possible.

**Material** gives a list of the material names defined in the material parameters list, see chapter 2.4.3. The selected name defines the parameters for the material which the software is using in calculations and evaluations. If a name of a read in measurement is not known the name is given with a '*' at the end. This might happen, if measurement data from a foreign user is read in.
For 'normal' measurements (vdP and Hall at a single temperature) only the name of the material is important and will be printed out as an information on any result plot. For simulated data, temperature dependent measurements and evaluations and for the calculation of the shallow doping out of the resistivity (see below) also some material parameters of the material table are be used. The material table can be changed and new materials can be added, see chapter 2.4.3.

**Calculate Ns by Rho** enables the calculation and print out of the concentration n resp. p in addition to the Hall result out of the resistivity result. This calculation uses the material parameters for the mobility in the material table. The material type can be defined independent of the Hall result (yes, n-type or p-type) or the last Hall result can be used (auto type). The type definition is important because different mobilities are used for n- and p-type. For 'normal' applications this flag should always say 'no'. Only for samples meant to get a correct resistivity measurement but a wrong or incorrect Hall measurement this flag makes sense. One example is compensated material or material with big mobility difference for n-type and p-type. The result of the resistivity measurement is effected linear by the quotient $b=m_n/m_p$ the Hall measurement with $p-n*b^2$ (see Theory Manual) therefore the Hall measurement can not be correct around p= app. $n*b^2$.

Activating this flag enables now to compare the measured concentration n from Hall measurements with one n* calculated from the resistivity measurement using a standard mobility model. If the magnitude of n and n* is similar, the Hall measurement seems to be correct. If n and n* differ a magnitude or more, it can be caused by the effect above and the Hall result gives not correct values for the carrier concentration.

**Show n corrected by Debye** shows additionally n resp. p calculated with the Debye length correction, see Theory Manual. This value will be denoted as n~ resp. p~.

**Sample ID** stands for a 10 characters long text that is meant to be used as an identification for the sample. The sample ID is a significant description of your sample. This ID will be used for automatic file names and for the data base option for comparison of results and so on. By this ID you can also search all stored files for this sample.
Forbidden characters for the ID are: '*', '?', '"', '<', '>', '|', '/', ':', '\', '. ', '@',' '. Depending on the parameters for the automatic file name (chapter 2.4.5) only uppercase characters are allowed. Upper and lower case characters of this ID will not be distinguished in the database and in the Window file system.

**Sample part** stands for a 2 characters long text that defines additionally the sample. If there are several samples that should have the same sample ID (e.g. coming from the same process) these characters can be used to distinguish between them. Sample ID and part are also used for the automatic file name creation, see 2.4.5.

**Thick** is the thickness of the layer. The input is in micro meter ($10^{-6}$ m). The parameter is used for the calculation of the resistivity and the carrier concentration. If no thickness can be defined (2-d electron gas) 1cm (input 1E4) as thickness can be used. Then the concentration will be calculated as sheet concentration. Resistivity and Hall coefficient are always printed in two ways (normal and sheet ....).

**Comment** enables you to input a comment to the sample or measurement, the maximum length are 60 characters. The comment will be saved into the data file and into the database.

**Subgroup** means sub directories for the data files. An explanation of this and the both buttons are given in chapter 2.4.5. This input is only visible if you confirm it at the database input. The input is only enabled if you have changed the sample ID. Put in the subgroup before the measurement, it will not be created automatically after the measurement.

At user class 5 is a **Results** button. It opens an input window with a list of the measurement results of the last measurement: Conc., Rho, Rh, Mobility, Doping (n- or p-type).

## 2.4.5 Use of Database

The right button **Database** at the 'Sample parameters' opens an input window that defines the use of the database, the database itself will be explained in chapter 5.4.
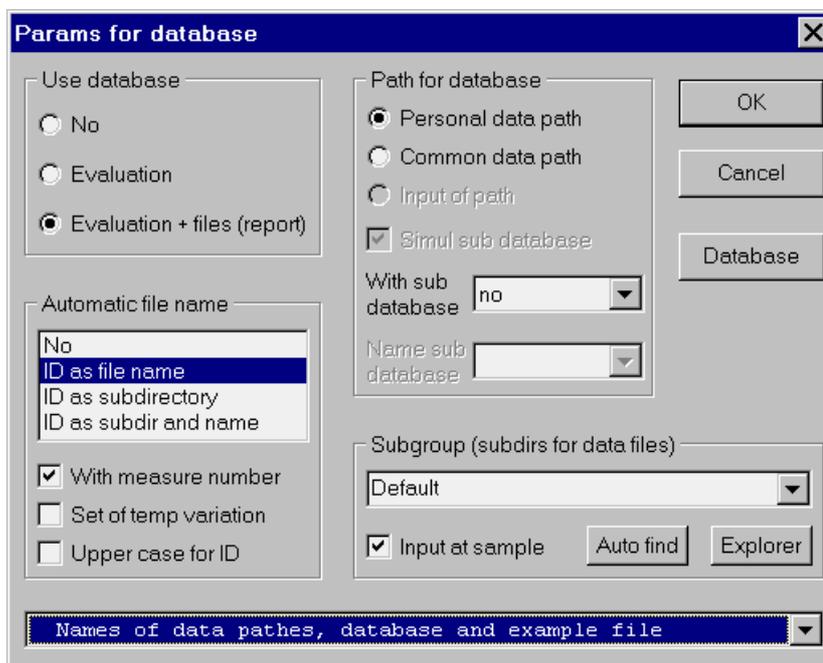


**Use of database** defines how you want to work with the database:

| | |
|---|---|
| **No:** | No database will be used, automatic file names are not possible. |
| **Evaluation:** | Only evaluation values will be saved into the **evaluation database**. Before saving you get a question or you have to call the save dialog. |
| **Evaluation + files:** | Additionally the measurement action, but not the measurement data, will be saved into the **file database** as a report. If measurement data will be saved then automatically this report will be done. |

**Automatic file name** defines how the file name should be generated. It is only a proposal. You can change it before saving data. In the following examples is 'ID' the sample ID and 'A' the sample part, the 2. example is 'With measure number':

| | |
|---|---|
| **No:** | The file name is not generated by the software, the user has to define it before the saving procedure. |
| **ID as file name:** | The file name is automatically generated using the sample ID, a '@' and the sample part, see 2.4.4.1. This is standard mode. Example for the file name is ID@A.HRA.HAL resp. ID@A_001.HRA.HAL. |
| **ID as subdirectory:** | Measurement data is saved in a new created sub directory with the ID as folder name. The file name is generated from the sample part and, if selected, the number of the measurement. Example is ID\A.HRA.HAL resp. ID\A_001.HRA.HAL. |
| **ID as subdir and name:** | Combination of the two option above. The measurement data are saved in a separate sub directory with the sample ID as directory name and the sample ID is also used for creating the file name, ID\ID@A.HRA.HAL resp. ID\ID@A_001.HRA.HAL. |

The checkbox **With measure number** activates the automatic counting of measurements for the given ID and contact. So in the 2. examples above the number 001 is automatically added. Therefore it can not happen with this option that several measurements are saved under the same name and former data will be overwritten.

**Set of temp variations** defines that in the following same measurements will be manually done for different temperatures. In this case the proposal file name is for example ID@A_00M001.HRA.HAL. For the next measurement at a different temperature set it to ID@A_01M001.HRA.HAL. This option enables the automatic plotting of all measurements (all in one …) of one temperature set. It is not necessary at an automatic temperature variation (tempscan). This option will be switched off by a change of the program module.

**Upper case for ID** allow only upper case characters for the input of sample ID.

**Path for database** defines the location of the database that should be used. If a database is not found at that selected location, a new one is generated by the software after request. You can select your **Personal data path,** the **Common data path** and an **Input of path** (directory), which are available depend on your configuration, see chapter 1.1.5.

**Simul sub database** is an option that is only available if the measurement program (measurement hardlock key) works in the simulation mode. By activation of this option the simulation data will not be saved into the measurement data path and database but in a special one.

**With sub database** means that a new database will be created in a sub directory of data path. In this case you have more than one database. This option you should only use if you have a lot of different samples. If there are a strictly divided directories for users or materials it makes also sense to use different databases. Normally you should only work with one database. Data saved in one database can also easily selected to different materials or users. For only data sub directories define a new subgroup (see below).

For the using of sub database there are some possibilities:

**No:** No sub database, only one database will be used.
**Year:** A sub database in a sub directory with the current year will be created, for example for the common data path 'Data\2010'.
**Year,check:** As above, but it will be checked if data of the current ID already exist in a directory of a year before. In this case the old year will be used.
**Material:** The material name will be used as sub database resp. sub directory.
**SimData:** Use of the predefined sub directory 'SimData', used for simulations.
**Input:** Input of the sub database name, up to 8 characters.

**Subgroup** means sub directories of data files. Don't save data directly to the main data path. You should use sub directories and make a structure for material, samples and measurements. Here you can define a sub directory with sub sub directories and so on. The maximum subgroup size is 48 characters. You can input a new directory, select an existing one or call the 'Explorer' by a button. The button 'Auto find' search for an existing subgroup of the current sample ID.
By activating 'Input at sample' you can input the subgroup also at the sample parameters. In the database you can search or select by Subgroup.

When activating the down arrow of **Names of data paths, database and example file** you get the following list:

```
Names of data pathes, database and example file        ▼
   Names of data pathes, database and example file
Personal data : C:\PhysTech\DltsData\Weiss
Common data   : C:\PhysTech\DltsData\Data
Eval database : C:\PhysTech\DltsData\Weiss\DLT_Eval.DBF
File database : C:\PhysTech\DltsData\Weiss\DLT_File.DBF
Data (sub)dir : C:\PhysTech\DltsData\Weiss\Default
Example file  : C:\PhysTech\DltsData\Weiss\Default\ID@A_001
```
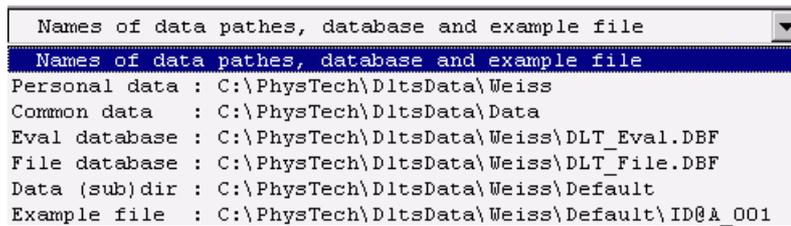
In some cases additional files will be created and saved. These files will then saved into a sub directory of your selected subgroup. The name of this sub directory will be taken from the main file name. For example, V/I-curves in a tempscan, if the main file name is ID@A_001.THA.HAL then the sub directory is ID@A_001. The V/I-curves names are T001.HTA.HAL, T002.HTA.HAL and so on.

**Notes and tips:**
- Upper and lower case characters of the sample ID will not be distinguished in the database and in the Window file system! So 'TestID' and 'TESTID' denote the same sample ID.
- Blanks in directory or file names are not forbidden if manually created resp. defined, but should not be used! Blanks in the subgroup or in the sample ID are not allowed. Therefore are no blanks in the proposal of the automatic generated file name.
- The automatic counting (with measure number) starts at the current number. So if the current name is ID@A_005, the proposal for saving would be ID@A_006. If you manually set here ID@A_011, the next proposal would be ID@A_012. You can use this to divide measurements in different blocks (applications).
- One sample ID, that means also one sample, should belong to only one subgroup.

It is possible that you get before saving data a **sample mismatch** warning:

This warning occurs if the sample parameters already saved for the given sample ID in the ID data base are not identical with the current sample parameters. So it should not be possible that at one measurement the material name for the same sample is 'Si', at the next measurement 'GaAs'. One sample ID should belong always to one sample. In the brackets you see the sample parameter which was changed.

```
Sample mismatch                          ✕
     Sample params (material)
  ⚠  are different between entries in ID data base
     and current sample!
     Apply current sample params for ID database?

     ☑ Show this dialog next time

   [  Yes  ]   [  No  ]   [  Help  ]
```
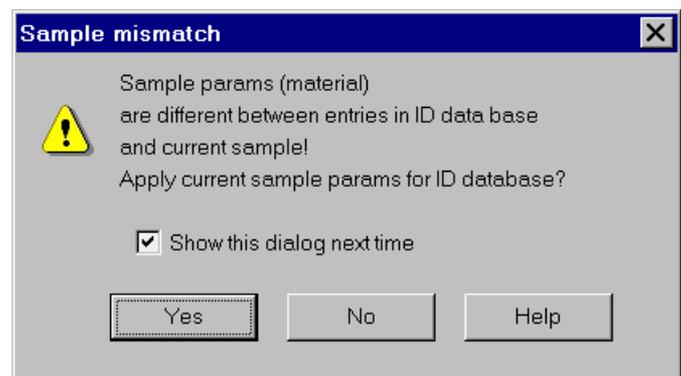
If you click onto the 'Yes' button then parameters in the ID data base will be changed to the new parameters. Clicking onto the 'No' button let the ID data base unchanged.
If deactivating the flag 'Show this dialog next time' then this dialog will not be shown and the ID database will not be changed at the next sample mismatch for the current ID. The deactivating is only valid for the current sample ID.

## 2.4.6 Temperature

This software tool is meant to control the sample temperature and to setup the temperature controller. The supported options depend on the possibilities of the used controller. Not all options are possible with every temperature controller. The minimum and maximum temperature can be changed only by the Set_Conf program (I3.4). The Hall system comes normally without a temperature controller.

After selecting this function, the actual sample temperature is measured and shown in Kelvin and Celsius. If the controller supports a vacuum measurement also the pressure in the sample chamber of the cryostat is shown in the temperature display window. Below that window the actual temperature set point and the actual control mode for the temperature controller is shown.

By the button 'Close' you go back to the previous menu.
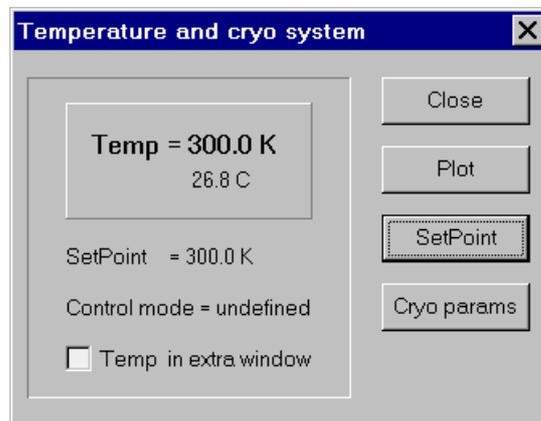
**Plot** starts a permanent temperature measurement and a permanent actualized plot of the temperature versus time. There you get information about the buttons by its hints. A special flag for testing deactivates only here the repeat of temperature commands if an error occurs.  If using 2 sensors both temperatures will be listed. The first value (TC or TempC) comes from the control sensor 1, the second (TS or TempS) from the sample sensor 2. Look in chapter 1.3.6 for information about the different temperatures. You can select showing sensor 1, 2 or both by the button 'Alternative plot'.

The **SetPoint** button opens an input field where the temperature set point can be changed.

If activating '**Reset heater/pump**' then heater and pump will be newly initialized if setting the temperature by the 'Start' button. Normally this is not necessary. But some controllers like the Lakeshore switch off the heater after the sensor (cables) was disconnected. And they don't switch the heater automatically on after the sensor was connected. By this flag our software knows that it have to switch on the heater and, if available, to set the maximum heating rate. This input will not be saved.
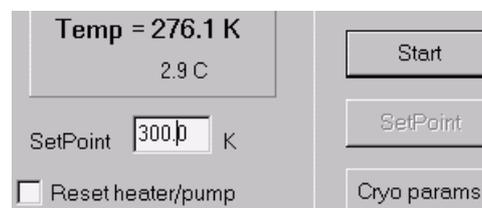
After clicking onto the SetPoint button the Plot button changes to the Start button.

The **Start** button transfers the set point to the temperature controller and starts the temperature regulation. The temperature will be measured and viewed during its change to the set point temperature. Hereafter changes the Start button to Plot button again.

The **cryo parameters** button opens a new input window, see next chapter.

The flag **Temp in extra window** opens after closing the temperature control window a small permanent available window that gives every 5 s the current temperature of the sample.
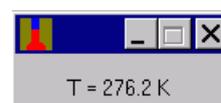
**Note:** If working with 2 sensors the temperature in this chapter comes from the control sensor 1. It will also be used for the regulation (ramp) as described in the next chapters.

## 2.4.6.1 Cryo parameters

At the isothermal program modules (V/I, vdP/Hall, Magneto) a new temperature will be set normally in one step, similar to a rectangular ramp. The following inputs define when the new measurement starts after a new temperature, that means how the program defines that a temperature is stable enough for the next measurement. These values are only for the isothermal measurements, for the temperature depending measurements there are separate ones and more possibilities.

Because the temperature setting at isothermal program modules use the same procedure as a boxcar (rectangular) temperature ramp, you find a description of the both top groups of parameters in chapter 2.4.6.2.1.
The both bottom parameters will be explained in 2.4.6.2.4.
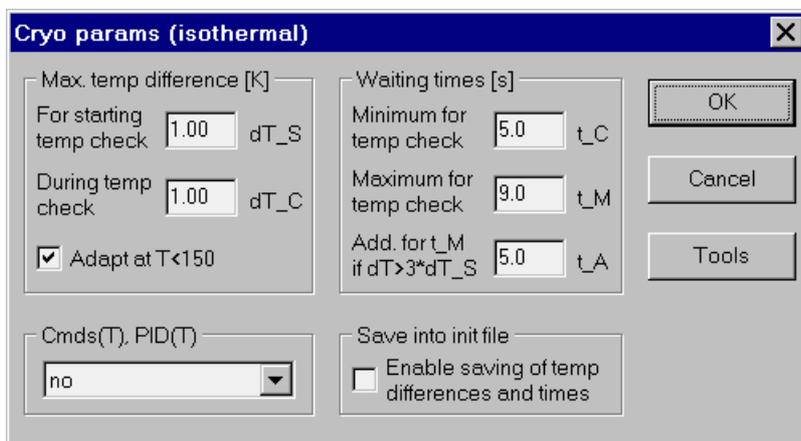


By the **Tools** button you get a menu with some tools. For these you need user class 5 or higher, the possibilities depend also from the temperature controller:

**PID parameters:**  The proportional, the Integral and the differential part of the regulation slope of the temperature controller can be defined.
**Temp depend cmds:** Definition of temperature depending commands transferred from the software to the temperature controller, only available if Cmds(T), PID(T) are used, see chapter 2.4.6.3.
**Other parameters:** Define LN2 and room temperature, give options if working with 2 cryo systems.
**Send commands:** Opens a command module to send commands or receive data from the temperature controller.
**Load/init cryo file:** Load the cryo file and initializes the controller.
**List cryo status:**  Gives a list of the actual used parameters of the controller.
**Temperature test:** Test routines for testing temperature ramps or regulations.
**Make/edit Tcal file:** Create or edit a cryo/temperature calibration file Tcal_???.cfg.


## 2.4.6.2 Cryo times and parameters for a ramp

This input module defines how the software and the cryostat with the temperature controller work together concerning the times for setting and regulating a new temperature. At the following input windows the both top groups of parameters will be called here **Cryo parameters**. These parameters depend on the kind of temperature **ramp** (boxcar, linear controller, linear computer). Different sets of Cryo parameters exist for isothermal and tempscan (normal, slow, fast, very fast, init file) measurements.
The other general 4 inputs at the following input windows will be explained in 2.4.6.2.4.

### 2.4.6.2.1 Boxcar (rectangular) ramp

The inputs define when the new measurement starts after a new temperature, that means how the program defines that a temperature is stable enough for the next measurement.

Two temperature differences and three waiting times can be defined to check a correct temperature regulation and start a measurement at a stable temperature $T$ close to the temperature set point $TSet$. Its meant as a synchronizing of the software with the cryostat for measurements at a fix stable temperature.



The **start cycle** for an isothermal measurement under respect of these parameters is:

1. After the definition of the kind of measurement, the measurement parameters and the measurement temperature $T\_S$ by the user and starting the measurement, the measurement cycle is started and the new temperature **set point TSet** is transferred to the temperature controller.

2. The temperature controller heats or cools the cryostat (and the sample) due to the set point temperature. During the cooling or heating the software measures continuously the actual temperature $T$.

3. When the **temperature difference dT** between the measured temperature $T$ and the temperature set point $TSet$ becomes smaller than the value **for starting temp check dT\_S** the software starts the **temp**erature stability **check**.

4. During the temp check the software checks whether the temperature difference $dT$ stays smaller than the value **during the temp check dT\_C**. The check is at least done for a **time** given in **minimum for temp check t\_C**. If $dT < dT\_C$ is always valid during $t\_C$, the measurement is started.

5. If $dT < dT\_C$ is not fulfilled during the time $t\_C$, the check procedure is continued till the time **maximum for temp check** t\_M has been reached. After this waiting time the measurement is started even if $dT$ is larger than $dT\_C$.

6. If during the temp check it happens that $dT > 3*dT\_S$, then the maximum time for check will be increased by **the additional waiting** time $t\_A$.
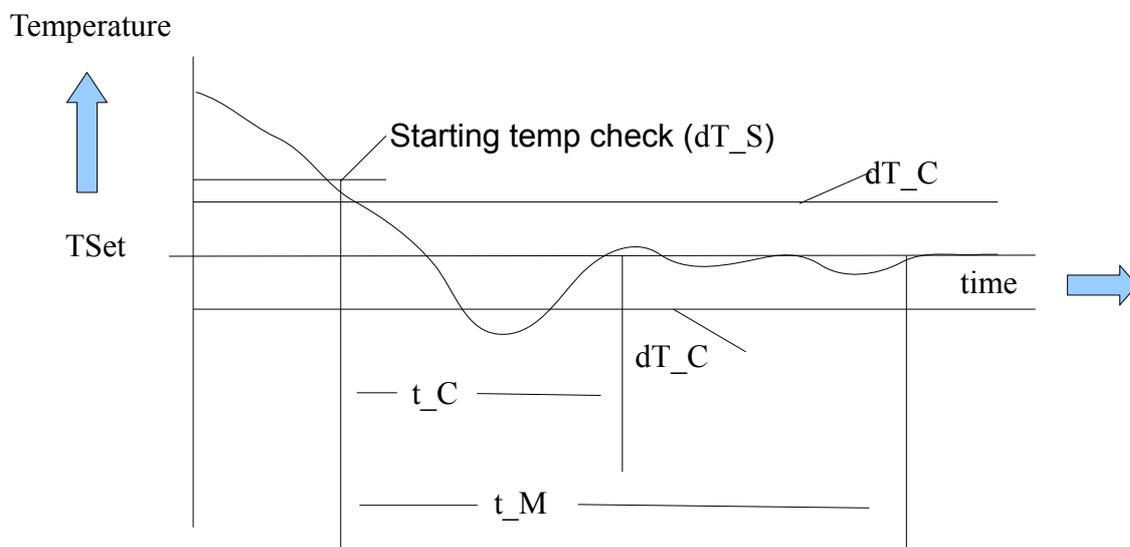
The flag **Adapt at T<150** reduces the given values for $dT\_S$ and $dT\_C$ with $1/T$ for temperatures below 150 K by the equation: $dT' = dT * (0.3+0.7*T/150)$.

The times and temperature differences given in the input window above are for normal tempscan measurements. The times can go up to minutes if the cryostat is oscillating or very slowly. When the temperature don't reach its set point, optimize the PID parameter, increase $dT\_S$ or deactivate the flag above.

### 2.4.6.2.2 Linear ramp of controller

At the tempscan inputs you can define that the linear ramp will be stopped and the temperature will be hold before a measurement. In this case you can define how the software waits before a measurement starts. This waiting is the same as for the computer ramp, see next chapter.
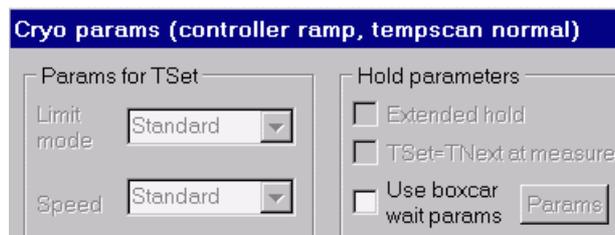


### 2.4.6.2.3 Linear ramp of computer

The software emulates a linear controller ramp if using the computer ramp. It increases or decreases the temperature set point $TSet$ of the controller in a loop to reach the temperature $TNext$ where the next measurement should be done. Only very small temperature differences, normally 0.1 K, will be used in a given time, defined by the ramp rate. During the measurements no new set point will be set, so the temperature will be 'hold'.

While setting $TSet$ in a loop 2 points will be considered:
- **TSet<TNext+TOfs** means that the set point of controller is always smaller as the next measurement temperature plus a temperature offset. If this can not be fulfilled the computer waits (called pause time) with setting new set point until next measurement was done.
  This point can be helpful if temperature runs too fast so that you have only less temperatures at which measurements will be done. But the controller must reach $TNext+TOfs$. Depending on your cryostat and controller this can be a problem if $TOfs$ is too small. So some cryostats don't reach that temperature which was defined by the set point. Therefore we have introduced $TOfs$.
- **TSet<TGet+TOfs** means that the set point of controller is always smaller as the current temperature plus an offset temperature. If this can not be fulfilled the computer waits (called pause time) with setting a new set point. So the difference between $TSet$ and the current temperature $TGet$ is only small.
  This point can be helpful if there is a big difference between $TSet$ and $TGet$. This can yield to regulation problems, so that the temperature oscillates. This point avoids this behavior but it can expand the time of the temperature ramp because the waiting.

$TOfs$ in the equations above is the offset temperature, it will be calculated by the software. The 'smaller sign' is valid for increasing of temperatures, at decreasing it is a 'bigger sign' and $TOfs$ will be used as a negative value.

The loop can be explained by following **simplification**:

For example it should be TGet=299.5K, TSet=299.5K, TNext=300K and TR=0.1K/s. Then first TSet will be set to 299.6K. The software waits then 1s before setting 299.7K. This will be repeated until 300K was reached.

In the practice the loop is more complex. So the 2 points above will be considered. TOfs will be calculated by the ramp rate TR. Additionally the 'pause time' will be limited by a time limit t_L calculated by TR:

TOfs = 0.2+sqrt(TR), t_L = 1/TR,  for example, TOfs=0.5K and t_L=10s for TR=0.1K/s

This is also a simplification. All calculated parameters depend on the Cryo times, the ramp rate, the limit and speed mode and the limit level. The initial **limit level** will be defined by the limit mode. If the time limit will be exceeded too often then the limit level TL will be exceeded. A bigger limit level can yield to a bigger TOfs and t_L. This means that the control by the 2 points above is not so strong. The limit level TL goes from 0 to 16.

We can divide the working for one temperature point in 4 **phases**:

1. The set point TSet is not closed to TNex*t,* for example the difference is bigger than 1K. Depending on the difference TNext-TSet, the set point TSet will be set in bigger steps, for example 0.2K, or in smaller times. This yields to a bigger effective ramp rate as defined. This will be done in a loop until TSet comes near to TNext.
2. TSet is closed to TNext. TSet will now be incremented resp. decremented in 0.1K steps. The time will be defined by the ramp rate or, if the flag 'Extended hold' is activated, in smaller rates. This phase will be finished when TGet reaches TNext. If a special flag is activated then TSet=TNext will be set at leaving this phase.
3. The software waits a fix time or as explained for the boxcar ramp.
4. The measurement will be done.

The left input group contains parameters for setting TSet.
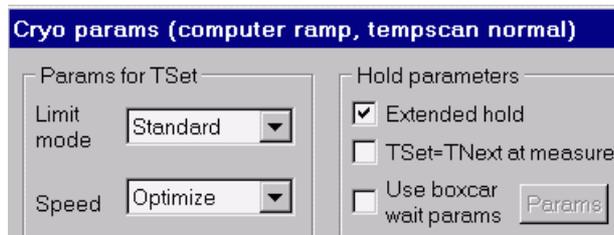


The **Limit mode** defines the initial limit level which is important for controlling the temperature stability:

**Standard:** The software starts with the old saved limit level.
**Adapt:** The initial limit level is the minimum of old limit level and 5. The limit level can also be decremented at the measurement. Usually it should be the best one but it can cost time if the limit level oscillates in rare cases.
**Fix start:** The software starts with a fix limit level of 5. The advantage can be a reproducible behavior, disadvantages occur if a much higher limit level is necessary or a much smaller level is possible.
**Tolerance:** The start limit level is the maximum of old limit level and 11. The time limit t_L will be cut in half. This yields to more tolerance in the temperature stability.

The software can increment the limit level at all modes. After the complete measurement the current limit level - 1 will normally be saved as old limit level. So the software starts in the standard limit mode one level lower as the final level at the last measurement. The limit level will only be saved at leaving the software if the flag 'Save into init file' is activated, see chapter 2.4.6.2.4.

The **speed mode** defines the temperature steps and pause time in phase 1 and 2 and so the effective ramp rate:

**Standard:** The standard mode uses in phase 1 a higher speed. In phase 2 the temperature steps are 0.1K, the time will be defined directly by the ramp rate.

**Optimize:** The speed will be optimized, that means in phase 1 it is much higher as in phase 2. This should give the 'optimal' speed and a faster ramp but can reduce the temperature stability.

**Fix:** The fix ramp rate defines always the speed but a pause time is also possible. The temperature steps are always 0.1K.

**High:** Similar to 'optimize' but designed for a high speed ramp. The temperature stability may be here not so good.

The input group '**Hold parameters**' contains options how the temperature should be hold:

**Extended hold** reduces the speed at phase 2. That means if $TGet$ is closed to $TNext$ then the effective ramp rate is smaller than the defined ramp rate. Activate this option except you want a high speed.

**TSet=TNext at measure** means that if $TNext$ was reached then the set point $TSet$ will be set to $TNext$. This improves normally the temperature stability during the measurement because it is possible that $TSet$ is 'faster' than $TNext$, especially at a big $TOfs$. But some cryostats have a problem with this feature because they don't reach that temperature which was defined by the set point.

If the temperature $TNext$ was reached then the software exits the $TSet$ loop and sets no new temperature set point, it 'holds' the current one. The software **waits** a time before the measurement can start. 2 kinds of waiting exist. The standard one is a simple wait procedure where the waiting time $t\_W$ depends on the ramp rate $TR$:

$t\_W = 0.2/TR$, for example, $t\_W$=2s for $TR$=0.1K/s

If activating **Use boxcar wait params** then the software waits until the temperature is stable enough, similar to the check temperature procedure introduced in chapter 2.4.6.2.1. But now the software starts directly the temperature stability check (cycle point 4) and $dT\_C$ has only a meaning for $t\_A$. The 'Params' button opens the input for these parameters which are the same as for the boxcar ramp.

If the measurements need a high temperature stability, for example for very sensitive or long measurements at one temperature, then you should activate this option. Define then strong criteria and long waiting times.

**Summary:** We prefer the computer ramp for the most applications. The default modes depend on the selected cryo times. The standard modes for the limit and speed mode are good compromises. The 'Optimize' mode should be the best speed mode, so it is the default one except for 'slow ' cryo times. There is 'Adapt' the default limit mode to get the highest temperature stability. Except for fast overview measurements the flag 'Extended hold' should be activated.

The temperature stability increase normally by activation of 'TSet=TNext at measure'. But some temperature controllers could have a problem with this option. So it is off by default, check this option with your cryostat.

'Use boxcar wait params' can be necessary for sensitive or very long measurements at one temperature. Here you should adapt manually these parameters.

The ramp rate input is not the effective rate but only a hint because the temperature will be hold during the measurement and, depending on the cryo times parameters, the software waits or uses temporary faster rates. In most cases the effective rate is smaller than the defined one.

A problem of the controller ramp can be a too small heating rate. Then the set point runs away while the current temperature hangs or is much smaller than the controller set point temperature. Finally the measurement will be finished before the measured temperature has reached his end point. The controller ramp don't wait except you have activated the hold option. The computer ramp avoids this problem because it holds always the temperature at the measurement.

**Note:** The quality of the temperature stability depends, also at the other ramp modes, from the cryostat, the controller, the selected PID parameters and from the ramp parameters as discussed. The predefined ramp parameters can not be optimize for all cryo systems. So you should adapt these parameters. The temperature test, see chapter 2.4.6.4, is here an important help.

### 2.4.6.2.4 General cryo options

The cryo input window contains for all ramp modes and for all cryo times the same additional input groups.

**Cmds(T), PID(T)** enable temperature depending commands and/or PID parameters. This is only available if such commands exist. At some temperature controllers various maximum heating power can be set for different temperature ranges:

**no:**          No such cmds will be used.

**last block:**  Only the last temperature block of these cmds will be used for all others.

**yes:**         For different temperatures ranges different cmds and/or different PID parameters will be used.

**Save into init file** means that all changes of the cryo parameters will be saved at program end into the init file of your selected configuration, normally hot start. In the other case are the changes only temporary, at program new start the old values will be loaded.

## 2.4.6.3 Temperature depending commands

At user class 5 here the definitions of temperature depending commands are possible. During a heating or cooling cycle the software now transfers all defined commands to the controller after the temperature has reached the temperature limit of the particular range. This can yield to a better (more stable) temperature regulation.

5 different temperature ranges can be defined. For each range the **maximum temperature** up to this range is valid and up to 8 different commands for the temperature controller can be defined, e.g. PID parameters, heating ranges etc.. An explanation of the syntax is in the file Cryo.Txt.
'Edit range number' defines the temperature range which is visible for editing.
By activating a flag these commands will be used also at a program cold start. A hot start will be defined by the 'Cmds(T),PID(T)' value.
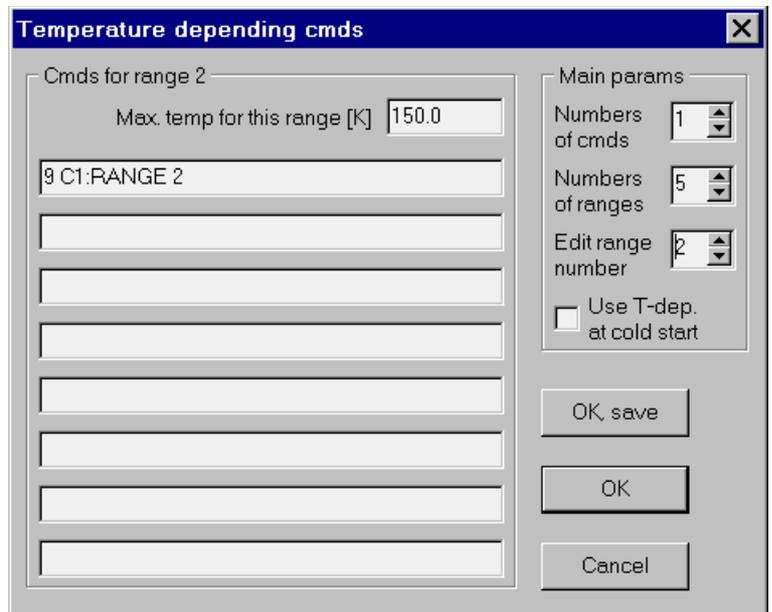
**OK** stores the commands only in the memory. After a new program start the old commands are valid.
**OK, save** stores additionally the commands into the particular cryo init file.

## 2.4.6.4 Temperature test

The quality of the temperature stability depends on the selected PID and ramp parameters. The default values can not be optimize for all cryo systems. So you should adapt these parameters. The following temperature test, available at user class 5, is here an important help. At a result you get a plot temperature versus time.

The inputs depend on the selected **ramp mode**:

Set stop temp, Set no temp, boxcar, linear controller, linear computer.

'Set stop temp' means the program sets the stop temperature and measures, for example, every 0.5s the temperature so that you can observe how the controller reach the stop temperature and how good the temperature stability is. 'Set no temp' means that the temperature will only be measured without setting a new set point. The other ramp modes are explained above. In all cases the measurement don't stop automatically after reaching the stop temperature, you have to do it manually. So you can check how stable the temperature is at the stop value.

The right picture is for the computer ramp mode.
The software sets at the begin the temperature to the **start temperature**. You get an information window with the set point, the current temperature and the time after setting the temperature. Start the test measurement manually if the current temperature is stable enough and has reached the start temperature.
The reaching of the **stop temperature** stops the setting of a new set point.

The **boxcar step** corresponds to the delta temperature at a tempscan, there it is the temperature difference between 2 tempscan data points. You have to observe the temperature stability at these boxcar steps. The **wait time at step** defines how long the software stays on this temperature without setting a new set point. **Time between 2 temps** means the time interval of the temperature measurements.

The **ramp params** as ramp rate and cryo times are already described above.
If activating **show regulation steps** then the temperature will not be measured only at the boxcar steps but also between these steps. **Show TSet** shows in the plot the temperature set points by a default blue line. **Mark steps temps** shows in the plot the boxcar temperature steps by a read line. You can also get some additional **info in status line**.

**Tip:** After cryostat installation adapt first the PID parameters. Then make 4 temperature tests with the boxcar, controller and computer ramp; for the last make tests without and with 'TSet=TNext' (chapter 2.4.6.2.3). Use standard cryo times and a ramp rate of 0.1K/s. Select 8s wait time at step for the boxcar ramp, 5s for the other ramps. If necessary change the PID parameters and repeat the tests. Compare the 4 results and select then the best ramp mode for your measurements. If 'TSet=TNext' yields to better results you have to activate it for every cryo times. You can improve the temperature stability by optimizing the cryo parameters, this must be done for all cryo times.

After you have finished the measurement you get the standard plot. Yo can save it in the presentation plot program. Other plots are available when clicking onto the **alternative plot** button.
If using 2 sensors then the temperature of one or both sensors or the difference of both sensors can be plotted. You can mark the temperature steps and show TSet at the computer ramp. The plot 'Difference at step' shows the temperature difference at the boxcar steps. For this the last temperature of each step will be subtracted from the other temperatures at this step. So you can check how stable the temperature is at these steps. For a better overview here a special time axis will be used which separates all wait time at steps by 1s. If activating 'without fix hold wait time' then only points will be shown which relative time is bigger than $0.2/TR$ resp. $(t\_C+t\_M)/2$.
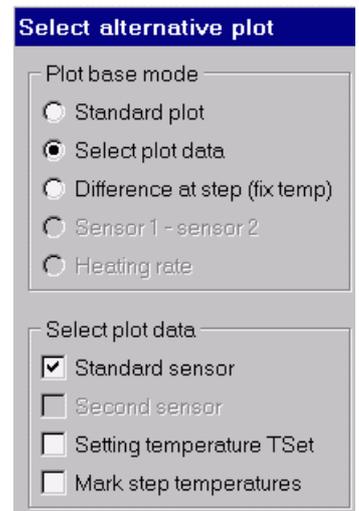
The following picture shows measurements for the 3 different ramp modes. The computer ramp was used without and with the flag 'TSet=TNext at measure'. The black lines represent the temperature measurements, the read lines the boxcar steps and the blue lines TSet at the computer ramp. The temperature should be nearly constant during the boxcar step (red line). It is not so important to reach here the exact (destination) temperature. For the boxcar ramp (top left) you can estimate the wait time until a measurement should be started. The best results give here the computer ramp with 'TSet=TNext' (bottom right). The 'hold command' don't work here fine at the controller ramp. An additional criterion is the effective ramp rate. This example is not representative for all cryostats and controllers! It gives you only a hint how you to use this tool.
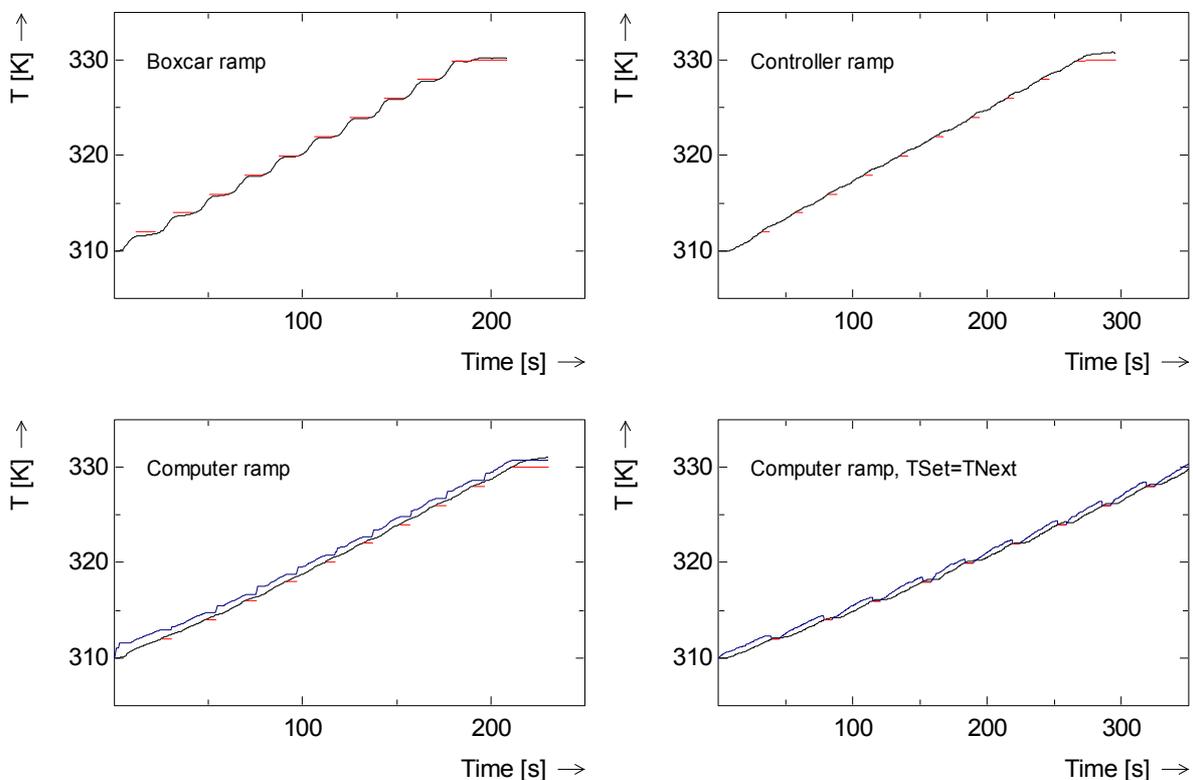
**Tip:** You can also check the temperature stability of a tempscan measurement by the difference temperature before – after measurement.

## 2.4.7 Monitor

The Monitor allows a WebView and monitoring of the measurement action. At user class 6 you get additional input sheets for checking the communication with the hardware and a Tool button for some diagnose tools. Extended diagnose tools are only available when calling the Monitor from the Utils menu of the Base tools. Be careful with the diagnose tools, especially the initialization of the measurement hardware and sending manually measurement commands.

### 2.4.7.1 WebView input sheet

The **WebView** allows to monitor the measurement via internet or a network directory. This input sheet is only visible in the isothermal or tempscan measurement module. It is only for long temperature depending measurements. With this option a HTML file will be created at the end of measurement or, for example every10 s, with measure message or/and measure picture.
You can load your monitor HTML file by every browser or with the program **WebWatch** in the directory Hall\Bin. You can copy this program to another computer and run there without installation. If you encrypt your measure pictures by a password you need the WebWatch program. This program can also poll in a time interval for the new monitor file, for example to get a message for the end of measurement.

At **Internet** the monitor file will be saved at a hidden directory on the PhysTech server. At **Directory** you can define a network directory for these files.
If you use FTP instead of HTTP for upload you must be sure that FTP is enabled on your computer.
By defining an additional **suffix** name of Web file nobody knows the complete name of your web file. You see the complete monitor file name at leaving this dialog in the status line.
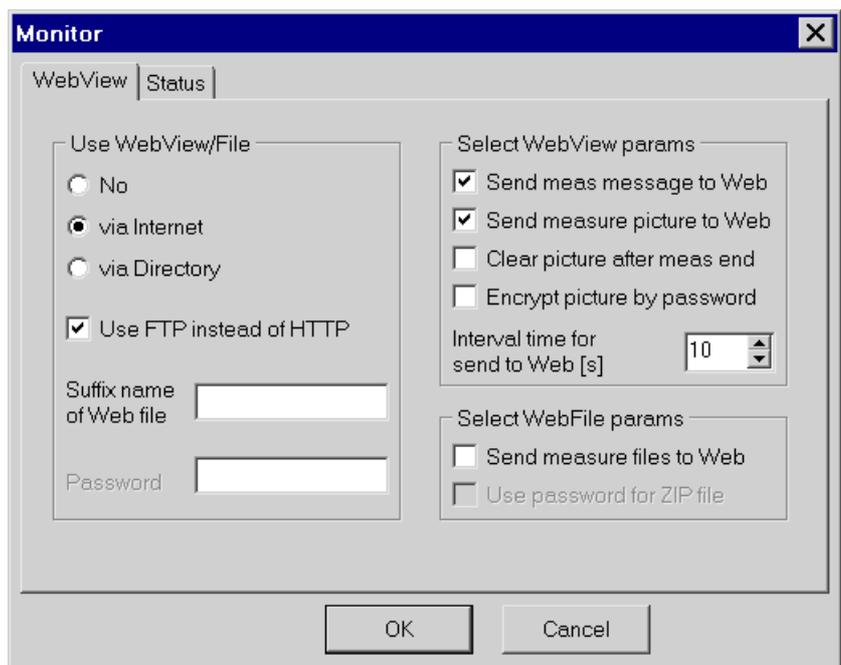


You can also send all new files with measurement data to the Web or your directory. These files will be packed into one ZIP file. You can encrypt this file by a password. The name of the ZIP file is the same as for the Web file (you see it in the status line) but has the extension ZIP instead of HTM.

## 2.4.7.2 Status input sheet

The status monitor gives some information about the status of the measurement. You can show this information in the **status line** or/and in a separate **window**, see next picture.

'**Plot temperature**' expands the status windows and plots the last temperatures.

By activating **Additional temp task** the temperature will be measured every 5 s and updated in the status line or status window.

If an error has occurred then you can get information about this error by the **LastError** button.
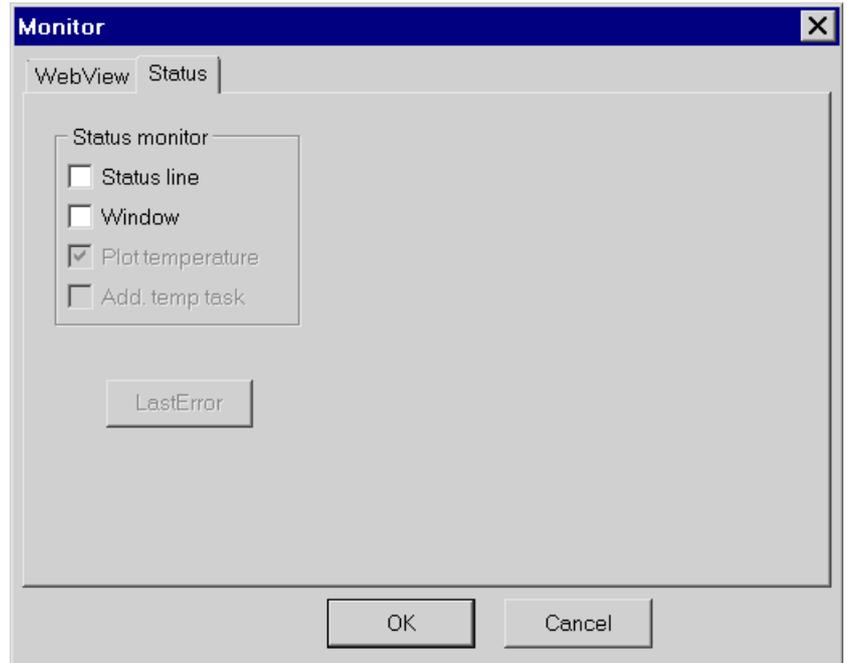


At user class 6 you can create a report file by the **Report** button and use an error monitor.



**Status window:**
Status denotes the current action, TempL shows the last measured temperature, Matrix the connected contacts. The actual field and current will be listed.

By activating 'Additional temp task' the current temperature will be shown and updated instead of the last temperature. The label is in this case 'Temp' instead of 'TempL'.
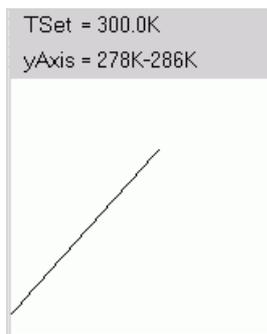


By the flag '**Plot temperature**' the last measured temperatures will be shown in a plot at the bottom of the Status window. The range of the x-axis is always 20s. The minimum and maximum values of the y-axis will be listed above the plot. These are the values of the white plot window and not of the black curve (data) inside of the plot.

The current temperature set point TSet will also be listed. If the temperature controller is not in the 'Set-Control' mode, for example at using the linear ramp of the controller, then the control mode will be shown here.

**Note:** The Status monitor shows only the temperatures of the first (control) sensor when using 2 temperature sensors.

# 2.5 Help menu
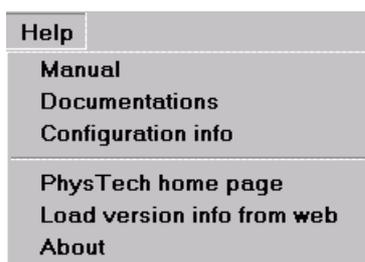
By the menu **Manual** the software manual will be opened at the page of the current program module.

At some help menus there is sometimes '**Manual for data**'. This opens the manual page for an explanation of the data or plot and not for the current program part, for example in the Standard Plot Program.

The **Configuration info** gives an overview about your software configuration. There you can also edit your user file, especially the maximum user class, see chapter 1.1.5.

**PhysTech home page** opens the home page of PhysTech.
**Load version info from web** checks your version and the newest version at the PhysTech server.
**About** gives an information about your software version.

At **Documentations** you can select one of the 5 **Manuals** (Hardware, Software installation, Software, Basic, Theory) or additional important information or publications by **Additional PDF's.** In **Txt-Files** there are very special information about the software, for the normal user it is not important.

You need a **PDF viewer** for showing help files by the F1-key or Help-button (navigating to a defined page).
At the installation resp. SetUp Configuration program you can select between the Adobe Acrobat Reader, an ActiveX control of the Adobe Acrobat Reader, the PDF viewer of your browser, the FoxitReader (Portable) or the SumatraPortable. For more details see chapter 3.2 of the Installation Manual.
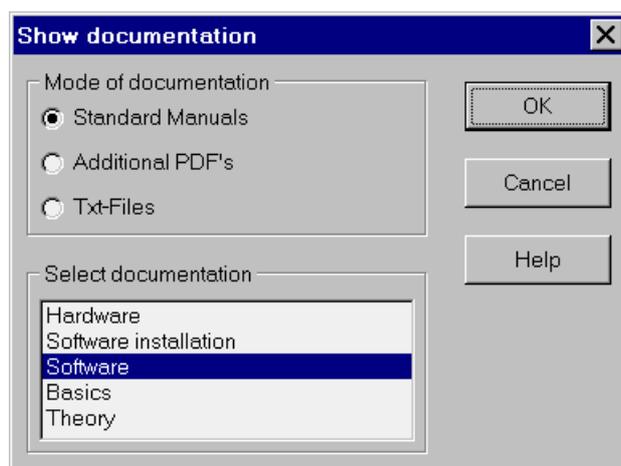
Calling Manual in the Help menu or using the Help button or F1-key the PDF viewer opens normally the manual at a defined page. The Adobe reader saves internally your last opened page. If you start the Adobe reader again with the same defined page (same help point) it opens your old page. If you start with a new defined page (new help information) it opens the new page.

In the most menus and input windows you get help information by the **F1-key**. At some input windows there is a help button. It have the same function as the F1-key. You get help information by the F1-key also if there is no help button!
In some input windows you get by the F1-key different help information depending on the selected input group. For example if there is an input group for interpolation then you get the help text of chapter 2.7.1 if activating this input group and pressing the F1-key.
At many buttons and inputs you get a hint by moving the mouse to this position.

**Note:** All help and information files are in the sub directory Hall\Sys\Doc.

# 2.6 Others

The following common functions come from the other menus Edit, List, Plot and Evaluate.

## 2.6.1 Compare reference

At the plot menu it is possible to compare the current data with a reference file. By the params button you can select the curve to compare, this depends on the program module. At the **plot curves** input group the curves for plotting will be selected: Data (current), reference or/and difference curve. **Difference parameters** are available if showing the difference. The difference will be formed by 'data – reference' or, if the flag is activated, by 'reference – data'.

If activating **Smooth** for difference then the data and the reference curve will be smoothed by splines for the forming of difference. The difference itself and the data and reference curve in the plot will not be smoothed by activating this flag! If data and reference curve have not the same x-axis then the x-axis will be interpolated to the x-axis of the data curve.

As **View styles** you can define to show all curves in one layer or to use for every curve a separate layer.

In **View parameters** you can activate to use different colors for every curve instead always the same if selecting separate layers.

For the symbols in the plots following **modes** are possible:

**standard symbol:** For all curves the standard symbol will be used.
**as view params:** The symbols will be set as defined for compare and difference symbols in the global plot parameters, see chapter 2.3.3.
**as many curves:** The symbols will be set as defined for curve 1 to 3 in the global plot parameters.
**2 symbols, 1 line:** The data curve uses the symbol for curve 1, the reference curve uses the symbol for curve 2, the difference curve will be shown by a line.
**only lines:** All curves will shown by lines.

**Connect points** will be explained in chapter 2.7.2.
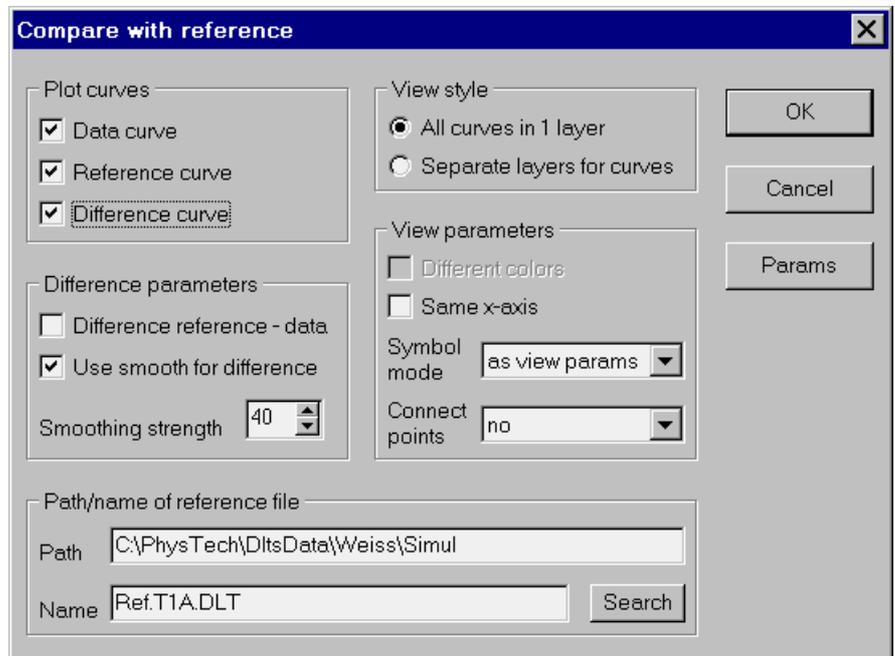
## 2.6.2 Approximation

In the Edit menu of some program modules there is at user class 5 the menu point Approximation. It means that all possible measurement data can be interpolated and/or smoothed. Smoothing will be made by splines, the input of strength is possible. Additionally the data can be sorted.
If activating interpolation then a new x-axis with equidistant steps will be calculated, following **interpolation modes** exist:
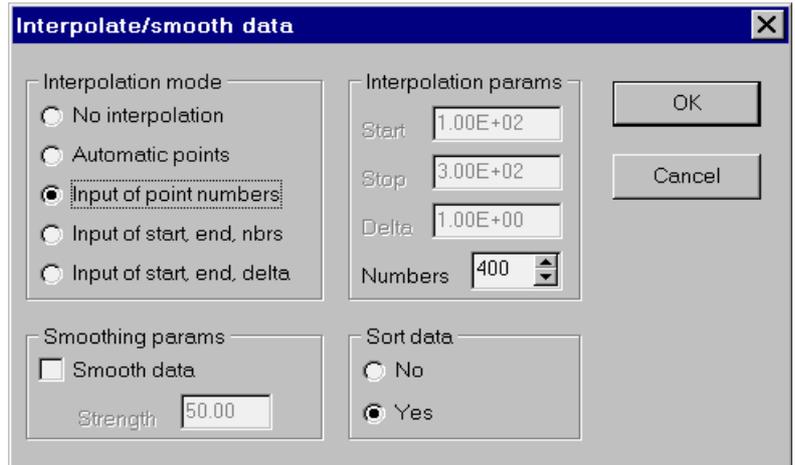
**No interpolation:** The data will not be interpolated.
**Automatic points:** Interpolation with automatic setting of interpolation points (new data numbers), see chapter 2.3.3.6.
**Input of start, end, nbrs:** For the interpolation you have to input the x-start and x-end value and the numbers of interpolation points.
**Input of start, end, delta:** For the interpolation you have to input the x-start, x-end and x-delta value.

## 2.6.3 Delete data

In the Edit menu of some program modules there is at user class 5 the menu point Delete data points/range. The data arrays/records will be internal in the memory modified, not in the file. This function deletes not only points of one curve but the full data record of the marked points.

**Delete data by** defines the base delete mode. The first both modes use x- and y-data. In 'Plot as y-axis' you must select the data (curve) for using as y-axis. This input depends on the current program module.

Following modes exist:

**Plot (deviation):** The x- and y- data will be shown in a special plot program in which you can delete one or more points by the mouse, see chapter 5.3.2.6.1.

**Editor:** The x- and y-data will be listed in a grid. In the menu Edit you can 'delete' a grid line. The line will not be really deleted in the grid but only marked as deleted by setting the x-axis value to -1E100, for more details look in chapter 5.4.1.2. You can also change there the values for the x-axis. A change of the y-values will not be applied.

**Setting valid params:** Only data with a given valid criterion will be applied. This criterion can be the last index, the index range or the x-axis range. Index mean the index of the data arrays, starting from 1 to numbers of data. The valid parameters will be defined in the Parameters input group.

**Deleting params:** Data will be deleted by given parameters. You can delete an index range, an x-axis range or not valid data. Not valid data for example are such data which x-values are -1E100. For a temperature as x-axis are all x<2 not valid.

If 'Plot' was selected as mode, you have to confirm the applying of the new data after leaving the special plot program.

By **Cancel** you stay in the plot program, by **No** you leave it without changing the data.

By **Yes** the new x-data will be applied. The data which has been marked as deleted will either be **removed** from the data arrays/records, or for these x-values new data will be **interpolated** over the valid points. The interpolation will be done for the old x-values, so that the x-axis remains. This option is not in all cases available.

**'Init report list of deleted points'** applies the current deleted points as new report list. If this flag is not activated, these points will be appended to the report list. This report list can be used for deleting the same points at new data, more details will be given in chapter 5.3.2.6.1.
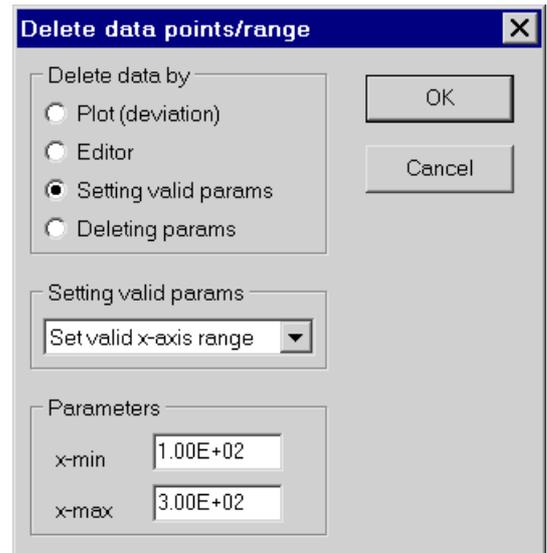
# 2.7 Common input parts

This chapter don't describe menu functions but only parts of input windows which will be used in some input windows.

## 2.7.1 Interpolation/Approximation

Interpolation means that additional data to the existing data will be created and shown in plots. In detail, at an interpolation a new x-axis will be defined with more than the existing x-values. The new x-axis contains equidistant x-values, the new y-values will be calculated from the original curve. The calculation will normally done by an interpolating and not approximating cubic splines. This means if a point of the new x-axis have the same value as the original curve then the calculated y-value has the same value as the original curve. The interpolation curve hits the original curve. The number of interpolation points will be defined in chapter 2.3.3.6.
By approximation (smoothing) the new curve don't hit the original curve. The y-values for the same x-values are different for the original and the approximated curve.

The standard input group for interpolation and approximation (smoothing) looks like:

**Yes** enables the interpolation and approximation. By activating **Interpolation** the plot data will be interpolated.
**Smoothing** activates the approximation of the curve. **Strength** defines how strong the smoothing is. 0 means no, 99 is maximal smoothing. A medium smoothing is 50, this is the default. The spline strength is normalized in respect to the x-axis data, so that same strengths have similar effects at different x-axis data.
If activating **Take out data** then not all original data will be used for the approximation. A special algorithm search 'bad' data. To simplify matters, if data points have a too big difference to the approximated data these data points will be neglected in calculation the smoothed data.
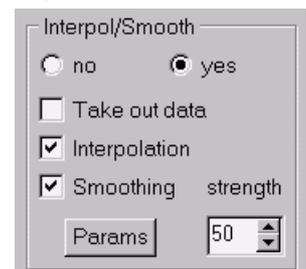
The input group below contains the main parameters, in some input windows these are the only inputs, in other inputs there is a **Params** button, which opens an input window with more possibilities, see picture below. In special cases, for example differentiation of data, there are only the inputs for smoothing.

In the **Data mode** input you can define if additionally to the new (interpolated/approximated) the **original data** should be shown. If using only the new curve you can select if the new curve has the plot symbol from the original curve or the special defined **interpolation plot symbol,** see chapter 2.3.2.1.
At activating **Window by both** the plot window will be calculated from the original and the new curve, in the other case only from the new curve.
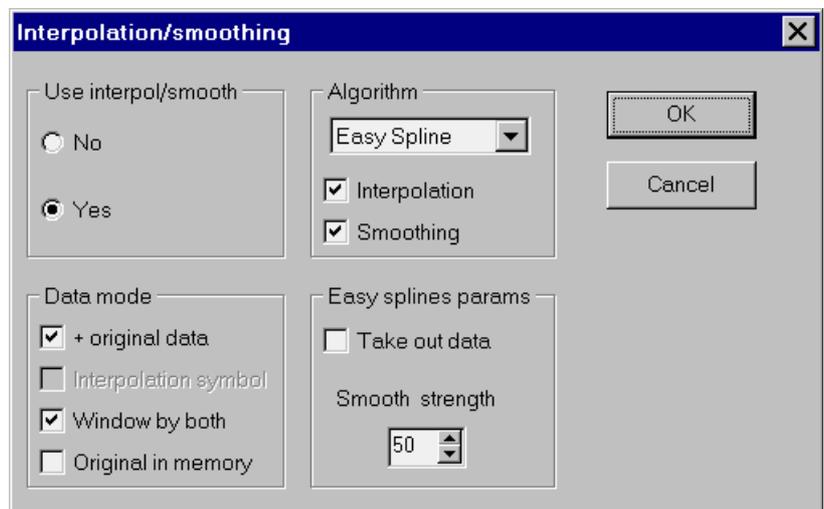
**Original in memory** means that the original curve instead the new curve will be used for further calculations, for example for applying into the Presentation Plot Program.

At the **Algorithm** you can activate interpolation and smoothing and select the algorithm:

| | |
|---|---|
| **Easy Spline:** | Use natural cubic splines, inputs are easier and less as Splines. |
| **Spline:** | Use natural cubic splines, full inputs with strength as a real value. |
| **Gauss:** | Use a Gauss smooth with sigma as smoothing parameter, for the interpolation the Aitken or Lagrange interpolation will be used. |
| **Polynomial:** | Use a polynomial with the polynomial order as smoothing parameter, all points are smoothed. |
| **Bezier:** | Use Cubic or N Bezier curves for smoothing, all points are smoothed and interpolated. Cubic Bezier yields only to slight smoothing. |

The next input group depends on the selected algorithm.
**Strength** defines how strong the smoothing is. 0 means no, 99 is maximal smoothing. A medium smoothing is 50.

If activating **Take out data** then not all original data will be used for the approximation. You get at the right a new input window except Easy Spline was selected.
Here you can define the maximum differences for taking out data.
There are 3 checks. The checkbox activates the check.
2 data means the difference between 2 data in percentage.
Approx. means the difference of the original curve and the first approximation before taking out data.
Deviation means the difference of the first approximation before taking out data and a second approximation after taking out data.
The final approximation will be done by the original valid data which were not taken out.
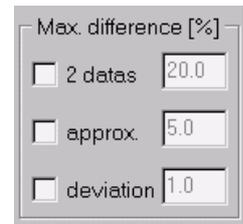
The following picture demonstrates the influence of the **smoothing strength**. The squares denote the original measurement data without smoothing. The lines are the by Splines interpolated and smoothed curves of these data. The smoothing strength are 45 (weak) for the green, 50 (medium) for the red and 60 for the maroon line. At strong smoothing the peak height increases, at overlapping of peaks also the peak position can change.
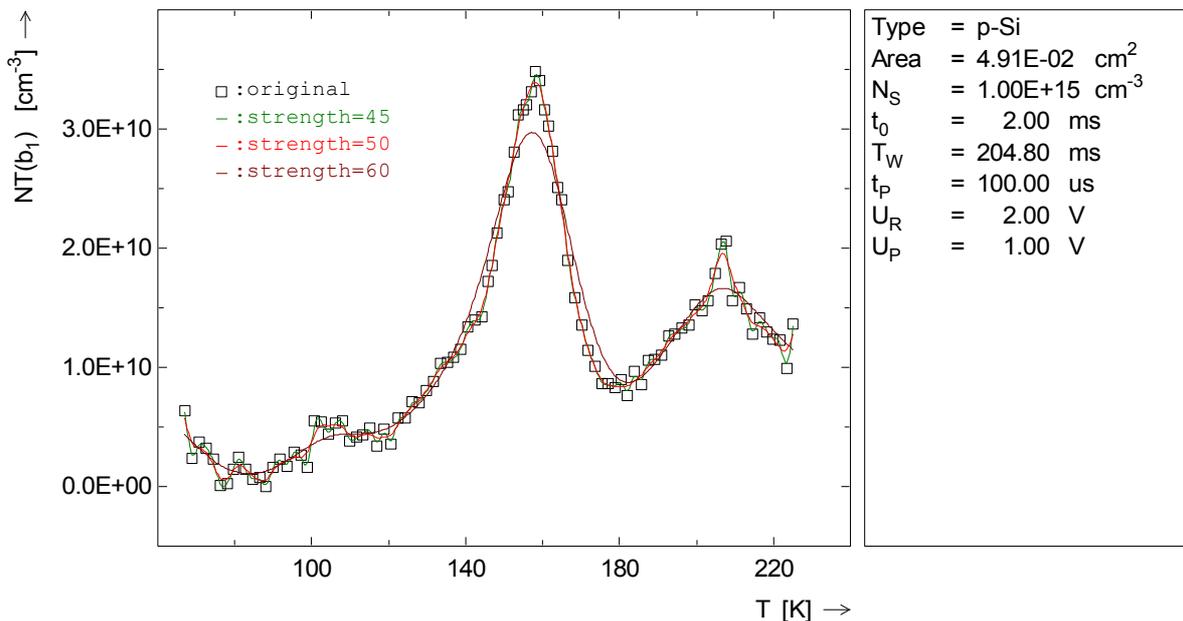
## 2.7.2 Connect points

The plot uses the default plot symbol (chapter 2.3.2.1) or the
symbols for curve (chapter 2.3.3.2) at plots with many curves.
At some input windows there is the input group Connect points.
It means that the points (symbols) can be connected by lines.

Following **connecting modes** are possible:

| | |
|---|---|
| **no:** | The points (symbols) will not be connected by lines. |
| **connect:** | The points (symbols) will be connected by lines, no interpolation or approximation will be done. |
| **connect + clip:** | As above but the lines will be clipped. Clipping of lines means that if a point (symbol) is outside the plot window then the line will be drown to the plot window and at the window cut off. In the other case only the visible points inside the plot window will be directly connected. |
| **interpol:** | The points will be connected by interpolated lines. The interpolation for the connection line will be done by splines without smoothing. |
| **interpol + clip:** | As above but the lines will be clipped. |
| **approx:** | The points will be connected by interpolated smoothed lines. The interpolation will be done by splines with weak smoothing strength 45. |
| **approx + clip:** | As above but the lines will be clipped. |
| **medium approx:** | The points will be connected by interpolated smoothed lines. The interpolation will be done with medium smoothing strength 50. |
| **medium + clip:** | As above but the lines will be clipped. |
| **cubic Bezier:** | The points will be connected by interpolated slightly smoothed lines using cubic Bezier curves. |

Activating the flag '**No symbols, only lines**' shows only the connection lines but not the symbols for the original data.

# 3. Measurement program modules

The four measurement program modules are V/I, VdP/Hall, Magneto and Tempscan. They have a similar menu structure. The File, View, Tools and Help menus were already explained in chapter 2, also the common functions of the measurement menu.
In the following the menus Edit, List, Plot, Evaluate and the special functions of the Measure menu will be explained separately for every program module.
These menus depend on the kind of sample (vdP/Hall or barshape), the user class, type of magnet, your hardware and your software package, see chapter 7.5 of Installation Manual. Especially the Edit menu gives much more possibilities at user class 5 and 6. In this chapter the menus for a vdP/Hall sample will be described up to user class 4.

The data during the measurement will be shown on the main canvas, after measurement or if you open a data file the standard plot resp. evaluation will be placed on this main canvas. On the main canvas there are no changes possible. By a click onto the button 'Plot Program' you see this plot in the plot program where you can change a lot of plot parameters and, depending on the kind of data, in some cases do a manual evaluation.

The **data** in the file contain a common file header and the measurement data array. The file header is similar for all measurement modules, the measurement data array are specific for the program module. At the list menu you see in 'File header' some main parameters of this header, see chapter 3.2.3.1 for an example. The sample parameters, also stored in the file header, will be shown in the sample parameters input window, see chapter 2.4.4.
The measurement data array of the V/I, VdP/Hall and Magneto program contains the voltages and the current values. The measurement data array of the tempscan contains a record for every temperature resp. x-axis data point. This record contains evaluation and measurement values and measurement parameters. A description of this record will be given later.
You can convert single curves or the complete file to ASCII data in the Edit menu 'Edit ASCII curve' or 'Edit ASCII file'. For this you need user class 5 or 6. You can also use the external program 'Convert data to ASCII'. You find it in your program folder.

All measurements base on V/I curves. The software sets the current, the voltage will be measured. 2-point and 4-point measurements are possible. In the first case only 2 of the 4 contacts will be used. Current and voltage use the same contacts. In the second case current and voltage use different contact pairs. 6 different contact pairs are possible with 4 contacts.

In most cases the Hall system comes without the option to measure the **temperature**. Then measurements are only possible at room temperatures, and optionally, at N2 temperature. Nevertheless the software will be described in the following for the temperature option.

With this option the temperature will be measured before and after the measurement of all V/I curves. The averaged value will then called temperature, Temp or 'T'; the temperature before will be called TempB or 'TB'. Both values will be saved into the data file. The difference of temperature before and after measurement will be called TempD or 'TD'.
If the cryo system have 2 temperature sensors (see installation manual), the temperatures of both sensors will be measured before and after measurement. Then the values will be averaged. Sensor 1 is the control sensor for setting the temperature, sensor 2 for the sample temperature. The value of sensor 2 will be further called temperature and will be used for the plots and evaluations. The value of the control sensor 1 will be called TempC or 'TC' and will also be saved into the data file. The difference between sensor 2 – 1 will be called TempV or 'TV', see also chapter 1.3.6.

# 3.1 V/I program

This module enables you to measure V/I curves, optionally at different temperatures. The data can be saved and the evaluation will give the 2-point or 4-point resistance.
A V/I curve is measured by several 'single value' measurements under systematical variation of the current.

The first character of the data extension is 'V' for the V/I measurement files. The second data extension character (chapter1.3.3) denotes this **kind of measurement**:
**1/2:**   1 V/I curve, 2/4-point measurement
**3/4:**   All 6 V/I curves, 2/4-point measurement

The V/I program module is not necessary for preparation measurements. For these you can make V/I and test of contact measurements by the 'Check measure' menu of every measurement program module.

## 3.1.1 Measure menu

The measurement menu contains the 2 common functions and the V/I measurements.

The input window for the different kinds of V/I measurements is always very similar, see next chapter.
Measurements of 1 or all 6 V/I curves are possible. The measurement can be done as 2-point or 4-point measurements. In the first case only 2 of the 4 contacts will be used. Current and voltage use the same contacts.

### 3.1.1.1 One V/I curve

The following picture shows the input window for the **4-point** measurement of 1 V/I curve. The input of the current and temperature input group will be explained in chapter 3.2.1.1, the Limit/Sens input window in chapter 3.2.1.2.

These measurements will normally done at **field** zero, but an input is also possible.
You can separately select the **contact** pairs for the current and for the voltage. Click onto the box for using of this contact. Only 2 contacts are possible, so that the software deactivates automatically a contact. 6 standard configurations exist at using 4 different contacts.
Only here at this measure mode you can select no standard configurations by using 1 same contact for I and V.
Only the inputs of the I-contacts are visible at a **2-point** measurement because I and V use the same contacts.
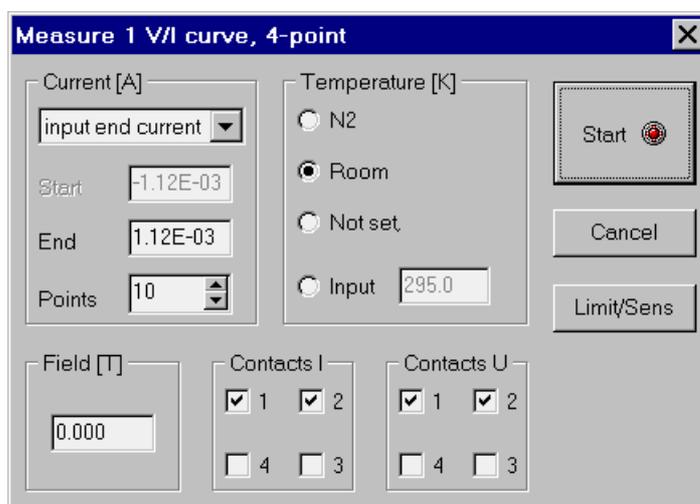
## 3.1.1.2 All V/I curves

The input window for the measurement of all 6 V/I curves is similar to the picture above, only the inputs for the contacts are here not visible.

At a **2-point** measurement the following resistances R(+,-) will be measured:
1. R(1,2)
2. R(2,3)
3. R(3,4)
4. R(4,1)
5. R(1,3)
6. R(2,4)

At a **4-point** measurement the following resistances R(I+,I-/V+,V-) will be measured:
1. R(1,2/4,3)
2. R(2,3/1,4)
3. R(3,4/2,1)
4. R(4,1/3,2)
5. R(1,3/2,4)
6. R(2,4/3,1)

After measurement or reading V/I data you see a **picture** with 3 plots on the main canvas. The following is an example for a 2-point measurement. Every plot contains 2 V/I curves. The linear regression will be automatically made and the resistance calculated. The text box at the top right contains some sample parameters and the calculated resistances.

## 3.1.2 Edit menu

By the edit menu it is possible to edit and modify the data in the memory. The file itself will not be changed. After reading the file again you lose the changes. For changes of the file you have to save the file, here you get a question for overwriting.

Copy ASCII curve copies the current and the voltage data line by line in an ASCII format to the clipboard. You can define the delimiter and the exponential format in the menu ASCII parameters. You find it in Tools of the plot or list program.

Del/new regress deletes the old regression of the V/I curves and calculates the regression again by a new evaluation plot. This can be helpful if you have set the regression range manually. If you change data, for example by deleting, then the regression will be automatically initialized.

At **user class 5** here is: Edit ASCII curve.

At **user class 6** here are: Edit ASCII file, Edit curve by plot, Paste ASCII curve.
Edit ASCII file means that the complete file will be shown in an ASCII editor, here you can edit all data (header and data arrays). After leaving the editor the changes will be applied for the memory data but not for the file itself. Use this option very careful because there is no data check. You find a description of the data structure in the file Data.Txt.

## 3.1.3 List menu

By the list menu it is possible to list the file header and the measure data.

A similar list of the file header will be shown in chapter 3.2.3.1.
The resistances of all V/I curves can be listed.
The data of 1 selectable V/I curve will be listed as lines and columns. In the first line there is the first current and voltage and so on. Three kinds of view here are possible: the data grid, the image without and with header and the ASCII editor, for more details see chapter 5.4.

At **user class 5** you can list the power P=V*I and the resistance R of every V/I point. First you have to select the V/I curve.

Three types for the **resistance** calculation exist:
**R=V/I:** The resistance will be formed by a simple division.
**R=(Vn-Vp)/(In-Ip):** The resistance will be formed by the slope between 2 points, the negative and the corresponding positive current point will be used.
**R=dV/dI:** The resistance will be formed by the deviation.

## 3.1.4 Plot menu

By the plot menu it is possible to plot the measure data.

| Plot | Evaluate |
| --- | --- |
| 1 V/I curve | |
| All V/I curves | |
| I/V curve | |

One V/I curve can be selected for a plot. There you can change manually the range of the linear regression.
The curve can also be shown as I/V curve with swapped x- and y-axis.
If measured, then all 6 V/I curves can be shown in one plot.

At **user class 5** you can plot the **power** P=V*I  and the **resistance** R versus the current. First you have to select the V/I curve. Three types for the resistance calculation exist as explained in the chapter before.

## 3.1.5 Evaluate menu

The evaluate menu shows the V/I curves automatically with the linear regression line.

| Evaluate | List |
| --- | --- |
| 1 V/I curve | |
| All V/I curves | |

One V/I curve can be selected for a plot. There you can change manually the range of the linear regression.
If measured, then all 6 V/I curves can be shown in one picture with 3 separate plots as shown in chapter 3.1.1.2.

# 3.2 VdP/Hall program

This module enables you to make vdP (van der Pauw) and Hall measurements by V/I curves, optionally at different temperatures. A V/I curve is measured by several 'single value' measurements under systematical variation of the current.
The resistivity of the sample can be calculated by a 4-point vdP measurement, Hall measurements yield to the Hall resistivity and the carrier concentration. The combination of both measurements gives the mobility.

These menus depend on the kind of sample (vdP/Hall or barshape), the user class, type of magnet, your hardware and your software package, see chapter 7.5 of Installation Manual. The RH 2035 allows normally not all options. So the compensation and the drift correction is not possible with the permanent magnet. The following menus and inputs are for the RH 2030 and RH 2010 with a VdP/Hall sample. The field input and the measurement with the permanent magnet is a little bit different, see chapter 3.2.1.8.

The first character of the data extension is 'H' for the VdP/Hall measurement files. The second data extension character (chapter 1.3.3) denotes this **kind of measurement**:

**M:**   Only Hall measurements
**N:**   Measurements at N2 temperature; vdP+Hall, vdP+Hall+2-point, vdP+2-point
**R:**   Measurements at room temperature; vdP+Hall, vdP+Hall+2-point, vdP+2-point
**T:**   Measurements at given temperature; vdP+Hall, vdP+Hall+2-point, vdP+2-point
**V**:   Only vdP measurements


## 3.2.1 Measure menu

The measurement menu contains the 2 common functions and additional measurements. For a complete sample characterization we always prefer the combined vdP and Hall measurement with 2-point contact check.

The input window for the different kinds of measurements is always very similar, see next chapter.
Only van der Pauw, only Hall or both measurements are possible.
At 'measure, sample params' you get before the main inputs a window with inputs for the measurement mode and the most important sample parameters.
'Check/correct drift measure' is a special measurement procedure to correct slow drift problems of samples, see 3.2.6.2.

## 3.2.1.1 VdP and Hall

The measurement parameter input window is similar for all measurement tasks. The following is for the vdP and Hall measurement.

The values for the maximum measurement current and the temperature can be defined. At Hall measurements the magnetic field and the Hall configuration and compensation can be defined. These inputs are not visible at only vdP measurements.

By activating a flag it is possible to do all 6 **2-point** measurements for checking the contacts.
An additional input sheet is available under Limit/Sense (explained in the next chapter), but this is of second interest.
The button '**Start**' starts the measurement cycle.

At **user class 5/6** there are more possibilities for the field variation and the Hall geometry.



### Current input group:

It is a principle of our Hall system that all resistances are measured as a function of the current. For the setting of the current **input mode** there are 3 possibilities:

1. **Input end current:** The current should be varied symmetrically to zero. Therefore normally only the absolute value of the maximum aquired current (End) has to be defined. The end value can be predefined at 'Test of contact' measurement, see chapter 2.1.1.1.3. The current starts from negative values and goes to positive.
2. **Start + end current:** If the I/V curves should be measured not symmetrically, also the start value of the current (including the sign) must be defined.
3. **Search best:** The best current can be automatically searched by the input of a destination voltage. The maximum current will be set in this way that all 6 2-point contact measurements reach maximal the given destination voltage. The search will be done separately for negative and positive current. Form this the absolute smallest value will be taken, so that all measurements vary the current symmetrically to zero.

How many V/I data points for every resistance is measured (from - End value to + End value or from Start value to End value) can be defined in '**Points**'.

**Field input group:**

The magnet field is always changed symmetrically to zero. As a standard a two field values measurement is used, at -B and +B. The value of +B can be defined in '**End**'. It should be close to the maximum value.
The Hall coefficient can also be calculated from a field dependent measurement of the Hall resistance. The flag '**Many points**' enables this measurement, the number of field values is defined in '**Points**'. The field starts from small negative values and goes to the maximum negative value, then it starts from small positive values and goes to the maximum positive value.
After the measurement the field order will be **sorted** before saving data. Then the first number represents the maximal negative, the last the maximal positive field.

**Temperature input group:**

Normally the Hall systems comes without a cryostat and without the internal Pt1000 option, see installation manual chapter 3.4. So only '**Room**' and, using our two temperature stage, '**N2**' temperature mode are available. Without a temperature measurement facility, the only use of this input is to define that temperature, that is shown on the prints. The temperature mode defines also the second data extension, see start of chapter 3.2.

Using a **temperature controller** you can input a new temperature or apply the current temperature. In the first case a new set point will be set to the temperature controller, normally the program waits until the temperature is stable. In the second case (not set) no command will be send to the controller, the measurement starts immediately.
If possible then the temperature will be measured before and after the measurement cycle. If activating **prepared for tempscan** the temperature will be additionally measured before the Hall measurement because setting of field can take a long time. In this time the temperature can drift. The additional temperature will be also saved and used in a tempscan.

**Hall geometry and compensation:**

A squared sample allows two different Hall configurations. '1,3/2,4' means the current path is set to the contacts 1 and 3, the voltage is measured using the contacts 2 and 4. This is the standard, and if **all 4** ohmic contacts are okay there is no need to change this. But if one contact shows not a good ohmic behavior, but it's not too bad for a measurement (it really happens) the measurement becomes better, if the bad contact is in the current path and not in the voltage one. This input gives now the user the possibility to change the Hall measurement paths.

Following **geometries** are possible:
- **1,3/2,4:** The standard mode.
- **2,4/3,1:** The alternative mode.
- **both, prefer contact:** First all measurement will be done for the '1,3/2,4', then all for the '2,4/3,1' configuration.
- **both, prefer field:** For every field first the '1,3/2,4', then the '2,4/3,1' configuration will be measured. This saves time of setting field. The hardware compensation is in this mode not possible.

The **compensation** possibility is a special hardware feature of the RH 2010 and RH 2030 Hall systems. It enhances for low resistivity material Hall measurement or does check of the results for reliability much easier. As compensation we understand the subtraction of the zero B-field I/V curve at Hall configuration (1,3/2,4 or 2,4/3,1) from these I/V curves measured at different magnetic fields. This will be done by **software**.
The result is a V/I curve (resistance) only caused from the Hall effect, and not from a sample misalignment. This misalignment is caused by geometric effects as there are not ideal squared sample or not homogenous layer. For standard and high resistivity material this misalignment can be seen, but does normally not influence the measurement and the result check. For low resistivity material the misalignment resistance can be so high, that the Hall effect gives only 1% of the measured resistance. In this case the results will normally (see below) still calculated correctly, but the check, how good the measurement had been is not any more possible, the I/V curves at different B-fields are overlapping each other. After using the compensation, only the corrected V/I curves are shown, with the slope changing due to the magnetic field, the **compensation plot**. The compensated voltages will be denoted as voltage* in the plots.

In addition to the software kind compensation also a **hardware** done compensation can be selected. Here the voltages of all currents will be first measured at field zero, called $U(I,0)$. Before then measuring at a given field the corresponding $U(I,0)$ voltage will be used for a hardware voltage compensation. The measured voltage is then the compensated voltage $U*(I,B)$. The not compensated voltage is $U(I,B)=U*(I,B)+U(I,0)$. This option is only useful when not the full amplification will be used. So the misalignment voltage, that means the absolute maximum voltage of the Hall V/I curve at field zero, must be bigger than 10 mV. In this case the hardware compensation can increase the voltage sensitivity. At too small voltages the results with hardware compensation are not so good as without because the limited resolution. Depending on the amplifier the resolution of the compensation is 25 uV, 250 uV or 2.5 mV. The measurement takes into account the resolution 'error'.

Following **compensation modes** are possible:

| | |
|---|---|
| **no:** | No compensation will be done at the measurement, a software compensation is later manually possible. |
| **hardware, only meas:** | A hardware compensation will be done but not shown after the measurement. You can select the compensation manually after the measurement. |
| **software, data:** | A software compensation will be done and shown. You can switch off later the software compensation. |
| **hardware, data+meas:** | A hardware compensation will be done and shown. You can switch off later the hardware compensation. |

**Note:** The software compensation is only an 'optical view', the result for Rh is similar with and without software compensation. Only the hardware compensation can give a better sensitivity or resolution. This is also valid if using the mode 'hardware, only meas'. Then the not compensated values $U(I,B)$ will be reconstructed from the compensated ones. But the sensitivity is the same as at the compensated values.

## 3.2.1.2 Limit/sensitivity params

The input window for the limit and sensitivity parameters is always the same. Depending on the kind of measurement (2-point, VdP, Hall) and hardware some inputs are not possible. Here are also hardware depending special features, for example the optical option.

At the **limit** input group you can select a limit at that the measurement stops. Limits are available for the voltage, the power and for both.

**Double voltage range** enables +-20V instead +-10V for the current source, the disadvantage is the bigger noise. Don't use it for small voltages.

Additional **wait times** are possible after setting field, between current setting and measurement of voltage and after setting the first current.
For the last there is a flag whether the software waits only at the first current at Hall contact configuration (setting of field) or at all contact configurations (all V/I curves). If using 2 alternate currents, see below, this waiting time after the 1. current will not be used for the Hall V/I curves.

**Note:** These times are additional times and normally not necessary because there are already standard waiting times in the software, for example for setting the field. Sample depending, additional times can be necessary.

At the **sensitivity** input group you can select the **measure time** for the voltage measurement: 2ms, 20ms, 200ms, 2s, 20s and 200s are possible.

A flag enables the use of the **highest amplification of preamplifier**. The advantage is a possible higher total amplification and resolution. The disadvantage is that problems can occur at high resistance samples because line frequency induced signals.

Activating a flag then all points of a V/I curve will be measured in the **same current range**. This is the default value and avoids possible jumps in the V/I curve based on switching of the current range. These jumps can be visible only at small voltages. On the other hand you work for every V/I point in the best current range if deactivating the flag. But for the hardware compensation this is important to use always the same current range.

Normally the current will be switched off after the measurement cycle. **Keeping current** on the sample is available by activating a flag. This can be helpful to avoid drift problems. Then a drift will not newly be initialized by applying of a current. By activating this flag normally the first current will be set to the sample after a complete measurement and after best current search of the contact test. For more details see chapter 3.2.6.1 and 3.2.6.5. You can switch off this current until the next measurement in 'Contact measure → Measurement → Set current off'. This can be important for changing the sample.

At the **Hall params** input group there can the **measure time** for Hall measurements separately be defined. As sensitivity means that the same measure time as in the sensitivity input group will be used.

At user class 5 the numbers of **V/I points** for the Hall measurements can be defined:

| | |
|---|---|
| **as selected:** | The same number of V/I points will be used as for the other configurations, definable in the current input group, see previous chapter. |
| **2 points:** | Only 2 current points will be used. |
| **2, 10 averages:** | Measurement at 2 current points, then 10 repetitions of this cycle and averaging. It will also be called 2 **alternate currents**. |
| **2, 100 averages:** | As before but 100 averages. |
| **10, 10 averages:** | Measurement at 10 current points, then 10 repetitions of this cycle and averaging. |

The 2 alternate currents are especially important if the sample shows drift signals, see chapter 3.2.6. The measurement by the 2 alternate currents technique can also better suppress noise and can so increase the sensitivity.

**Note:** Also at 2 points (alternate currents) the V/I curves for zero, minimum and maximum field have the full point numbers because additional current points will be measured but not averaged. The point numbers and the measure time for these additional points is the same as for the VdP measurements. But the automatic linear regression uses also here only the 2 averaged points. The additional points will not be measured if selecting only 'Hall' in the measurement menu or not activating 'Many field points'.

The used measurement times of a measurement will be listed on the file header, see chapter 3.2.3.1. If the numbers of V/I points at the Hall configuration differs from the points at the other configurations it will be listed also there.

### 3.2.1.3 Measure, sample params

Here you get before the main inputs a window with inputs for the measurement mode and the most important sample parameters.

As **measure mode** can be selected vdP, Hall or both. By activating a flag it is possible to do all 6 **2-point** measurements for checking the contacts.
The **sample** parameters and the subgroup were already explained in chapter 2.4.4.

After clicking onto the OK button the main input window of chapter 3.2.1.1 will be opened.

### 3.2.1.4 Measured V/I curves

At the **2-point** contact measurement the following resistances R(+,-) will be measured:
1.  R(1,2)
2.  R(2,3)
3.  R(3,4)
4.  R(4,1)
5.  R(1,3)
6.  R(2,4)

At the 4-point **vdP** measurement the following resistances R(I+,I-/V+,V-) will be measured, the first 4 are the vdP V/I curves:
1.  R(1,2/4,3)
2.  R(2,3/1,4)
3.  R(3,4/2,1)
4.  R(4,1/3,2)
5.  R(2,4/3,1)
6.  R(1,3/2,4)

At the 4-point **Hall** measurement with 2 fields and the standard configuration R(1,3/2,4) the following resistances R(I+,I-/V+,V-/B) will be measured:
1.  R(1,3/2,4)            , B = 0
2.  R(1,3/2,4/-B)         , B = maximal negative
3.  R(1,3/2,4/+B)         , B = maximal positive

At vdP and Hall measurements the 6. vdP measurement will not be done if using the same sensitivity and numbers of V/I points for vdP and Hall. If selecting the R(2,4/3,1) configuration for Hall then the vdP measurements 5 and 6 will be swapped.

## 3.2.1.5 During the measurement

During the measurement every I/V point and every configuration is shown in a particular plot. The actual measurement configuration and the passed measurement tasks are shown in the info line on the top of the plots.
The measurement configuration is shown by a schematic sample with colored pads. Contact 1 is the top left square, contact 2 the top right, contact 3 the bottom right and contact 4 the bottom left.
The meaning of colors are:
**green:**       2-point measurement (current path and voltage path at the same contacts)
**red:**          Current path
**blue:**         Voltage path
**black:**       Open (not used)

The following shows an example for the Hall V/I curve (1,3/2,4):
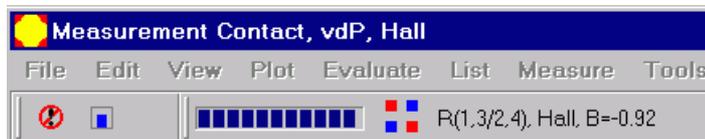


## 3.2.1.6 Permanent magnet

If using a permanent magnet then the field inputs for the Hall measurement as described in chapter 3.2.1.1 are not enabled. In this input window you get in the status line following message: Remove sample from the magnet field! So before starting the measurement, also a Hall measurement, remove the sample from the magnet field.

You get following **information box** if the negative field is necessary. Please put then the sample into the negative field and click 'OK'. If you use LN2 wait a little bit for the temperature.
After the measurement was done at the negative field you get an information to put the sample into the positive field.
If the plot with the menu bar at the top will be shown, you can remove the sample from the magnet field.
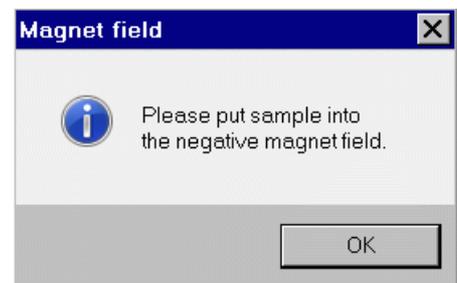


If using a **motor** driven permanent magnet then the magnet will be automatically moved into the correct position without the above information box. After the measurement the magnet will be set into the zero-field position.

At simple V/I curves in the 'Contact measurement' menu, chapter 2.1.1.2, or in the V/I program module, you can select in the input window 'Use field': 'no' (no field), '-F' (negative field) or '+F' (positive field).

## 3.2.1.7 Plot after measurement

During the measurement all V/I curves will be shown.
After measurement or reading data you see one or two **pictures** (pages) on the main canvas. Every picture can contain 1 to 3 plots, in these plots are 1 to 6 curves. These pictures depend on the kind of measurement (VdP, Hall, both), existing 2-point measurements and the field variation (2 or many points). All to describe is too much. Only the 2 standards will be explained here.
More possibilities for showing the data you get in the Evaluate menu. If also measuring the 2-point V/I curves then you get here by 'All-Plot' the same plot as after the measurement. If two print pages exist then is after the measurement or after reading data the first page not visible. The first page is only on the main canvas of the screen not visible, but it will be shown by a printer or by saving the graphic. In the Evaluate menu → 'All-Plot' is a stop box between two pages.

The following two examples are from a p-type sample. The sign of slope depends at the Hall curves on the n- or p-type doping. The linear regression will be automatically made and the resistance calculated. The text boxes at the right contain some sample parameters and evaluation values, the abbreviations are explained in chapter 1.3.4.

The **first** standard mode is the 2-point contact, vdP and Hall measurements with one Hall geometry and 2 field points. The first page (not visible on the main canvas) shows the 2-point contact measurements as in chapter 3.1.1.2.
The second page shows at the top the 4 vdP V/I curves and at the bottom the Hall V/I curves of 2 fields for the '1,3/2,4' configuration. The 2 Hall curves at field zero are not shown but measured.
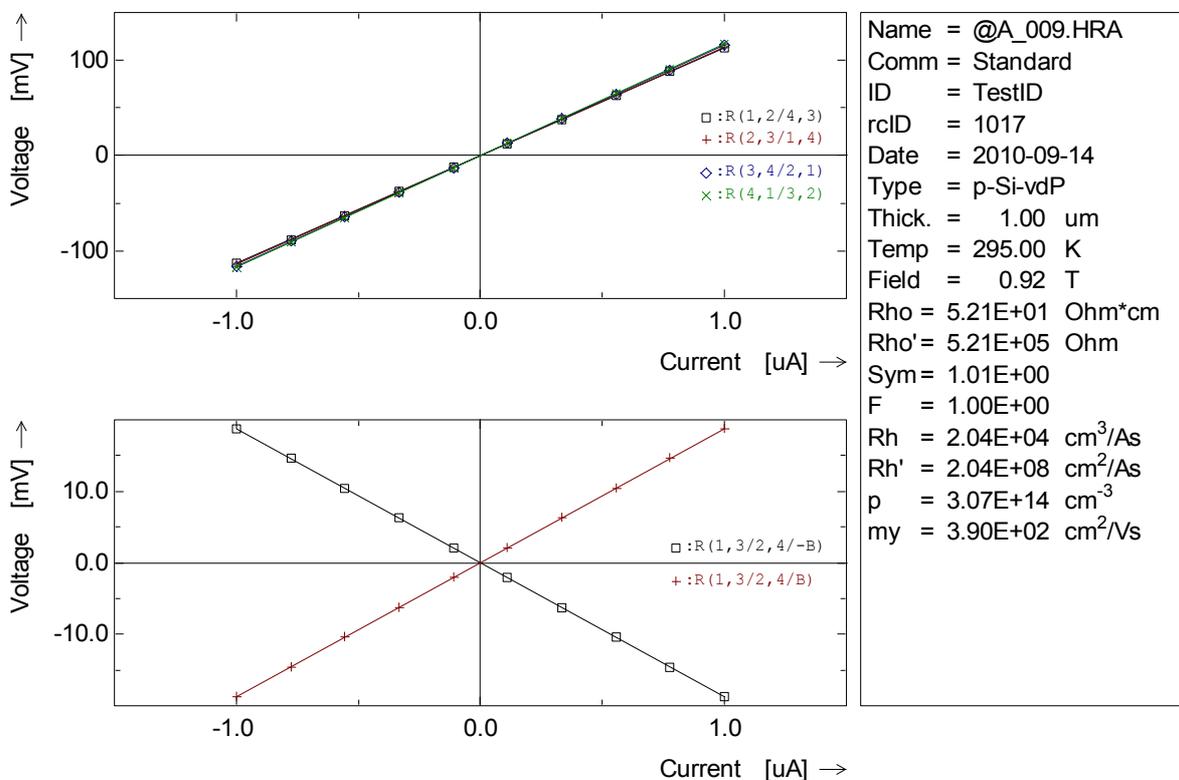
The **second** standard mode is the 2-point contact, vdP and Hall measurements with one Hall geometry and many field points. The first page (not visible on the main canvas) shows at the top the 2-point and at the bottom the vdP V/I curves.

| Name | = @A_011.HRA |
| Comm | = Standard |
| ID | = TestID |
| rcID | = 1019 |
| Date | = 2010-09-15 |
| Type | = p-Si-vdP |
| Thick. | = 1.00 um |
| Temp | = 295.00 K |
| Field | = 0.00 T |
| R(1,2) | = 5.00E+02 |
| R(2,3) | = 5.05E+02 |
| R(3,4) | = 5.10E+02 |
| R(4,1) | = 5.15E+02 |
| R(1,3) | = 5.20E+02 |
| R(2,4) | = 5.25E+02 |
| R(1,2/4,3) | = 1.13E+05 |
| R(2,3/1,4) | = 1.14E+05 |
| R(3,4/2,1) | = 1.16E+05 |
| R(4,1/3,2) | = 1.17E+05 |
| R(1,3/2,4) | = 2.04E+01 |
| R(2,4/3,1) | = 2.06E+01 |
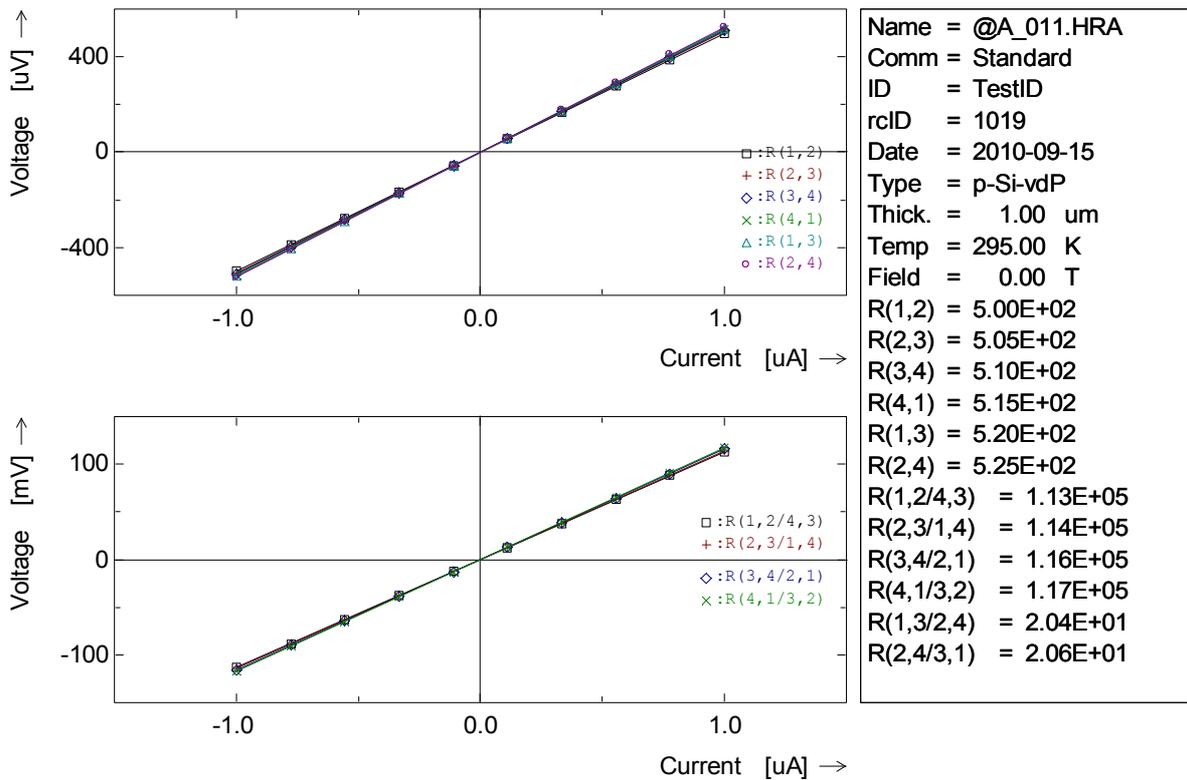
The second page shows at the top the Hall V/I curves at +-B and at the bottom the Hall resistance versus magnet field.

| Name | = @A_011.HRA |
| Comm | = Standard |
| ID | = TestID |
| rcID | = 1019 |
| Date | = 2010-09-15 |
| Type | = p-Si-vdP |
| Thick. | = 1.00 um |
| Cont. | = 1,3/2,4 |
| Temp | = 295.00 K |
| Field | = 0.92 T |
| Rho | = 5.21E+01 Ohm*cm |
| Rho' | = 5.21E+05 Ohm |
| Sym | = 1.01E+00 |
| F | = 1.00E+00 |
| Rh | = 2.04E+04 cm$^3$/As |
| Rh' | = 2.04E+08 cm$^2$/As |
| p | = 3.07E+14 cm$^{-3}$ |
| my | = 3.90E+02 cm$^2$/Vs |
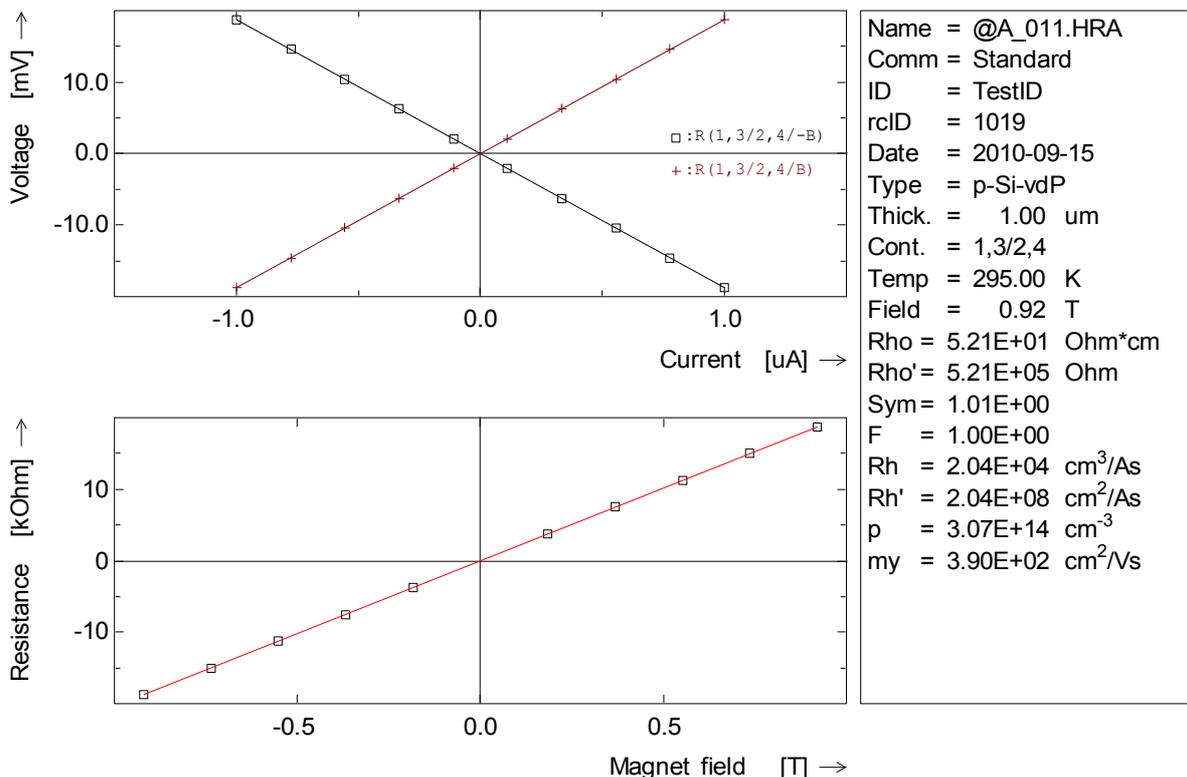
### 3.2.1.8 Barshape

The barshape measurements use only the contacts resp. cables 1 to 3. At the 4 point measurements additional the contacts 5 and 6 will be used for the currents I+ and I-.
The diagram on the right shows the contacts of the barshape structure.
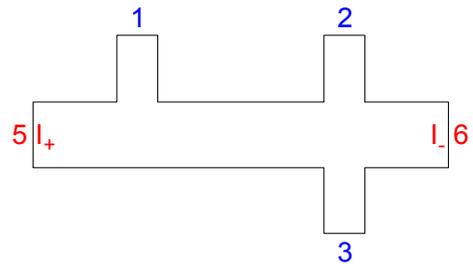


At the **2-point** contact measurement the following resistances R(+,-) will be measured:
1. R(1,2)
2. R(1,3)
3. R(2,3)

At the 4-point **Rho** measurement the following resistance R(I+,I-/V+,V-) will be measured:
1. R(5,6/1,2)

At the 4-point **Hall** measurement with 2 fields the following resistances R(I+,I-/V+,V-/B) will be measured:
1. R(5,6/2,3)          , B = 0
2. R(5,6/2,3/-B)       , B = maximal negative
3. R(5,6/2,3/+B)       , B = maximal positive

## 3.2.2 Edit menu

By the edit menu it is possible to edit and modify the data in the memory. The file itself will not be changed. After reading the file again you lose the changes. For changes of the file you have to save the file, here you get a question for overwriting.

 Copy ASCII curve copies the current and the voltage data line by line in an ASCII format to the clipboard. You can define the delimiter and the exponential format in the menu ASCII parameters. You find it in Tools of the plot or list program. Del new/regress and compensation will be explained blow.

At **user class 5** here is: Edit ASCII curve.

At **user class 6** here are: Edit ASCII file, Edit curve by plot, Paste ASCII curve, Restore data.
Edit ASCII file means that the complete file will be shown in an ASCII editor, here you can edit all data (header and data arrays). After leaving the editor the changes will be applied for the memory data but not for the file itself. Use this option very careful because there is no data check. You find a description of the data structure in the file Data.Txt. You can use also the program **DataConv** for converting one or more binary data files into ASCII files. You find it, called 'Convert data to ASCII', in your Hall\Tools program folder.

### 3.2.2.1 Del/new regress

Here are 2 modes possible:
**Delete/init regression** deletes the old regression of the V/I curves and calculates the regression again by a new evaluation plot. This can be helpful if you have set the regression range manually. If you change data, for example by deleting, then the regression will be automatically initialized.
**Hall reg. from min/max current** deletes the old regression as the mode before. But the linear regression for the field depending Hall V/I curves will be calculated in a special way. Here only 2 V/I points will be used for the calculation of slope and offset, these 2 points are the minimum and maximum current resp. the 2 alternate currents.

### 3.2.2.2 Software compensation

This makes the compensation by software. As compensation we understand the subtraction of the zero B-field V/I curve at Hall configuration (1,3/2,4 or 2,4/3,1) from these V/I curves measured at different magnetic fields. The compensated voltages will be denoted as voltage* in the plots. If compensation was done, the function 'Clear software compensation' is in the edit menu. It is a reversible function, you get back the original data. If the compensation was made by hardware, 'Hardware compensation' resp. 'Clear hardware compensation' is in the edit menu.

**Note:** The compensation requires user class 5 at drift measurements because the compensated values can give problems for the drift correction.

## 3.2.3 List menu

By the list menu it is possible to list the file header and the measure data.

| List | Measure | Tools |
|------|---------|-------|
| File header | | |
| Resistance | | |
| V/I data | | |
| Debye correction | | |

The file header will be shown in the next chapter.
Resistance shows the data header, the resistances of all V/I curves and the evaluation values.
The data of 1 selectable V/I curve will be listed as lines and columns. In the first line there is the first current and voltage and so on. Three kinds of view here are possible: the data grid, the image without and with header and the ASCII editor.

The results compared with the results of the Debye correction can be shown.

At **user class 6** you can list the V/I header.

### 3.2.3.1 File header

The **file header list** contains in the first block the relevant file, sample and measurement parameters. This block will be also called data header. The second block depends on the file format:

```
Name    = TestID@A_001.HRA
Comm    = Standard
ID      = TestID          rcID    = 1001
Date    = 2011-05-18      Type    = n-Si-vdP
Thick.  =   1.00 um
Temp    = 295.00 K        TempD   =   0.00 K
Field   =   0.50 T

DataVers = 3.2                  FileVers = 3.2
Sensors  = 1
Measure  = 20ms
```

| | |
|---|---|
| **Name** | : Base file name without ID and data extension HAL. |
| **Comm** | : Comment |
| **ID** | : Sample identification, see in 2.4.4 |
| **rcID** | : Record ID in the file data base |
| **Date** | : Date of measurement |
| **Type** | : Type of doping (n- or p-type), material name, sample type. |
| **Thick** | : Thickness of layer = D |
| **Temp** | : Temperature |
| **TempD** | : Temperature difference after - before |
| **Field** | : Field of the magnet |
| **DataVers** | : Program version of the data at measurement |
| **FileVers** | : Program version of the saved file |
| **Sensors** | : Numbers of temperature sensors |
| **Measure** | : Measure time for each V/I point, 2. value for Hall measure time if different |

## 3.2.3.2 Debye correction

The data header as above will be shown as first block in this list, but here not printed.
The second block compares the standard results with the results of the Debye correction.
The corrected values will be denoted with a '~'.

```
Debye         = 2.078E-05 cm
Thick~        = 7.922E-05 cm
Debye/Thick   = 2.078E+01 %
Rho           = 5.213E+01 Ohm*cm
Rho~          = 4.130E+01 Ohm*cm
Rho'          = 5.213E+05 Ohm
Sym           = 1.010E+00
F             = 9.999E-01
p(Rho)        = 3.021E+14 cm⁻³
p(Rho)~       = 3.814E+14 cm⁻³
Rh            = 2.036E+04 cm³/As
Rh~           = 1.613E+04 cm³/As
Rh'           = 2.036E+08 cm²/As
p             = 3.066E+14 cm⁻³
p~            = 3.871E+14 cm⁻³
my            = 3.905E+02 cm²/Vs
```

**Debye**     : Calculated Debye length
**Thick~**    : Thickness D minus Debye length
**Rho**       : Sample/layer resistivity
**Rho'**      : Rho/D
**Sym**       : Symmetry factor
**F**         : Correction factor
**p(Rho)**    : p calculated from measured Rho and my of material table
**Rh**        : Hall coefficient
**Rh'**       : Rh/D
**p**         : Carrier concentration, holes
**my**        : Carrier mobility

## 3.2.4 Plot menu

By the plot menu it is possible to plot the measure data.
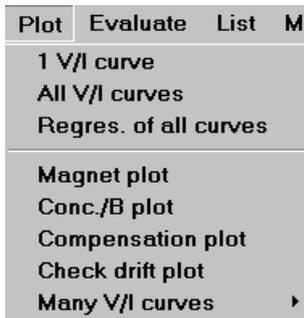
One V/I curve can be selected for a plot. There you can change manually the range of the linear regression.
All V/I curves of 2-point, VdP or Hall can be shown in one plot or plot after plot for making a new linear regression.
A magnet plot and a concentration versus field plot exist with many possibilities. The compensate plot compares original and compensated V/I curves. A special plot for checking slow drifts of the sample is visible at user class 5 or the drift measurement was done, it will be explained in chapter 3.2.6.3.
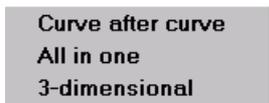
Plot with many V/I curves are possible at Hall measurements at many field points. You can show these curve after curve, all V/I curves in one plot or in a 3-dimensional view.

At **user class 5** there is a mapping plot at many V/I curves. In the magnet plot are more possibilities. User class 6 allows showing differences of 2 V/I curves .

**Note:** Also at the 2 (alternate) current points Hall measurements, as described in chapter 3.2.1.2, the V/I curves for zero, minimum and maximum field have the full point numbers because additional current points will be measured but not averaged. So you will see at these Hall V/I curves the 2 currents (normally averaged 10 times) and additional the standard (normally 10) points. So you have for the minimum and maximum current each 2 points. The automatic linear regression uses also here only the 2 (averaged) current points. The 'Check drift measurement', see chapter 3.2.6.2, uses 2 current points with 10 averages for the Hall configuration. In 3.2.6.2 a plot for these V/I curves will be shown.

### 3.2.4.1 One V/I curve

One V/I curve can be selected for a plot. The data mode distinguish between the 2-point, vdP and Hall measurements. Depending on this data mode you have to select a 2-point or 4-point contact. The vdP mode contains all 4-point measurements without field. At the Hall data mode is a contact only selectable if you have measured both Hall geometries. At Hall you can select the field number of the V/I curve. Field number 0 is the V/I curve without field, 1 is for the maximal negative field.
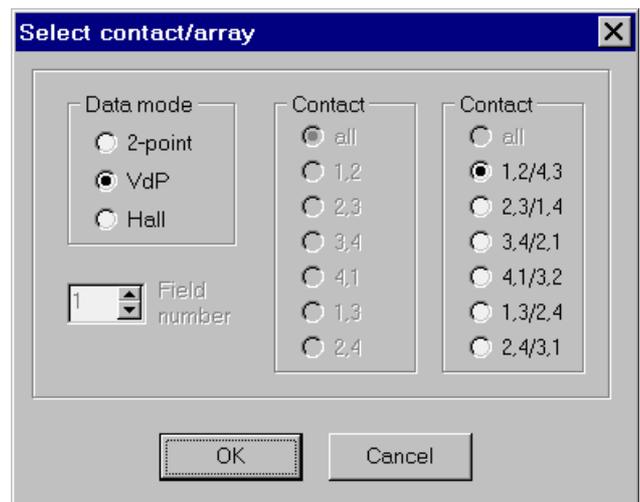
**Note:** The field order in the file and here in the input window is not the same as measured. After the measurement the fields will be sorted. 'Voltage*' as axis means that these are the compensated voltages done by hardware or software.

## 3.2.4.2 Regression of all curves

All V/I curves of 2-point, VdP or Hall can be shown plot after plot for making a new linear regression. At the text header there will be the regression mode (RMode) shown: 3 means by software, 4 by auto regression, 5 by manual regression.
At Hall V/I curves with many fields there is a feature to show at the top the actual V/I curve and at the bottom a plot Hall resistance versus field. The slope of the actual V/I curve will be marked by a red square symbol. Changing the regression of the V/I curve gives a new position of this point.

## 3.2.4.3 Compensation plot

The following shows at the top the measured (not compensated) V/I curves for field zero, -B and +B. At the bottom there are the software or hardware compensated V/I curves for field -B and +B. The compensation will be denoted by a '*'.
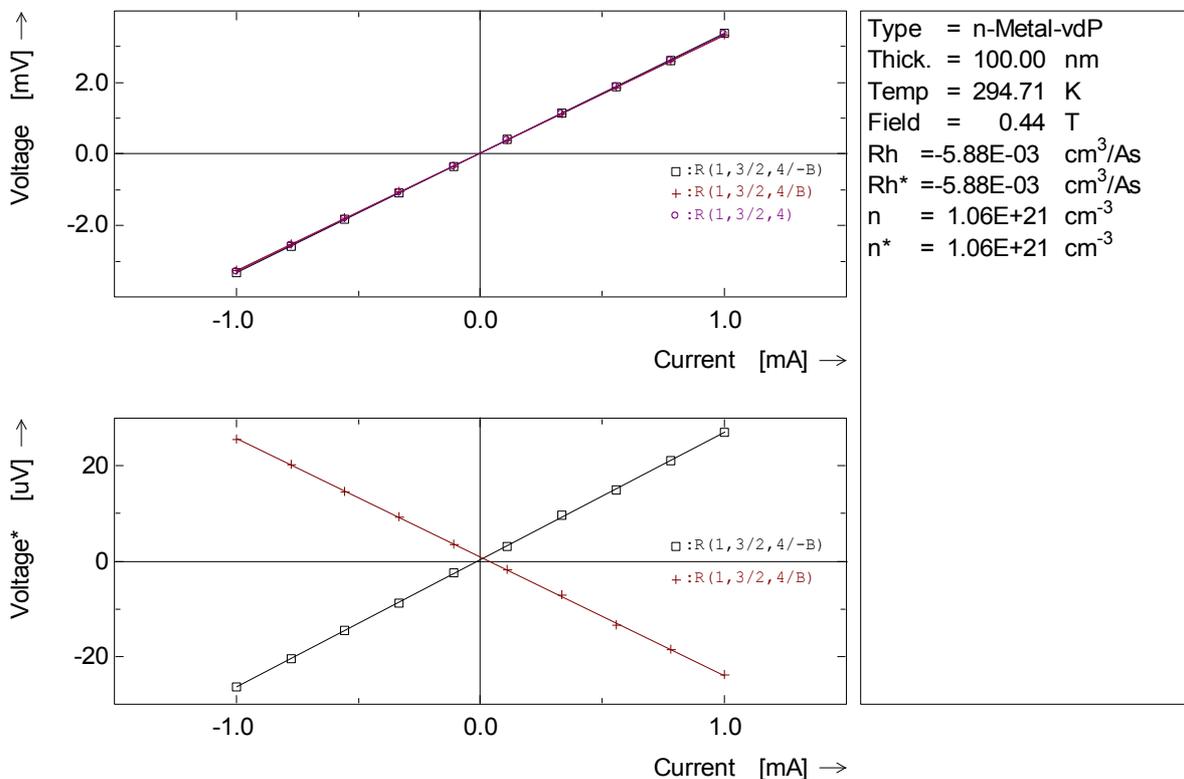


The Hall V/I curves in the uncompensated plot overlap completely. This is due to the fact, that the Hall Voltage is very small compared to the misalignment voltage at zero B-field. The maximum voltage is app. 3mV.
Our software can now subtract the zero filed V/I curve pointwise from that ones measured at +B or -B values (or several ones). This is our so called compensation.
The compensation plot shows linear field dependent V/I curves, but with a maximum voltage of only 30uV. So the field dependent Hall effect was for this sample only 1% of the misalignment voltage.
The results, mobility and carrier concentration, is not effected by using these different plots, but it gives a much better information about the quality of the measurement.

## 3.2.4.4 Magnet plot

This plot shows an evaluation value, like Rh, versus the magnet field. This plot is only available if the measurement was done at many field points. You get in the input window much more possibilities at user class 5, for example the selection of the **base data mode**. Usually (standard) all points of the Hall V/I curve will be measured at one fix field. Then the next field will be set and all points of the V/I curve will be measured. At user class 6 there is also a field variation at a fix current possible, similar to a lock-in. Then the next current will be set and the voltages at different fields will be measured. The base data mode applies the data as measured or restores the data temporary.

If measured 2 Hall geometries then the activation of '**2,4/3,1 geometry**' selects the alternative Hall geometry instead the standard '1,3/2,4'.
As **y-axis** you can select the voltage (only at 'Field at fix current' as base data mode), the Hall resistance, Rh, the concentration Ns or the mobility my.

Rh, Ns and my were normally calculated by the slope from the resistance versus field. For showing these values versus field this calculation is not possible because this yields to one plot point. Other calculations will be done here by selecting the **field mode:**
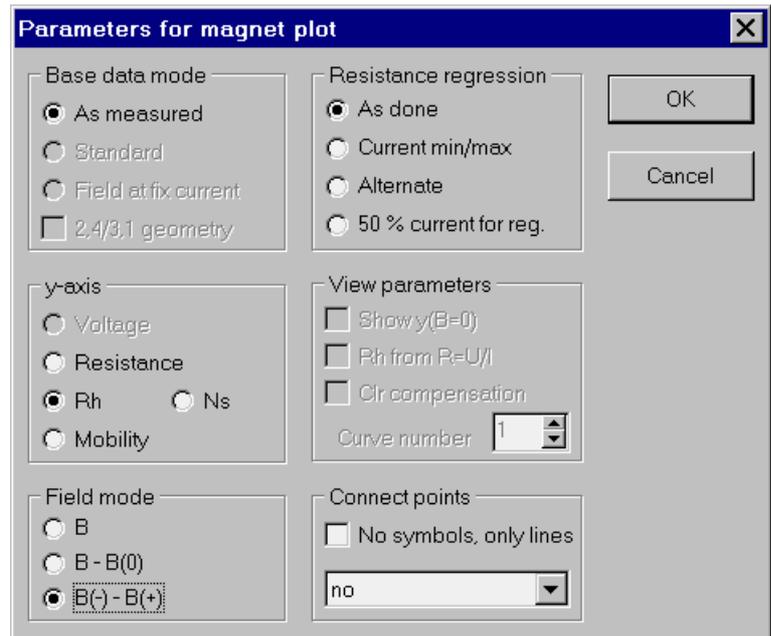
**B:** Direct calculation from resistance without difference forming.
**B-B(0):** Slope will be calculated from every field point subtracted the resistance at zero field.
**B(-)-B(+):** The slope between the resistance of one negative and the corresponding positive field point will be used.

Some possibilities exist for the calculation of the **resistance** from the V/I curve:

**As done:** The resistance will be applied from the V/I curves.
**Current min/max:** The resistance will be calculated at the minimum and maximum current.
**Alternate:** Similar as above, but you can select the curve point number.
**50% current for reg.:** Only these current points will be used which absolute values are same or bigger as 50% of the maximal current.

## 3.2.4.5 Conc./B plot

This plot shows the concentration n resp. p or Rh versus magnet field. If selecting '**Show all plots**' then additionally the Hall resistance will be shown in a separate plot window.
As **y-axis** is Rh, Rh' or n resp. p. possible.
If activating **Minimum range** then only y-values will be shown which are bigger than 20% of the maximum.

**Rh resp. n/p** can be calculated by two ways:

**Slope from +-B field:** The slope between the Hall resistance of one negative and the corresponding positive magnet field point will be used.
**Deviation over field:** The deviation of the Hall resistance over the field will be used.

Activating of '**+-B x-axis**' shows in the first case the same y-values also for negative fields. For the other case (deviation), the smoothing strength is selectable.
A **minimum field** for showing data can be input.

The **Hall geometry** can be selected if geometries were measured.
The data can be **smoothed**, separately for resistance and Rh resp. n/p.
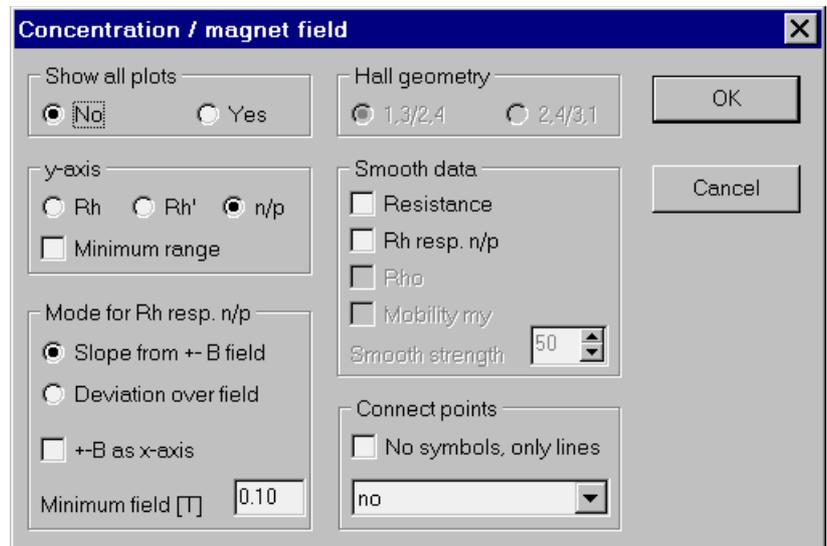
## 3.2.5 Evaluate menu

The evaluate menu shows the V/I curves automatically with the linear regression line.

| Evaluate | List |
| --- | --- |
| van der Pauw | |
| Hall | |
| vdP and Hall | |
| Magnet Hall | |
| All-Plot | |
| All without R/B | |
| Contact-Plot | |
| All 4-points | |

The possibilities depend on the existing data: 2-point, vdP, Hall. At Hall 1 or 2 configurations can be used, 2 or many field points are possible. Therefore a lot of different plots are possible, not all are available with all data.

The face of 'All-Plot' and 'All without R/B' depend on the data. 'All plot' is the same as showing after measurement or reading data.

'Magnet Hall' and 'All without R/B' are only enabled at many field points. The following is a small explanation for 2-point, vdP and Hall data. Only 1 Hall configuration will be used. 2 and many field points will be explained.

| | |
| --- | --- |
| **Van der Pauw:** | The first 2 vdP V/I curves are in a plot on the top, curves 3 and 4 are in a plot at the bottom. |
| **Hall:** | The V/I curve for -B (maximal negative field) is in the top plot, the curve for +B (maximal positive field) is in the bottom plot. |
| **VdP and Hall:** | The 4 VdP curves are in the top plot, the 2 Hall curves for -B and +B in the bottom plot. |
| **Magnet Hall:** | One plot with Hall resistance versus magnet field. |
| **All-Plot:** | Between the 2 pages is a stop text (plot next page). *2 fields:* 1. page: Contact plot; 2. page: vdP and Hall. *Many fields:* 1. page: all 6 2-point curves at the top, all 4 vdP curves at the bottom; 2. page: the 2 Hall curves for -B and +B are on the top, the Hall resistance versus magnet field plot is on the bottom. |
| **Contact plot:** | 3 plots with each 2 curves of the 2-point measurement, as shown in chapter 3.1.1.2. |
| **All 4-points:** | 3 plots with each 2 curves of the 4-point measurement. The vdP curves are in the top and bottom left plot, the 2 Hall V/I curves at field zero are in the bottom right plot. |

At **user class 5** there is a 2-layer evaluation.

If the measurement was done with the option of a drift correction, then you get at the Magnet Hall evaluation a question for doing and showing the drift field correction. This evaluation will be described in chapter 3.2.6.3.

### 3.2.5.1 Linear regression

The linear regression will automatically done. You can change the regression manually for every V/I curve if selecting '1 V/I curve' or 'Regression of all curves' in the plot menu. There you have some possibilities.
At the most plots of the evaluate menu of the vdP/Hall module you can change the linear regression. If possible you find in the Evaluate menu of the plot program 'Delete regression' and 'Auto regression'.
If selecting **Delete regression** the linear regression will be deleted. No regression lines will be plotted, no results will be shown. This 'delete mode' will be internal saved. For removing the delete mode you have to make a new regression (but not 'New auto range for V/I') or select 'Del/new regress' in the main Edit menu.
If selecting **Auto regression** then the range of the regression for all V/I curves of the same data mode will be changed. Which data mode is enabled depends on the selected action in the evaluate menu.

The following input window will be shown. One regression mode is **Set manual range for V/I**. Here you get a plot with all V/I curves of the selected data mode. Then you have to select the x-start and x-end value of the linear regression, valid for all V/I curves together.

Another regression mode is **New auto range for V/I**. Here the linear regression will be done with automatic search of the regression range, that means x-start and x-end value. For this mode you can select the **minimum range** for auto regression:

| | |
|---|---|
| **80 %:** | Minimal 80% from the total range will be used. |
| **55 %:** | Minimal 55%, that means negative and positive current. |
| **30 %, I<0, I>0 enable:** | Minimal 30%, only negative or positive currents are possible. |
| **30 %, negative current:** | Minimal 30%, only negative currents will be used. |
| **30 %, positive current:** | Minimal 30%, only positive currents will be used. |
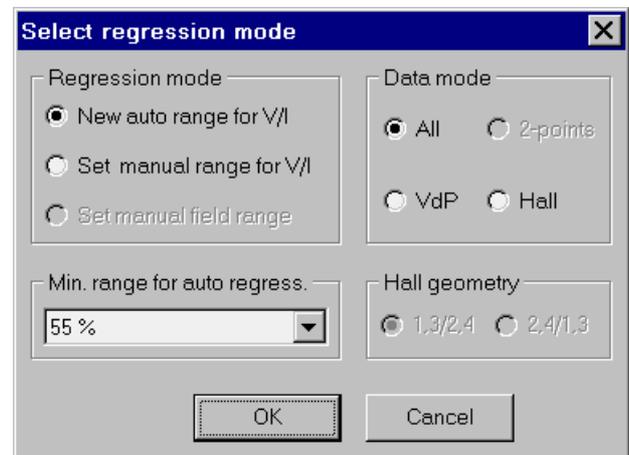
## 3.2.6 Drift correction

Depending on the material it is possible that samples show a drift signal. That means that the voltage changes with time but without changing the magnet field. This yields to an additional voltage and therefore resistance which don't come directly from the measurement but from the sample drift. This gives an error especially in the Hall evaluation (concentration and mobility) because the voltages of the Hall configuration are much smaller than the voltages of the vdP configuration. The quantity of this error depends on the ratio drift to Hall voltage. The drift is especially a problem for materials as ZnO. One reason for the drift can be the applying of the current. Light on the sample can also produce or increase a drift.

In the following drift means a sample effect and not a simple change of voltage because the temperature in the sample changes based on the current change. This thermal effect based on the current appears usually only at higher currents, it will be discussed later in chapter 3.2.6.5.

PhysTech has developed a special evaluation which corrects the sample drift in the Hall configuration. This method needs the electromagnet. The drift correction is a **special feature** of the PhysTech Hall system.

## 3.2.6.1 Theory of drift correction

Theoretical the drift voltage should be exponential by time. But in most cases the sample drift (not the thermal drift discussed in chapter 3.2.6.5) is very slow. Then the drift can be treated as a linear signal during the measurement.

An example for a slow linear drift process gives the next picture. It shows the voltage versus time. The current was fix at this measurement. We call such curves time curves.
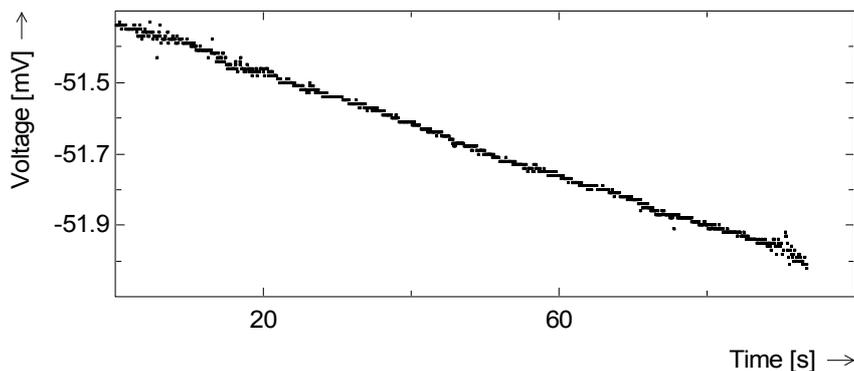


We can divide the sample drift during a standard observation (total measurement time) up to some hundred seconds in 3 cases:

1. The drift is **fast**. Then you can start the measurement after the drift is finished. Use the waiting times as explained in chapter 3.2.1.2.
2. The drift is **exponential**. Keep the current on the sample and try so to avoid the drift. If this don't help then no evaluation is possible if the drift voltage is in the range of the Hall voltage.
3. The drift is **linear** because it is very slow. Then our drift correction can correct the drift voltage and gives the correct results for concentration and mobility.

Normally the current will be switched off after the complete measurement. During the measurement the last current, normally the maximum positive, stays on the sample between the different V/I curves.

In all 3 cases of drift it can be helpful to **keep** the maximum **current** on the sample, see chapter 3.2.1.2. Then the drift will not newly be initialized by applying of a current. This can avoid or reduce the drift voltages. If using this option the first current, normally the minimum negative, will be set on the sample after the complete measurement is finished. The relay matrix will be set to the Hall standard configuration '1,3/2,4'. This current will also be set after searching the best current. The first current will also be applied on the sample between the different V/I curves of a Hall measurement at use of the standard mode for the Hall points (default 10 points). If using the 2 alternate currents then this first current will not be set between the different V/I curves of a Hall measurement. The last current, normally the maximum positive, remains on the sample. So every point resp. repetition starts with switching of current sign.

You have to wait a time after setting this current and start of measurement. This waiting can often be 'fulfilled' by the contact test. Another possibility is to repeat the measurement. You can switch off this current until the next measurement in 'Contact measure → Measurement → Set current off'. This can be important for changing the sample.

In the following the drift correction for the **third case** will be introduced. We assume a slow, most linear, drift of the sample. The voltage and therefore the resistance changes without changing the current or the magnet field. At the Hall configurations this can yield to a problem because the field depending changes of the Hall voltages are small. The resistance change because drift can be bigger than the resistance change because magnet field.

To reduce the influence of the drift on the V/I curves only 2 current points should be measured as described in chapter 3.2.1.2. These 2 points have a more 'similar' time at which the measurement was done.

PhysTech has developed some different methods for the drift correction. The two main **correction modes** are:

| | |
|---|---|
| **2 cycles, linear (L):** | The correction uses also the 2. measure cycle. A linear correction will be done between the corresponding field points between the first and second measure cycle. This mode is normally the best one but need a 2. measure cycle. |
| **Average field -+ (A):** | Only the first measure cycle will be used. The correction will be done as an average over the negative and positive field. Without the 2. measure cycle this mode will be taken. |

In the following we will discuss these two correction modes and give some example plots of drift measurements. We assume a drift process which change the voltages linear with the time. The drift increments or decrements the absolute voltages with time, independent of the current sign. But the current sign defines whether the voltages (not the absolute ones) increase or decrease. For example, if the absolute values increase, then the positive voltages at positive currents increase and the negative voltages at negative currents decrease. It is not a simple fix voltage offset. So the calculated resistance changes by the drift.

At the **correction mode (L)** the full measurement cycle will be repeated. For every field point exist now 2 Hall resistance values. The differences don't origin from the Hall effect but from the sample drift. These values give the y-axis for the correction. The x-axis is the time at which the measurement was done. Assuming a linear drift, from these 2 points the resistance can be calculated for the same time. These will be done for every field point, so that it seems that all field points would be measured at the same 'drift time'. The slope of the corrected resistance versus field curve is then without an influence of the drift (assuming a linear drift) and give therefore the correct value for the concentration. The absolute Hall resistance contains further the drift, but this offset is not from interest.

The next picture illustrates correction (L). It shows in the plot at the top the measured resistance versus time. The red crosses (+) denote the first measurement cycle, the green crosses (x) denote the second measurement cycle.

2 corresponding points of 1 field will be marked by a red and green arrow as an example. Here the points of maximum negative field will be selected as an example. From the corresponding 2 points of cycle 1 and 2 the resistance will be calculated (blue square) by a linear slope (blue line) for a fix defined time $t_C$. The time at maximum positive field of cycle 1, denoted with a blue arrow, will be selected as $t_C$. This is the normalization point as discussed above. For all fields of cycle 1 the corrected resistance will be calculated with the help of the corresponding point of cycle 2. The time $t_C$ is for all field points the same, so that it seems that all field points would be measured at the same 'drift time' and have the same 'drift offset'.

The plot on the bottom shows the resistance of cycle1 and 2 and the corrected resistance versus field. Resistance of cycle 1 and corrected resistance have at the normalization point (maximum positive field of cycle 1) the same value. The example points will also be marked here by arrows. So the first black square point here is the example of the corrected value (blue square) of the top plot. Remember that time and field don't increase in the same way. The bottom right plot of the picture of correction mode (A) illustrates this fact.
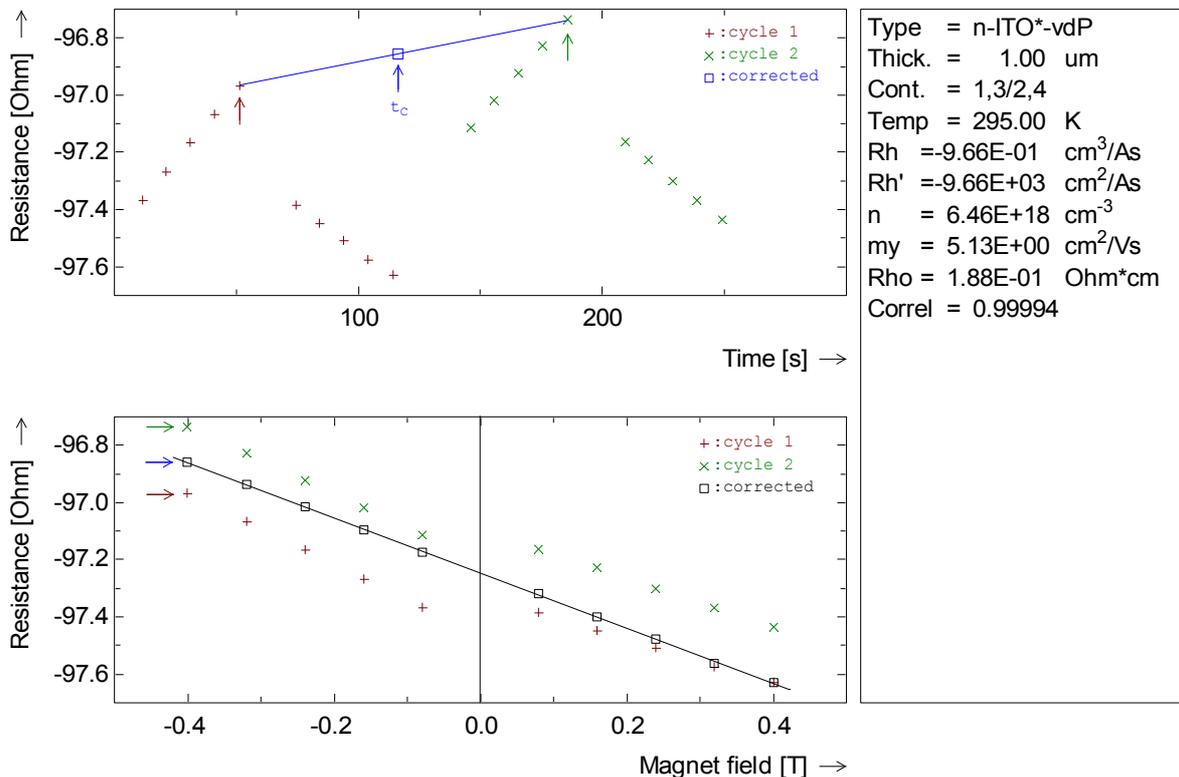
The **correction mode (A)** uses the fact that time and field don't increase in the same way. For negative fields time and field axis are inverse, for positive fields have time and field axis the same direction (see bottom right plot in the picture below). Therefore a slope can be calculated for the negative and one for the positive field. As a simplification the average gives a linear drift curve, that means resistance (or more exactly said voltage) versus time. Normalized to time zero the calculated drift value will be subtracted from the measured value.

This correction assumes that you have a symmetrical R(B) curve without drift, that means that the slopes over the negative and over the positive field are the same. Without drift is R(B)=R(-B)+R0 where R0 is constant for all fields. Deviations of this symmetric will be interpreted as a linear drift. This correction requires that the time steps between all negative and all positive fields are the same. Normally the measurement fulfills this condition.

The next picture illustrates correction (A). It shows a measurement with an extreme drift. The top left plot shows the resistance versus time, the bottom left the resistance versus field and the bottom right the magnet field versus time. The red crosses mark the measured resistance, the black squares the corrected resistance. The plot show definitely that the most changes come from the drift. In the plot on the top left the first 5 points will be used for the slope at negative fields, the last 5 points for the slope at positive fields. The slope of the corrected resistance is the average of the slopes over the negative and over the positive field.
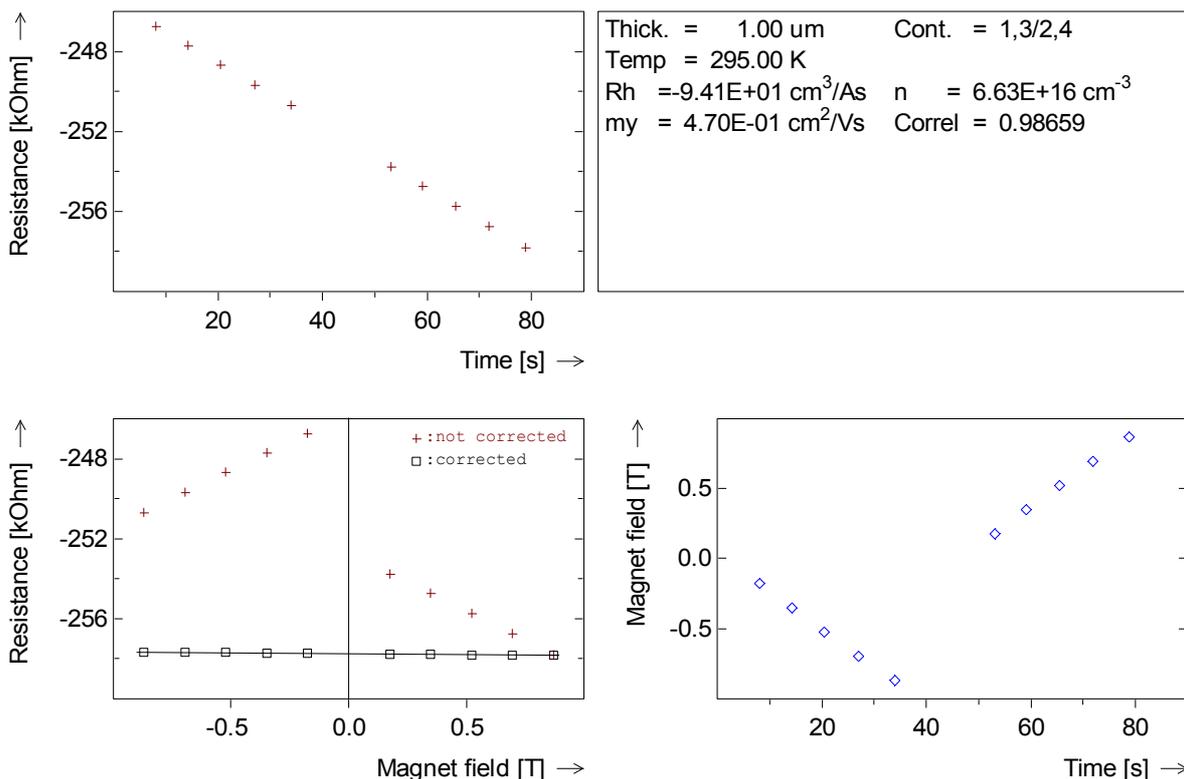


The measurement above is an extreme example. The drift is much bigger than the Hall effect. So it seems that you see only a linear drift of the sample. Nevertheless an evaluation of the corrected values is possible as the linear regression line shows in the plot on the top left.

## Details of drift correction:

The explanation above is a simplification. All corrections will not be done at the resistance but at the voltage. Using 2 different currents these 2 measurements were not done at the same time. A correction of the voltage corrects also this time difference. The correction will be done by assuming a linear drift.

**Correction method (L)** repeats the Hall measurement cycle, so we have 2 'same' measurements at different times. The corrected voltage $U_C(B)$ for field B will be calculated by:

$$U_c(B) = \frac{U_2(B) - U_1(B)}{t_2 - t_1}(t_c - t_1) + U_1(B)$$

$U_1(B)$ and $U_2(B)$ are the measured voltages at measurement cycle 1 and 2; $t_1$ and $t_2$ are the corresponding times. Time zero is start time of the measurement. $t_C$ is the defined time for which the correction will be calculated. We set this time $t_C$ to that time at which the measurement was done at maximum positive field of the first measurement cycle. This has the advantage that this time is always inside the times $t_1$ and $t_2$ which will be used for the calculation of the slope of the correction (first part of the equation above). So we have always a linear interpolation and not an extrapolation. This reduce possible errors if the drift is not purely linear. This selection of $t_C$ has also the effect that the correction will be normalized to the maximal positive field as shown above. That means that the corrected and the original curve have the same value at this field.

**Correction method (A)** works only with one measurement cycle. The voltage at one current will be plotted versus time. Then the slopes $m_N$ and $m_P$ at negative and positive fields will be calculated separately by linear regression. If N is the numbers of field points, B=0 neglected, then the point numbers from 1 to N/2 were measured at negative fields, the points from N/2+1 to N at positive fields. In the example plot above on the bottom left the first 5 points will be used for the slope $m_N$ at negative fields, the last 5 points for the slope $m_P$ at positive fields. The corrected voltage $U_C(B)$ for field B and time t will then be calculated by:

$$U_c(B) = U(B) - \frac{m_N + m_P}{2}(t - t_c)$$

Both corrections will be done on the voltages. The **resistance** will be calculated by 2 corrected voltages at one field. For these the 2 points of the V/I curve at the minimal (maximum negative) current I- and maximal (maximum positive) current I+ will be used. Normally only these 2 points will be measured for a drift correction, see chapter 3.2.1.2. The corrected resistance $R_C(B)$ is then:

$$R_c(B) = \frac{U_{+C}(B) - U_{-C}(B)}{I_+ - I_-}$$

**Tip:** The resistance versus time curves are a great help to proof whether the deviations of the resistance versus field curves come from a linear drift process of the sample. You get these curves in the plot menu 'Check drift plot', see chapter 3.2.6.4.

### 3.2.6.2 Measurement

This is a special measurement procedure to correct slow drift problems of samples.
The input is similar as the standard. Always vdP and Hall measurements will be done, the Hall measurements by using many field points. The Hall geometry can not be selected.

**2 alternate** current points with 10 repetitions resp. averages will be used for the Hall V/I curves, an explanation is given in 'V/I points for Hall' in chapter 3.2.1.2. It is not necessary to reduce here the point numbers for all V/I curves manually to 2.

Only the hardware **compensation** (only meas) is enabled at the drift measurement because the compensated values can give problems at the drift correction. Hardware compensation and measurements are not done at the same time.

By activation of **Full drift correction** the complete measurement cycle will be repeated a second times. This is the best way for the correction.

As discussed above it can be from great advantage to **keep current** permanently on the sample to reduce the drift voltage. You find this flag by clicking onto the Limit/Sens button. For more details see in chapter 3.2.6.1.

The **plot** after the measurement is similar as the 2. example in chapter 3.2.1.7. The bottom plot of the second page contains now the not corrected, the corrected or both resistance versus field curves. An example for this plot will be given in the next chapter.
The top plot of the second page shows the Hall **V/I curves** at +-B as following simulation illustrates:
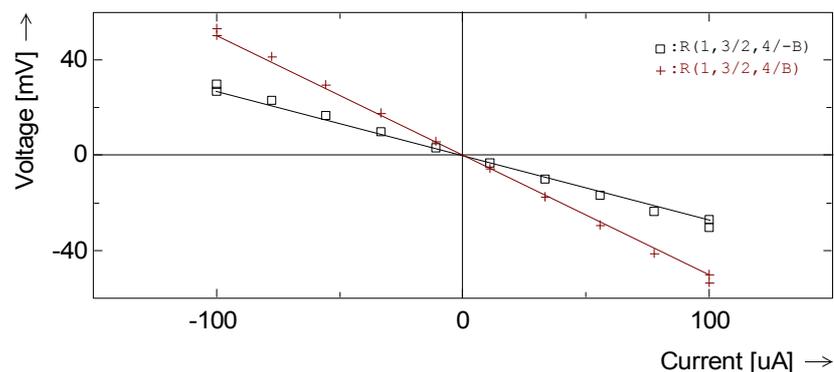


At the drift measurement only 2 alternate and averaged current points will be measured for the Hall V/I curves because this is better for the noise suppression and the drift correction. For zero, minimum and maximum field an additional V/I curve will be measured with the parameters of the vdP measurement. So you see each 2 points for the minimum and maximum current in the plot above. The black squares denote here the V/I points at -B (minimum field), the red crosses denote the V/I points at +B (maximum field). The 'isolated' points come from the alternate measurement, the other from the additional V/I measurement. The automatic linear regression uses also here only the 2 alternate points as the straight lines demonstrate. The lines don't connect the points of the additional V/I curves!

The 2 points of the same current have different voltage values because the drift. These 2 points were measured at different times. The additional V/I curve was measured after the 2 alternate currents. So the additional V/I points have in this example a bigger absolute voltage because they were measured later. Although there is a linear drift the V/I curves are still linear. The slope, that means the resistance, will be effected by the drift and is 'wrong'. The simulation above is an extreme example. How much the 2 points of the same current differ, depends on the drift.

**Note for user class 5:** The software buffers the standard V/I point mode of Hall params, see chapter 3.2.1.3, if making a drift measurement. For the drift measurement only the 2 alternate currents will be used. If making a standard measurement after a drift measurement, the software restores the buffered point mode. An exception is if you apply, after a question dialog, the measurement parameters of the last measurement or the loaded file. This is valid for user class 5 or higher. At user class 4 the V/I point mode of Hall params can not be selected and so always the standard mode, by default 10 points, will be used for a standard measurement.

**Tip:** Voltage versus time measurements are possible in 'Test of voltage', see 2.1.1.2.

### 3.2.6.3 Evaluation

If the measurement was done with the option of a drift correction, see previous chapter, you get in the Evaluate menu at the Magnet Hall evaluation a question for doing and showing the drift field correction. Only here you get this input window. Nevertheless the inputs are also valid for the All-Plot and for the default plot at the main canvas after a measurement or reading data.
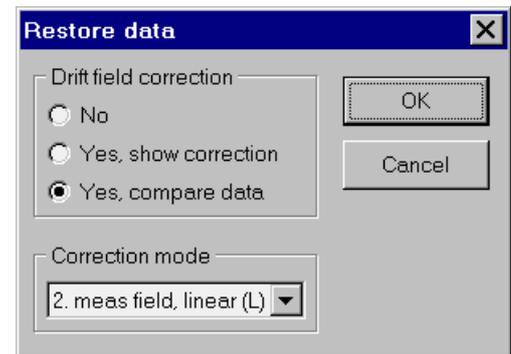
For the **drift field correction** you can select:

| No: | The data will not be corrected, the original data will be shown. |
|---|---|
| **Yes, show correction:** | The correction will be done and shown. |
| **Yes, compare data:** | The correction will be done and shown. Additionally the original data will be shown. |

If the measurement was done with the option 'Full drift correction' (2. cycle) then you can select the **correction mode**:

| **2 cycles, linear (L):** | The correction uses also the 2. measure cycle. A linear correction will be done between the corresponding field points between the first and second measure cycle. This mode is normally the best one but need a 2. measure cycle. |
|---|---|
| **Average field -+ (A):** | Only the first measure cycle will be used. The correction will be done as an average over the negative and positive field. Without the 2. measure cycle this mode will be taken. |

**Note:** Only the measurement of 2 alternate currents instead of a complete V/I curve yields to a good correction at big drift signals. Use normally correction method (L).

**Tip:** You get more plot possibilities for the drift correction in the plot menu.

In the following **example** the crosses are the not corrected data, the squares are the corrected data. Here correction mode (A) was used. The correction was normalized to the maximal positive field. This normalization is only possible when measuring only 2 points of a Hall V/I curve. The not corrected data have different slopes for negative and positive fields because the different influence of time. The corrected values are on a good line and give good results. If the correction data will be shown, then the evaluation will be done always by the linear regression over the corrected data.
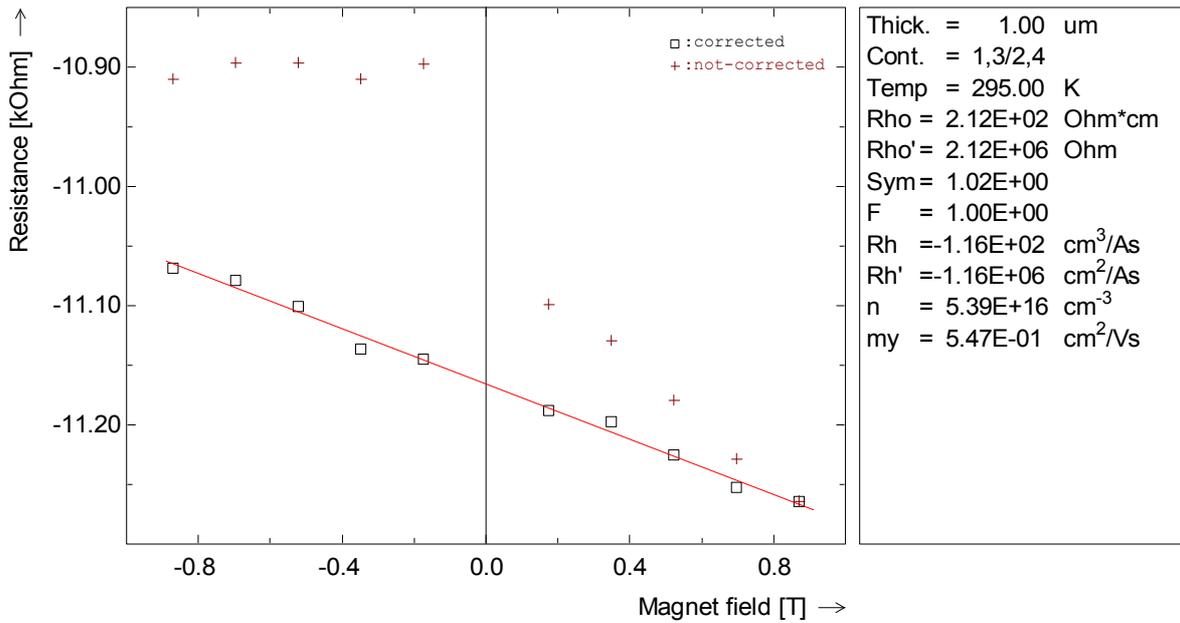
## 3.2.6.4 Check drift plot

This special plot for checking slow drifts of the sample is only visible if a drift measurement (chapter 3.2.6.2) was done or at user class 5 a Hall measurement with many fields. Usually the correction will only be shown in the evaluation menu. Here in the plot menu you have more possibilities but it is not necessary for the evaluation.
One application is to proof whether the deviations of the resistance versus field curve come from a linear drift process. This check can done by the resistance versus time curve. The default standard picture shows the time curve and the field curve.

The view of the following inputs depends on the type of Hall measurements, that means whether a second geometry or a second cycle was measured and so on. The visible and available inputs depend also on the base/geometry mode and on the user class. So at user class 6 you can select from up to 8 modes of drift field correction, depending on the type of measurement. At lower user classes you can only select between mode (L), (A) and (A2). With one geometry resp. measurement cycle only mode (A) is available.
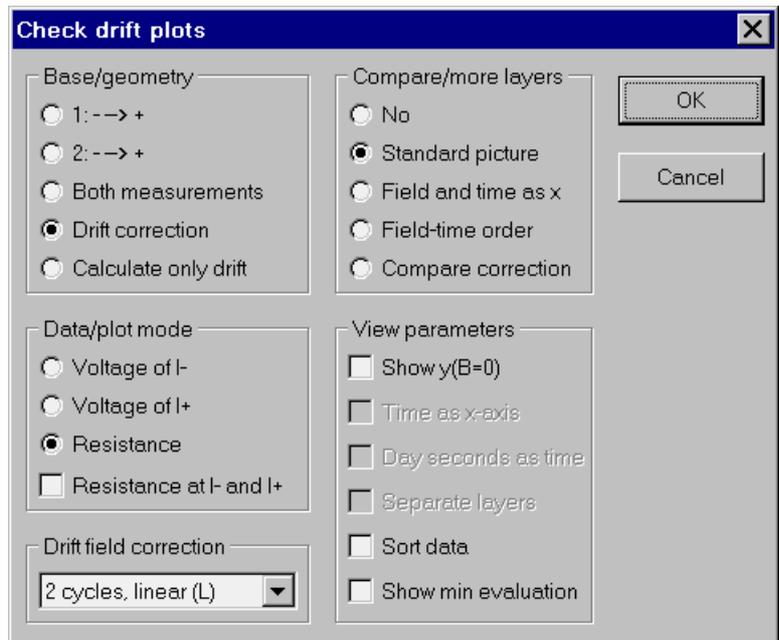
Following **base/geometry** modes exist:

**1: - → + :**          Select the data of the 1. geometry resp. measurement cycle. '-→ +' means that the field was varied from negative to positive fields.
**2: - → + :**          Select the data of the 2. geometry resp. measurement cycle if exist.
**Both measurements:** Select data of both geometries resp measurement cycles. The 1. data will be marked by black squares, the 2. by red crosses.
**Drift correction:**   Shows the measurement data corrected by the drift.
**Calculate only drift:**   Shows only the drift values, that means the measured values subtracted by the corrected values.


**Data plot/mode** defines which values will be shown as y-axis:

**Voltage of I-:**      Shows the voltage at the minimal (maximum negative) current I-.
**Voltage of I+:**      Shows the voltage at the maximal (maximum positive) current I+.
**Resistance:**         Shows the resistance. The evaluation of the carrier concentration and mobility is only here possible. You get this evaluation by a linear regression from R over B.

The resistance of the original data can be calculated by a linear regression over the full V/I curve or only by the 2 currents I- and I+ if activating the flag '**Resistance at I- and I+**'. The resistance for the correction will always be calculated by these 2 points.

Following **Drift field correction** modes are available by user class 5:

**2 cycles, linear (L):**     A linear correction will be done between the corresponding field points between the first and second measure cycle. This mode is normally the best one but need a 2. measure cycle.

**Average field -+ (A):**     Only the first measure cycle will be used. The correction will be done as an average over the negative and positive field.

**2. cycle, average (A2):**     As (A) but uses the 2. cycle.


**Compare/more layers** defines how many layers (plots) or curves will be shown:

**No:**     No comparison, shows only one curve in 1 layer.

**Standard picture:**     Shows at the top a resistance versus time plot and compares at the bottom plot the corrected data with the measured data. This mode is only visible at base mode 'Drift correction' and data mode 'Resistance'. An example follows at the next page.

**Voltage of I- and I+:**     Shows both voltages at I- (at the top) and I+ (at the bottom), only enabled if the data mode 'voltage of I-' was selected. This mode is only visible if the mode 'Standard picture is not visible.

**Field and time axis:**     Shows in one layer the field as x-axis, in the other layer the time as x-axis.

**Field time order:**     Shows on the left top the y-data (for example the resistance) versus field, on the left bottom y versus time and on the right bottom the field versus time.

**Compare correction:**     Compares the corrected data (black squares) with the original measured data (red crosses), only enabled at base mode 'Drift correction'. The evaluation and linear regression will be done by the corrected data.

In the chapter 3.2.6.1 a drift correction of the resistance will be shown. One plot uses the 'Compare correction' option, the other one the 'Field time order'.


In **View parameters** are additional options for the view of the plot:

**Show y(B=0):**     Shows also data measured at B=0.

**Time as x-axis:**     Selects the time at which the measurement was done as x-axis instead of the field. Time zero is the start of measurement. This option is not for all modes available.

**Day seconds as time:**     Time zero is not start of measurement but the begin of the day.

**Separate layers:**     Shows at 'Compare correction' the data in 3 separate layers. At the left top plot there are the corrected data, at the left bottom the original and at the right bottom the difference.

**Sort data:**     Sorts the data for the plot.

**Show min evaluation:**     Shows a calculated minimum value for the carrier concentration, called here Ns, and a maximum value for my without using the linear regression of R over B. This can be helpful if the linear regression is not possible.

**All points:**     Shows also the time points of the second measurement cycle, not always visible.

The next picture shows the **standard picture** of a measurement with an **extreme drift**.

It shows in the plot at the top the measured resistance versus time. The red crosses (+) denote the first measurement cycle, the green crosses (x) denote the second measurement cycle. The blue diamonds represent the time normalized curve of the second cycle, called '2nT'. For this curve the time axis will be normalized to the first (start) time of the first cycle. The teal triangles represent the time and resistance normalized curve of the second cycle, called '2nTR'. Here additionally the resistance values of this curve will be normalized to the first resistance value of the first cycle. The measure times of cycle 1 and 2 are the same, so that the normalized curves (diamonds and triangles) of the second cycle always have the same x- values as the first cycle.

If the drift is full linear and the noise is small, also the y-values of the normalized curve '2nTR' (teal triangles) and of cycle 1 are the same. This is valid for this measurement. The y-values of the normalized curve '2nT' (blue diamonds) differ from those of cycle 1. The strength of the difference depends on the strength of the drift. At a linear drift the difference should be constant for all points. The resistance changes based on the drift are much larger as the changes based on the magnetic field. So you see at this extreme measurement only a linear time curve, the influence of the field is 'optical' not visible.

Nevertheless an evaluation is possible as the plot at the bottom demonstrates. It shows the resistance versus field. The red crosses (+) are the measured data of cycle 1, the black squares are the data corrected by method (L) and give suitable results.
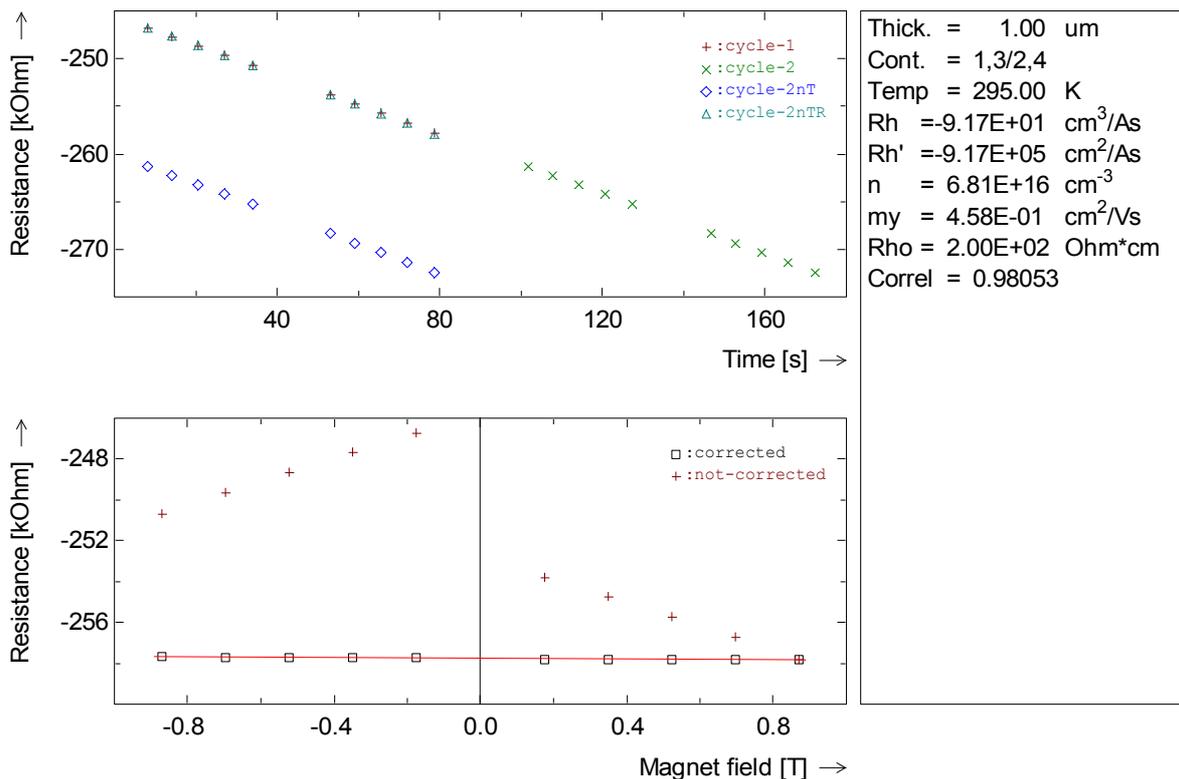
If the drift is not so strong, you see not a pure linear time curve (red and green crosses) but the influence of the drift and field, as the top left plot of the next picture illustrates on a measurement with a **small drift**.

Here are the points of cycle 1 and normalized curve 2nRT (teal triangles) are similar. They are not identical because not pure linear drift. The difference between cycle 1 and the normalized curve 2nT (blue diamonds) is about constant so that the drift is about linear.

The resistance time curves have 2 parts with opposite signs of slopes if the drift don't dominate too much (or if there is no drift). The reason is that time and field don't increase in the same way. For negative fields time and field axis are inverse, for positive fields have time and field axis the same direction. This illustrates the bottom right plot.

The bottom left plot shows the corrected and not-corrected resistance versus field.
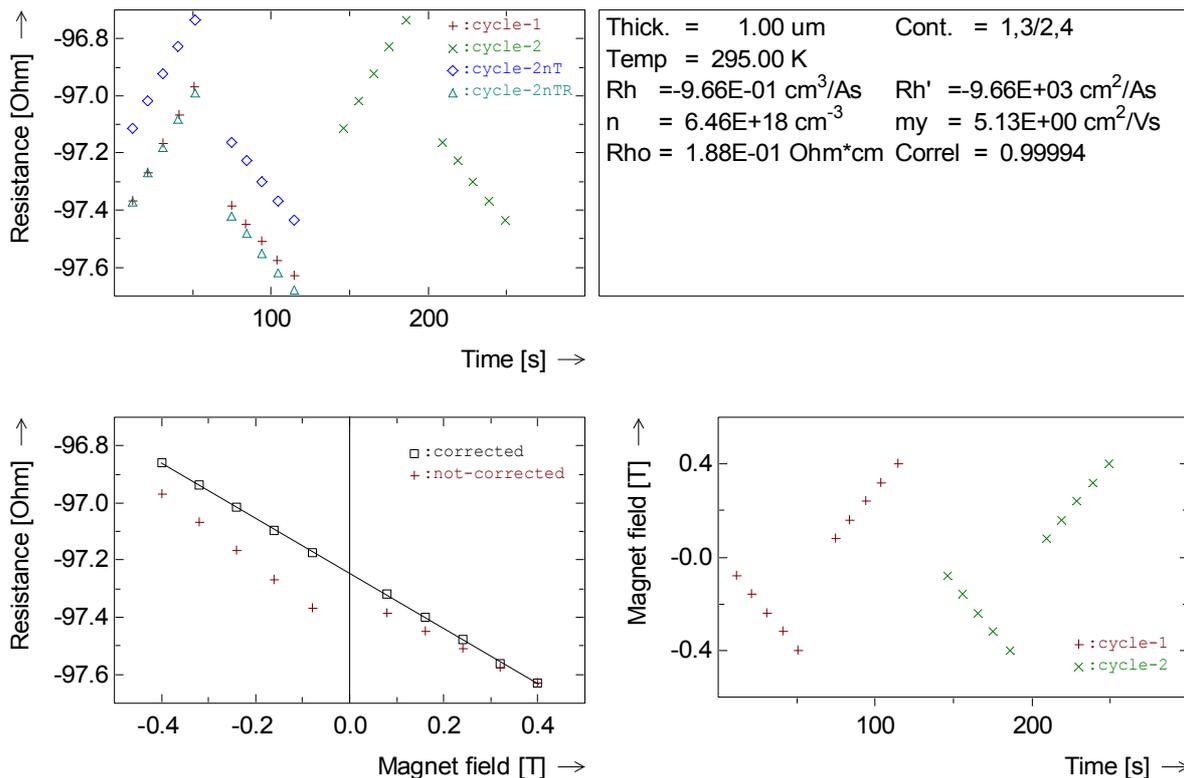


## Summary for time curves:

**a)** If there is no drift, the curves of cycle 1, '2nT' and '2nRT' are identical.

**b)** The normalized curve '2nTR' have the same values as cycle 1 if the drift is linear.

**c)** The y-values of the normalized curve '2nT' differ from those of cycle 1 if there is a drift. The strength of the difference depends on the strength of the drift. At a linear drift the difference should be constant for all points.

**d)** If the linear drift dominates extremely, you see a pure linear time curve for cycle 1 and cycle 2.

**e)** If the influence of the magnet field dominates, the drift then the resistance versus time curves have 2 parts with opposite signs of slope and different absolute values of slope. Without drift are the absolute values are the same. If the resistance change based on the field are similar to that based on the drift, the 2 slopes have the same sign but different values.

**f)** If the time curves don't show a definite direction, the drift is not linear and a correction is not possible. But it can happen that the drift is 'about' linear for the 1. or 2. cycle. Then you can try correction mode (A) resp. (A2).

### 3.2.6.5 Thermal drift

Also a thermal drift can exist. This means the voltage changes because the temperature in the sample changes based on the applying of a current. This type of drift is exponential and relative fast. This thermal effect based on the current appears normally only at higher currents.

Following **methods** exist to avoid the thermal drift in the V/I curves:

1. Use **lower currents** if possible.
2. **Keep current** permanently on the sample.
3. Define a **wait time** after first current, see chapter 3.2.1.3.

The following picture shows time curves of our reference sample. The current of the 3 measurement curves of the top plot was 10 mA. The black points denotes there a measurement at which this high current was applied on the sample at measurement start. You see an exponential thermal drift with 2 time constants.
If keeping permanently the current on the sample (method 2), there is no thermal drift as the red curve demonstrates. You find more details of keeping current in chapter 3.2.6.1. It is important that also the switching between negative and positive current (2 alternate currents) don't yield to a thermal drift. This demonstrates the blue curve. For better clearness this curve was shifted on the y-axis.
The plot on the bottom shows a time curve at a current of 100 uA. Although the current was set to the sample at the start of measurement there is no thermal drift. The current swaps between 2 values. These represent the resolution of the ADC at the given amplification.
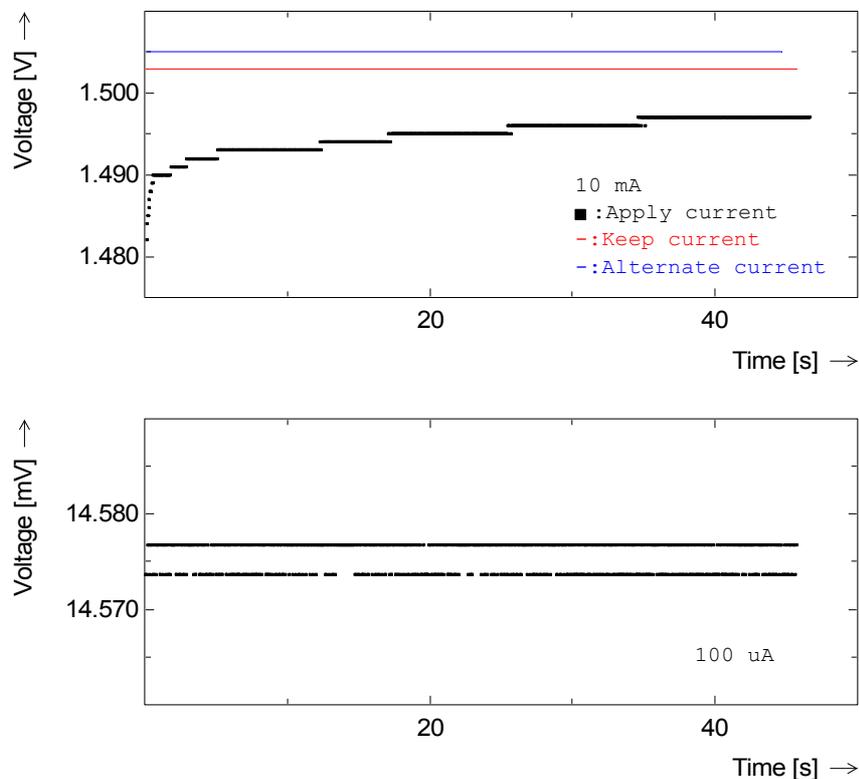
# 4. Routine program and calibration

## 4.1 Routine program

This program module leads directly to the combination measurement of all 2-point, all 4-point van der Pauw and Hall resistances. This is the easiest way to get the results for the sample/layer resistivity, mobility and carrier concentration. The user is guided through all necessary input windows and test measurements. Only the combined vdP and Hall measurement is supported.

### 4.1.1 Measurements

The measurement of a new sample should always be started with '**New measurement**' of the measure menu. This leads directly to the test of contact, then to the sample parameter inputs and then to the vdP/Hall input window. After clicking there onto the 'Start' button the measurement starts, for more information read chapter 3.2.1.1. After the measurement you get the question for saving the data or for calling the data task input window.

Following inputs and tasks exist for **New measurement**:

  **1**.a) Input: Test of contact (chapter 2.1.1.1.3)
  1.b) Measurement: Test of contact
  1.c) Confirm: Go on if test is okay; if a contact is bad (see Note below) then contact the sample again and repeat the test
  1.d) Confirm: Take over the found current as global current
  **2**.a) Input: sample parameters (chapter 2.4.4)
  2.b) Input: Use of database, only at every first use of program start (chapter 2.4.5)
  **3**.a) Input: VdP/Hall measurement parameters (chapter 3.2.1.1)
  3.b) Measurement: 2-points, vdP and Hall
  3.c) Confirm: Save data or data task window (chapter 1.3.2 and 2.2.3)

**Note** for test of contact: If some resistances could not be measured (gives ----), the measured voltage is too high (>10V) therefore the current range could be too high. If a complete row can not be measured, one contact may be bad. Normally, if one contact is bad, three contacts pairs (rows) can not be measured, because every of the 4 sample contacts are used for 3 contacts pairs.

Always a **test of contact** (contact check) should be at the start of an unknown or even a known sample. The contact check means a test of the electrical connection of the ohmic contacts to the pads and a check of the ohmic behavior of the ohmic contact of the sample itself. The test of contact gives also a help to define the current range.

**Measurement** opens directly the vdP/Hall input window (chapter 3.2.1.1). Only at first time after program start the software asks for the sample and database parameters.

## 4.1.2 Structure

This program module has not all functions and not the same structure as the other measurement modules of chapter 3.

Only reduced menus for File, Plot, Measure and Help exist. At **File** you can save and print the data, call the Data task procedure and change the program modules. Reading of data is here not possible, but you can read these data in the vdP/Hall program module.
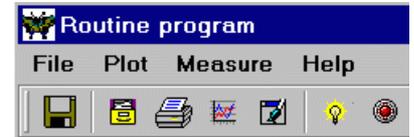


**Plot** shows the standard plot either on the main canvas (Refresh) or in the Application plot program.

At **Measure** are the above described possibilities 'New measurement' and 'Measurement'. You can start these functions also by the last two buttons in the toolbar.

**Help** was already explained in chapter 2.5.

Reflected on the **software**, the Routine and vdP/Hall modules are the same. The Routine module use only a small part of the vdP/Hall program and the menu is strongly reduced. The work in this module will usually done by user class 2.

## 4.1.3 Easy program

The easy program is the same as the routine program but it will be started directly. A movement to another program module is not possible.

For **starting** the Easy program, start the standard Hall program by activating the Hall icon on your desktop. In the start input window type in the user name and select as Program mode 'Measure, EasyProg', see chapter 1.1.1.

At the **first start** with a new user name you get two other input windows (chapter 1.1.5 and 1.1.6). Confirm both with 'OK'.

The **measurement** will be started by 'New measurement' for a new sample or by 'Measurement' for a repetition. For more details see chapter 4.1.1.

# 4.2 Calibration

The calibration procedures are in the program module Base Tools. These are not enabled at user class smaller 4 or in the simulation mode. Three calibrations can be selected in a sub menu of Calib: the system calibration, the field calibration and the offset voltage. The field calibration is different for the permanent magnet (RH 2035) and the electric magnet (RH 2030, RH 2010).

## 4.2.1 System calibration

This routine calibrates the ADC and internal amplifiers. The calibration is automatically done during every start of the software. If the hardware has been switched on just before the software start, it's useful to do this calibration after the hardware has been warmed up.

## 4.2.2 Field calibration for permanent magnet (RH 2035)

The inputs are the values of the negative and the positive magnetic field of the permanent magnet. If changing values, these values should be saved into the configuration file of the permanent magnet. In the other case the software loads the old values at the next program start. The values will be saved after clicking onto the '**OK**' button.

You can change the field values by input or by a calibration procedure. Click for this onto the '**Calib**' button, following input window appears:
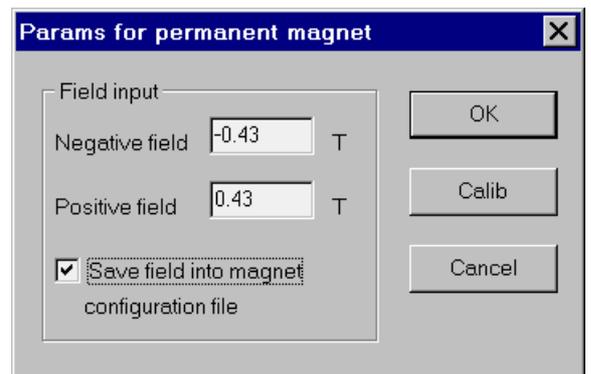
**Current** means the measurement current, it should be **1.00E-4 A** for any of our reference samples.
**Conc.** means the carrier concentration of the reference sample listed at the back of it, for n-type (PhysTech's reference sample) you have to input negative values, for p-type positive.
**Thick** is the thickness of the layer, normally 10 um.
**Limit/Sens** is explained in chapter 3.2.1.2.
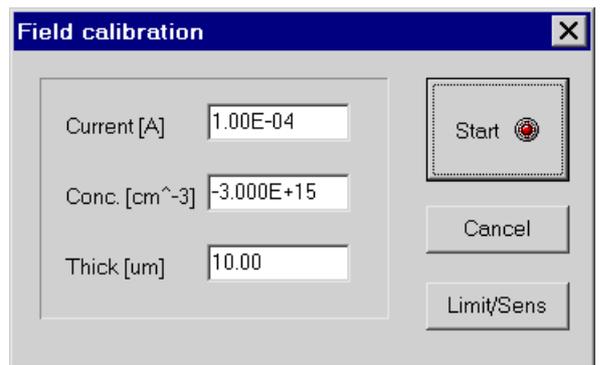
The inputs that have to be done depend from the reference sample. After Start is activated, the system is measuring the hall coefficient at negative and positive field and uses the known concentration for calculating the magnetic field itself**.** Then the program goes back to the previous window with the new fields.

**Note:** For negative resp. positive fields are only negative resp. positive input values available. If a calibration yields to the wrong sign, you get a warning. Look at the note of the end of the next chapter for the reasons.

## 4.2.3 Field calibration for electric magnet (RH 2030, RH 2010)

Use for this calibration the reference sample (delivered with the system) for the measurement. Put in the sample mounting with the correct side into the sample holder and the sample holder with the correct position into the magnet, see pictures in the hardware manual.

After selecting this routine, the following input window appears:
The inputs that have to be done depend from the reference sample. The values are listed on the back of the reference sample carrier.

**Current** means the measurement current, it should be **1.00E-4 A** for any of our reference samples.

**Conc.** means the carrier concentration of the reference sample listed at the back of it, for n-type you have to input negative values, for p-type positive. PhysTech's reference samples are always **n-type**.

**Thick** is the thickness of the layer, normally 10 um.

**Points** gives the number of data points that will be measured for the calibration curve. The value of 80 should only be enlarged, if the Hall coefficient of a sample should be measured in dependance of the magnetic field using more points than 80.

**Limit/Sens** is explained in chapter 3.2.1.2.

Activation of **only symmetric fields** repeats the calibration after the first run and takes for the negative and positive field the same absolute maximal value. After the next run negative and positive fields have the same absolute values. That gives more accuracy for the interpolation. The Hall measurement with many points uses as a standard 10 points. At 80 calibration points now the used negative and positive field points match the calibration table without interpolation.

After **Start** is activated, the system is measuring the Hall coefficient at different magnetic fields and uses the known concentration for calculating the magnetic field B itself. After the measurement has been finished, the final curve is shown and you can save the calibration by the green **'Apply'** button, see picture at the next page. If the measurement looks OK, it should be saved and the magnetic field has been calibrated now. If you leave by 'Cancel', the new calibration will not be saved and not be applied. The old calibration is then further valid.

The calibration will be done in the same order as a normal Hall measurement. First the measurement goes from 0 to the biggest negative voltage (negative field). Then the measurement goes from 0 the maximum positive voltage (positive field). Before each start at 0 the remanence will be deleted.

**Note:** The calibration of the magnet field has to be done every time the pole tips gap has been changed. It's normally not necessary to calibrate the magnetic field if the pole tips has not been changed after the last calibration.

The next picture shows the plot window after the calibration was done. The x-axis is the voltage set for the magnet field, the y-axis is the calculated magnet field.
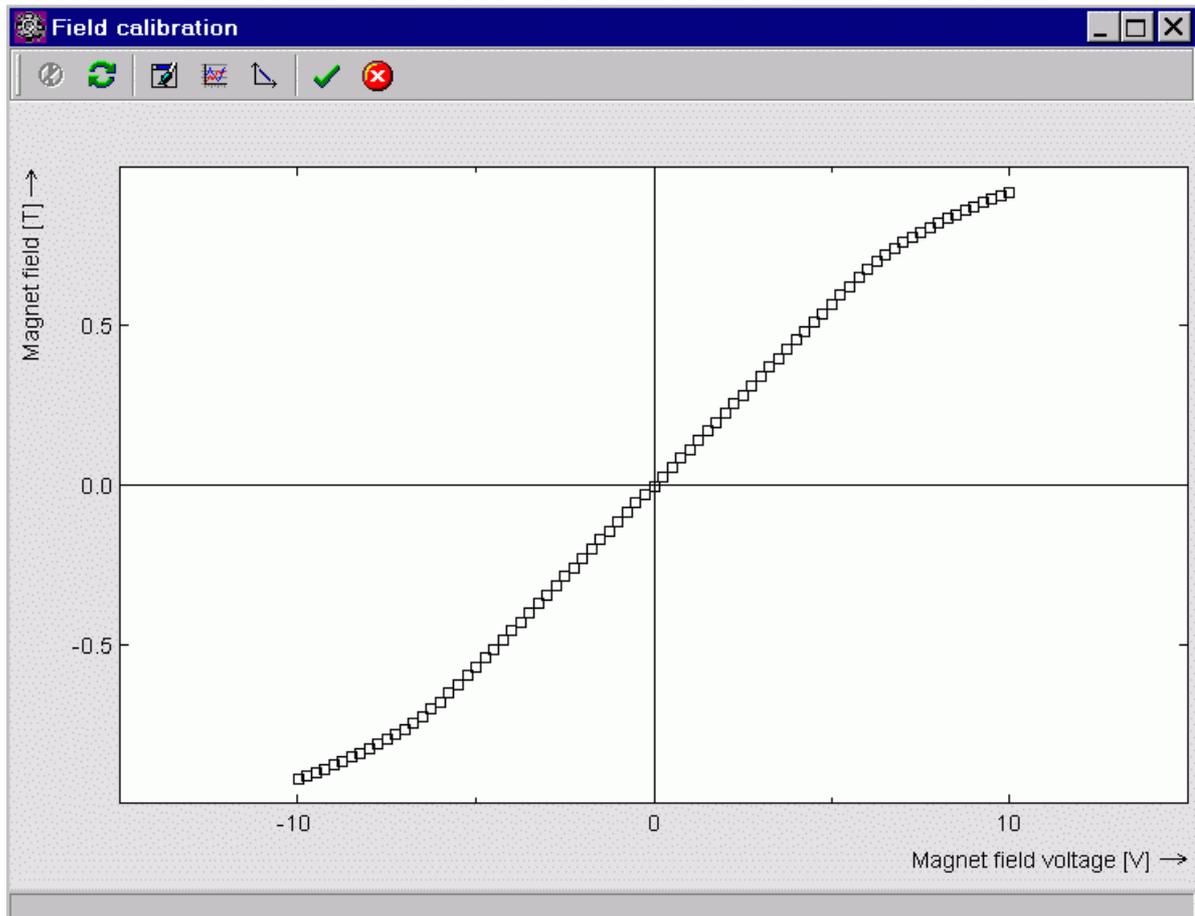


| | |
|---|---|
| ⊘ | **Break** the calibration, only enabled during measurement. |
| ⟳ | **Repeat** the calibration. |
| 🗒 | **Refresh** the plot. |
| 📈 | **Plot program** will be called for the current plot. |
| ⌐ | **Swap plot** between magnet field, resistance and F/Fmax*Umax/U. |
| ✓ | **Apply** and save new calibration curve. |
| ✖ | **Cancel** calibration. |

In the explanation above is F the magnetic field, Fmax the maximal magnetic field, U the magnet field voltage and Umax the maximal magnet field voltage.

**Note:** Following must be fulfilled: Negative voltages give negative fields, positive voltages give positive fields. In the other case there is a mistake. The reason is either the wrong sign for the concentration, the wrong position of the sample holder in the magnet or a mis-match of the cables to the sample holder. Please look for this in the hardware manual.

## 4.2.4 Offset voltage

This calibration here is not a hardware calibration as in 'System'. It is only a software calibration or correction. This voltage offset will be subtracted from the measured voltage. An offset does not affect van der Pauw or Hall results, the offset correction gives only a visual better **Zero** of the V/I curves.
No calibration file for the voltage offset exists after installation. So you should do this calibration after software installation when the hardware has been warmed up. Normally it is not necessary to repeat this calibration.

Depending on you measurement system 2 kinds of offset **corrections** are possible:
1. Correction by **one offset** value for all amplifications.
2. Correction by **separate offsets** for each amplification of the voltage amplifier.

The input called 'Separate for each amplification' defines which correction will be used:

**A) no, one offset for all:**
Uses always calibration 1.

**B) at hardware compensation:**
Uses calibration 2 at the compensation mode 'hardware', otherwise calibration 1.

**C) always amplification specific:**
Uses always calibration 2. Select this mode because it is the best.



The type of calibration and the inputs depend on the selected mode:

**Mode A:** Use for this calibration our reference sample as for the field calibration, select for the current 1.0E-4 A. After clicking onto the 'Calib' button the measurement starts. 2 V/I points with opposite current sign will be measured and the offset will be calculated by interpolation to current 0. Then this value will be shown in an input field.

**Mode B:** Uses Mode A and C.

**Mode C:** This calibration needs no sample, the offsets will be measured directly with an open matrix. 2 different types of amplifiers (measure- and pre-amplifier) with each 3 amplifications exist. All 9 combinations of offsets will be measured and shown in a data grid. You can edit these data.

Only if you leave the input window with 'OK', the offsets will be applied and saved into the voltage calibration file.

**Note:** Normally the offset is only a 'visual' disadvantage. The resistance will be calculated from a voltage difference or from the slope of a V/I curve. A fix voltage offset has here no effect. If the amplification changes during a V/I curve, the offset is not fix. But the offset changes during a V/I curve are normally very small compared to the absolute voltage. This is not valid for the hardware compensation. The different offsets can here yield to a smaller sensitivity. So use here correction mode 2. Here it can also be helpful to repeat the offset calibration before a very sensitive measurement with hardware compensation.

# 5. Common program modules

Depending on the kind of work which you do in the main program modules you can call further common program modules (tools), so different plot programs, list programs and the database. These tools will be explained in the following chapters.

Program tools have his own sub window with menu bar and toolbar. The plot or list will not shown on the main canvas but on the canvas of the sub window.
Normally this window will be shown under the caption line of the main window or as a kind window, see chapter 2.3.1.
The 'Exit' entry at the file menu was replaced by 'Close'. By 'Close' you don't exit the main program but you close only the program tool and go back to the measurement or previous program. The same will be done by clicking onto the additional 'Close' button in the toolbar.

If calling a function of another common program module the current window will be replaced by the window of the called program module (tool). So only one sub window is visible, dialogs not considered.

# 5.1 Standard plot program

The most used common program module is the Standard Plot Program. If you select a plot or an evaluation the program shows this plot normally by the standard or application plot program. In the standard plot program you can change the axis of the plot window, the plot symbol, the linear regression (if possible) and so on.
Many parameters in this plot program are only local, this means if leaving and entering again this program tool then these parameters will be set to the default ones. The global plot parameters are an exception, see chapter 2.3.3.
Some options are not enabled if more than one curve will be shown. The 'plot software option' is necessary for some functions, e.g. for the Tools menu.
This plot program has no own data type. You can also here open the measurement data without leaving the plot program.
Which menu entries and tool buttons are visible and enabled, depend on the kind of data.
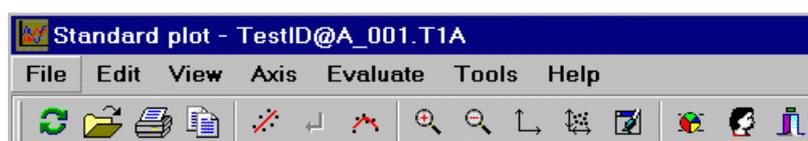
The following buttons of the **toolbar**, except for the regression, are visible in most cases:

**Repeat** the inputs of plot.

**Open** a measurement data file.

**Print** the plot on a printer.

**Copy page** to clipboard.

**Linear regression**, sets start and end value by mouse and calculate regression.

**Apply** the selected plot and so on, for example for the linear regression.

**Interpolate** plot points by a line.

**Zoom-in** the plot window.

**Zoom-out** the plot window.

**Axis** input parameters for the plot window.

**Axis rescale** to the standard window.

**Refresh** the plot**.**

Call the **Presentation plot program.**

**User button** is a user definable button, see chapter 2.3.4.

**Close** the standard plot program and goes back to the previous program.

The following buttons only visible in special cases:

Shows **Next** file or data point.

**Data tasks** for saving and printing data, save evaluation to database.

Current **level number**, toggles between first and last level by mouse click.

Following **shortcuts** exist for the menu, but not all are always possible:

| | |
|---|---|
| **F1:** | Help information, opens this manual at the corresponding chapter. |
| **F2:** | Repeats the inputs of plot. |
| **F5:** | Refresh the plot. |
| **F7:** | Calls the library. |
| **F8:** | (Automatic) linear regression, sets start and end value by mouse. |
| **Ctrl+F8:** | Starts the manual linear regression. |
| **F11:** | Personal hot key 1, see chapter 2.3.4. |
| **F12:** | Personal hot key 2, see chapter 2.3.4. |
| **Ctrl+C:** | Copy page to clipboard in the bitmap format. |
| **Ctrl+O:** | Opens a measurement data file. |
| **Ctrl+P:** | Print the plot. |
| **Ctrl+S:** | Save the current measurement data. |
| **Ctrl+V:** | Paste a bitmap graphic from the clipboard. |
| **Enter:** | Apply the selected plot and so on, as Apply button. |
| **PageUp:** | Shows previous file or data point. |
| **PageDown:** | Shows next file or data point. |
| **Alt+F4:** | Close the standard plot program. |

## 5.1.1 File menu

The standard plot program has no own data type. If coming from a measurement or sub program, you can also here read the (measurement) data and show the last selected plot. It is not necessary to leave the plot program, read the measurement data and then to call the plot program again. For this option you must have read measurement data or saved the last measurement. If not saving the last measurement, you can here save these data. If not saving data or if an evaluation is possible, then here the Data task entry is visible. Several tasks, so saving and printing the data and saving evaluation values into the database, can here done.

Save ASCII data saves the current x,y plot values line by line in an ASCII format to a text file. This option is only enabled if one curve will be shown. You can define the delimiter and the exponential format in the ASCII parameters of the Tools menu. Print opens a dialog for printing the plot. If installed a HPGL printer (I3.2) then here is a special entry for its use. By 'Close' the standard plot program will be closed and the software goes back to the previous program.

**Programs** opens a sub menu for further program tools. If calling one of these tools the software jumps to this tool and don't come back to the standard plot program. If closing this tool, the software goes back to the previous program module, normally one of the measurement or sub programs. If more than one curve will be shown, only the presentation plot program is enabled.

ListData lists the data in a grid, image or ASCII editor (chapter 5.4)
EditData enables to edit the x/y-data in a grid or ASCII editor (5.4)
EditPlot enables to change, read and plot the x/y-data (5.3.2)
CompPlot compares in a plot the current data with saved data (5.3.6)
PresPlot opens a new complex plot program with many features (5.2)

The presentation plot program is here the perhaps most important program tool. It gives the possibility to show curves of (manually loaded) different files. You can also show different plots (layers) in one picture. There you can also save the full picture without a graphic format.

If showing curve by curve from many data points or files (e.g. I/V curves at many temperatures), a **Next datas** sub menu exist for navigating to next or previous data or to input the data number, for more information see chapter 5.1.7.1.

### 5.1.1.1 Save graphic

Save graphic opens a sub menu for saving the plot in a graphic file format. Bitmap and vector formats exist: BMP, PCX, GIF, JPEG; PLT, HPGL, WMF / EMF, EPS, ACAD. Before saving you get a special dialog for some parameters and the standard Windows dialog for saving data. For saving into the PDF format use a virtual PDF printer.

**Tip:** WMF or EMF is the standard format for saving plots. If you need a bitmap format use GIF. The JPEG format is not suitable for plots.

#### 5.1.1.1.1 Bitmap formats

Depending on the bitmap graphic format (BMP, PCX, GIF, JPEG) you get similar inputs. The following input is for the BMP format. For PCX and JPEG files you can select the compression.

The enabled inputs depend on the **Size mode:**
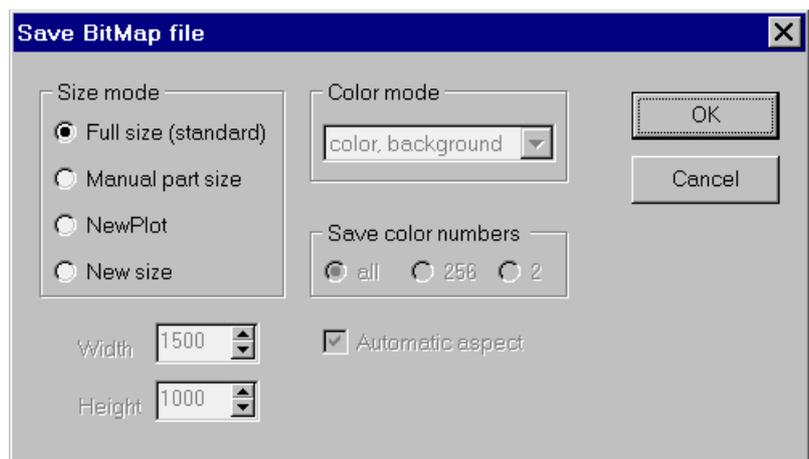
| | |
|---|---|
| **Full size:** | This is the standard mode. The graphic will be saved as shown on the screen. |
| **Manual part size:** | You can select a part of the plot by the mouse. |
| **NewPlot:** | You can select the color mode and the saved color numbers. |
| **New size:** | You can select a new pixel size and the color mode. At activating 'Automatic aspect' is only the input of width necessary. |

The **color mode** defines the background color and the use of a color plot:

| | |
|---|---|
| **mono, white lines:** | Monochrome plot with white lines and symbols. |
| **mono, black lines:** | Monochrome plot with black lines and symbols. |
| **256 grey scales:** | 256 grey scales, no background color. |
| **color, transparent:** | Color plot, transparent background. |
| **color, no background:** | Color plot, no background color (white background). |
| **color, background:** | Color plot, background is as on the screen, including the special background inside the plot window. |

**Save color numbers** defines the numbers of colors: 2, 256 or all.
If the data were interpolated then there is the additional input **Print data** (chapter 2.2.4).

## 5.1.1.1.2 Vector formats

At PLT and HPGL you get similar input windows as for printing, see chapter 2.2.4.
At **Windows meta files** you can select the color mode and between Aldus (WMF) and Enhanced (EMF) meta file. The EMF format is the newer and better one. If possible use this format for saving vector graphics.
Only monochrome ACAD files are possible.

## 5.1.1.1.3 EPS format

The EPS (**E**ncapsulated **P**ost **S**cript) format is also a vector graphic:

The color mode is as above but without the transparent mode.
The values for size and positions (coordinates) can be saved in the file as integers or as real numbers.
A factor can be defined for the thickness of lines.

For the **scaling** from plot coordinates or sizes to the values in the EPS file there are 3 possibilities:
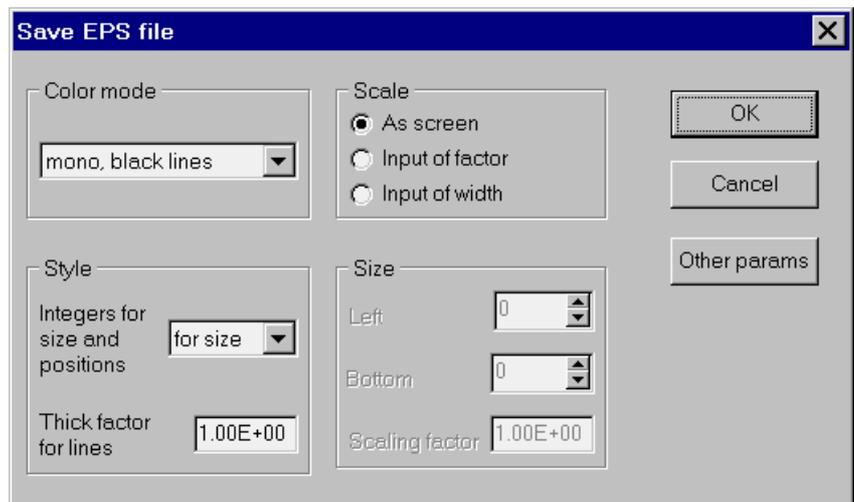


| | |
|---|---|
| **As screen:** | The same values as for the screen will be used. |
| **Input of factor:** | All plot positions, sizes and so on will be multiplied with a user defined scaling factor. For the plot positions there can be defined a left (x) and a bottom (y) offset. |
| **Input of width:** | All plot positions and sizes will be scaled to a given maximum width. For the positions there can be defined a left (x) and a bottom (y) offset. |

**Other params** opens a new input window which will be used in similar way also for the printer and other graphic formats:

The used fonts can make problems if using an EPS file with another program like Ghost-Script. Most PostScript interpreter don't know the Windows fonts Courier New, New Times Roman or Arial. Some EPS interpreters break then the plot, some ones give a warning, others ones go on without a warning. If the interpreter don't break but don't know the used font, it will replace this font by another one. The size of this font can be different as the original in Windows used one. Then positions and style of the text may be bad, especially at right centering text because this centering needs the exact text length.

Normally you use for the **font mode** 'As font input', that means for the EPS file the same fonts will be used as for the screen. You can also select a fix or a proportional Windows font for all used fonts. The vector fonts are old fonts and should only be used if absolute necessary.

**Tab. pos avail** means where a tabulator for EPS is available if there is a tabulator in the text. After a tabulator the text will be broken. For the start of the text after the tabulator a new x-position will be calculated by a medium character width. So you can center a text for a table. The tabulator is only helpful at proportional fonts (variable character width), for fix fonts (fix character width) as Courier New this is not necessary.
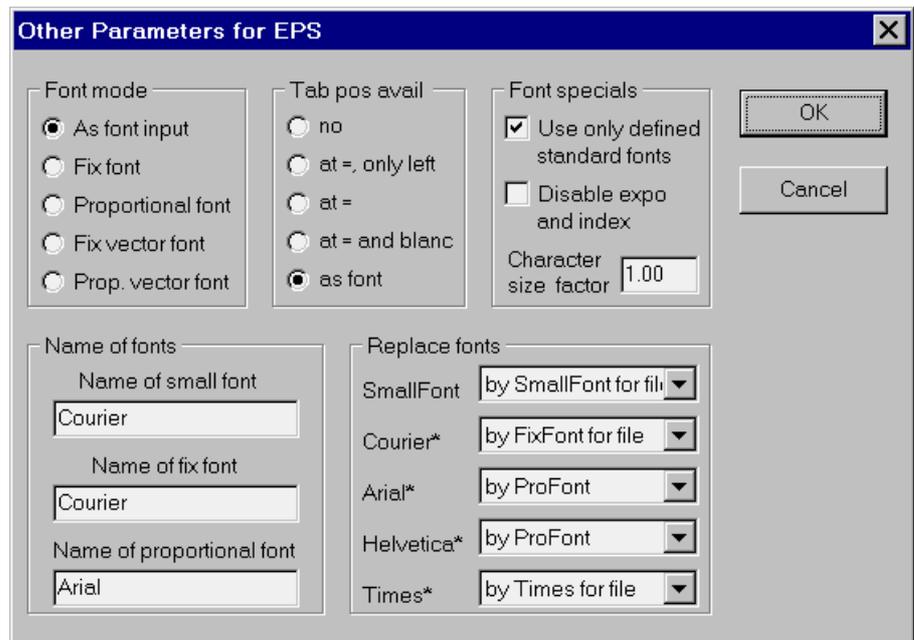
The modes for the available **tabulator** positions are:

| | |
|---|---|
| **no:** | Don't use tabulators. |
| **at =, only left:** | At a '=' is a tabulator available, the new text position starts directly at the '=' sign. |
| **at =:** | At a '=' is a tabulator available, blanks directly after the '=' sign will be treated as a tabulator. |
| **at = and blank:** | At a '=' and every ' ' is a tabulator available. |
| **as font:** | The tabulator is available as defined for the used font (chapter 2.3.3). |

To avoid the EPS font problems discussed above there is the option to **use only defined standard fonts**. If activating this option then you can define the files using for the EPS file. The 3 font names at the left bottom window part are the names for the standard small, fix and proportional font in the EPS file. Use only fonts which your EPS interpreter knows!
At the bottom right window part there are the names and modes of Windows fonts which you will be replaced by the EPS standard fonts. 'Courier*' means all font names which contain the string 'Courier', for example Courier New.

Following modes exist for 'Arial*', other inputs are similar:

| | |
|---|---|
| **no:** | No replacement of the 'Arial*' fonts. |
| **by Arial:** | The font name will be replaced by 'Arial'. |
| **by ProFont:** | The font name will be replaced by the name of proportional font. |
| **by Arial for file:** | As above, but only valid for saving into a file. |
| **by ProFont for file:** | As above, but only valid for saving into a file. |

**Note:** At EPS there is no difference between the mode 'only valid for saving into a file' and the other mode because EPS is only possible for saving into a file. At HPGL it is also possible to send the graphic directly to a HPGL printer.

At the **font specials** input there are some other options. So you can disable exponent and index in the text. The character size for the fonts can be multiplied with a factor. This can be helpful if the EPS interpreter replaces unknown fonts by unfavorable standard fonts.

## 5.1.2 Edit menu

By the edit menu it is possible to copy a graphic or the data into the Windows clipboard.



'Copy page' copies the graphic as a bitmap into the clipboard, 'Copy graphic' as a Windows meta file (WMF or EMF). 'Copy ASCII data' copies the current x,y plot values line by line in an ASCII format, only enabled at one curve. 'Copy select' asks for the format before copying. 'Paste' shows a bitmap graphic from the clipboard on a definable position of the screen.

### 5.1.2.1 Copy select

Some different types of **copy modes** exist:
1. Bitmap graphics
    1. BitMap BMP, full page as on the screen
    2. BitMap BMP, part of the plot defined by the mouse
    3. GIF
    4. JPEG
2. Vector graphics
    1. Windows meta file, WMF (Aldus) or EMF (Enhanced) selectable
    2. HPGL / PLT
    3. Postscript EPS
3. ASCII data, only enabled if one curve is been shown
    1. as CSV (comma separated values)
    2. normal ASCII data, special column delimiter
    3. ASCII data as text with data number and caption
4. Plot header as text

Separate **ASCII column delimiters** exist for clipboard data and clipboard text. Following delimiters are possible: blank, double blank, comma, semicolon, tab, &, ";", "tab", cr, lf, cr+lf. Many programs use a blank or a comma as a separator, Excel uses the tabulator character, DBase the semicolon. The ASCII data will be saved in the exponential format, you can define the numbers behind the point.
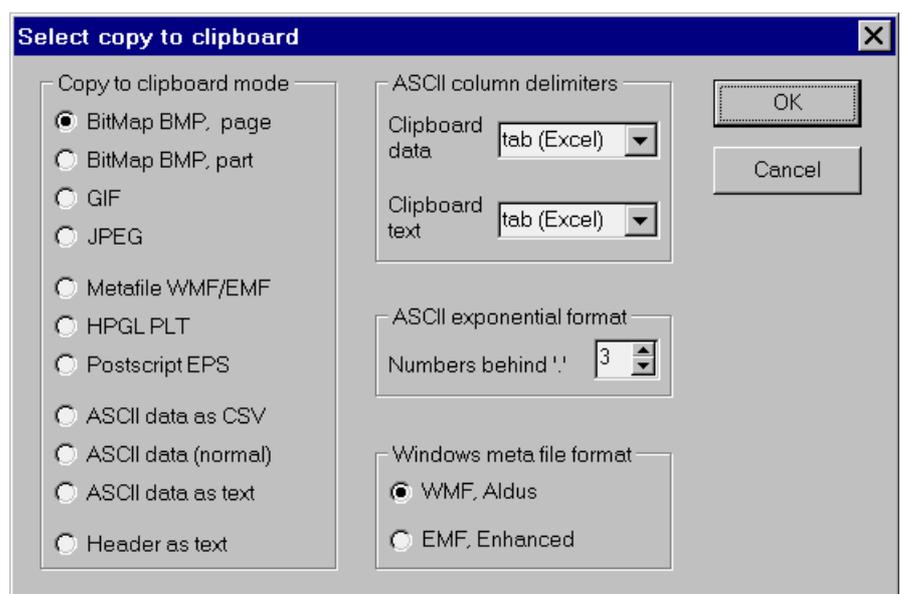
## 5.1.3 View menu

In the view menu you can set the window and canvas size, curve and global plot parameters and personal short cuts.

'Curve params' are the local params for the shown curve. 'Global plot params' were already explained in chapter 2.3.3.
If different curves will be explained then you can change the default explain position.
'Init plot' makes a new window/axis initialization, 'Refresh' plots the plot again.
'Interpolation' opens a input window as described in chapter 2.7.1.
'Personal hot keys' and 'New size' were already explained in chapter 2.2.4 and 2.2.5.
'New canvas' defines manually the canvas size instead to set it from the form size. The inputs are similar to 'New size'.

### 5.1.3.1 Curve params

#### 5.1.3.1.1 One curve

If only **one curve** was shown in the plot then the following input window opens. All these parameters are only local, this means if leaving and entering again this plot program then these parameters will be set to the default ones.

Following **symbols** are available:
1. Square
2. Cross +
3. Diamond
4. Cross x
5. Triangle
6. Circle
7. Full square
8. Full circle
9. 3x3 points
10. Point
11. Line
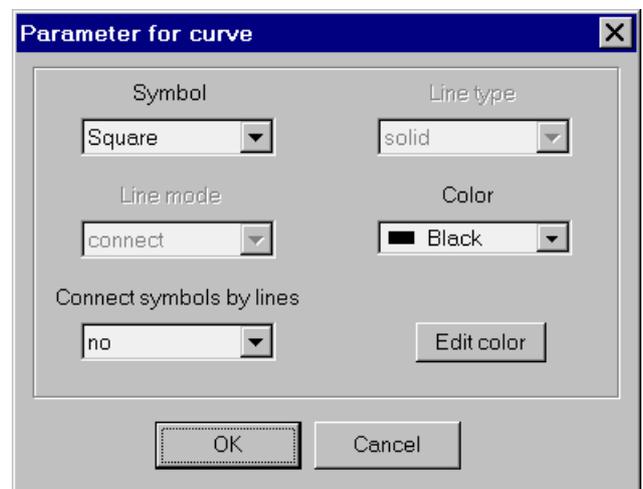
If selecting the line then you can set the **line mode**, for an explanation see below:
1. connect
2. connect + clipping
3. interpolation
4. interpolation + clipping
5. approximation
6. approximation + clipping
7. medium approximation
8. medium approximation + clipping
9. approximation by cubic Bezier curves
10. vertical line to the window minimum
11. vertical line $\rightarrow$ 0

Following **line types** are available: solid, dash, dot, dash-dot, dash-dot-dot.

Following **connecting modes** are possible if the selected symbol is not the line:

| | |
|---|---|
| **no:** | The points (symbols) will not be connected by lines. |
| **connect:** | The points (symbols) will be connected by lines, no interpolation or approximation will be done. |
| **connect + clip:** | As above but the lines will be clipped. Clipping of lines means that if a point (symbol) is outside the plot window then the line will be drawn to the plot window and at the window cut off. In the other case only the visible points inside the plot window will be directly connected. |
| **interpol:** | The points will be connected by interpolated lines. The interpolation for the connection line will be done by splines without smoothing. |
| **interpol + clip:** | As above but the lines will be clipped. |
| **approx:** | The points will be connected by interpolated smoothed lines. The interpolation will be done by splines with weak smoothing strength 45. |
| **approx + clip:** | As above but the lines will be clipped. |
| **medium approx:** | The points will be connected by interpolated smoothed lines. The interpolation will be done with medium smoothing strength 50. |
| **medium + clip:** | As above but the lines will be clipped. |
| **cubic Bezier:** | The points will be connected by interpolated slightly smoothed lines using cubic Bezier curves. |

At **color** you can select one of the standard colors as listed at the right. If the old selected value was not a standard color then this color will be listed in the standard color dialog as 'Other'. The **Edit color** button opens the Windows dialog for editing the color. There you can select all possible colors.

### 5.1.3.1.2 Some curves

If **some curves** were shown in the plot then the following input window opens:

If activating a flag then the symbols will be **connected** as default defined. In the other case you can select the connecting mode for all curves as described in chapter 2.7.2. These inputs here are local.

The **symbols** and **colors** for each curve can not be local defined. For these the symbols and colors for curve 1 to 6 of the global plot parameters will be used, see chapter 2.3.3.1 and 2.3.3.2.
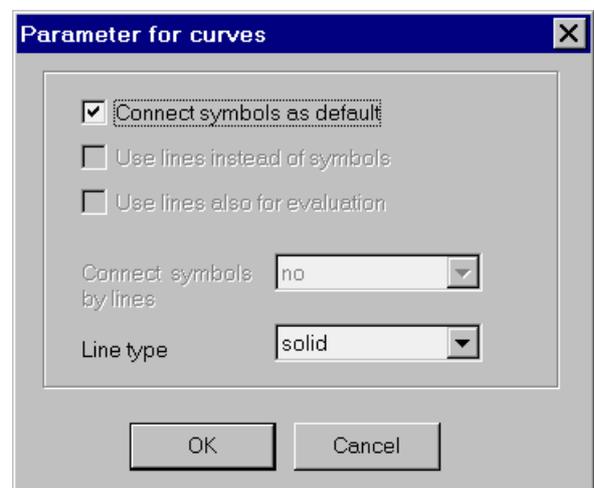
## 5.1.4 Axis menu

This menu enables to set the axis of the plot and a new plot window. This can be done by an input, by the mouse or by the zoom function.



'Axis input' opens an input window for the x,y-axis parameters.
'Axis mark' enables to set a new plot window by marking the left/bottom and right/top point. You can define points inside of the plot window (zoom) or outside, but the defined points must be inside of the canvas.
'Axis rescale' restores the standard plot window.
'Zoom in, out and undo' are the standard zoom functions. For zooming-in you have to mark the center point by the mouse.

### 5.1.4.1 Axis input

Separate input sheets exist for the x- and y-axis, at 3-dimensional plots additionally for the z-axis. In the following only the inputs for the y-axis will be explained.

#### 5.1.4.1.1 Window input sheet

The **Window values** input group contains the inputs for the minimum, maximum and delta value of the axis. The numbers of intervals (axis ticks) will be set by the delta value.
The x/y data are always in the base dimensions (see chapter 1.3.5), for example V for the voltage. Nevertheless it is possible to show the axis as mV. The **factor for numbers** is for this use. In the example of mV the factor must be set to 1000, then all numbers at the axis will be multiplied



with this factor. But the inputs for the window values must be in the original dimension V.

**Text** is the axis caption text, it can contain characters for index ($_) and exponent ($^). For the end of the index text use $^.

The **numbers format** for the axis numbers can be decimal (1.23), exponential (1.23E+00) or short exponential (1.23E0). You can define the total numbers and the numbers behind the point.
If the **axis style** is linear, no change is possible in the standard plot program. Is it logarithmic, then you can select between logarithmic text, for example log. voltage, and logarithmic axis ticks.

**5.1.4.1.2 Axis input sheet**

The window around the plot will be defined by **Axis line and numbers.** If selecting bottom and top for x-axis and left and right for y-axis then a full window will be drawn around the plot and on the bottom and left axis line there is the numbers and axis text. 'Additional at x=0' is as left and right, and draws a vertical line at x=0. You can also select the kind of **axis ticks**. Left and right means that the ticks are inside of the left and right axis line. Other possibilities are left inside or outside of the axis line, or grid lines.
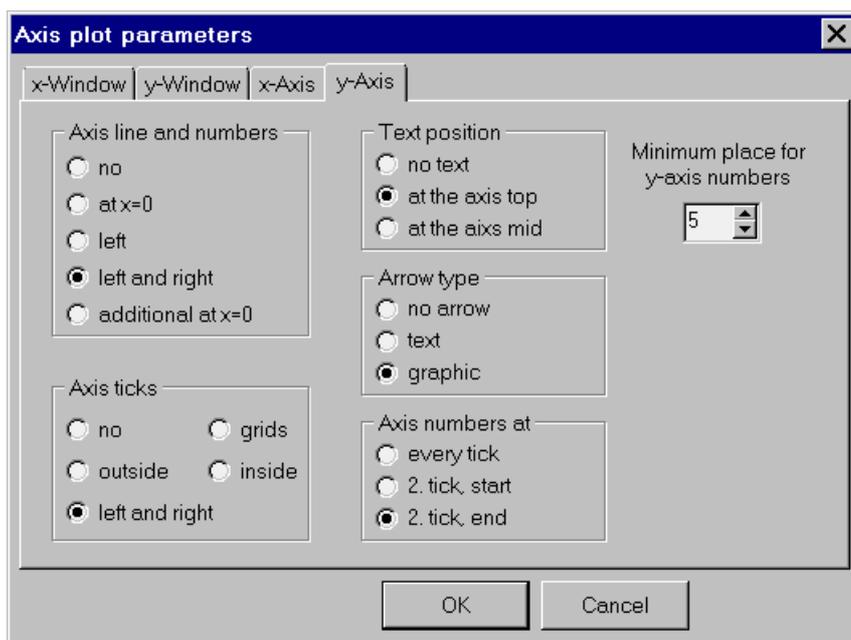
**Text position** defines the position of the axis text.
Top means that the y-axis ends at the top line.
The **arrow type** behind the axis text is only a text string or a graphic arrow.
**Axis numbers at** defines when at the axis the number will be printed. It can be done at every tick or every 2. tick. At start/end means that there is at the first/last tick a number.

For the y-axis there is also the input of the **Minimum place for y-axis numbers**. This means that software reserves the place for the selected numbers. This shifts the left axis line and change the size of the plot. This can be important if you compare different plots on a paper.

## 5.1.5 Evaluate menu

The possibilities of this menu depend on the kind of data. An evaluation by a linear regression is not always available. To apply the evaluation in the evaluation database (EvalBank) is only possible if an evaluation is available and was done. In some cases you can list the evaluation results in a special data grid or text window.

'Auto regression' is the standard linear regression, the 'Manual regression' can be started directly and with inputs of its parameters.
You can also delete a done linear regression. Then no regression line and no results will be shown.
If there are more levels available then in the Evaluate menu is the entry 'Level number' to set the current level number for the regression. In the toolbar you can then also see and change the current level number. A mouse click onto the level number button in the toolbar toggles between first and last level. Instead of 'Delete regression' the entry 'Delete level' exist which deletes only the evaluation/regression of the current level.

If calling the library or the fit, then the curve or evaluation will be compared with other curves coming from the library or the fit function. Have a look in the corresponding chapters for these functions. Library and fit are only available for special plots/evaluations of the DLTS software. The shown fit or library will be denoted by a hook left on the menu. To clear this function call it again and click onto the Cancel button in the input window. 'Save eval as file' exist sometimes to save the plot curve into a measurement data file.

### 5.1.5.1 Auto regression

Auto regression is the standard linear regression, sometimes it will be called only regression. You have to set the **x-start** and **x-end** value of the range, which are used for the linear regression, by mouse or vertical marker (marking line). Left and right cursor keys move the marker slowly along the x-axis to the left resp. right, Up and Down move it in big steps to the left resp. right. The regression-start resp. -end value will be shown in the status line during the movement. The arrow in the marker denotes that the start or end value have to be set. Instead a new definition of start and end value you can apply the old (predefined) values by the 'Enter' key or button.
After setting the right point (end value) the evaluation results will be calculated again and then drawn by a straight line and shown in the text header or evaluation data grid. The old result text will be deleted but not the old regression lines. So you can compare the influence of different regression ranges. For deleting the old lines refresh the plot.

At the application plot the regression will be **done automatically** at calling the plot. In this case the regression line is normally red instead of black. You can change the color of the regression line in 'Global plot parameters', see chapter 2.3.3.1. The (red) regression line of the application plot program will there be called 'Application regression', the other (black) 'Standard regression'.

The **correlation** factor provides an indication of the deviation of the data from the regression. But be careful with the interpretation because the correlation factor is not very sensitive. You find a value of 0.99 in many cases.

The following picture shows an example for the auto linear regression:
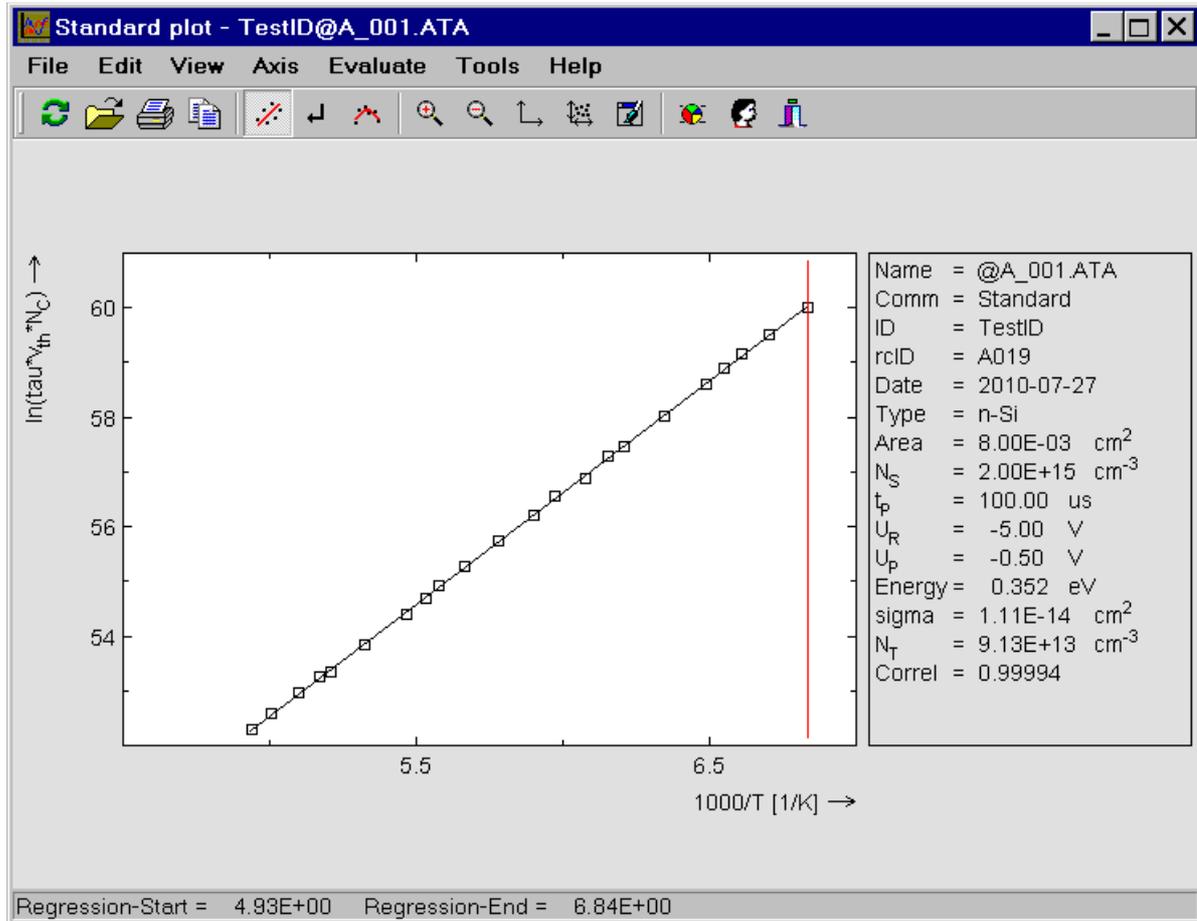


## 5.1.5.2 Manual regression

For the manual regression you have to set the x/y-start (left) and -end (right) point by mouse or cross marker (see chapter 5.1.6.5). How this option works, depends on the following parameters:

For all modes is valid that only plot/data points will be used for the linear regression which x-values are inside the selected x-range.
The first mode is '**Set xy-range for regression**'. If not activated 'Mark range' then only points will be used which y-values deviate less as a given maximum difference from a line calculated by the x/y-start and end value. For the maximum difference you have to input the per cent y-window range. If activating '**Mark regression line**' then you have not to input a value but to define a 3. point for the maximum y-difference.
To use the plot instead the data array is normally not necessary.
In the first manual regression mode only the used points for the linear regression will be selected. The calculation of the linear regression and so the drawn line will be done in the normal way.
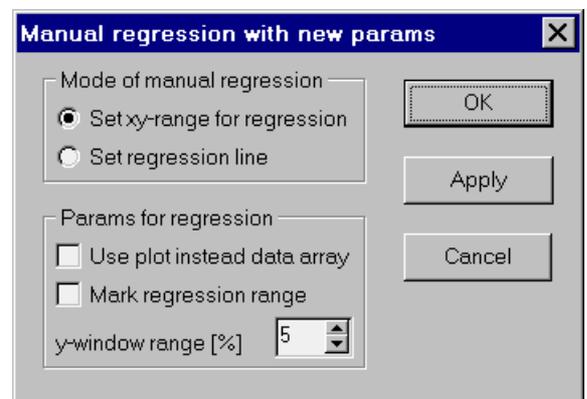
The second mode is '**Set regression line**'. In this case you define directly the line by the left and right point. This means the 'regression line' goes through these 2 points. No linear regression will be calculated for the line and results. The results will be calculated from the slope and offset of the defined line. Normally no correlation factor will be calculated and shown in the text. It is also possible to show 1.0 for the correlation value, see chapter 2.3.3.6. Another option is to activate the flag '**Calculate correlation factor**'. Then the correlation factor will be calculated from the given line and all data which x-values are inside the selected x-range.

In special cases there is an input for selecting the **NT value**. NT will not be calculated from the x/y values in the plot program but by special values of the main program! NT can be calculated by the average of all points of the used regression range, or by marking a point and searching of the corresponding NT value.

**Note:** The manual regression can be necessary at using many levels. If levels overlap in the x-axis then you can not separate the levels for the linear regression by setting x-start and x-end point. It is possible that you make the linear regression about the data of 2 'real' levels. Setting the x/y-start and the x/y-end point solves this problem.

The **menu** entry 'Manual regression' starts directly this regression, the entry 'Params for ManuRegress' opens the input window with the parameters. The 'Apply' button there applies only the inputs, the 'OK' button starts additionally the manual regression.

The following picture shows the manual regression with the mode 'Set regression line':
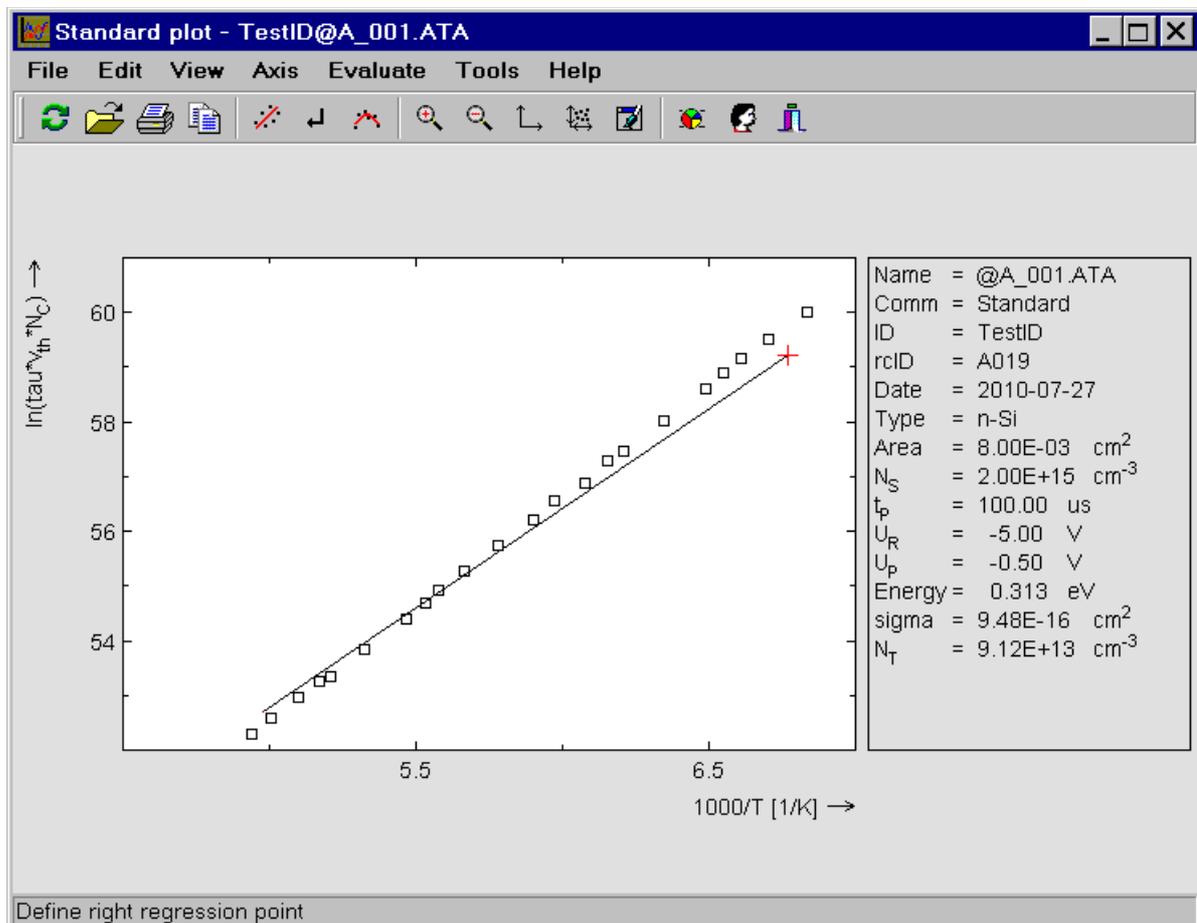
### 5.1.5.3 Apply to EvalBank

You can save the evaluation results in the **evaluation database**.
If the evaluation gives a sample parameter likes Ns, it can be applied as sample parameter and for the simulation.
If the evaluation was already saved in the database, you get the question, whether you want to delete the existing record.
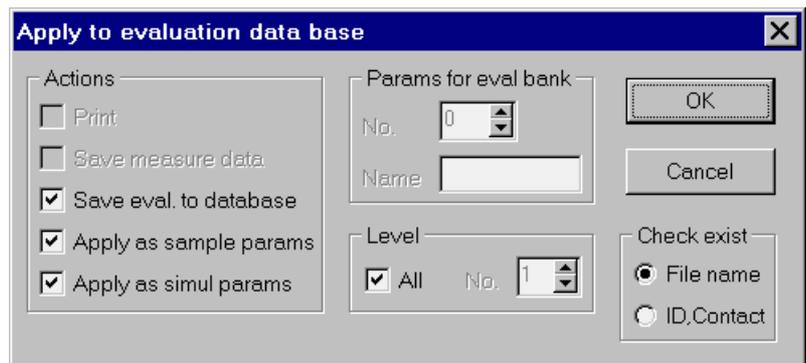
If saving Arrhenius data in the evaluation database a selection of **level** is possible.
At some evaluations and deactivating 'All levels' you can define a **number** and **name** of evaluation. The name is only for searching in the database (eval bank). The number is only for an easier comparison of results in the database. So you can restrict at the database your search of results by selection of an evaluation number.

'**Apply as sample params**' applies the results into the sample parameter set.
'**Apply as simul params**' applies the results as simulation parameters. When 'all levels' is activated, the number of levels will also be defined.

**Check exist** search if the new **file name** or the **ID and contact** already exist in the database.


### 5.1.5.4 List results

In some cases you can list the evaluation results in a special data grid or text window. It is a non-modal window which may not be closed by an 'OK' or 'Cancel' button. This window will be closed at leaving the plot program or by a refresh of the plot. It can be separately moved on the screen, the program saves its position for the next call. If you click onto the left top icon of this window you get additionally to the standard Windows menu entries 'Minimize, Close ...' some special options.

An example will be shown on the right. For this text window the following additional options exist:
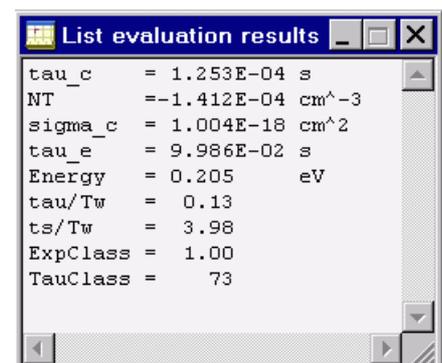
'StayOnTop' means that this window is visible in front of all other windows.
'Font' enables the selection of the text font and size.
'Copy' copies the text into the Windows clipboard.
'Editor' calls the integrated ASCII editor with the evaluation text.
'Image' calls the List Image program.

If activating 'StayOnTop' then this window will not be closed at refreshing the plot. So it stays during the total plot program until you close it explicitly or leave the plot program. You can also mark the text and then copy it into the clipboard by the Ctrl-C key.

## 5.1.6 Tools menu

This menu contains some different functions.

User class was already explained in chapter 2.4.1.
ASCII parameters contains parameters for copying, saving and reading ASCII data.
List data lists the x/y-data as lines and columns.
Compare data compares the current data with other ones from an ASCII file or clipboard.
It is possible to create an extra window with a plot or data grid of the current data.
Marker tools are a help to identify a point or get its position.

At **user class 5** there are ActiveX/OLE tools. ChartFX is a chart plot program, Formula One a spread sheet. You can call Excel (Microsoft) or Calc (OpenOffice) with the current data or save into the Excel or Calc format.

### 5.1.6.1 ASCII parameters

The parameters for copying, saving and reading ASCII data are in this input window.

The first input group contains the **ASCII column delimiters**, following delimiters are possible: blank, double blank, comma, semicolon, tab, &, ";", "tab", cr, lf, cr+lf.
Many programs use a blank or a comma as a separator, Excel uses the tabulator character, DBase the semicolon,Tex/ Latex the "&" sign.
At reading ASCII data/text there is the possibility 'auto search' and 'auto all'.
The first mode takes the first valid delimiter as delimiter for all columns, the second mode accepts all valid delimiters for every column.

Different **delimiter inputs** exist for:
1. Save ASCII data into a file.
2. Save ASCII data into the Windows clipboard.
3. Save ASCII text into a file or into the clipboard.
4. ASCII data or text to the editor or from the editor.
5. Read ASCII data from a file or from the clipboard.
6. Read ASCII text from a file or from the clipboard.
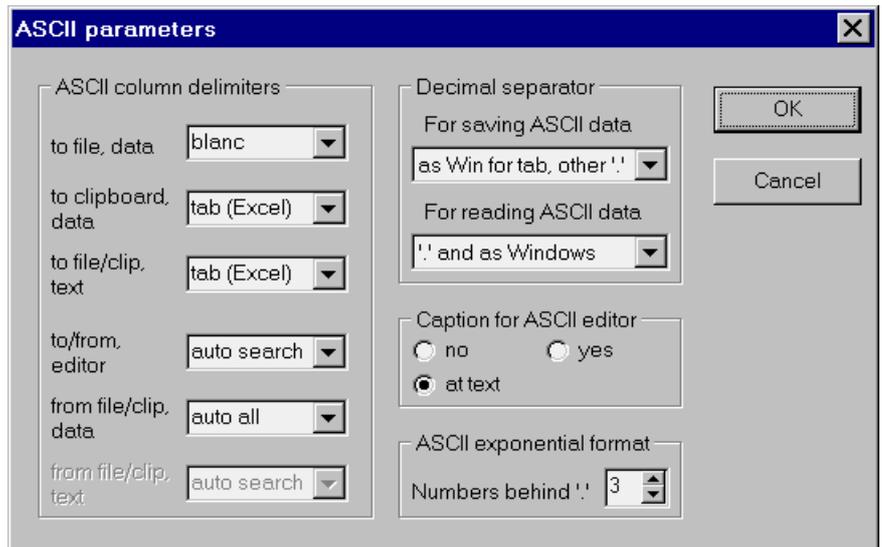
There is no big difference in ASCII data or text. ASCII text contains as first line the caption for x and y. Normally ASCII data will be used.

The **decimal separator** can be selected for saving and reading ASCII data. This separator can be the point (standard English) or that one defined in the Windows operating system. At saving ASCII data there is the option: **as Win for tab, other "."**. This option means if the column delimiter is a tab, then the decimal separator is as in Windows defined, in other cases it is a point. This can be helpful when copying to Excel with local country definitions. At reading ASCII data there is the option: **"." and as Windows**. This option means the point and the decimal separator as in Windows defined will be accepted.

**Caption for ASCII editor** means when using the internal ASCII editor, the first line contains the caption for x and y. The caption is available only for ASCII text or for text and data (yes).

The ASCII data will be saved in the exponential format, you can define the **numbers** behind the point. **Leading blanks** can be deleted but then negative and positive values have different lengths. While this doesn't lead to a nice structure, it may be necessary for foreign programs when using a blank as delimiter. The mode 'auto' deletes leading blanks only at saving data into a file or clipboard if the delimiter is a blank.

### 5.1.6.2 List data

List data lists the x/y-data as lines and columns. Three kinds of view here are possible: the data grid, the image without and with header and the ASCII editor, for more details see chapter 5.4. In opposite to the call of the ListData program in the sub menu 'File → Programs' here the software comes back to the plot program.
If only one curve will be shown, that means only x and y data exist, the program jumps directly to the last used kind of ListData program.

If **some** (many) **curves** exist, that means more than one y data column, you get the following information:

At some curves it can be that the curves have similar but not the same x-values. But in the data list is only one x-array possible. So the software reduce and interpolate all arrays to the same x-axis. This is the first x-axis and takes into account the range of the other x-axis. If all have the same x-axis then the interpolation gives the original x-and y-values because the data will not be smoothed. For more information see Note in chapter 2.2.2.
Only one x-array and maximal 6 y-arrays can be listed.
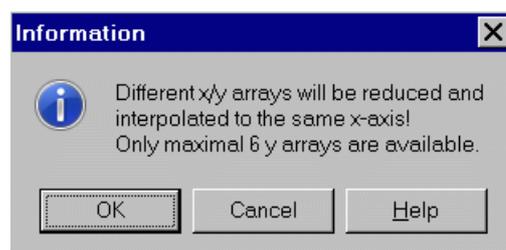
In some cases the curves have a total different x-axis. Then you get the following message: Different x/y arrays will be concatenated!
Here the different curves will be concatenated to one curve with a total x/y-array.

## 5.1.6.3 Compare data

This function compares the current data with other ones from an ASCII file or clipboard.

You can **compare** the data by a plot or a list. At a plot you can also show the reference curve. For plot and list is the showing of the additional difference data possible. Following **difference** modes exist:

1. y1+y2
2. y1-y2
3. y2-y1
4. y1/y2
5. y2/y1
6. y1*y2
7. (y2-y1)/y1

y1 are here the current y-values, y2 the reference (compare) y-values.
The data can be smoothed for the difference forming. The shown current or reference data are then not smoothed.

The **reference** (compare, y2) data can be read from an ASCII file or from the clipboard. These data must be ASCII x/y-data in columns and lines. For the delimiters see chapter 5.1.6.1. It is not necessary that the x-values of the current data and of the reference curve are identical. At the plot both curves will be shown with its own x-axis. For the difference forming and for the list, both x-axis will be reduced to the same axis as described in the second part of chapter 5.1.6.2.
You can define the **symbols** for the reference (compare) and for the difference curve. More possibilities gives the program tool 'Compare data' of the file menu.
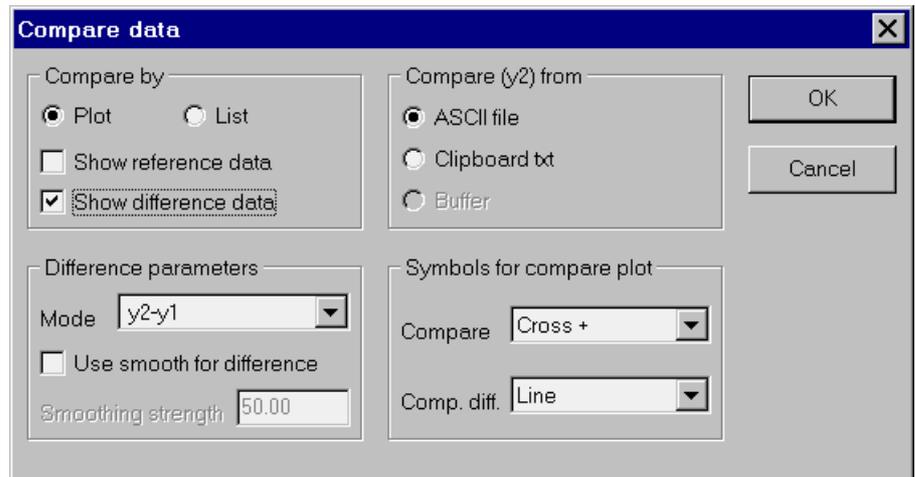
## 5.1.6.4 Create extra window

It is possible to create an extra window with a bitmap (plot) or data grid of the current data. These are separate windows which you can place on the screen. These can be helpful to compare data. Note, that such a window may stay on top, see chapter 1.2.4. You can create some windows defined by the window number. The **size** of the bitmap window can be:

**Old:**          The old defined size will be used.
**Automatic:**  Depending on the selected canvas size the window size will be set.
**Tiny:**          Very small size.

The size of the **canavs** can be the current canvas size of the plot program or big, small or tiny.
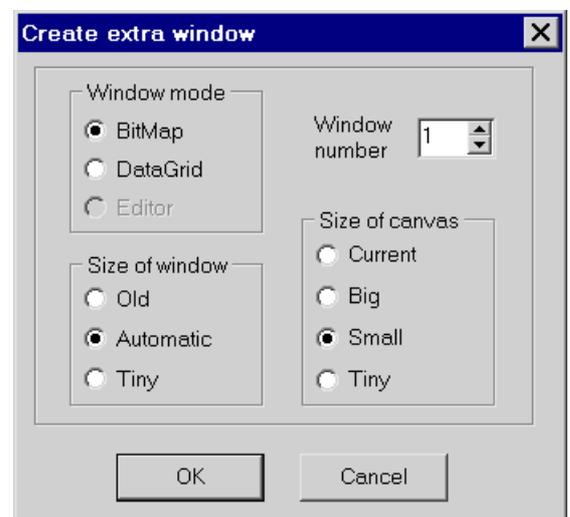
## 5.1.6.5 Marker tools

At marker tools there is a **vertical**, **horizontal** and **cross** marker. You can set these markers by mouse or move by the cursor keys. After setting or during movement by the cursor keys you get in the status line the absolute value of the position in axis dimension and percentage of the axis. If the axis was multiplied with the axis factor for numbers, see chapter 5.1.4.1.1, additionally the original data value without this factor will be shown.

**Example:** On the x-axis is a voltage (base dimension V), the axis text is mV and the axis factor for numbers is 1000. On the status line will be shown:
  xAxis,Data,Perc = 5.000E+00, 5.000E-03, 80.0
That means the x-axis value is 5 mV, the data value is 5.0E-3 V and the position is 80 % of the total x-axis size.

The vertical marker shows the x-position, the horizontal marker the y-position and the cross marker x- and y-position. You can move the markers by the cursor keys. The following description of movement is also valid for other program parts:

| **Horizontal** marker: | Cursor left/right | → slow along the x-axis to the left/right |
|---|---|---|
| | Cursor up/down | → fast along the x-axis to the left/right |
| **Vertical** marker: | Cursor left/right | → slow along the y-axis to the top/bottom |
| | Cursor up/down | → fast along the y-axis to the top/bottom |
| **Cross** marker: | Cursor left/right | → slow along the x-axis to the left/right |
| | Cursor up/down | → slow along the y-axis to the top/bottom |
| | Cursor + Ctrl-key | → fast movement |

At the marker tools there is also the **mouse marker**. The x- and y-position of the mouse will be shown in the status line during the mouse movement. Normally for the mouse marker a cross will be used. But you can switch off this cross and show the original mouse cursor, see chapter 2.3.3.7.

If selecting a new marker the cross and mouse marker will be deleted but not the vertical and horizontal ones. So you can have a vertical and horizontal marker at the same time. You can also combine these both markers with the standard marker used for linear regression, vertical and horizontal plots and so on. These both markers have a special color (fix marker). In the marker sub menu there is an entry for deleting the marker. All markers will be deleted by refreshing the plot.

**Mouse and marker, general:** At many tools and functions you can mark and apply a point by the mouse and vertical or cross marker, for example at the linear regression. The movement of the markers was explained above.
In most cases the left mouse click sets the marker at the mouse position, applies the point/ data and the software goes on. The cursor keys move only the marker. For applying the point/data of the marker position (after cursor movement) and going on you have to click onto the 'Apply/Enter' button or to press the 'Enter' key or to do a right mouse click. 'Enter' don't apply the mouse position but the marker position!
In some cases (e.g. maximum analysis) the left mouse click sets only the marker but don't apply the point. For applying the point/data and going on then you have to click onto the 'Apply/Enter' button or to press the 'Enter' key or to do a right mouse click.

## 5.1.6.6 Excel/Calc

As spread sheet **program** you can at user class 5 select Microsoft Excel or OpenOffice Calc.

You can apply the data and **call** Excel resp. Calc. For this you must have installed it on your computer. Another mode is to **save** the x/y-data in the Excel/Calc format.
For Excel are 3 possibilities for saving:
1. with Excel
2. without Excel
3. with the program Formula One

The format differs by these modes. The best is the first one but you need Excel on your computer. Formula One supports only the old Office 97 format.
You can also save the column captions.
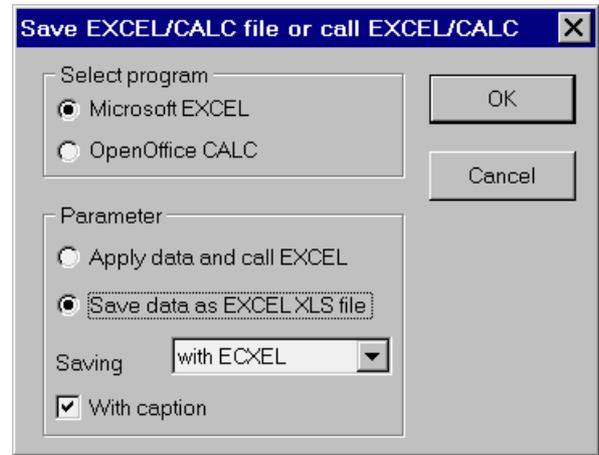
**Note:** Normally it is better to copy/save the ASCII data and paste/read them in Excel/Calc.

## 5.1.7 Many curves

Sometimes a measurement data file contains curves at many data points, for example the tempscan contains internal transients at each temperature. It is also possible that a file is part of a file set, for example transients or V/I curves at different temperatures. The temperature is in both examples the parameter for the single curves.

For these both cases you get in the plot menu of the main program an entry to read and plot these curves (as shown on the right) or you can select the base view in an input window. The mapping plot is only available at user class 5.

Four **base views** are possible:

| | |
|---|---|
| **Curve after curve:** | Only one curve will be plotted. It starts from the first curve. You can navigate to previous or next curve, see chapter 5.1.7.1 |
| **All curves in 1 plot:** | All curves will be shown in one plot, see chapter 5.1.7.2. |
| **3-dimensional**: | A 3-dimensional plot will be shown with the parameter as z-axis, see chapter 5.3.3, |
| **Mapping-plot:** | A color mapping area plot will be shown, see chapter 5.3.4. |

If selecting 'Curve after curve' from an input window, the flag 'Start with movi plot' is visible. Its activation starts a slide show of the single curves. For the other 3 base views a button exist which leads to the special parameters of the selected view.

## 5.1.7.1 Curve after curve

In the file menu of the standard plot program there is the sub menu **Next datas** for navigating between the files or data points:

Shows the curve of the **next** file or data point.
Shows the curve of the **previous** file or data point.
Input of file or data point **number**, first or last can directly be called by clicking onto the 'Min' or 'Max' button.

You can also navigate by the PageDown (next), PageUp (previous), Home/Pos1 (first), End/Pos2 (last number) key and by the NextData button in the toolbar.

Depending on the kind of evaluation it can be that the 'Next datas' sub menu has another face. So the next data entry can be called 'Next data, apply'. This means the curve resp. the evaluation will be applied for further use or for other files. There can also be the entry 'Next data, not valid F9'. This means the current curve will not be applied and the next curve will be shown. F9 is a shortcut for this. Sometimes a menu entry for inputs of parameters exist.

In the file menu there is the menu entry 'MoviPlot program' for starting a slide show, see chapter 5.3.5.

The '**Axis menu**' is expanded by the following 4 entries which defines whether the x- and y-axis will be set newly or kept at plotting new data:

| | |
|---|---|
| ✓ New x,y-axis at new data | Sets a **new x- and y-axis** at new data, this is the standard. |
| New y-axis at new data | Sets only a **new y-axis** at new data, keeps the x-axis. |
| Full y-axis at new data | As before but the y-axis considers also the hidden points. |
| Old axis at new data | Keeps the **old x- and y-axis** at showing new data. |

The Marker tools (sub menu of Tools) contains the additional entry '**Permanent marker**'. Its activation shows a permanent vertical marker. It stays also on its position when loading new data.

If the measurement data file contains curves at many data points then the caption of the plot program is: data point N – file name. If the file is part of a file set then the caption is the current file name.

**Note:** If showing curve by curve from many data points or files then the 'Next datas' menu is visible as described above. Files will be loaded here without opening the file dialog. But if files exist from a variation (e.g. I/V curves at many temperatures) and you call in the plot menu of the main program any function else as a curve by curve plot, then the file dialog opens at 'Next data' with the new name as proposal. The 'Input of data number' is not visible in the 'Next datas' sub menu.

### 5.1.7.2 All curves in 1 plot

All curves will be shown in one plot. An input window with some parameters for this plot exist. Either this window is the main input window after calling the menu entry or it is a (sub) parameter window of the main input window where you can select the base view.

You can define the start and maximal end **number** of files or data points. Normally the end number is 999 so that all files or data points will be used. **Step** means whether every file (step 1) or every second (step) and son on will be used. Sometimes the curves are very closed together, so you can define a y-**offset** between the curves for a better overview. The offset can be small or big.
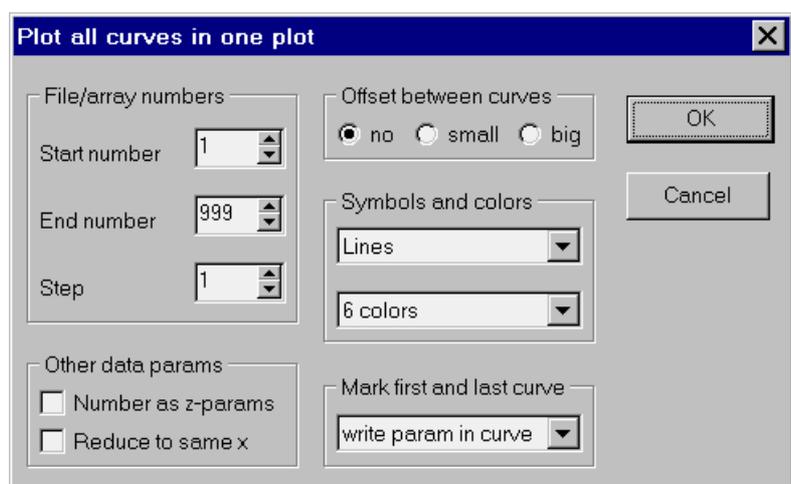
Normally the parameter which was varied (for example the temperature) is the parameter for the **z-axis**. You can also select the file resp. data point number as z-parameter. This parameter will be used at this plot only for the horizontal or vertical plot.

If the curve have different x-axis, it is possible to reduce all curves to the **same x-axis**.

You can select as **symbols** the standard symbol, lines, interpolated lines or different symbols. Different symbols use the symbols for curve 1 to 6.

The symbols or lines of the different curves have always different **colors**:
- **6 colors:** The colors for curve 1 to 6 will be used, see chapter 2.3.3.1.
- **Blue-red palette:** The colors start from dark blue and go over green to bright red.
- **Blue-yellow palette:** The colors start from dark blue and go over green to yellow.
- **Rainbow palette:** Uses the rainbow spectrum.

The z-parameter for the **first and last curve** can be shown in the plot:
- **No:** Doesn't show the z-parameter of first and last curve.
- **Write param in curve:** Writes the z-parameter on the first and last curve.
- **By squares and text:** Marks the first and last curve by small squares and lists the z-parameter in the symbol explanation.

Following menu entries are not enabled at many curves: Save/Copy ASCII data, ActiveX/ OLE tools and the programs ListData, EditData, EditPlot and CompPlot. The listing of the data is restricted as in chapter 5.1.6.2 described.

**Tip:** Use the 3-dimensional plot for the list or export of all y-columns. There is no restriction to 6 y-columns and all x/y-arrays will be interpolated to the same x-axis.

In the **View menu** there are additional entries for Vertical and Horizontal plots, in the toolbar there are also buttons for these plots. In special cases there is a menu entry for Vertical evaluation. Normally the vertical plot is more important than the horizontal.

**Vertical plot** means that you mark by the vertical marker a point on the x-axis. For this x-point (x0) the y-value of all curves will be searched and applied for a new plot with only one curve. If the x0 point don't exist at a curve (only important at curves which have not exactly the same x-axis) then the curve will be interpolated. The new x-axis is here the parameter of the old z-axis parameter, for example the temperature. The new y-axis is the y-value of all curves at x0.

The **horizontal plot** is similar to the vertical plot. Here you use the horizontal marker to mark a y0 on the y-axis. The new y-axis is the x-value of all curves at y0. Each y/x-curve will be interpolated to find the x-value to the given y0. This works only correctly when only 1 x-value exist for 1 y-value (bijective).

**Vertical evaluation** uses the data of the vertical plot for a special evaluation. The kind of evaluation depends on the data.

The following picture on the top shows some curves at different temperatures in one plot. The picture on the bottom is the vertical plot of the first picture at about 100 ms.
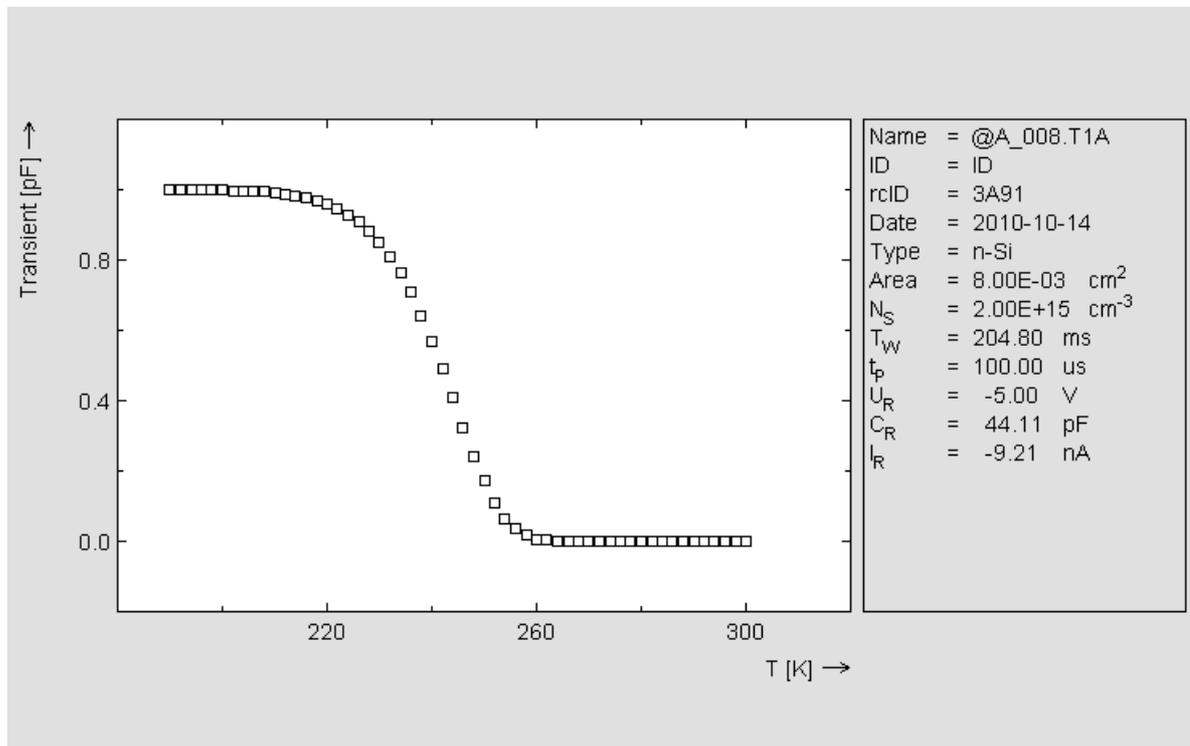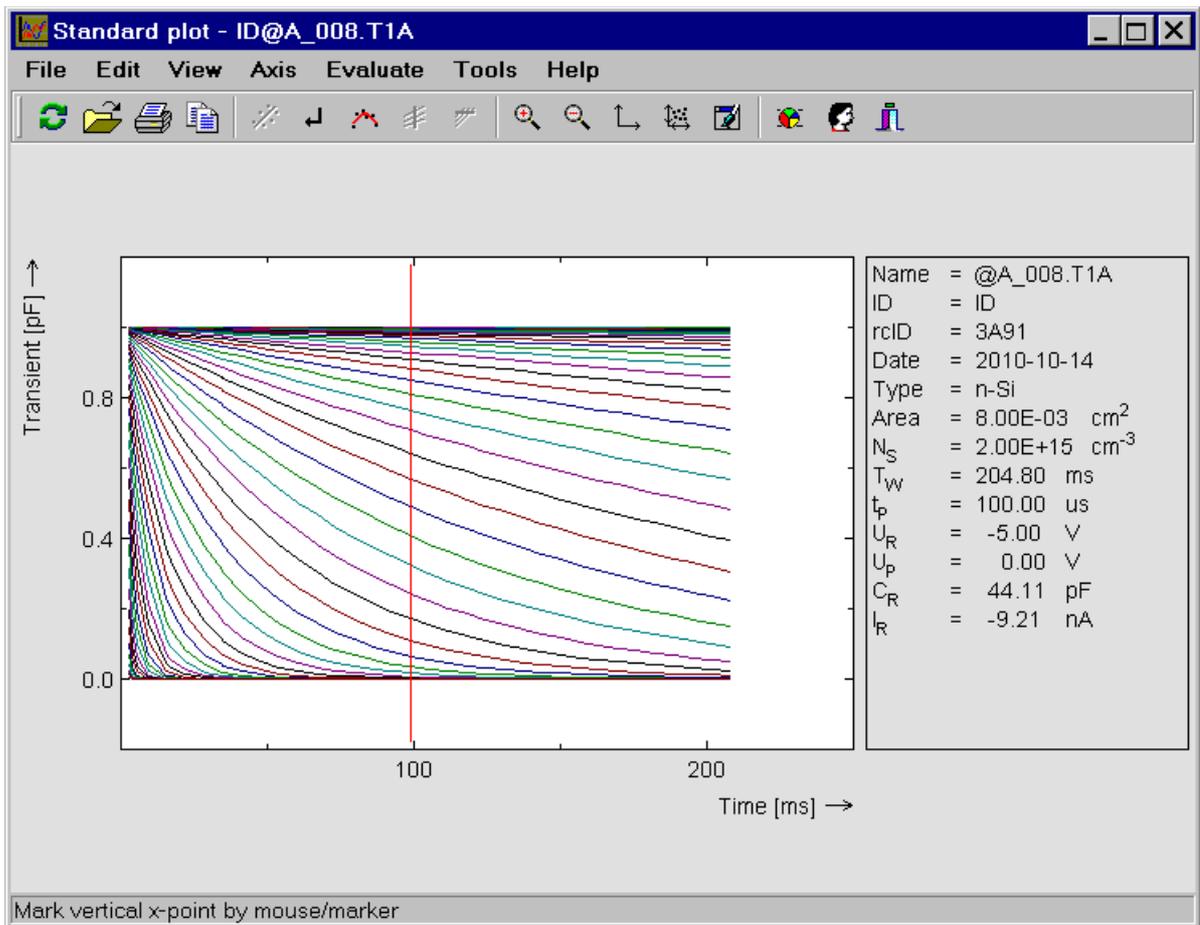
# 5.2 Presentation plot program

The greatest flexibility in data presentation is provided by the option Presentation Plot Program. This chapter describes the functionality provided by this optional program.
The presentation plot program allows data from different curves resp. files to be plotted on the same axes for a direct comparison. The axes are auto scaled to ensure that all of the selected plots fit into the correct axes. In addition to comparing curves it is also possible to compile a picture from different types of plots with independent axes for each plot, that means to make multiple plots per picture. We call the different plots in one picture 'layers'. Up to 4 layers per picture are possible. Every layer can have many curves. A curve means one x/y-data array.
Annotation of the plots is also possible, you can draw text and graphics in the plot. All parameters as the plot axis, symbols and so on will be set automatically but can be changed manually. You can save the full picture with all data arrays and parameters in its own data format without using a graphic format, the data extension is F??.

Some menus are similar to the standard plot program, others have extended features. Which menu entries and tool buttons are visible and enabled, depends on the kind of data.



The following buttons of the **toolbar**, except for the regression, are always visible:

**Open** a presentation data file.

**Save** a presentation data file.

**Print** the plot on a printer.

**Copy page** to clipboard.

Active **layer number**, toggles between first and last layer by mouse click.

Show only **one layer**, the active one. The face changes at a one layer plot.

Input of all **plot parameters**.

Call input of **last parameters**.

**Linear regression**, sets start and end value by mouse and calculate regression.

**Apply** the selected plot and so on, for example for the linear regression.

**Zoom-in** the plot window.

**Zoom-out** the plot window.

**Axis** input parameters for the plot window.

**Refresh** the plot**.**

Call the **Edit plot program.**

**User button** is a user definable button, see chapter 2.3.4.

**Close** the Presentation plot program and goes back to the previous program.

Following **shortcuts** exist for the menu, but not all are always possible:

| | |
|---|---|
| **F1:** | Help information, opens this manual at the corresponding chapter. |
| **F2:** | Call input of last parameters. |
| **F5:** | Refresh the plot. |
| **F8:** | (Automatic) linear regression, sets start and end value by mouse. |
| **Ctrl+F8:** | Starts the manual linear regression. |
| **F11:** | Personal hot key 1, see chapter 2.3.4. |
| **F12:** | Personal hot key 2, see chapter 2.3.4. |
| **Ctrl+C:** | Copy page to clipboard in the bitmap format. |
| **Ctrl+O:** | Opens a presentation data file. |
| **Ctrl+P:** | Print the picture. |
| **Ctrl+S:** | Save the current presentation data. |
| **Ctrl+V:** | Paste a bitmap graphic from the clipboard. |
| **Enter:** | Apply the selected plot and so on, as Apply button. |
| **Alt+F4:** | Close the presentation plot program. |

**Tip:** Sometimes it is necessary to go several times through the same input window. Use then the button 'Last parameters' or its shortcut. It calls that input window which you have opened at last by the menu or toolbar.

## Base syntax and definitions:

**Picture** means a complete picture on the screen with one or more plots.
**Layer** means one plot of the picture. A picture can have up to 4 layers. Every layer can have many curves and objects. An additional special layer 0 exist, which can contain only objects but not curves.
**Curve** means a x/y-array.
**Objects** are text or graphic elements of a layer, layer 0 is also possible.
**Transferred plot** means the plot which should be transferred into the presentation plot.
**Current plot** means here usually the same as transferred plot.

The **parameters** will be divided in 3 groups:

| | |
|---|---|
| **All layers:** | The parameters are valid for all layers (the total picture). These are the parameters for applying, the header and so on. |
| **One layer:** | The parameters are valid only for one layer. These are the plot axis, the regression mode, objects and so on. |
| **One curve:** | The parameters are valid only for one curve. These are the plot symbol and color and so on. |

## 5.2.0 Entering the Presentation Plot Program

The Presentation Plot program can be called from another plot program (Standard, Application, Edit, 3-dimensional) or from the Base Tools. This sub program applies the current total plot (picture), also called transferred plot, with all layers, curves (data), evaluation and text.

### 5.2.0.1 Main window

If entering the presentation plot program the following main window occurs for transferring the current plot data into the presentation plot program.
If you confirm with '**OK**' then the data will be applied and the new picture will be shown.
At '**OK, input**' additional the extended input window of chapter 5.2.0.2 opens.
If leaving with '**No apply**' the current plot will not be applied. Then you hold the old picture resp. data of the presentation plot program.
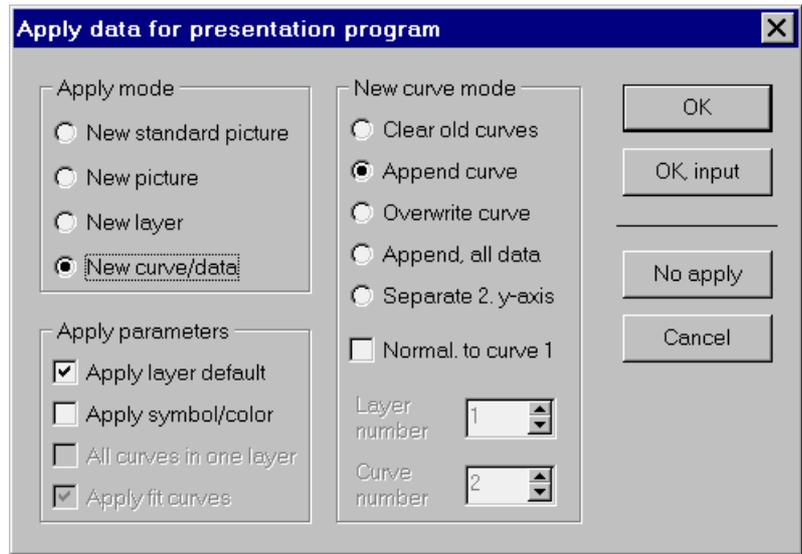


You can apply the current plot as a new picture. In this case the old data of the presentation plot will be deleted. You can also compile a new picture by the new and old data.

The **Apply mode** defines the kind of applying the current plot:

| | |
|---|---|
| **New standard picture:** | This is the standard mode. The current plot with all layers and curves as new picture resp. data. If more than one current layer exist then only this input is possible. |
| **New picture:** | Similar as before but default apply parameters for the standard picture will not be set. The inputs for the 'layer mode' occurs, see below. Select a special layer mode or confirm with 'OK, input' and go through the extended input window. |
| **New layer:** | A new layer can be created by the current plot or an old layer can be overwritten. For the last you have to input the layer number. The inputs for the 'layer mode' occurs. You must select a special layer mode or confirm with 'OK, input' and select in the extended window a new layer position. |
| **New curve/data:** | You can keep all existing data of the presentation plot. The 'new curve mode' defines how a new curve (or all) will be applied. You have to input the layer number. This mode is only possible if the transferred plot contains only one layer. |

The header can only be applied at the modes 'New (standard) picture'.

If selecting a new layer you can define the layer position in the extended window. An easier way is to set the size and position of layer by the **Layer mode**:

**Extended select:** You have to go through the extended input window.

**2 layers:** The new picture contains 2 plots. The layer number defines the layer position. Layer 1 will be shown on the top, layer 2 on the bottom.

**3 layers:** As before but with 3 layers: left-top, left-bottom, right-bottom.

**Layer in layer:** A small layer 2 will be drawn inside on the right top of the big layer 1.


The **New curve mode** defines how the new curves will be transferred to a existing layer:

**Clear old curves:** The existing curves of the selected layer will be deleted. The layer contains then only the new curves.

**Append curve:** This is here the usual standard mode. The new data will be append as new curve(s) to the layer. The software increases automatically the curve number.

**Overwrite curve:** An existing curve will be overwritten. You have to input this curve number.

**Append, all data:** The data will be append to an existing array (curve). Old and new data are saved in one array. By the flag 'No overlap' only new data which x-data are not in the x-range of the old data will be applied.

**Separate 2. y-axis:** The new curve uses a separate 2. y-axis. The y-axis of the current plot will be transferred as a 2. y-axis of the selected layer.

If activating '**Normal. to curve 1**' then the new curve(s) will be normalized to curve 1. That means the minimum and maximum values of the new and the first curves are the same.


The **Apply parameters** input group contains flags for the applying of data and parameters:

'**Apply layer default**' sets the default parameters for a new layer. In the other case the main parameters of the first layer will be used. These parameters are not the axis, curves and objects.

'**Apply symbol/color**' applies the symbols and colors of the transferred curves, only enabled if setting the previous flag. In the other case the symbols and colors are associated with the curve number.

If the current plot contains similar curves in various layers then '**All curves in one layer**' transfers all these curves in one layer of the presentation plot.

If the current plot contains additional fitting curves then these curves can be applied by activating '**Apply fit curves**'.


**Tip:** Activate 'Apply symbol/color' at many curves. If this flag is not activated and a symbol explanation will be applied from the current plot then the symbols and colors of the explanation differ from that ones of the curves. If the current plot has only one curve you should usual deactivate this flag. There are different flags for one and many curves.

## 5.2.0.2 Extended window

The following input window opens if you click in the main window on the 'OK, input' button. It contains extended apply parameters.

The main parameter here is the **Layer size/position**. This setting is necessary for manual compiling of a picture with multiple plots. The white area denotes size and position on the screen, the selected will be yellow colored. You can select it by mouse. Following possibilities exist:
Full, Left-top, Left-bottom, Right-top, Right-bottom, Standard, Manual, Left, Bottom, Big.
If selecting '**Manual**' then you have to input the per cent left, right, top and bottom position of the layer, relative to the canvas. In 'View → Positions' you can use the mouse for this, see chapter 5.2.3.6.
The flag '**Raster**' sets the positions to a virtual raster as described in chapter 2.3.5.
If activating '**Small**' then small symbols will be used for the curves, see chapter 2.3.3.4.
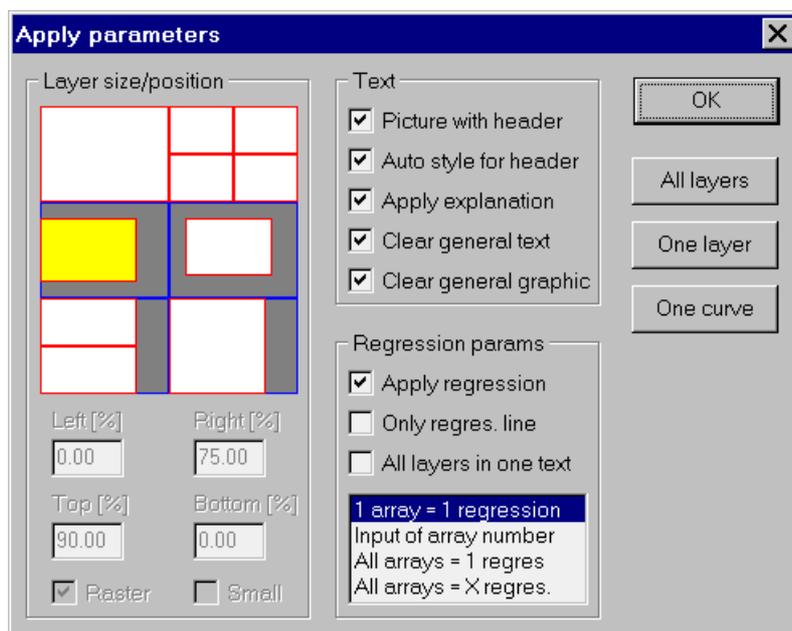
The input group **Text** contains parameters for the picture style and for text/graphic objects.
'**Picture with header**' applies the text header and shows it on the right side of the plot.
'**Auto style for header**' sets the style and position of the header by the layer position.
'**Apply explanation**' applies a symbol explanation of the current plot.
'**Clear general text**' clears the text, which was defined for all layers, called layer 0.
'**Clear general graphic**' clears the graphic, which was defined for all layers, called layer 0.

For the parameters of the linear **Regression** exist a separate input group:
'**Apply regression**' means that the regression mode and range will be applied.
'**Only regres. line**' defines as regression mode 'Only line' so that only the regression line will be shown but not the results. If the current plot lists the results in the text header box this evaluation text will be integrated in the text header.
'**All layers in one text**' lists the regression/evaluation results of all layers in one text box.
One of the 4 regression **array modes** can be selected, see chapter 5.2.5.

3 separate **buttons** call the parameters for all layers, for the active layer and for the active curve. It is similar as described in 5.2.3.1 but not all input sheets are here visible.

**Note:** If selecting 'Standard picture' in the main window then some text and regression parameters will first be set from 'Default from standard picture', chapter 5.2.3.2.

### 5.2.0.3 First call

As discussed in chapter 1.1.1 and 1.1.2 some initialization files will be loaded at program start or first call of the measurement module. The configuration mode, see chapter 1.1.1, defines which set of initialization files will be loaded. The presentation plot program has also an init file for its configuration. In opposite to the other initialization files here you will be asked at the first call whether you want to use the original file or the file defined by the configuration mode. The reason is that it could be that you have leaved the program after a very special work in the presentation plot program. At a hot start you would load these very special parameters.

Following modes for reading the **configuration init file** exist:

**No, read original init file:** Independently from the selection of the configuration mode the original init file PresProg.Cfg from Sys\Init will be loaded.

**Only apply params:** The init file defined by the configuration mode will be loaded, for example that one for a hot start. But only the parameters for applying data will be used from this file. The other parameters come from the original file.

**Only apply/base params:** As before, but additionally the base parameters will be used.

**Yes, read all params:** All parameters of the init file defined by the configuration mode will be read.

### 5.2.0.4 Compiling a picture

Usually you enter the presentation plot program with the apply mode 'New standard picture'. The whole picture with all layers and all curves will be transferred. Then you can change the axis or evaluation or add objects as text to the plots to achieve best results. The presentation plot program will also be used for compiling a new picture. So you can show different curves in one plot for a comparison. The program also allows data from multiple files of different types, such as a tempscan file and a corresponding Arrhenius file, to be plotted into the same picture. In this case each set of data will be plotted on an independent set of axes which can be independently moved around.

The common **sequence** for compiling a picture is the following:

1. Select in your main program your **first plot** and call then the presentation program.
2. For showing different curves in one plot (application example 1) use the **apply mode** 'New standard picture'. In the other case use 'New picture' and define the layer mode or/and go through the extended window.
3. **Leave** the presentation program.
4. If necessary read in your main program data form a new file. Select in your main program your second plot and enter the presentation plot program again.
5. Use the **apply mode** 'New curve' or 'New layer'.
6. Repeat steps 3 to 5 until the picture is finished.
7. If necessary, make changes (axis, symbols...) and add objects.

### 5.2.0.5 Special applications

This section describes the compiling of a new picture for some special applications. The common sequence will be described in the previous chapter. The following arabic numeral refers to the sequence number. You can normally leave the main window by 'OK'.

**I. Different curves in one plot:** Data from different temperature scans, different samples, different coefficients or different V/I curves may be plotted on the same axes. The program will automatically scale the axes so that all of the data will fit in. It is however possible to override this and to set your own axes. The different curves must be similar. This means that the x- and y-axis of all curves must be identical, for example that all curves have the temperature as x-axis.
  **(2)** For the first curve or curves use the apply mode 'New standard picture'.
  **(5)** For the next curves use apply mode 'New curve' and curve mode 'Append curve'.

**II. Multiple plots per page, one curve:** It is possible to display up to four separate plots on a single page and have them positioned automatically by the software. Each plot is still treated as separate layer and may have different axes from the other plots. So one layer can contain a tempscan, another one the Arrhenius plot. The standard multiple plots per page consist of 2 or 3 layers. Then you have additional space for the text header. The following describe the sequence for 2 layers.
  **(2)** For the first layer select apply mode 'New picture' and layer mode '2 layers'.
  **(5)** For the second layer use apply mode 'New layer' and keep the layer mode.

**III. Multiple plots per page, many curves:** Every layer can contain many curves. As the current plot have many curves then all these curves will be applied in example II. You can also add manually a curve. The following describe the sequence for 2 layers with 2 curves in layer 1.
  **(2)** For the first layer select apply mode 'New picture' and layer mode '2 layers'.
  **(5)** For curve 2 of layer 1 use apply mode 'New curve'  and curve mode 'Append curve'.
  **(5)** For the second layer use apply mode 'New layer' and keep the layer mode.

**IV. Layer in layer:** A small plot can be drawn inside on the right top of a big plot. Each plot is referred to as a layer. An example will be shown at the end of this chapter.
  **(2)** For the big layer select apply mode 'New picture' and layer mode 'Layer in layer'.
  **(5)** For the small layer use apply mode 'New layer' and keep the layer mode.
  **(7)** Usually the picture is not perfect. Set the best size and position of the small layer in 'View → Plot params for → Position'. Optimize also the axes.

**V: 2 different y-axis:** One plot can contain 2 curves with different y-axis, for example curve 1 shows the current and curve 2 the capacitance versus temperature. This layer has then 2 y-axes. An example will be shown at the end of this chapter.
  **(2)** For curve 1 use the apply mode 'New standard picture'.
  **(5)** For curve 2 use apply mode 'New curve' and curve mode 'Separate 2. y-axis'.

**VI. Difference of 2 curves:** It is possible to show 2 curves and its difference in 1 or 3 plots. For this create a picture with 1 layer and 2 curves as explained in example I. Then go to the Edit menu and select 'Make difference'. By 'Restore layer' you can there restore the 1-layer plot into 3 separate layers with each 1 curve.

**VII: 3-dimensional plots:** You can manually make a 3-dimensional plot by many curves. For this transfer many curves with the same x-axis into one layer of the presentation plot. Apply many curves in one step from a current plot or/and curve by curve. Look in 'Apply input sheet' of chapter 5.2.3.2 for applying the z-values. A 3-dim plot can be temporary created in 'View → One layer plots' (chapter 5.2.3) or be set as default for the current picture. For the last set in 'Params for one layer → input sheet Base' the axis mode to '3-dim', see chapter 5.2.3.X. The button '3d params' defines the parameters of the 3-dim plot.

**VIII: Regression:** The linear regression will be applied from the current plot. Sometimes it can be important to calculate the regression over different parts of the curve(s). In other cases you want to calculate one or more regressions over all curves. Compile the plot and define in the extended entering window the regression array mode. You can change it also in the Evaluate menu. Chapter 5.2.5 gives more information.

**IX: Additional text:** You can add objects like text, lines, symbols, boxes and graphics to the layers. For a new text call 'Objects → New text'. See chapter 5.2.7.X for a detailed explanation.

The following picture shows 2 layers. The first contains 3 curves. The 3. curve has a separate y-axis. The small layer is inside of the big layer 1 and has 1 curve. Additional text and graphics are included in this picture. So this is an example for application I, IV, V and IX.
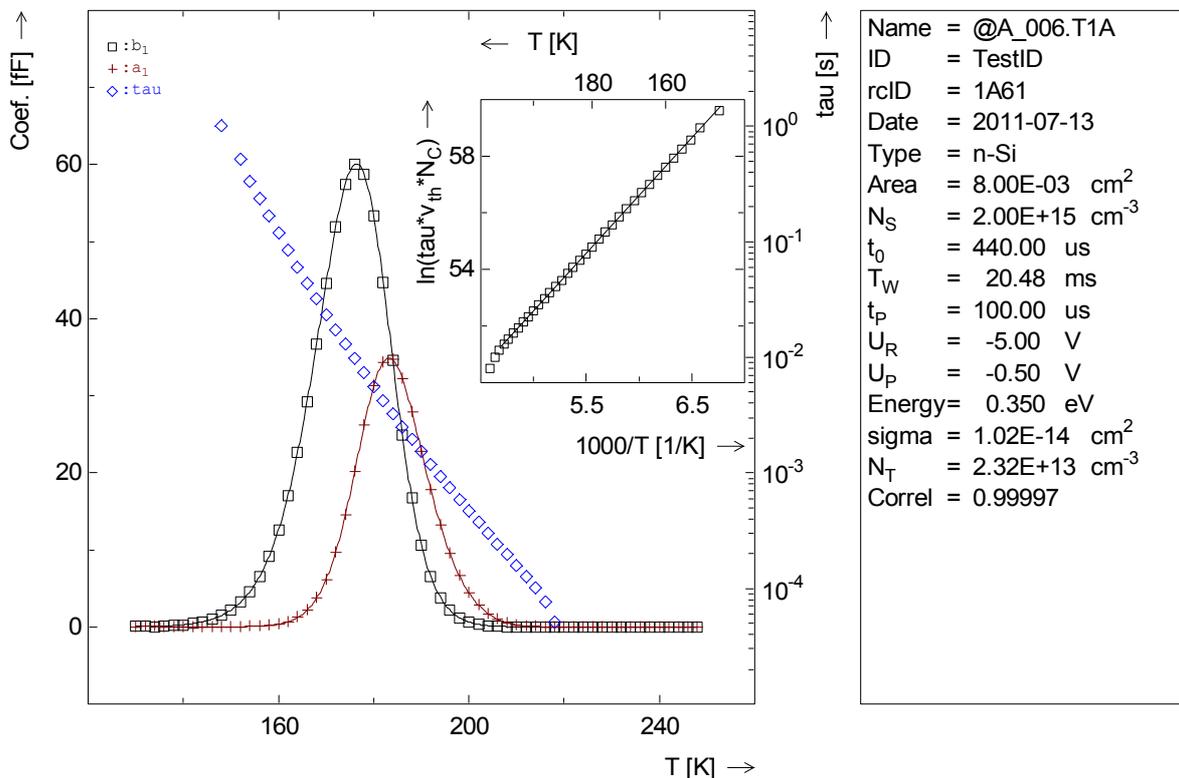
## 5.2.1 File menu

The presentation plot program has its own data type, so you can read and save files of the presentation plot program.



Save ASCII data saves one or more x,y curves line by line in an ASCII format to a text file. Read ASCII data reads one or more curves from an ASCII file.

Save graphic opens a sub menu for saving the plot into a graphic file format. Bitmap and vector formats exist: BMP, PCX, GIF, JPEG; PLT, HPGL, WMF / EMF, EPS, ACAD. An explanation was given in chapter 5.1.1.1.

By calling EditPlot program the program jumps with one selected curve to the edit plot program and comes then back.

Print opens a dialog for printing the plot. By 'Close' the presentation plot program will be closed and the software goes back.

### 5.2.1.1 Read and save presentation data

If reading a presentation file then you can select after the input of the file name the **reading mode**:



- **Read full picture:** All layers from the file will be read. The new picture consists of only the read layers. If the plot configuration was saved with this file then you can activate to read it here.
- **Read 1 layer:** Only one layer from the file will be read. Then you get the input window for applying the data of file to compiling a new picture, see chapter 5.2.0.
- **Read 1 curve:** Only one curve will be read.
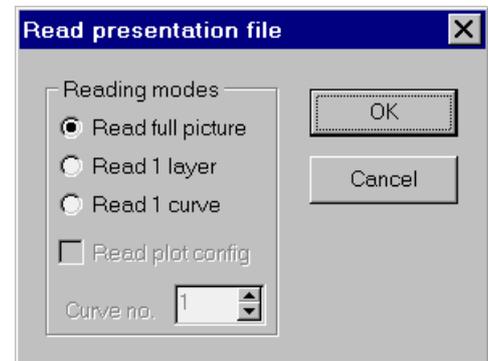
If saving a presentation file then you can select after the input of the file name the **saving mode**:



- **Save full picture:** Parameters and data of all layers will be saved. The data extension is F0?. By activating a flag the plot configuration will be saved into a separate file, see below. Then the data extension is F9?.
- **Save 1 layer:** Only one selectable layer will be saved. The data extension is F1? for layer 1 and so on.
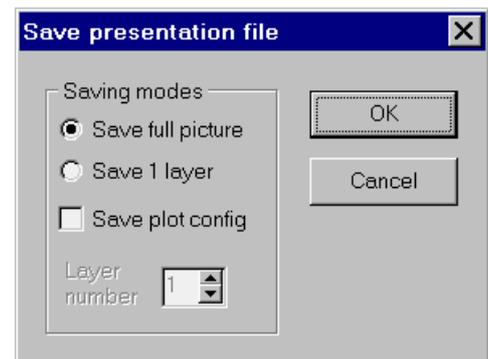
The presentation plot program uses some parameters of the current **plot configuration**, for example the color for the regression line and the definitions of the axis fonts. If you change these global plot parameters and read later an old presentation data file you don't get the same view as at that time at which you have saved the file. Therefore you have the possibility to save also the plot configuration into a separate file if saving the presentation data. This configuration file has the name as the presentation file but instead the program extension the extension CFG. This file has the structure of the initialization file Plot.CFG from the program directory Sys\Init. After leaving the presentation plot the program asks you for restoring the old global plot configuration.

## 5.2.1.2 Read and save ASCII data

If reading ASCII data from a text file you can select the **reading mode**:

1. **Read 1 curve, standard:** This is the standard mode. 1 curve will be read, x must be in the 1. column, y in the 2.
2. **Read 1 curve, input:** 1 curve will be read, you have to input the column number for the x and y-data. When selecting column 1 for x and y, x will be read from the odd lines (1,3,5,..), y from the even lines.
3. **Read 1 curve, table file:** 1 curve of a special table file will be read, for example a temperature calibration file.
4. **Read 1 layer:** Read all columns of file. The first one is x, the second y1, the third y2 and so on.
5. **Read 1 layer with z-axis:** As above but the first line contains the z-axis values, necessary for 3-dimensional plots.

At read mode 2, 4 and 5 you can **skip lines** of the file, necessary if the file has a header. At these modes you can also deactivate the flag '**With x-axis**'. Then the x-data will not be read but will be set to data (line) number.
If selecting -1 as x- or y-column, the old x- or y-values will be kept. The number of old and new data points must be identical! This feature needs user class 5.
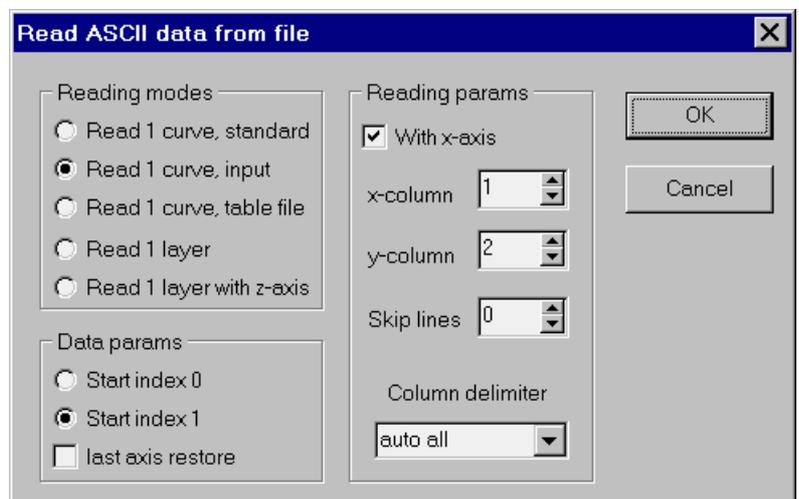
Starts index means the first index of data array, normally it starts from 1, so you have data x[1],...x[N], where N is the numbers of data points.

If activating '**Last axis restore**' then the ASCII data will be restored in respect to the axis restore (change) mode of the layer, see 'View → Params for layer → Array → Change x/y-axis'.
The **delimiter** between the columns can be selected, for more details see chapter 5.1.6.1.

After confirming the window above you get the inputs for compiling a new picture, see chapter 5.2.0.

If saving ASCII data into a text file you can select the **saving mode**:
1.  **1 curve, standard params:** This is the standard mode. 1 curve will be saved, x into the 1., y into the 2. column.
2.  **1 curve, input of params:** 1 curve will be saved, you have to input the column number for the x and y-data.
3.  **1 curve, table file:** 1 curve will be saved into a special table file.
4.  **1 layer, all curves:** Save all curves of one layer. x will be saved in the 1. column, y1 in the 2., y2 in the 3. and so on.
5.  **1 layer with z-axis:** As above but the first line contains the z-axis values, necessary for 3-dimensional plots.
6.  **x,z,y as 3 columns:** All x-data of all x-arrays will be saved into the first column, x-array after x-array. Ally-data will be saved into the third column. The second column contains the z-data, it will be applied from the value for z-axis of every curve.

At save mode 2, 4 and 5 you can deactivate the flag '**With x-axis**'. Then the x-data will not be saved.
If saving all curves of a layer you can activate a flag for '**Check x-axis**'. In this case all x-arrays of the layer will be checked. If these are different, the common x-range will be used and all y-arrays will be interpolated to the x-array of the first curve.
If more than one layer exist, you have to select the **layer number**. For the modes 1 to 3 you have also to input the **curve number**.
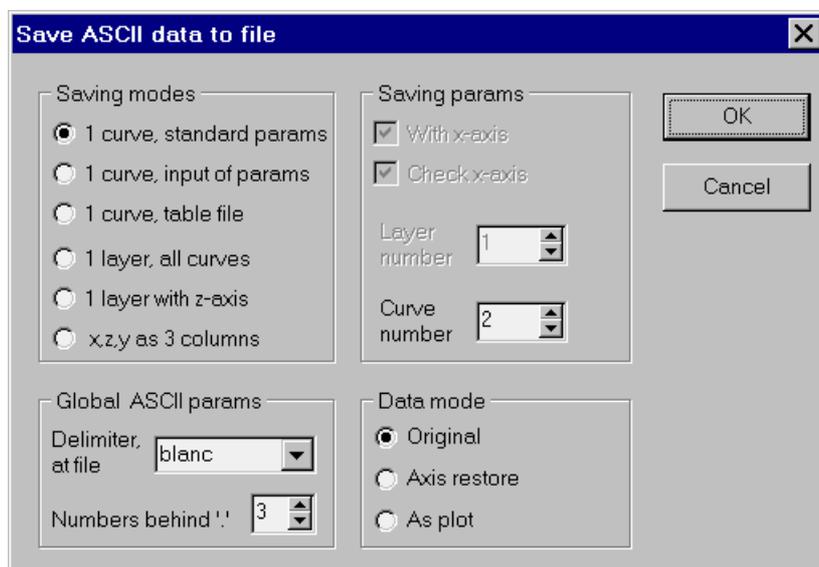
The **delimiter** between the columns can be selected, for more details see chapter 5.1.6.1. The ASCII data will be saved in the exponential format, you can define the **numbers** behind the point. Both inputs are global and valid for the total program.

The **data mode** decides how the data will be saved:
**Original:**      The original data without interpolation and so on will be saved.
**Axis restore:**  If the data will be changed in respect to the axis, see above, or the data will be combined by 2 curves then these 'calculated' data will be saved.
**As plot:**       The curve will be saved as you see it in the plot. If interpolating then the interpolated data will be saved. An axis restore will be taken into account.

## 5.2.2 Edit menu

By the edit menu it is possible to copy a graphic or the data into the Windows clipboard, to paste a graphic or ASCII data, to edit data, to delete arrays and to restore arrays or layers.



'Copy page' copies the graphic as a bitmap into the clipboard, 'Copy graphic' as a Windows meta file (WMF or EMF).
'Copy ASCII data' copies one or more selectable x/y-arrays line by line into an ASCII format, similar to chapter 5.2.1.2.
'Copy select' asks for the format before copying, see 5.1.2.1.
'Paste' shows a bitmap graphic from the clipboard on a definable position of the screen.
'Paste ASCII data' read ASCII data form clipboard similar to chapter 5.2.1.2.
'Edit ASCII data' load one selectable array (curve) or all arrays of a layer into the grid or text editor. There you can edit these data and apply the changes into the presentation plot.
'Normalize' all plotted curves to one reference curve.
'Delete array' removes one selectable curve from the plot.

By 'Restore array' one or all arrays of a layer will be used for compiling a new picture. The main window for entering opens as described in chapter 5.2.0.1.
'Make difference' is enabled if the active layer has 2 curves, or if 2 layers with the same numbers of arrays exist and a 3-dim or mapping plot will be shown.
'Delete same points' deletes same points of all curves of a layer.
'Restore layer' restores one layer into 2/3 layers, or restores all curves into one layer.
'Apply vertical' is visible at a vertical plot was done and apply this plot a new layer.

### 5.2.2.1 Make difference

If the active layer has 2 curves, then you can build a difference between the 2 curves and store this new curve as a 3. curve of the layer. If there was already a difference formed, so that the layer has yet 3 curves, then you can call this function again and the old 3. curve will be overwritten.
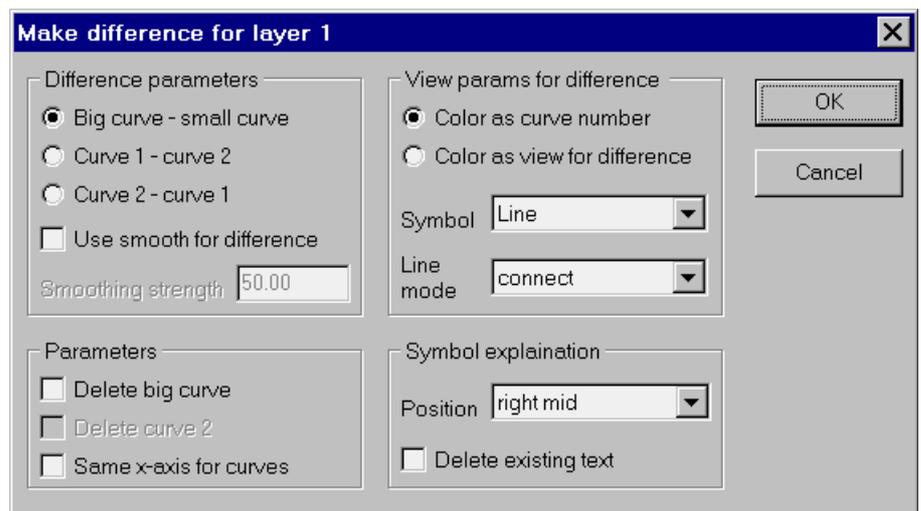


At the **Difference parameters** you can select how the difference should be formed:

At '**Big curve – small curve**' the curve with the biggest y-value will be searched, the other (small) curve will then be subtracted from this one. At '**Curve 1 – curve 2**' curve 2 will be subtracted from curve 1. The opposite is also possible. 1 and 2 denote the curve numbers of the layer. If activating a flag then the curves can be **smoothed** before difference forming. The smooth is only valid for the difference forming, the original curves will not be changed. You can input the strength of the spline smooth, see also chapter 2.7.1.

In the **Parameters** input group you can activate some flags:

So you can **delete** the big curve at the first difference mode, curve 1 and curve 2 at the other both difference modes. 'Delete' means that this curve(s) will not be longer in the plot. The layer contains then 1 resp. 2 curves.

'**Same x-axis**' means that the x-arrays of the original curves will be checked. If these are different, the common x-range will be used and the y-array of the 2. curve will be interpolated to the x-array of the first curve. This flag is only valid for the original data and changes so these data. The difference forming uses always this check.

**View parameters** define the symbol, line mode (see chapter 5.1.3.1.1) and color of the difference curve. The color is either the color for curve 3 or the special color for a difference curve, see chapter 2.3.3.1.

**Symbol explanation** defines the position of a text which explains the origin of the curves: left top, left bottom, right bottom, right top, right mid, right down. No additional text will be shown by 'no explanation'. Activating 'Delete existing text' delete all text objects of the active layer, except the selected symbol explanation.

## 5.2.2.2 Delete same points

This function deletes same points of a curve in various ways. Each curve of the active layer will be checked. Following **base modes** exist:

**Delete same x-points:**    Only the x-array of each curve will be checked. If a curve contains data points with the same x-value then the 'double' points will be deleted.

**Delete same points:**    As before, but if a curve contain points with the same x and y values then the 'double points' will be deleted.

**New curve, no same points:**    A new additional curve will be created by using all data points of all curves. This new curve will then be checked for same points.

**New curve, only same points:**    As before, but the new curve contains only data points which exist in all curves.

The **Params for same x-points** define criteria when 2 values will be treated as 'same'. Depending on this you can input a maximum difference or a factor. The last criterion allows also a logarithmic check for logarithmic data. By activating x=ln(x') is valid: |x2-x1|<=xd, where xd=-ln(1-f) and f is the factor by input.

If checking not only the x-value but points, then the y-parameters are enabled.



Delete same points/curves of layer

Base mode
- ● Delete same x-points
- ○ Delete same points
- ○ New curve, no same points
- ○ New curve, only same points

Options
- ☑ Sort result curve/array
- ☑ Average result points
- ☐ Delete original curves
- ☐ Without last curve

OK    Cancel

Params for same x-points
- |x2-x1| <= 1.0E-30
- |x2-x1| <= xd
- |x2-x1| <= (Max-Min)*f
- 1-f <= x1/x2 <=1+f
- 1-f <= x1/x2 <= 1/(1-f)

● x=x'   ○ x=ln(x')   ○ x=log(x')

Factor f   1.000E-02

Params for same y-points
- |y2-y1| <= 1.0E-30
- |y2-y1| <= yd
- |y2-y1| <= (Max-Min)*f
- 1-f <= y1/y2 <=1+f
- 1-f <= y1/y2 <= 1/(1-f)

○ y=y'   ○ y=ln(y')   ● y=log(y')

Factor f   5.000E-02

Some **options** exist. So the curves can be sorted. At the last base mode the result points can be averaged over the same points. The original curves can be deleted at the last 2 base modes, so that the layer contains only the new curve. If one of the last 2 base modes was already done then the flag 'Without last curve' is enabled. That means the new curve will not be used at a repetition.

### 5.2.2.3 Restore layer

This procedure restores one layer with many curves into 2 or 3 layers, or restores all curves of all layers into one layer.

The first case is only available if one layer with 2, 3, 4 or 6 curves exist. Then 2 or 4 curves of layer 1 will be restored into 2 layers with each 1 or 2 curves, 3 or 6 curves of layer 1 will be restored into 3 layers with each 1 or 2 curves. The plot window of each new layer is the same as the old one.

You get the following input window. If activating 'New symbols' and 'New colors' then the symbols and colors correspond to the new curve number in the new layers, see chapter 2.3.3.1. In the other case the old symbols and colors will be kept.
If activating 'Clear text' means that all text objects of the first layer will be deleted. In the other case the first text object, usually the symbol explanation, will be splitted into 2 resp. 3 parts.
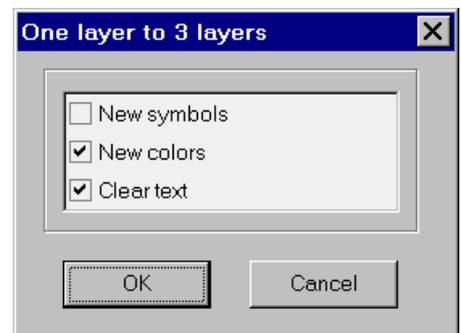


If more than one layer exist then all curves of all layers can be restored into one layer. The input window is the same as in the first case.

### 5.2.2.4 Normalize arrays

This procedure normalizes one or all plotted curves to one reference curve. It will be done only at the plot, the data itself will not be modified. The flag 'Plot with offset', array input sheet of chapter 5.2.3.3, will be activated by using the 'Yes' button. It will be deactivated by clicking onto the 'No' button. The flag 'Axis rescale' rescales the axis for the next plot.

The normalization can be done by setting an offset or factor for each curve. At the first mode the curves will only be shifted on the y-axis. At the last mode, additionally the minimum value of each curve can be subtracted. The normalization can be done to the first/last data point, the minimum/maximum or to a given value of the reference curve. The number of the reference array can be selected, its y-minimum value can be subtracted.
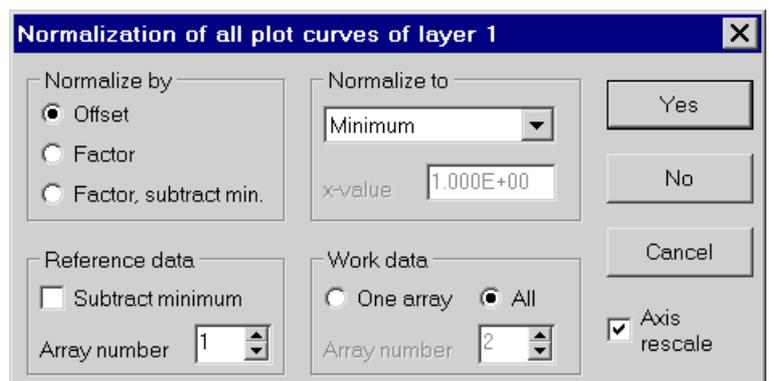
## 5.2.3 View menu

In the view menu you can set the window and canvas size, personal short cuts, global and all presentation plot parameters.

'All plot params' are the parameters for the active presentation plot, it opens a general input. 'Global plot params' were already explained in chapter 2.3.3. 'Refresh' plots the plot again.

'Plot params for' opens a sub menu for the presentation parameters for all layers and for the active layer and curve, similar to 'All plot params'. Special inputs allow to set the layer position and 3-dim parameters.

'New canvas' allows to define manually the size of the canvas instead to set it bythe form size.

'Plot all layers' shows all layers on the screen. This is the standard mode. If selecting a one layer plot, the face of the fifth button in the toolbar changes. This button toggles the view between 'Plot all layers' and 'One layer plot'.

In the sub menu of 'One layer plots' you can also select a special view for the active layer. At 'Current size' the active layer will be shown in its size, at 'Full size' it will be shown in the full screen size.
'One array' shows only the active curve. Navigate by the PageDown (next) and PageUp (previous) key and by the Next button in the toolbar. You can make a vertical or a horizontal plot from the active layer, as described in chapter 5.1.7.2. The active layer can be shown as a 3-dimensional plot.

'Restore plot cfg' restores the old plot configuration, it is visible if you have load a new plot configuration from file, see chapter 5.2.1.1.

### 5.2.3.1 All plot params

This is the most important input window for the parameters of the presentation plot. As described above these are divided in 3 groups:

**All layers:** The parameters are valid for all layers (the total picture). These are the parameters for applying, the header and so on.

**One layer:** The parameters are valid only for one layer. These are the plot axis, the regression mode, objects and so on.

**One curve:** The parameters, as plot symbol and color, are valid only for one curve.

Here you can select the active layer and the active curve number of this layer.
The 3 buttons opens the different input sheets for the parameters for all layers, for the active layer and for the active curve of this layer. The main inputs will be described in the next chapters. The axis and object input parameters are also available in special menus and will be explained there.
'**All symbols**' changes the symbol, line mode and color of each curve of the selected layer by one dialog.
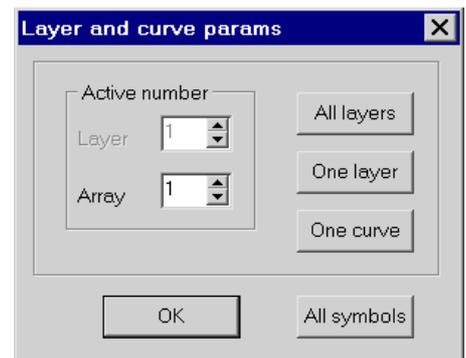
## 5.2.3.2 Plot params for all layers

These parameters are valid for all layers, the inputs are grouped in 4 input sheets.

### Apply input sheet:

Here are the parameters for applying a plot into a presentation plot.

The input group '**Default for standard picture**' contains parameters for applying if using the apply mode 'New standard picture', see chapter 5.2.0.1.

If 'Automatic size' is activated, the size of the plot, which will be transferred into the presentation plot, will be applied.

The flags 'Picture with header', 'Apply explanation' and 'Apply regression' were already explained.

'Set regression style' deactivates the flags 'Only regres. line' and 'All layers in one text' and sets the regression array mode, usually to '1 array = 1 regression'. For more details look in chapter 5.2.0.2.
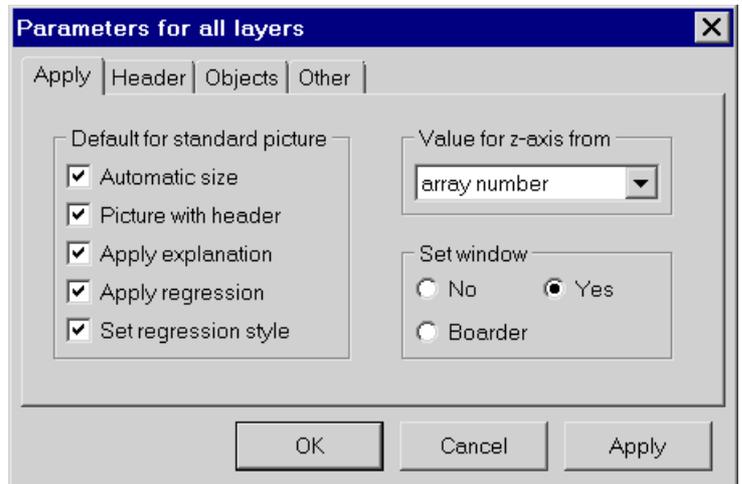
'**Set window**' will be used at apply mode 'New curve' for setting a new plot window:

**No:** The layer window of the presentation plot will be kept.
**Boarder:** The layer window will be changed if the boarder (axis) of the plot which will be transferred into the presentation plot is bigger.
**Yes:** If the new curve(s) contain data which are outside of the layer window then the layer window will be expanded.

'**Value for z-axis from**' defines which value (parameter) will be set for an optional z-axis, which will be used for 3-dimensional and mapping plots. The standard is 'array number', is the number of curve will here be applied as z-value. Another possibility is the temperature, additional possibilities depend on your program. When using the z-axis define this mode before applying data into the presentation plot program. Click for this at entering the presentation program onto the 'Ok, input' button (chapter 5.2.0.1) and then onto the 'All layers' button (chapter 5.2.0.2). You can later edit the z-data in the 'Other' input sheet of 'Params for one layer', see chapter 5.2.3.3. The z-axis text will automatically be defined by applying a new picture or a new layer. This mode has no effect when starting the presentation plot program from a 3-dimensional or mapping plot or from 'all curves in one plot'.

**Header input sheet:**

Here are the parameters for the text header. The flag 'Picture with header' enables the showing of the text header. Following header **styles** resp. positions are available:

| | |
|---|---|
| **mid:** | The header will be shown in the mid. |
| **top:** | The header will be shown on the top. |
| **top and right:** | 2 lines will be shown on the top, the other on the right. |
| **standard right:** | The header will be shown on the right besides the plot boarder. |
| **quarter, 2 columns:** | The header will be shown in the left-right quarter. |
| **manual:** | Input of left and top position in per cent canvas coordinates. |
| **manual, 2 columns:** | As above, but the header will be shown in 2 columns. |

If changing the style from one with 2 columns to a style with 1 column then you will be asked for making a header with 1 column. In this case the text control commands for a 2. column, $TT, will be deleted. The opposite happens if changing from 1 column to 2 columns style. The flag '**Raster**' sets the manual defined positions to a virtual raster as described in chapter 2.3.5.
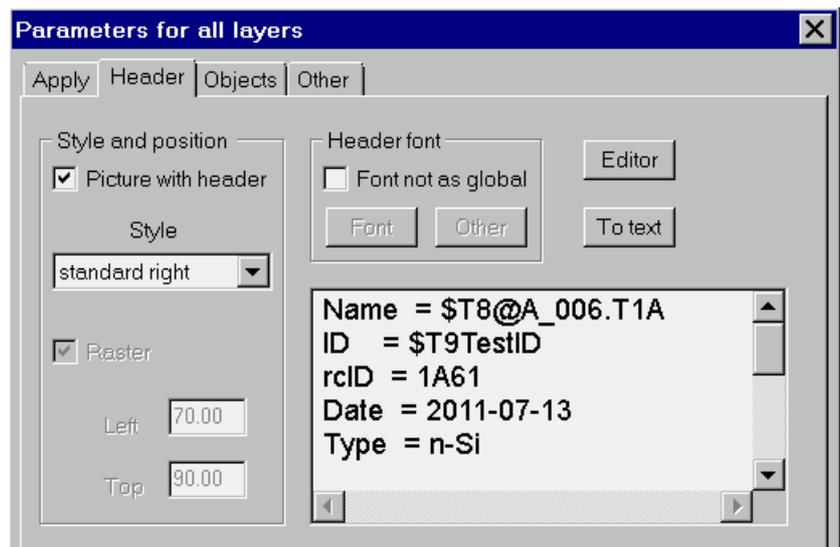


Usually the global defined header **font**, see chapter 2.3.3.3, will be used. By activating a flag you can locally define a font for the header.

The memo **text** field allows to edit the header text. The text control commands will be explained in chapter 5.2.7.X. Clicking onto the 'Editor' button calls the integrated standard editor. The 'To text' button copies the header into a text object.

## Objects input sheet:

Here you can define whether text and graphic objects are available for layer 0. These objects don't belong to a normal plot layer. The standard application here is a caption of the picture. If text or graphic objects exist then you can reduce its numbers.

3 buttons exist for opening the input window for 'New text', 'Text' and 'Graphic'. These inputs are similar to those described in chapter 5.2.7.

The setting of the **text position** is restricted. Following modes exist:



**manual:**      Input of left and top text position in per cent canvas coordinates.
**caption:**     The text will be shown on the bottom of the picture.
**screen top:**  The text will be shown on the top of the picture.
**scr top+:**    As above, but the x-position is at the plot boarder, the y-position is a little bit lower.
**screen left:** As above, but the x-position is at the picture start.
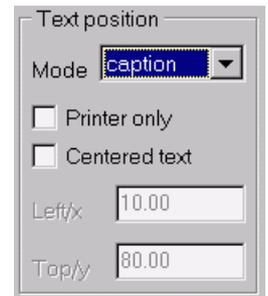
If using the caption mode then it is possible to plot the text only on the printer and not on the screen. The text can here also be shown centered in the x-mid of the picture.


## Other input sheet:

Here you can restrict the maximum numbers of layers.
The **size for one layer plots** can be defined here: Full, Big, With header. The first modes don't show the header, the last shows the header and uses a big screen size.

### 5.2.3.3 Plot params for one layer

These parameters are valid for the selected layer, the inputs are grouped in 6 input sheets.

**Base input sheet:**

Here are the parameters for the **layer size/position**, as described in chapter 5.2.0.2.

A plot has normally 2 axes, the x- and the y-axis. The software allows the use of additional axes, so that you can have for example 2 curves in 1 layer with 2 different y-axis. If it is an independent axis then you can define it separately in the axis menu.
Following **axis modes** exist:

**normal:**        Only one x- and one y-axis exist.
**+ top:**          An additional x-axis on the top of the boarder exist.
**+ right:**        An additional y-axis on the right exist.
**+ top, right:** An additional top x-axis and right y-axis exist.
**+ 3-dim:**       The plot will be shown in a 3-dimensional style, that means with an additional z-axis. This needs many curves.
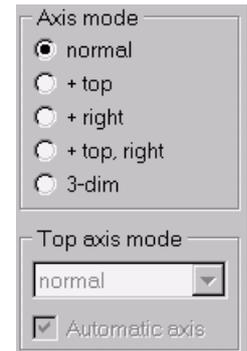
At an additional top axis you can select the **top axis mode**:

**normal:**        The top axis is an independent full definable axis.
**1/T → T:**      Not an independent axis, the top axis will be calculated from the standard x-axis. The application is an additional top temperature at an Arrhenius plot.
**T → 1/T:**      As before but shows on the top a 1000/T axis, the x-axis must be T.
**T → E:**        As before but calculates from the temperature (x-axis) an energy with the help of energy and capture cross section of the physical parameters.
**tau → E:**      As before but calculates from the time constant (x-axis) an energy with the help of temperature and capture cross section of the physical parameters.
**E → T:**        Opposite to T → E
**E → tau:**      Opposite to tau → E

If not defining the normal top axis mode then the flag '**Automatic axis**' is enabled. This means the text, steps and so on will be automatically set. In the other case you can input these values in the axis menu as x2-axis. The window minimum and maximum will not be used for this axis but calculated from the standard x-axis.

If using the **3-dim** axis mode then a button for the 3-dimensional parameters and the flag 'Check x-axis' will be visible. By not activating of this flag, the software don't check whether all curves of the layer have the same x-axis. In the other case the software test it and inter-polate the curves to one common x-axis if necessary, similar as saving ASCII data of all curves, see chapter 5.2.1.2.
The 3-dim plots shows an additional z-axis. The data for the z-axis come from 'Value for z-axis' of each curve and will be automatically set by entering the presentation plot. You can change this value separately for each curve in the 'Other' input sheet of parameters for one curve or commonly for all curves in the 'Other' input sheet of parameters for all curves.

If using an axis mode with an independent additional axis, except the 3-dim axis mode, then you have to define for every curve which axes the curve uses. This must be done in the 'View' input sheet of parameters for one curve, see chapter 5.2.3.4.

## Array input sheet:

Here are the common parameters for all arrays (curves) of the selected layer.

The **plot modes** input group contains flags for showing the curves with different y-offsets, see 'View' input sheet in chapter 5.2.3.4, and for interpolation and approximation (smooth).
If **smoothing** the curves then you can also plot additionally the not smoothed original data. The approximation will be done by the Easy spline mode, see chapter 2.7.1. You can select the smoothing strength and the taking out of data.

The scaling of both axes may be changed independently from linear to logarithmic and reverse. For the logarithmic you can use only negative or positive values or the absolute value.
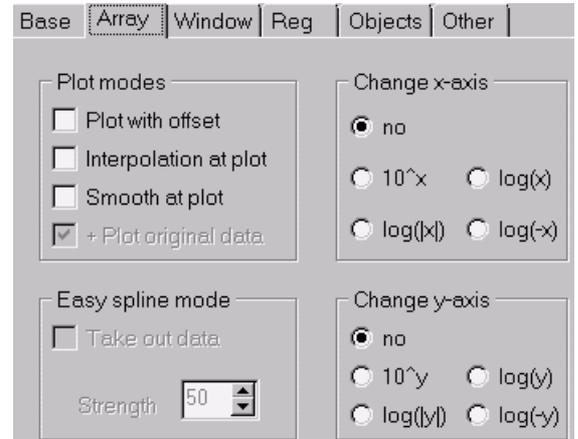
**Note:** All functions here don't change the original data arrays, only the curves will be plotted in the selected kind.

## Window input sheet:

Here are style parameters for the layer window and some other style parameters.

You can select a per cent **scale** of the global size for:
size of symbols and axis tick and the thickness of axis boarder, symbols and lines.

Usually the global defined **axis fonts**, see chapter 2.3.3.3, will be used. By activating a flag you can define locally fonts for the axis text and numbers. In the other case a per cent size of the global fonts is selectable.
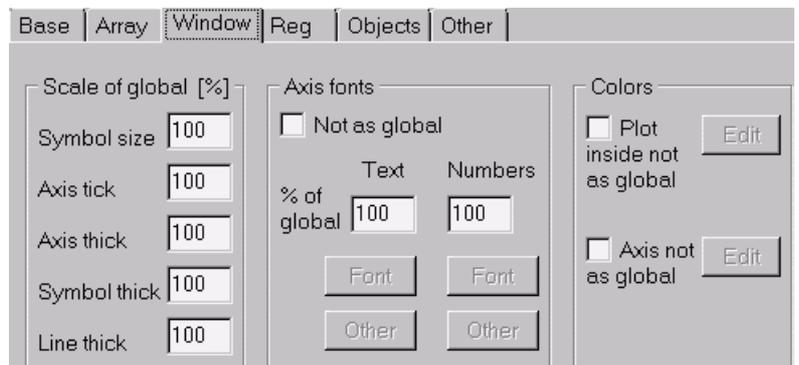
In the **Colors** input group you can define whether the color for the plot inside and for the axis will not be used as global defined, see chapter 2.3.3.1. In this case you can select the color by the 'Edit' button.

**Regression input sheet:**

This input sheet contains the parameters for the linear regression of the selected layer.

The regression mode defines which evaluation will be done by the linear regression. Further evaluation values will be calculated by the slope and section of the linear regression. Usually the regression line through the curve(s) will be drawn and the results listed. Following **regression modes** exist in all main programs:

| | |
|---|---|
| **No regression:** | No linear regression resp. evaluation will be done. |
| **Only line:** | Only the regression line will be drawn but not the results listed. |
| **Slope:** | Only slope and intersections of the linear regression will be listed. |
| **Energy:** | Arrhenius evaluation with listing only the energy. |
| **Arrhenius:** | Arrhenius evaluation, shows energy and capture cross section. |
| **Richardson:** | Calculates barrier height and Richardson constant. |
| **V/I resistance:** | Calculates resistance from a V/I (voltage versus current) curve. |
| **I/V resistance:** | Calculates resistance from a I/V curve. |
| **n-factor:** | Calculates n-factor from a I/V curve of a diode. |
| **Ns by C/V:** | Calculated shallow concentration from a $1000/^{\wedge}C2$ versus V curve. |

At the **DLTS** program are additional following modes available:

| | |
|---|---|
| **Arrhenius with NT:** | Similar to Arrhenius but additional the value for NT will be listed, but this value can not be calculated by the presentation plot program. It will be applied from the transferred plot at the entering. |
| **Zerbst:** | Zerbst evaluation of a transient. |
| **Nss:** | Calculates the capture cross section from a Nss plot. |
| **Capture:** | Calculates the capture cross section at a capture process. |

At the **Hall** program are additional following modes available:

| | |
|---|---|
| **Magnet:** | Calculates Rh and concentration at a field variation. |
| **Seebeck:** | Calculates Seebeck constant. |

The **regression type** is a sub mode for the regression mode. So its meaning depends on the regression mode but also on the data. The input is only a number. It will be set as the regression mode by the transferred plot.

The regression **array mode** defines how the regression will be done over the different arrays, it will be later explained in chapter 5.2.5. You can set it also in the Evaluate menu.
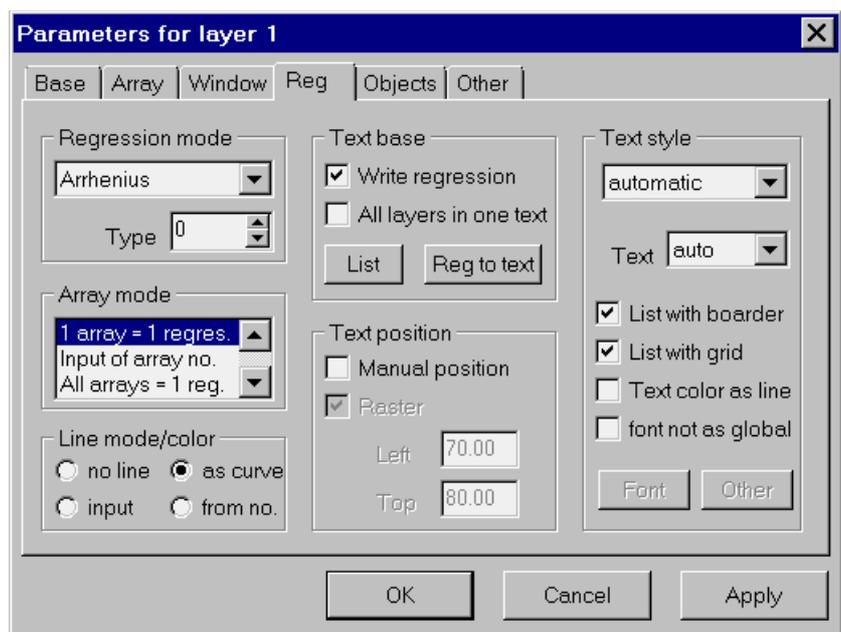
The **line mode/color** defines the color of the regression line:

**no line:**      No regression line will be drawn.
**input:**         You can input the color for each line, see chapter 5.2.3.4 input sheet 'Reg'.
**as curve:**    The line has the same color as the curve.
**from no.:**    The color will be defined by the regression (level) number. Here the global plot parameters will be used.

'**Write regression**' write the results either in the header or in a separate text box.
'**All layers in one text**' lists the regression/evaluation results of all layers in one text box. This input is valid for all layers.
The '**List**' button opens the integrated editor and list all regression/evaluation results of the selected layer.
The '**Reg to text**' button copies all regression results into a text object.

You can set the position of the regression text box by activating '**Manual position**'. Then you have to set the left and top position in per cent canvas coordinates. '**Raster**' sets the manual defined positions to a virtual raster.

The **text style** input group contains parameters for the regression text box and defines the use and main style of the text list box:

**automatic:**       Sets the style automatic. If only one regression number resp. level exist then the results will be listed in the text header.
**hori, no dim:**    Lists the results in a separate horizontal text box. Horizontal means that all results of 1 regression number (level) will be listed in 1 line. No dimensions of the values will be shown in the caption for saving space.
**horizontal list:**  As before but shows also the dimensions.
**vertical list:**    As before but the all results of 1 level are in 1 column.

For the Arrhenius regression mode you can select the energy text.
'**List with boarder**' draws a boarder around the list text box.
'**List with grid**' shows the list text box with a grid.
'**Text color as line**' uses the same color for the text as for the line, depending on the regression number. In the other case the color is black.
'**Font not as global**' allows to select a separate font for the regression text box. In the other case global defined data font will be used.

## Objects input sheet:

Here you can define whether text and graphic objects are available for the selected layer. If text or graphic objects exist then you can reduce its numbers.

3 buttons exist for opening the input window for 'New text', 'Text' and 'Graphic'. These inputs are similar to those described in chapter 5.2.7.

## Other input sheet:

Here you can restrict the **numbers of curves** and regressions. If a linear regression is available then the numbers of regression correspond usually to the numbers of curves, see previous chapter.

The plot shows normally the boarder and the curves. By deactivating a flag the boarder or the curves will not be plotted.

The button '**Axis**' allows the access to the axis inputs as in the Axis menu.
The button '**Edit z-val**' opens the grid editor for editing the z-values of all curves.

An input group contains **Physical parameters**: Temperature, time constant tau, energy, capture cross section sigma. These parameters are valid for all curves of the selected layer. Normally they are not necessary, but will be used for an additional top axis, see 'Base' input sheet of this chapter. 'Temperature' exist also separately for each curve. For the linear regression this value will be used.

If the layer comes from a plot with **many curves**, see chapter 5.1.7, then an additional input window is visible. The dimension of the z-parameter can be input. The z-parameter for the first and last curve can be written into the curves or be marked by squares with explanation text.

## 5.2.3.4 Plot params for one curve

These parameters are valid for the selected curve, the inputs are grouped in 4 sheets.

**Base input sheet:**

Here are the parameters for the **symbol** and color of the curve, as described in 5.1.3.1.1. An additional input for the scale size of symbols exist. The default is 100%, this means the symbol size is as global defined and used in the other plot programs.

**View input sheet:**

Here are parameters for showing the curve.

The **Smooth/plot** input group contains flags for showing, interpolating and smoothing the curve.
If **smoothing** the curves then you can also plot additionally the not smoothed original data. The approximation will be done by the Easy spline mode, see chapter 2.7.1. You can select the smoothing strength and the taking out of data.
All functions here and in the following don't change the original data arrays, only the curves will be plotted in the selected kind.
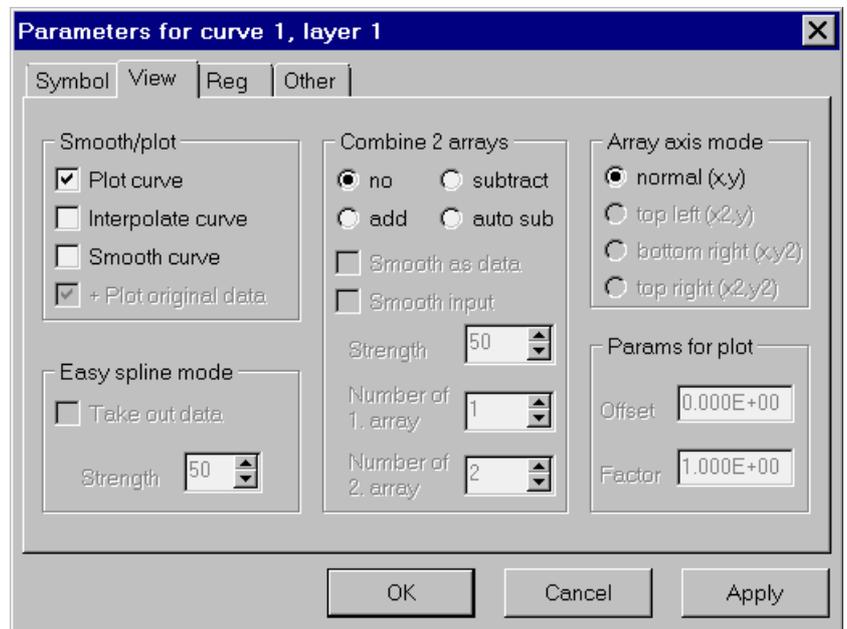


You can **combine 2 arrays** by addition or subtraction. 'Auto sub' means that from the curve with the biggest y-value the other curve will be subtracted. For the combination you have to input both array numbers, except in the mode 'auto sub' and the curve number N is bigger than 2. In this case the curves N-2 and N-1 will be used.
The arrays which will be used for the combination can be smoothed. This smoothing is only valid for the combining, it don't change the curves itself. You can smooth the combined curve as in 'Smooth/plot' or input a separate strength. Independently from the approximation both arrays will be reduced to the same x-axis at the combination, similar as explained in chapter 5.2.1.2.

The combined array replaces the selected curve at the plot but don't change the original data. It don't create a new curve, the curve which belongs to this array number will not be shown. If you want to show all original curves and additional a combined curve you have to create a new curve. For this select in 'Edit → Restore array' as curve mode '1 curve, standard params' and then as apply mode 'New curve/data'. For the difference of 2 arrays it is easier to call 'Edit → Make difference'.

The **array axis mode** is enabled if you have the selected an independent 2. axis, see axis mode of 'Base' sheet in chapter 5.2.3.3. Then you must define to which window axes the selected x- and y-array refers:

| | |
|---|---|
| **normal (x,y):** | The curve uses the standard bottom x-and left y-axis. |
| **top, left (x2,y):** | The curve uses as x-axis the top x2-axis. |
| **bottom right (x,y2):** | The curve uses as y-axis the right y2-axis. |
| **top right (x2,y2):** | The curves uses the top x2- and the right y2-axis. |

If activating 'Plot with offset', see 'Array' input sheet of chapter 5.2.3.3, then you can here define an **offset** and factor for each curve. This is only for showing the curve, the y'-values of the shown curve are calculated by y'=y*Factor+Offset.

### Regression input sheet:

This input sheet contains the parameters for the linear regression of the selected regression number. It is only visible if the regression mode of the layer is not 'no regression'.

If there is more than one regression possible, see regression array mode in chapter 5.2.5, then you can here input the regression (level) number. The **regression number** may not refer to the curve number. So if you have 2 curves and 3 regressions you can at every curve edit the regression by selecting the regression number. How to create a new regression number will be explained in chapter 5.2.5. A change of the regression number fills all inputs with the corresponding values.

If the regression array mode is 'Input of array no.' then you can here input the **array** start and end number over which the regression will be done. The input is also in the Evaluate menu possible. An array can be excluded in the 'Other' input sheet of its curve.

'**Plot reg line**' draws the regression line for the selected regression number '**Write reg text**' writes the results either in the header or in a separate text box.
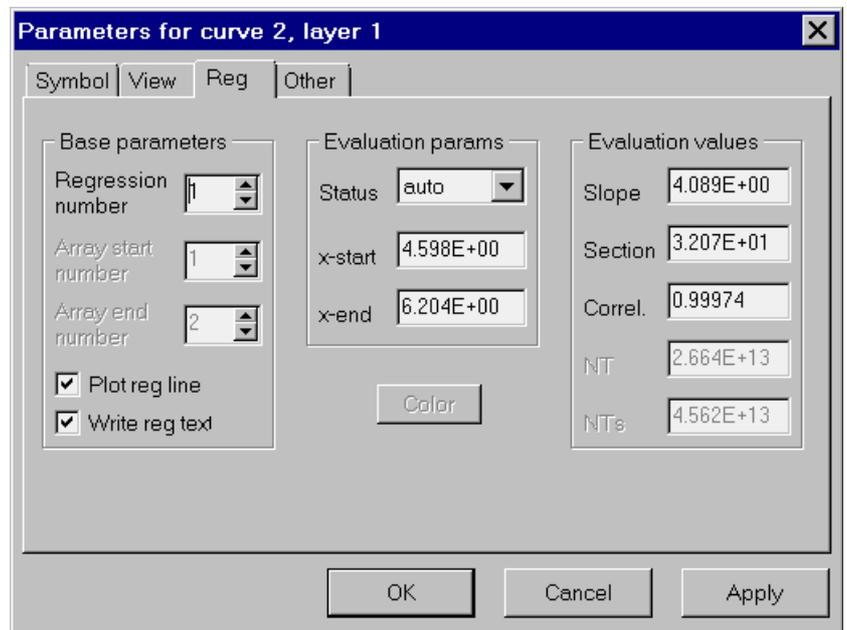


The **color** button is enabled if you have selected 'input' for the color of the regression line, see 'Reg' input sheet of chapter 5.2.3.3.

In the **Evaluation params** you can change the x-start and x-end of the linear regression. Normally these values will be set by the transferred plot or manually in the Evaluate menu. The **status** denotes how the regression was done:

**not init:**     No regression calculation was done.
**auto:**        An auto regression was done, see chapter 5.1.5.1.
**manu-range:** A manual regression was done with the mode 'Set xy-range for regression', see chapter 5.1.5.2.
**manu-line:**   As above but with the mode 'Set regression line'.
**manu-plot:**   As above but no new calculations.


The status defines also whether the standard evaluation values slope, section and correlation will be new calculated at the plot. If selecting 'auto' these 3 values will be new calculated. An input of these values makes then no sense. The manual regression keeps the values for slope and section. The correlation factor will be new calculated at 'manu-range' and, if global enabled as described in chapter 2.3.3.6, at 'manu-line'.
Slope and section are the direct values from the line. At the result list not these values but evaluation values calculated from these will be shown. For example, at an Arrhenius evaluation the energy will be calculated from the slope. The 'Arrhenius with NT' evaluation can have 2 additional values. Here you can input both, these will not be new calculated.




**Other input sheet:**

Here you can restrict the first and last **array** index of the curve and edit the x- and y-array by the integrated grid or text editor.

The **regression** can be disabled for the selected curve. The flag here belongs to the curve and not the regression (level) number. The regression number may not refer to the curve number. So for example, you can have a regression number 2 which uses curve 3, while curve number 2 will not be used for the regression. This flag can also be important for the regression array mode 'Input of array no.' if you want to exclude an array of the selected array range.

The value for **z-axis** can here be changed, it is only important for 3-dim and mapping plots. It is normally this parameter which is varied when many curves are to be plotted together.

An input group contains **Physical parameters**: Temperature and doping type. These parameters are valid only for the selected curve and will be used for special evaluations, that means regression modes. So the doping type will be used at the Arrhenius evaluation for the labeling of the energy. A change of the doping type here changes only this label but not the data and evaluation results!

### 5.2.3.5 Symbols for all curves

Here you can change the symbol, line mode and color of each curve of the current layer by one dialog. So a line can be set as symbol for each curve by 'one click'. If the flag 'New symbols' is not activated, the current symbols of the curves will not be changed.
Each of the following **possibilities** have to activate by a separate flag called 'New …':

- **Symbols:** 2 possibilities exist for setting a new symbol for each curve:
  - 'As curve number' sets the symbol by the curve number. Curve 1 gets the square, curve 2 the cross and so on, for more details look in chapter 5.1.3.1.1. Only the symbols 1 to 8 will be used.
  - 'All curves the same' defines for each curve the same selectable symbol.
- **Color:** 2 possibilities exist for setting a new color for each curve:
  - 'As curve number' sets the color by the curve number as explained in chapter 2.3.3.1. Only up to 8 colors will be used.
  - 'Palette' applies the color either from the blue-red or the rainbow palette, see chapter 5.1.7.2. Curve 1 gets the first color (blue), the last curve gets the last color (red). An inverse order is also available.
- The **Symbol scale** size for all curves can be input. 100% means the symbol size is as global defined.
- The **Line mode** can be set as described in chapter 5.1.3.1. This has only an influence when a curve will be drawn by lines.
- **Connect symbols** by lines can be set as described in chapter 5.1.3.1.

After clicking onto the 'Ok' button the selected actions will be done. The new symbols, colors and so on will then applied as new curve parameters. If a flag is not activated, this parameter will not be changed. The action will be done for all existing curves of the current layer. If you add later a new curve to the layer, the parameters of the new curve will not automatically be changed. You have to call this dialog again. All flags are deactivated after a program start.
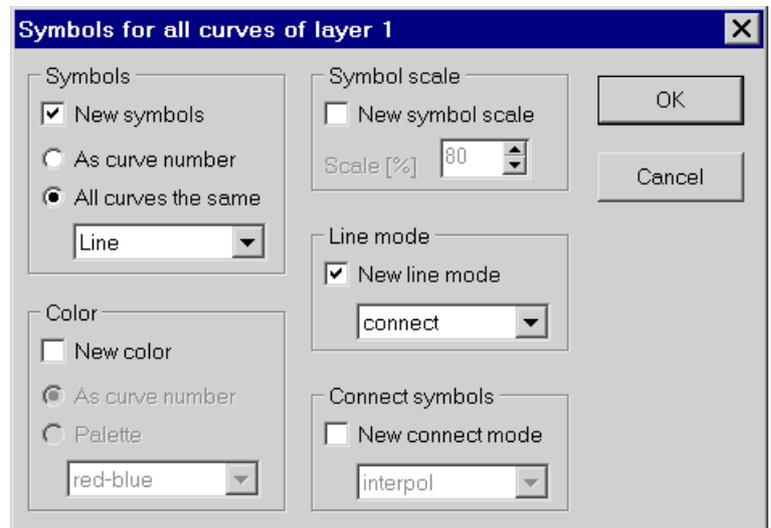
### 5.2.3.6 Position

Here you can change the positions of the layer, the header and the list text box of the regression results. These inputs are also in other input windows possible and are already explained, see chapter 5.2.0.2, 5.2.3.2 (Header) and 5.2.3.3 (Reg). There you can only input the position value or, for the layer, select predefined position types. Here you can additionally set the coordinates by mouse clicks on the screen plot.

For this you have to select in the input box 'SetPos for' for which you want to set the position by mouse: layer, header, regression. The selection for each mode is only enabled if the manual position was activated for it. The 'SetPos' and 'Show' button, see below, is only enabled if one mode of 'SetPos for' is enabled.

For the layer you have to set the left top and the right bottom corner by mouse, for the header and regression only the left top point. All coordinates are in per cent canvas coordinates.

There are 3 additional smaller buttons:
- **SetPos:** Shows the full plot and marks the current setting of point. After defining of the new point(s), the program goes back to the 'position' input window.
- **Show:** Similar as above, but the full plot with the new position will be shown after defining the new point(s). The program goes only back to the input window after pressing a key or a mouse click.
- **Refresh:** No new setting by mouse, the current plot will be shown. The program goes back to the input window after pressing a key or a mouse click.

**Note:** Activating of the 'Raster' flags sets the coordinate values to a virtual raster as described in chapter 2.3.5. So the final positions may not identical with these ones you have set by mouse or input.

## 5.2.4 Axis menu

This menu enables to set the axis of the plot and a new plot window. This can be done by an input, by the mouse or by the zoom function. The functions are the same as in the standard plot program, an explanation was given in chapter 5.1.4. The axis refers to the active layer, selectable in the View menu and shown in the toolbar as a button caption.

'Axis input' opens an input window for the x,y-axis parameters.
'Axis mark' enables to set a new plot window by marking the left/bottom and right/top point. You can define points inside of the plot window (zoom) or outside, but the defined points must be inside of the canvas.
'Axis rescale' restores the standard plot window.
'Zoom in, out and undo' are the standard zoom functions. For zooming-in you have to mark the center point by the mouse.

## 5.2.5 Evaluate menu

The possibilities of this menu depend on the kind of data. An evaluation by a linear regression is not always available. Look in chapter 5.1.5 for a description of the automatic and manual regression.

'Auto regression' is the standard linear regression, the 'Manual regression' can be started directly and with inputs of its parameters.
'Regression array mode' defines how the regression will be done over the different arrays.

The regression refers to the active layer. If there is more than one curve you get normally the input for the **regression number**:

You have to input the regression number. In the standard case this number corresponds with the curve (array) number for which the automatic or manual regression should be done. The kind of inputs depends also on the 'Regression array mode'. You can change it in the Evaluate menu, explained at the end of this chapter. If the array mode 'Input of array no.' is selected then you have here to input the array start and end number over which the regression will be done.

At this mode and at the mode 'All arrays = X reg.' you can also create a new regression number. The maximum numbers of regressions resp. evaluations is 9.

In the regression input sheet at 'View → Plot params for → One layer → input sheet Reg', see chapter 5.2.3.3, you find further parameters for the linear regression and evaluation which are valid for all curves of the selected layer. The regression parameters for a special curve are in 'View → Plot params for → One curve → input sheet Reg', see 5.2.3.4. There you can also delete the regression.

The **Regression array mode** defines how the linear regression resp. evaluation will be done over the different arrays resp. curves of the active layer:

- 1 array = 1 regression: This is the standard mode. The linear regression will be done separately for each curve. The regression number refers to the curve number. At calling the regression you get a question for the regression number if more than one curve exist, see above. But it is not necessary to do it for all curves, only regressions done will be drawn. You can also deactivate a regression number, see chapter 5.2.3.4.
  *Application*:1 curve with 1 regression or many curves with each 1 separate regression.

- **Input of array number:** This mode has the greatest flexibility. Regression number and array number are independent. You create a regression number and define which array range will be used for the calculation. For one array range are many regressions possible. You can exclude arrays of the array range at the 'Other' input sheet of 'Params for one curve'.
  *Application*: Many regressions over the same or different arrays ranges, or not using all arrays for the regression.

- **All arrays = 1 regression:** Only 1 regression is possible, all curves will be used. There is no input for the regression number or array range necessary.
  *Application*: 1 regression over all curves.

- **All arrays = X regression:** All curves will be used and you can define many regressions over all curves.
  *Application*: Many regressions over all curves.
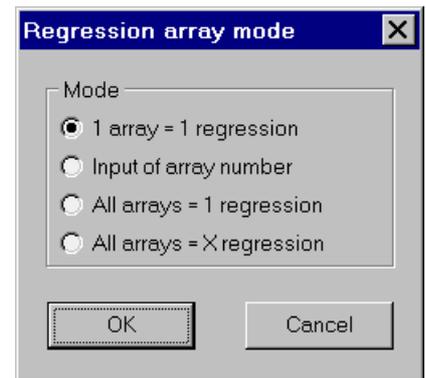
**Note:** At some evaluations the regression number will also be denoted as level number.

## 5.2.6 Tools menu

This menu contains some different functions. The functions are similar as in the standard plot program, for more information see chapter 5.1.6.

ASCII parameters contains parameters for copying, saving and reading ASCII data.
List data lists the x/y-data as lines and columns. You have to select layer and curve number in a similar input window as the second one in chapter 5.2.1.2.
You can create an extra window with a plot of the active layer. For the creating a separate data grid window you have to select layer and curve number in a similar input window as in 5.2.1.2.

Marker tools are a help to identify a point or get its position.

The ActiveX/OLE tools with its sub menu is only visible at user class 5. ChartFX is a chart plot program, Formula One a spread sheet. You can call Excel or Calc with the current data or save into the Excel or Calc format.

## 5.2.7 Objects menu

This menu allows to create and edit objects and to insert these in the plot. Objects are text or graphic elements of a layer. The inputs here are valid for the active layer. Objects for layer 0 can only be created and edit in the 'Params for all layer', see chapter 5.2.3.2.

'New text' create a new text object with default parameters and opens then 'Text' input window. Here you can edit the existing text objects or create or delete an object.
'Graphic' allows to create a new graphic object or to edit an existing one.

### 5.2.7.1 New text

The 'New text' function is similar as the 'Text' function. But before it opens the normal text function, you get an input window for the new text mode. It defines the default font for a new text and some other parameters. Following **new text modes** exist:

**PresFont, default:** This is standard mode. The so called presentation font will be used. It is global defined, see chapter 2.3.3.3.
*Application*: Standard text inside the plot.
**PresFont, 85%:** As above but sets the font scale to 85%.
**Data explanation:** Uses the data font.
*Application*: Data grid inside of the plot.
**Symbol explain:** Uses the symbol font in simple mode, see next chapter.
*Application*: Explanation of plot symbols inside of the plot.
**Caption inside:** Uses the caption font with font scale 75%.
*Application:* Caption inside of the plot window.
**Caption outside:** Uses the caption font and activates the canvas coordinates system.
*Application:* Caption at the top or bottom outside of the plot window.
**Local font:** Uses not a global font as the other modes but a local font which you have to define.

If not otherwise denoted above, the new text mode sets also following default parameters:

- Activation of the axis coordinates system instead of the per cent canvas coordinates.
- Setting of the font scale to 100 %.

The input of the new text mode is valid for all layers except layer 0.

The new text can be filled by a **template**:

**Empty:** The new text is empty.
**Last text:** The text of the last input will be used.
**By curves:** The template contains an explanation of symbols and colors of each curve.

A new text object will be created after setting the new text mode. For this the maximum number of text objects will be incremented. The parameters of the last text object, if exist, will be copied to the new object. The default parameters as the font will then be set for the new text object. Then the input window for 'text' opens as described in the next chapter.
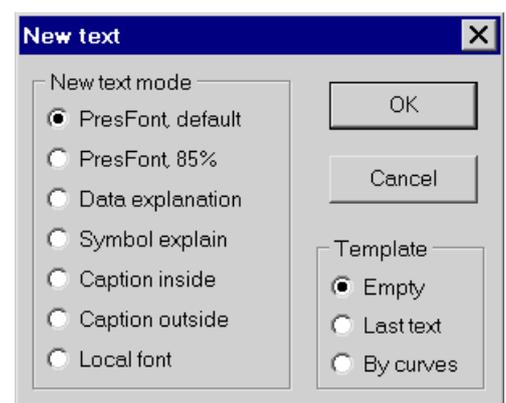
### 5.2.7.2 Text

Here you can create a new text object or edit an existing one.

The **text number** is the number of the text object. Up to 50 text objects per layer are possible. You can select one of the existing text objects. A change of the text number fills all inputs with the corresponding values.

You can create a new text object by the '**New**' button. The parameters of the last text object, if exist, will be copied to the new object. Here the default parameters will not be set by the new text mode as described in the previous chapter.
The '**Delete**' button deletes the selected text object. The text numbers will then be reorganized.
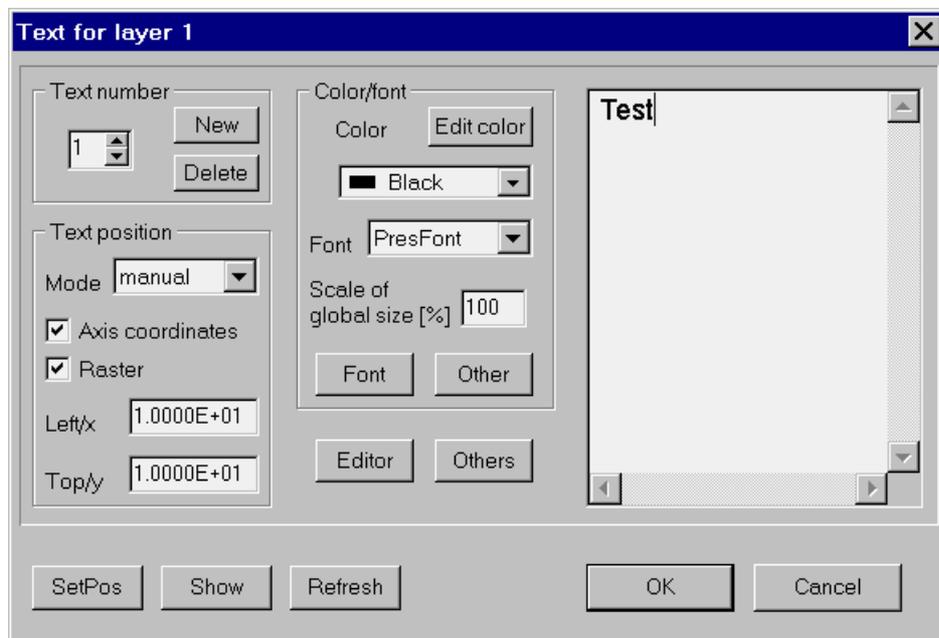
Following modes for the **text position** exist:

| | |
|---|---|
| **manual:** | Input of the left and top text position, can be set also by mouse. |
| **left/top:** | Left top inside of the plot window. |
| **left/bot:** | Left bottom inside of the plot window. |
| **right/bot:** | Right bottom inside of the plot window. |
| **right/top:** | Right top inside of the plot window. |
| **right/mid:** | Right middle top inside of the plot window. |
| **right/center:** | Right center inside of the plot window. The text is centered around the middle of the y-axis. |
| **out/top:** | On the top outside of the plot window. |
| **reg. list:** | Left top inside of the plot window, optimized for a regression list text. |
| **caption:** | The text will be shown on the bottom of the picture. |
| **screen top:** | The text will be shown on the top of the picture. |
| **scr top+:** | As above, but the x-position is at the plot boarder, the y-position is a little bit lower. |
| **screen left:** | As above, but the x-position is at the picture start. |

Activating of '**Axis coordinates**' uses the axis (world) coordinates system of the selected plot (layer) instead the per cent canvas coordinates system.
'**Raster**' sets the manual defined positions to a virtual raster. Then the final positions may not identical with these ones you have set manually, but usually it likes nicer.
The **Left/x** and **Top/y** coordinates (axis or per cent canvas) are enabled at the manual text position. You have to define the left top corner of the text.

The text **color** can be selected by the color input box or by the standard color dialog.

The **font mode** defines the text font:

| | |
|---|---|
| **PresFont:** | The so called presentation font will be used. |
| | *Application*: Standard text inside the plot. |
| **Header font:** | The header font will be used: |
| | *Application*: Usually only for the header. |
| **Data font:** | Uses the data font. |
| | *Application*: Data grid inside of the plot. |
| **Symbol font:** | Uses the symbol font. |
| **Symbol, simp.:** | Uses the symbol font in simple mode. Scale, color and 'Others' parameters are not enabled, optimized for symbol explanation. |
| | *Application*: Explanation of plot symbols inside of the plot. |
| **Local font:** | Uses a local font which you have to define. |
| **Caption:** | Uses the caption font. 'Others' parameters are not enabled. |
| | *Application:* Caption inside and outside of the plot window. |

Except the local font, the fonts are global defined, see chapter 2.3.3.3. The input windows which open by the '**Font**' and '**Other**' button change the global valid parameters of the global font. So here these inputs are forbidden for the header, data and symbol font. The inputs for the presentation, caption and local font are allowed because the presentation and caption font will not be used automatically from the software, they are reserved for the presentation plot program. The local font is only local valid for this text number.
The **scale of global size** sets the font size relative to the global selected size of the global font.

The memo **text** field allows to edit the text. Clicking onto the 'Editor' button calls the integrated standard editor. The command characters will be described in the next chapter. The 'Others' button will be described on the next page.

If selecting the **manual position** then you can set the left top corner of the text also by a mouse click or by cursor keys. For this there are 3 additional smaller buttons:

- **SetPos:** Shows the full plot and marks the current setting of point and draw the text on the old (current) position. No refresh of the plot will be done, so you can compare the old and new position. After defining the new point, the program goes back to the 'text' input window.

- **Show:** Similar as above, but the plot will be refreshed and while marking the old (current) position the text will not be drawn. And the full plot with the new position will be shown after defining the new point. The program goes only back to the input window after pressing a key or a mouse click.

- **Refresh:** No new setting by mouse, the current plot will be shown. The program goes back to the input window after pressing a key or a mouse click.

In the **status line** you get normally the information 'Mark left/top point by mouse/marker'. If drawing a line or arrow with the text then you have here also define its end point. So you get in the status line first the hint 'Mark start point', this is the text position, and then the hint 'Mark end point', this is the position of line resp. arrow end.

**Note:** The left top position is not the real start (left top corner) position of an individual character. A virtual cell size independently from the character will be used.

The '**Others**' button opens an additional input window .

A grid, line or arrow can be drawn with the text.
For the **line** and **arrow** you have to define the end point of the line resp. arrow, either by input or by mouse. The coordinate system is the same as for the text. The start point will be calculated by the text position in such way, that the line don't go through the text. By activating 'centered on text' starts the line from the middle of the top, bottom, left or right of a virtual box around the text. In the other case a vertical or horizontal line will be drawn from the text to the end point. If this is not possible then the start point of the line is a corner of the text.
You can also draw the text with horizontal and vertical **grid** lines. The text columns must be separated by semicolons. Usually you should here use a 'grid with boarder'.
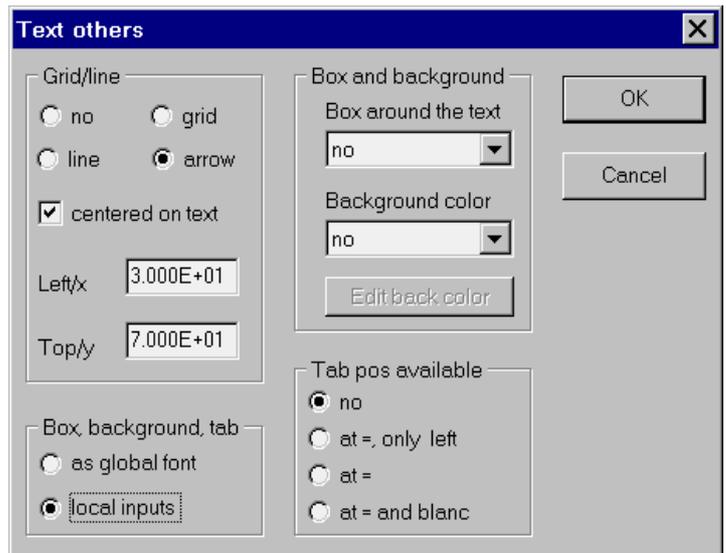
2 modes exist for the **box, background and tab** of the text:

| | |
|---|---|
| **as global font:** | The input is here not available, the parameters of the global font will be used, see 2. input window of chapter 2.3.3.3. |
| **local inputs:** | Local inputs here are available, they are only valid for the current text number and replace only for this the corresponding global values. |

The inputs for the local font are always possible, they are here the same as in the 'Other' button above. The local font is only valid for the current text number!

Following possibilities exist for a **box** around the text: normal box, shadow, 3-dim box.

Following modes for the **background color** of the text or the box are possible:

| | |
|---|---|
| **no:** | No background color. |
| **text, color input:** | Background of the text, color input by the 'Back color' button. |
| **box, color input:** | Background of the box, color input by the 'Back color' button. |
| **box, plot color:** | Background of the box, the color is the global color 'Plot background', see chapter 2.3.3.1. |
| **box, inside color:** | Background of the box, the color is the global color 'Plot inside'. |

**Tab pos available** means after which character the software can set a tabulator and starts a new position. This is useful at proportional fonts for list of data with text and values. A more detailed description was given in chapter 5.1.1.1.3.

**Tip:** If the text includes a '=' character and another tab mode as 'no' is selected, this is the default by the data and header font, then spaces between the words can occur. To avoid this sets the tab mode locally to 'no' or switch it off by control commands. These commands allow on the other hand also to set the tab mode as explained in the next chapter.

### 5.2.7.3 Control characters

The text objects and the header can contain control characters. These are characters resp. character groups which will not be shown but control the face of drawing the text, for example for drawing an index or exponent. We use as control character only the **dollar** sign '$', followed by other characters which yields to a control character group. These are composed of the '$' and one base sign, in some cases followed by other character.

In the following list denotes 'N' a 'character number' that means if the number is 0 to 9 then N is '0' to '9', if the number is 10 then it is 'A' and so on. This is similar to the hexadecimal system. The important **control character groups** are:

**$$:**   Shows only the **dollar** sign.
**$^:**   **Exponent**, draws the following text a little bit higher.
**$_:**   **Index**, draws the following text a little bit lower.
**$<:**   **Left**, sets the following text one character size to the left.
**$F:**   **Font**, toggles between the standard font character set and the greek charset 161.
**$A**N**:** **Angle**, draws the next text rotated, N denotes here the angle:
          0..9: 0..90 degree, A: 180, B: 270.
**$C**N**:** **Color**, draws the next text or symbol with the color defined by N. For '0' to 'F'
          denotes N the global color number, see chapter 2.3.3.1:
          1..6: color for global curve number 1..6;  7: color for fit curve, and so on.
          For 'K' to 'Z' is N the color of the base color dialog:
          K:black, L:maroon, M:green, N:olive, O:navy, P:purple, Q:teal, R:gray, S:silver,
          T:red, U:lime, V:yellow, W:blue, X:fuchsia, Y:aqua, Z:white.
          'a'..'t': Sets the color of the curve number 1..20 of the current layer, only valid for a
          text object in the presentation plot program.
**$S**N**:** **Symbol**, draws a symbol defined by N. N is the symbol:
          1:square, 2:+, 3:diamond, 4:x, 5:triangle, 6:circle, 7:full square, 8:full circle,
          9:3x3 points, A:point, B:horizontal line, C..E:longer line, F:dash line, H:dot line,
          H:dash-dot, I:dash-dot-dot, J:space.
**$T**N**:** **Tabulator** control. Meaning of N:
          0: disables the tabulator control for the whole following text.
          0..3: as the input in the previous chapter,.
          5: sets only on the current text position a tab.
          8: disables tabulators and the control characters.
          9: disables the control characters.
          T: tabulator for a header with 2 columns.


**Tip:** For a manual symbol explanation use only one text object with several text lines and not some text objects with each one line. Start line 1 with $Ca, line 2 with $Cb and so on, then the text will be drawn in the color of the curves. A symbol will be drawn by $SN where N is the symbol number. For the tabulator see tip above.


**Note:** If using an index (exponent), don't forget to insert an exponent (index) after the character group. For example, use N$_S$^.

### 5.2.7.4 Graphics

Here you can create a new graphic object or edit an existing one of the active layer. A graphic object belongs as a text object to a layer.

The graphic **number** is the number of the graphic object. Up to 50 graphic objects per layer are possible. You can select one of the existing graphic objects. A change of the graphic number fills all inputs with the corresponding values.

You can create a new graphic object by the '**New**' button. The para- meters of the last text object, if exist, will be copied to the new object. The '**Delete**' button de- letes the selected object. The graphic numbers will then be reorganized.

The left, right, top and bottom **position**, in per cent canvas coordinates, of the graphic is neces- sary. '**Axis**' uses the axis coordinates instead the canvas coordinates. '**Raster**' sets the positions to a virtual raster.
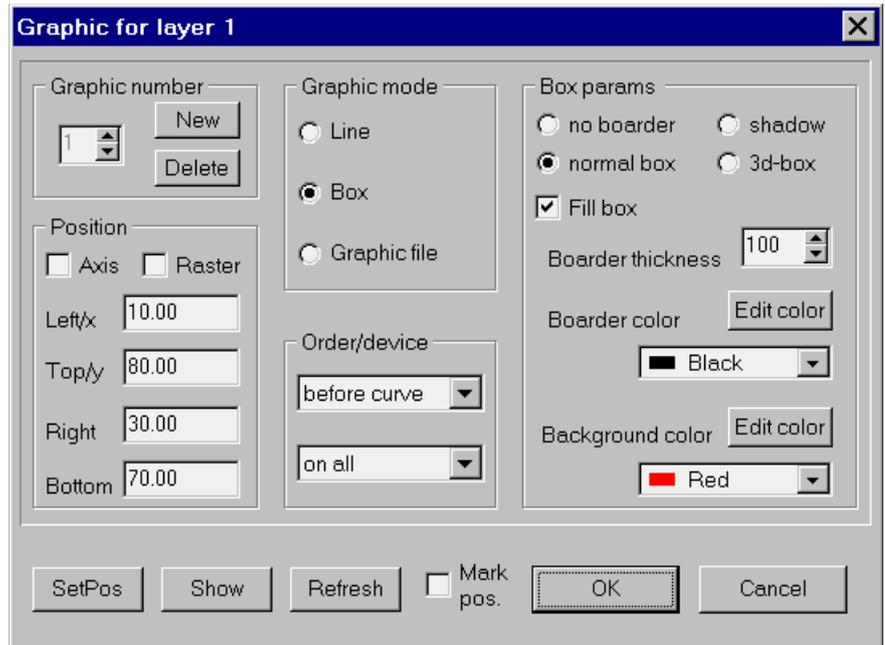
3 **graphic modes** are available, the parameters on the right depends on this:

**Line:** A line will be drawn. Parameters are the line type, the thickness and the color. The line can have an arrow on its end. A horizontal or vertical line will be drawn by the option 'horizontal/vertical'. The software draws here a hori- zontal line by (x1,x2,y1) if |y2-y1|<=|x2-x1|, in the other case a vertical line.

**Box:** A box will be drawn. Parameters are the type, thickness and color of boarder. The box can be filled with a background color.

**Graphic file:** A saved graphic can be loaded and drawn, the program supports BMP, JPG, GIF, WMF and EMF file formats. You can draw the graphic in original size or stretch it into the marked size. The graphic can also be shown transparently. The graphic will not be saved into HPGL, PLT, EPS and DXF files.

The steps by showing a layer are: start of layer, draw curves, draw texts, layer end. The graphic **order** defines when a graphic should be drawn: layer start, before curve, before text, layer end.

You can select on which **devices** the graphic will be shown:

**on all:** The graphic will be shown on all devices.
**not printer:** The graphic will be not shown on a printer, opposite to the next mode.
**as printer:** The graphic will be shown only on a printer and similar output devices a printer or HPGL file.

The **buttons** has the same meaning as in chapter 5.2.7.2. Here you have always to set 2 points, first the left-top and then the right-bottom corner.

At user class 6 there is the additional flag 'Mark pos', which also exist in the input window for the text object. This option means that the positions of all text and graphic objects will be marked by a big cross (+). It is only for testing. The flag is global and is valid for all layers and all objects. It will not be saved into the presentation data file.

# 5.3 Other plot programs

This chapter describes not complete new plot programs but modifications or extensions of the standard plot program or other common parts of the plot programs.

## 5.3.1 Application plot program

The Application Plot Program is only a modification of the standard plot program. In some cases the plot opens the application instead of the standard plot program.

There are 3 **differences** resp. reasons for an application plot:

- The linear **regression** can be done automatically at calling the plot. Sometimes there is in the input window before doing the plot, a question for starting with the 'Auto regression'. In all these cases the regression line is normally red instead of black. You can change the color of the regression line in 'Global plot parameters', see chapter 2.3.3.1. The automatic (red) regression line will there be called 'Application regression', the other (black) 'Standard regression'.

- The application plot can contain more than one **layer**, that means more than one plot per page. In this case it not possible to change the windows of the various plots. For this use the presentation plot program.

- The picture can even be composed of 2 canvas (screen) **pages**. Between the 2 pages you get the information box 'Plot next page'. Usually these 2 canvas pages will be shown on one paper page by a printer.

If there are 2 pages then is in the View menu the entry 'Page number'. Here you can define to show only the first or the second page or both pages.

## 5.3.2 Edit plot program

The Edit Plot Program is an extended version of the standard plot program. In opposite to this the edit plot program can modify the data and can load data from ASCII files. You can call it from the standard plot program if the plot contains only one curve, means only one x/y-array. It can also be called from the presentation plot program or from the Base Tools. The edit plot program can save the x/y-array and read these from an ASCII file. But only the pure ASCII data will be saved or loaded, not the parameters for the window and so on as the presentation plot program will do.
The *application* for the edit plot program is to edit (modify) the x/y-data and then to plot it or to apply it into the presentation plot program.
The menus and the toolbar are similar to the standard plot program, in the following only the new possibilities will be explained.

If **entering** the edit plot program from the standard or application plot the following window occurs. The current x/y-array will always be applied.
You can also apply the current header and the current regression mode. But this may yield to problems by reading x/y-data from a file because the header will not be saved. It will be taken from the current global data. So it can happen that the header don't belong to your x/y data. Some regression modes don't use only the x/y-array but additional parameters which will also not be saved in the edit plot program.
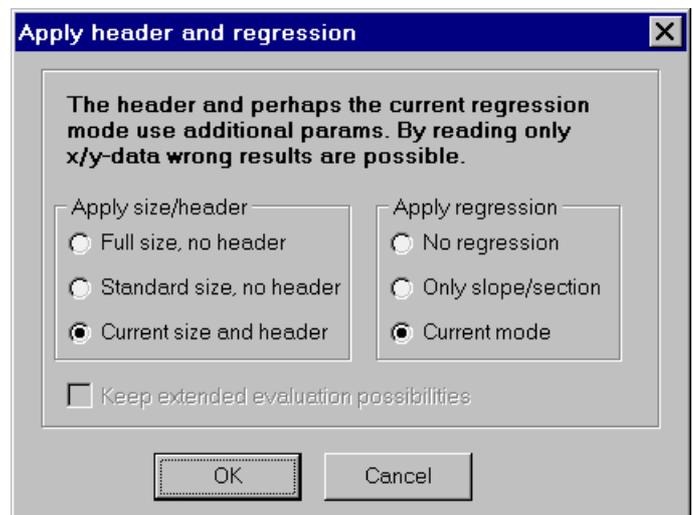


Following modes exist for applying the **size/header**:

| | |
|---|---|
| **Full size, no header:** | The plot uses the full (possible) canvas size, no text header will be shown. |
| **Standard size, no header:** | The plot has the standard size but without showing the text header. |
| **Current size and header:** | The edit plot uses the current size and header position of the standard plot program. |

Following modes exist for applying the **regression** mode:

| | |
|---|---|
| **No regression:** | No linear regression is available. |
| **Only slope/section:** | A linear regression with calculating only slope and intersection x0 with the y-axis and y0 with the x-axis is available. |
| **Current mode:** | The current regression mode of the standard plot will be applied. |

You can change also later the size/header in 'View' and the regression mode in 'Evaluate'.

The additional flag 'Keep extended evaluation parameters' is only enabled at user class 5. If activated then all possibilities of the Evaluate menu of the standard plot program are further on available, as 'Fit', 'EvalBank', 'Data tasks' and so on. Be careful with this option because a lot of problems can occur.

### 5.3.2.1 File menu

The edit plot program has no own data type. You can only save the x/y data into an ASCII file or load these data from an ASCII file.

If reading ASCII data an input windows opens similar as described in chapter 5.2.1.2. The old data will be overwritten. The option 'Reset plot axis' sets the axis of the plot window by the new data. In the other case the old window will be kept.
'Save ASCII' data saves the current x,y plot values line by line into a text file. The input is similar as described in chapter 5.2.1.2. By an additional option it is possible to save the data in the decimal format instead of the standard exponential format.

### 5.3.2.2 Edit menu

The Edit and the Data menu are perhaps the most important menus of the edit plot program. Here you can edit the x/y-data points.

'Paste ASCII data' pastes ASCII data from the Windows clipboard and overwrite the current data. The x-array will be taken from the first, the y-array from the second column. The plot window will not be reset.
'Edit ASCII data' opens the grid or ASCII editor for editing the x/y-data, see chapter 5.4.1.
'Sort data' sorts the data by the x-array.
You can delete single data points or a data range, new points can be inserted and existing points be moved. These can be done by mouse or marker. In the 'special 'edit' mode the deleted data remain in the data array with setting x to -1E100, see chapter 5.4.1.2.
A powerful tool to delete points is 'Delete by deviation' in the Data menu, see chapter 5.3.2.6.1.

#### 5.3.2.2.1 Delete, insert, move

At all the following functions you can use the mouse or the cursor marker. The mouse click marks the point and calls then the action. If using the marker you have to go to the point by the marker and then to press 'Enter' for applying the point and calling the action.

**Delete data range:** The left and right marked data range will be deleted.
**Delete data point:** The marked point will be deleted. For deleting a further point you have first to click onto the menu. You can delete some points with only each one mouse click by 'Delete by deviation', see chapter 5.3.2.6.1.
**Insert data point:** Inserts on the marked position a new data point. This point will be append on the existing ones. There is no automatic sort.
**Move data point:** Allows marked data point to be moved to a new x/y position. First you have to mark an existing point and then the new position.

## 5.3.2.3 View menu

By 'Header' you can define the plot size type and whether the header should be shown. It is the same as at entering the edit plot program, see start of chapter 5.3.2. 'Old auto size and header' means here the 'current size and header' at entering the edit plot. 'Refresh' plots the plot again.
'Init plot' makes a new window/axis initialization.
'Reset plot' makes more than 'Init plot'. It sets additionally the standard values for the boarder and window face, deletes the axis text and sets the regression mode to 'slope'.
'Interpolation' interpolates also here only the curve at drawing but not the x/y-data array if selecting 'Original in memory', see chapter 2.7.1. For interpolating or smoothing of the data you must disable this flag or select 'Data → Smooth, Devi, Int'.

## 5.3.2.4 Axis menu

'Log. axis+data' forms linear data to logarithmic data and reverse. The scaling of axis will be set automatically to the data type. x- and y-axis (array) may be changed independently from the other, as the input window below shows. If the data/axis is linear then you can select as **data/axis** 'Keep linear', 'Make logarithmic' or 'Make exponential'. The last is usually not necessary because the software tries to detect the current face. If the data/axis is logarithmic then you can select between 'Make linear', 'Keep logarithmic' and 'Make logarithmic'. By leaving with 'OK' the plot axes will also be newly initialized.

Following **logarithmic types** exist:
ln, log10, log10 with log. axis.
At the first 2 possibilities only logarithmic data will be formed, the axis is linear with the text prefix 'ln' resp. 'log'.
At the 3. type the axis will be shown in a logarithmic face.

For the logarithmic '**Sign/abs**' you can use only negative or positive values or the absolute value.
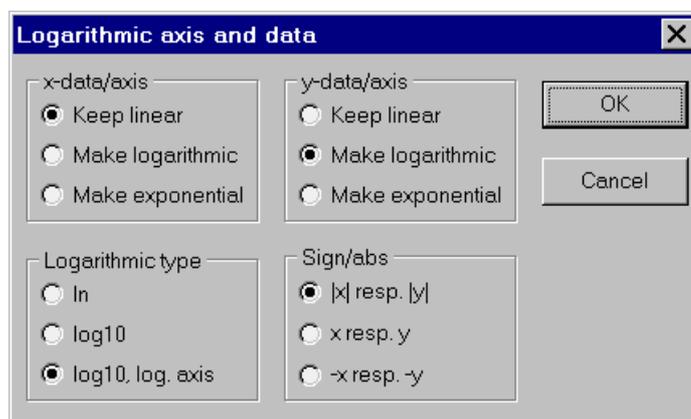
## 5.3.2.5 Evaluate menu

Normally the extended evaluation menus as 'EvalBank' are not visible in the edit plot program, see 'entering' at start of chapter 5.3.2.
The regression mode can be selected. The input is the same as explained in chapter 5.2.3.3. Usually it will be automatically defined at entering the edit plot program.

## 5.3.2.6 Data menu

This is a sub menu with a lot of possibilities to change the x/y-data. Only a short description will be given here.

'Buffer' opens a sub menu to load/save data from/to buffers, 'Delete by deviation' is an important tool for deleting data points by plot and will also be used in similar way from some measure program modules.
'Change data' and 'Smooth, Dev, Int' are also important functions of the Data menu. The last allows a smooth (approximation), interpolation, deviation and integration of data.
'Calculator' calls a semi-conductor calculator, needs user class 5.

Following possibilities exist for working with the buffers:

'Undo' restores the data from the Undo buffer.
Data can be saved to *the* (main) buffer or load from it. If loading then the current plot data will be overwritten.
Three additional buffers I, II and III exist for saving the current data into these buffers. The buffers can then be used later.
'Add. plot of buffer' shows in all plots of the Edit plot program additionally the data of the buffer.

'Data tools' opens a sub menu with following tools:

'Delete same x resp. points' are described in chapter 5.2.2.2.
'x → transient FFT' restores the data by interpolation in such way that it can be used for the FFT (Fast Fourier Transform). That means the new x-data will be equidistant and the numbers of points are a power of 2.
'Make Fourier spectrum' calculates the FFT and applies the spectrum as new data.

### 5.3.2.6.1 Delete by deviation

This is an important tool for deleting data points by plot and will also be used in similar way from some measure program modules, see chapter 2.6.3. This function opens a combined input and plot window. The inputs are on the left side, on the right is the plot. Some buttons and plot parameters are above the plot.
Following **buttons** exist:

**Do:** Do the selected action with the current data, means for example the deleting of an array range. It shows the result plot and applies its data as the current data.

**Undo:** Undo the last action.

**Show:** Do the action and shows the result plot, but don't apply the data.

**Plot:** Plots the current data, it don't refresh the 'Show-plot'.

**Tools:** Input of curve and axis parameters, copies ASCII data, lists and edits the plot data in a data grid or in the ASCII editor, lists the deleted data. Loads the entry data or buffers data as current data, saves the plot data in a buffer. The x- and y-values can be changed by calling the editor.

You can **compare** the current data in the plot with the undo, entry or deleted data. 'Undo' data are the data before clicking onto the Do-button, 'entry' data are the data at starting this menu point. 'Deleted' data are these points which were already deleted. By activating '**Auto window**' the plot window will be set automatically.
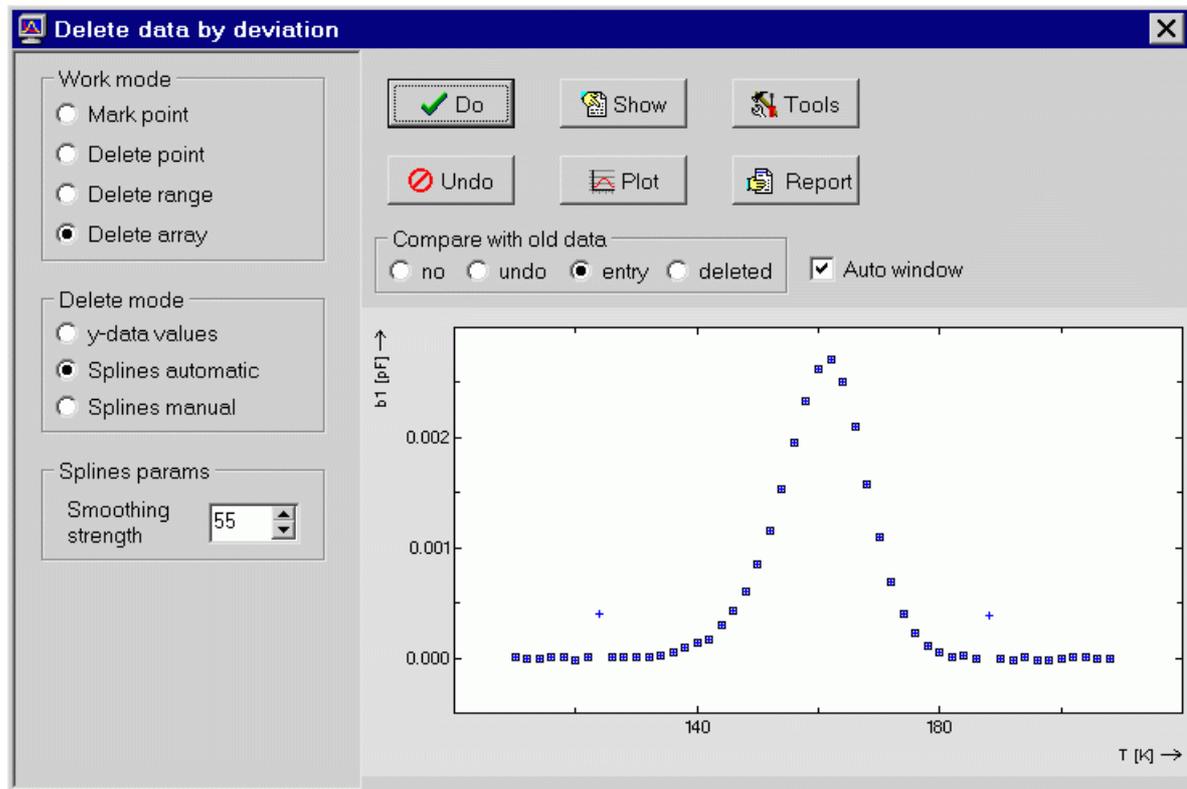


The deleting of data can be done in several ways, called **Work mode:**

| | |
|---|---|
| **Mark point:** | The mouse marks a data point. Only one point can be marked. You can delete the point by the 'Delete' button which hides the 'Do' button. |
| **Delete point:** | A mouse click onto a point delete it. |
| **Delete range:** | The left and right marked data range can be deleted by the 'Do' button. |
| **Delete array:** | The program searches the full data array for 'bad' points. |

The **Delete mode** defines criteria for the work 'Delete array':

| | |
|---|---|
| **y-data values:** | You can delete all points with y=0, y<0 or y>0. |
| **Splines automatic:** | Calculates a smoothed spline with a given strength and checks then the difference between smoothed and origin y-value. If it is too big, the corresponding point will be deleted. |
| **Splines manual:** | Similar as above but you can define manually the maximum difference between original and smoothed y-values. The inputs are the same as explained in chapter 2.7.1 for 'Take out data'. |

The x-values of the deleted points from earlier sessions will be saved into a **report list**. This enables to delete the same x-values in many curves (files), click onto the 'Report' button for this feature. The report list contains only points of earlier sessions but not of the current session. When leaving the current session, you can reset this list by a flag.

The points of the report list can be marked (shown) in the plot by green 'x'-crosses. The report list contains only x-values and searches the nearest y-values for the plot. It may be, that the points of the report list don't match the y-values of the current data. Therefor it is possible to mark the points of the report list by vertical lines instead of symbols. But a 'bad' y-value is no problem for deleting data by the report list because only the x-values are here necessary.

A small menu opens by clicking onto the **Report** button:
Marks the data of the report list in the plot, uses a vertical line for the marked points, edits the points of the report list or deletes the current data by the report list (see above and note).

**Note:** When deleting by the report list, a point of the current data will be searched for each x-value of the report list. This will be the nearest x-value, a 100% match is not necessary. Don't call this function 2-times because then additional points will be deleted. When using this function, call it first after the entry. If necessary, delete then additional points by the work modes. Don't call this function after deleting points by the work modes.

The following input window appears if leaving the 'Delete by deviation' function. It defines whether the changed data should be applied.

Following buttons exist:

**Data + axis:** The new data and the new plot axes will be applied. A separate input defines whether only the x-axis, the y-axis or both axes should be applied.

**Data:** Apply only the data but not the plot axis.

**No apply:** The changed data will not be applied, the program restores the entry data.

**Cancel:** Goes back to the 'Delete by deviation'.
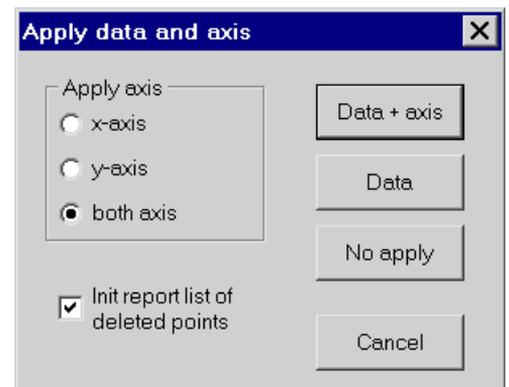
'**Init report list of deleted points**' resets the report list and applies the current deleted points as new report list. If this flag is not activated, these points will be appended to the report list.

When this tool will be called from a measure program module and not from the edit plot program, you get a different input window at leaving. This may allow additional features, for more details look in chapter 2.6.3 or in the corresponding description of the measurement program.

### 5.3.2.6.2 Change data

This function uses as a similar kind of combined input and plot window as introduced in chapter 5.3.2.6.1. But the inputs are divided in 5 input sheets: x-data, y-data, Paste, Normal, Other. The action depends on the selected input sheet. So the y-data of the current plot array will be changed by 'y-data'. At 'Paste' you can paste ASCII data from the clipboard or read from an ASCII file. These data can be combined with the existing ones, for example addition, subtraction or appending.
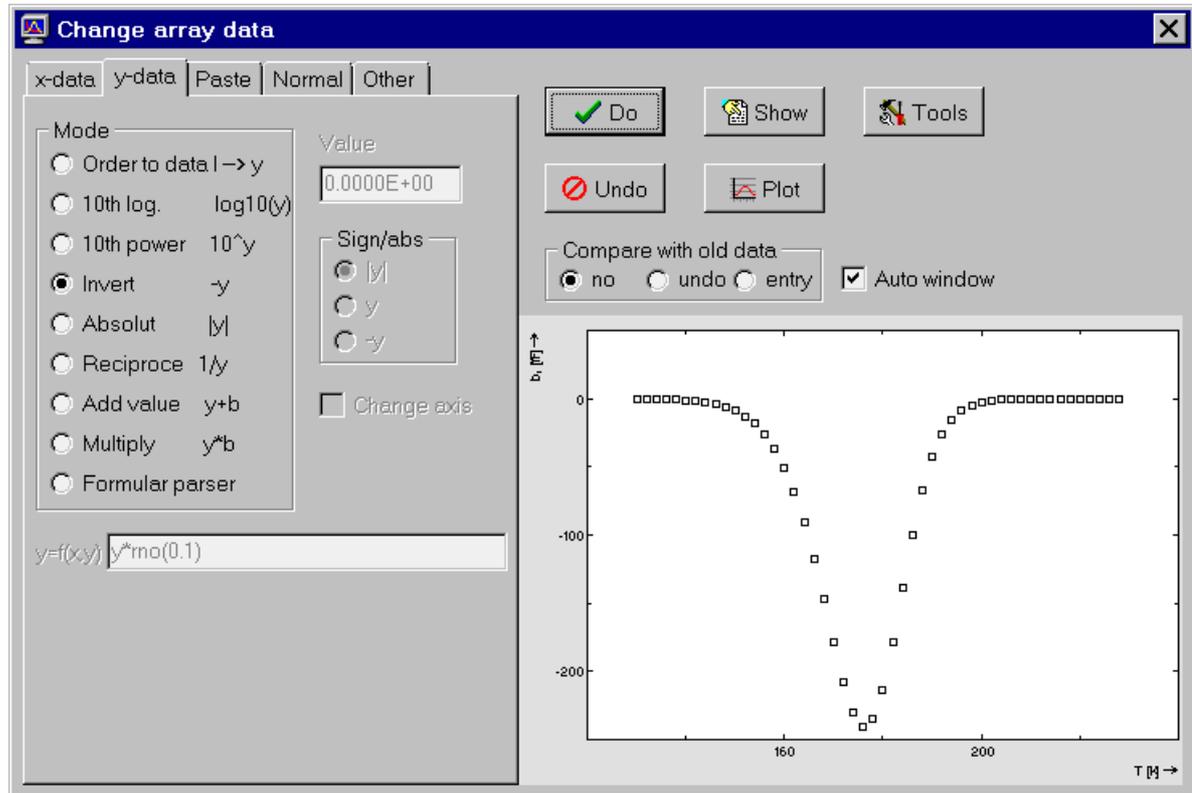


The buttons are also similar as in the previous chapter.
But the **Tools** button has extended possibilities:
- Input of curve and axis parameters
- Copy, Paste, Save and Read ASCII data
- List and edit the plot data in a data grid or in the ASCII editor
- Load the entry data or buffer data as current data, save the plot data in buffers
- Compare the current data in a list with the entry, undo or buffer data

# 5.4 List and Edit data programs

This chapter describes the list and edit data programs. The edit data programs base on the list data programs, but are extended in the file and edit menu.

**3 views** exist for the list programs:
1. **List grid program:** The data will be shown in a grid.
2. **List image program:** The data will be shown on a canvas image.
3. **ASCII editor:** The data will be listed in an ASCII editor.

Not all views exist in all cases. The image view doesn't offer an edit possibility. The grid view is available only for x/y data, the list view may show additionally a header, the ASCII editor shows either x/y data or a header. Often you can switch between the 3 views, the last selection will be stored when possible. A list program will be opened either automatically by the list menus or manually in 'Tools → List data' of the plot programs (chapters 5.1.6.2 and 5.2.6). The list and edit data program can also be called from the Standard Plot program (see chapter 5.1.1). The possibilities of the list programs depend on this origin.

## 5.4.1 List/Edit grid program

The list/edit grid program is the grid view of the list data program. The x/y-data will be shown in a grid with a caption. The fix (grey) column denotes the number of data point. If more than one curve (y-array) exist, the grid contains one column for each y-array. If coming from a list menu, the columns will be labeled by its meaning. A data header can not be shown in the grid program. The caption 'List grid' or 'Edit grid' distinguishes between list and edit data program (list or edit mode).
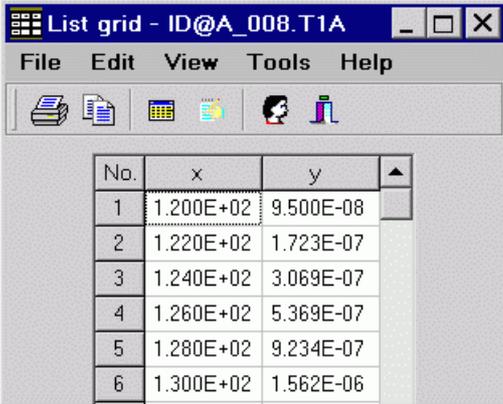
The following buttons of the **toolbar** are not visible in all cases:

| | |
|---|---|
| | **Repeat** the inputs of list parameters, if available. |
| | **Open** a measurement data file, if available. |
| | Shows **Next** file, if available. |
| | **Print** the grid on a printer. |
| | **Copy** data to clipboard. |
| | Jumps to the list **image** program. |
| | Jumps to the ASCII **editor**. |
| | **User button** is a user definable button, see chapter 2.3.4. |
| | **Close** the list program and goes back to the previous program. |

Following **shortcuts** exist for the menu, but not all are always possible:

| | |
|---|---|
| **F1:** | Help information, opens this manual at the corresponding chapter. |
| **F2:** | Repeats the inputs of plot. |
| **F11:** | Personal hot key 1, see chapter 2.3.4. |
| **F12:** | Personal hot key 2, see chapter 2.3.4. |
| **Ctrl+C:** | Copy ASCII data into the clipboard. |
| **Ctrl+O:** | Opens a measurement data file. |
| **Ctrl+P:** | Print the data. |
| **Ctrl+V:** | Paste ASCII data from the clipboard. |
| **Ctrl+Del:** | Delete a line (data point) in the grid. |
| **Alt+F4:** | Close the list plot program. |

### 5.4.1.1 File menu

The entries of the file menu depend on the origin of the data. When coming from a list menu, you can read here the (measurement) data and list these as before. If there was an input of parameters, you can repeat this input by 'Repeat'. If not saving the last measurement, you can here save these data.

'Save ASCII data' saves the current x,y values line by line in an ASCII format to a text file. In opposite to the Standard Plot Program, many y-arrays (columns) can be saved here. You can define the delimiter and the exponential format in the ASCII parameters of the Tools menu.
'Save ASCII text' saves additionally the grid caption in the first line and, if selected for the grid, the number of data point in the first column. Separate column delimiters and decimal separators exist for this special saving mode.
'Print' opens a dialog for printing the data.

You can jump with the current data to the list image program or the ASCII editor.
By 'Close' the program will be closed and the software goes back to the previous program.

If showing curve by curve from many data points or files (e.g. I/V curves at many temperatures), a 'Next datas' sub menu exist for navigating to next or previous data or to input the data number, for more information see chapter 5.1.7.1.

**Programs** opens a sub menu for further program tools, it is only visible when coming from a list menu. If calling one of these tools, the software jumps to this tool and don't come back to the list program. If closing this tool, the software goes back to the previous program module, normally one of the measurement or sub programs.

EditData enables to edit the x/y-data, switches to the edit mode.
Shows the x/y-data in the standard plot program.
EditPlot enables to change, read and plot the x/y-data (5.3.2).
PresPlot opens a new complex plot program with many features (5.2). It may be better, to call first StdPlot and from there PresPlot.

If selecting '**StdPlo**t' or '**EditPlot**' program and more than one curve are shown, the following input window opens, where you have to select the x- and y-data.

'**Mode for y-array**' defines which array(s) will be applied as y-data(s):

- one y-array
- y1, y2
- y2-y1
- y2/y1
- (y2-y1)/y1
- (y2-y1)/x
- all y-arrays

'y1, y2' and 'all arrays' are not allowed for the Edit plot program. You have to input the column number(s) of the grid for y1 (and y2).
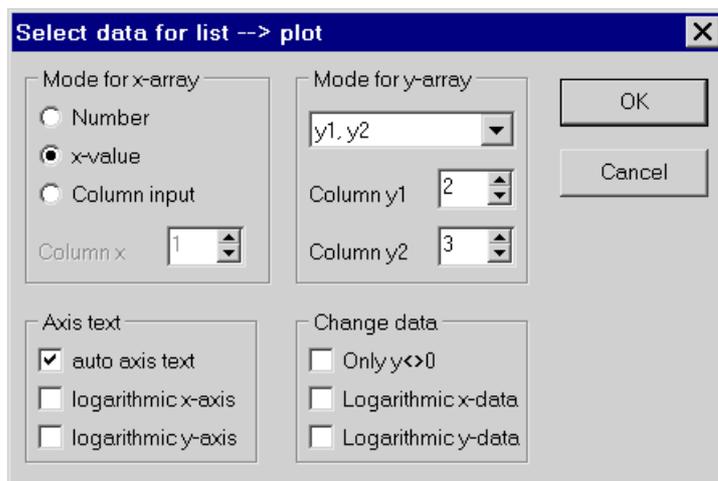
'**Mode for x-array**' defines which data will be applied as data for the x-axis:

| Number: | The number of data point will be applied as new x-data. |
| x-value: | The x-column of the grid will be used as x-data for the plot (standard). |
| Column input: | You can input the column number of the grid. |

Column number 1 means the x-data of the grid, column number 2 means the (first) y-data array of the grid. The grid column with the data number will be denoted as column 0.

The **axis text** of the plot will be applied from the grid header by activating 'auto axis text'. 'Logarithmic x- or y-axis' defines a logarithmic axis style, but doesn't change the data. Special flags exist for the logarithmic calculus of the x- or y-data, the logarithmic axis style will here automatically be set. The activation of 'Only y<>0' selects only y-data which are unequal zero.

The entry '**Read ASCII data**' is visible in the edit mode, it opens an input windows similar as described in chapter 5.2.1.2. The **reading modes** 1 to 3 were already explained there:

1. **Read 1 curve, standard**
2. **Read 1 curve, input**
3. **Read 1 curve, table file**
4. **Read all columns** of the ASCII file
5. **Read text**

The special mode 5 treats the ASCII file as text and applies directly the file columns into the grid columns. At the other modes the file columns will be converted into numbers. The input group 'Text params' appears for mode 5. The information that the text file contains 'only/some/no' real data (not text) columns is for searching the decimal separator.
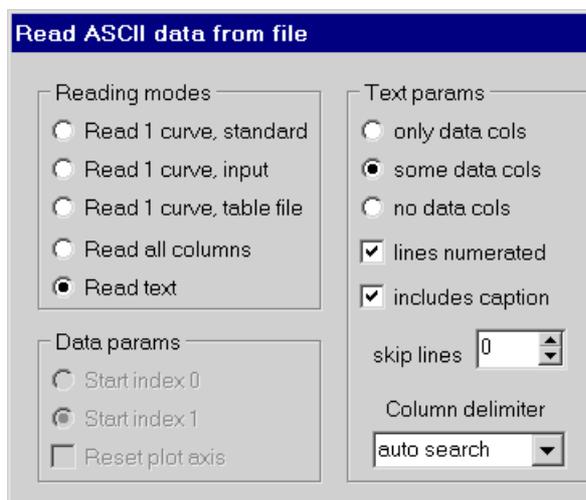
You have to inform the software when the text file includes numerated lines or a caption. Look in chapter 5.1.6.1 for the column delimiter.

## 5.4.1.2 Edit menu

Here it is possible to copy the data into the Windows clipboard or to paste data from there.

| Edit | View | Tools | Help |
|---|---|---|---|
| Copy page | | | |
| Copy data | | Ctrl+C | |
| Copy select | | | |
| Paste | | Ctrl+V | |
| Delete line | | Ctrl+Del | |
| Insert line | | | |
| New line numbers | | | |

'Copy page' copies the grid as a BMP graphic into the clipboard.
'Copy data' copies the grid data line by line in an ASCII format.
'Copy select' asks for the format before copying, see chapter 5.1.2.1. But now only the BMP and ASCII modes are enabled. 'Paste ASCII data' pastes ASCII data from the clipboard and overwrite the current data, see previous page for the input dialog. This feature is only visible in the edit mode.

You can **edit** the data cells of the grid in the edit mode (caption Edit grid). Click onto the cell and input the new value. You can go to the next cell by the 'Tab' key. A line in the grid, means one data point, can be deleted by 'Ctrl+Del'. You may insert an empty line at the current row position. A marked (blue) cell can be edited by a right mouse click.

In rare cases a **special edit** mode exist where the line will not immediately be deleted, but only marked as deleted. Its value for the first column (x-value) will be set to -1.0E+100 or -2.0E+99. The reason is that other data columns in the calling program will also be deleted. The deleted lines will not be applied when saving ASCII data or calling a plot program from the Tools menu. These data remain in the data array when calling the list image program or ASCII editor. Don't change at the special edit mode the numbers of lines in the ASCII editor, mark a line as deleted by setting x to -1E100.

## 5.4.1.3 View menu

Here you can set parameters for the view of the grid, so the font and its size.

| View | Tools | Help |
|---|---|---|
| Select font | | |
| Numbers of digits | | |
| All exponentials | | |
| ✓ Numerate lines | | |
| Personal shortcuts | | |

'Numbers of digits' defines the precision at an exponential view, it is the numbers behind the point. For example, 1.123E-10 has 3 digits. It may be that values of some columns will be shown in a fix decimal format. By activating 'All exponentials' all columns will be shown in the exponential view.
The lines can be numerated in an own grey column, labeled by 'No'. This column will not be taken into account at 'Save ASCII data', but at 'Save ASCII text'.

The 3 menus above are not enabled in the **edit mode**, the lines are always numerated.

If coming from a **3-dimensional** plot, the grid contains on the top an additional line with the z-values, as shown on the right. The view menu is then expanded by 3 entries:

| No. | x | 1 | 2 |
|---|---|---|---|
| z | 0.000E+00 | 1.200E+02 | 1.220E+02 |
| 0 | 2.800E-03 | 2.357E-02 | 2.359E-02 |
| 1 | 4.000E-03 | 2.357E-02 | 2.359E-02 |
| 2 | 5.600E-03 | 2.357E-02 | 2.359E-02 |

| ✓ Numerate columns |
|---|
| Invert axis x/z |
| Invert z-order |

You can numerate the columns as shown in the example. Then the z-values will also be saved when saving ASCII data.
The x- and z-axis can be inverted. The x-values will then be shown in the first line, the z-values in the first column. Then the z-order can be inverted, means the last z-value will be shown on the top.
In the edit mode lines and columns are numerated, x- and z-axis can't be inverted.

## 5.4.1.4 Tools menu

This menu contains some different functions.

User class was already explained in chapter 2.4.1.
ASCII parameters contains parameters for copying, saving and reading ASCII data, see chapter 5.1.6.1.
It is possible to create an extra window with a plot or data grid of the current data, see chapter 5.1.6.4.

At **user class 5** there are ActiveX/OLE tools as described in chapter 5.1.6.

In the **edit mode** you can usually jump here to the standard, edit and presentation plot program. For this you have to select the x- and y-data as explained above. The software comes back to the edit program after closing the plot program but doesn't apply changes of data.

**Statistic** shows some important values of the selected column: Numbers of data points, minimum value, maximum value, sum, average, variance.

```
Statistic values
Data      : x
Numbers   =            65
Min       =   1.200E+02
Max       =   2.480E+02
Sum       =   1.196E+04
Average   =   1.840E+02
Variance  =   1.408E+03
```
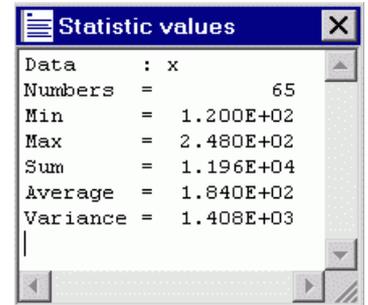
## 5.4.2 List image program

The list image program is the image view of the list data program. The data will be shown on a canvas image. The possibilities of the image view are similar to the grid view, therefor only a short description will be given. But, additionally to the style of view, there are 2 big differences:



- The image view has no edit mode.
- The image view may show additionally a header, as shown on the right.

The header may be a special data header or a global sample header with the most important sample parameters. It is also possible that no x/x-data exist but only a data header.
The toolbar contains a button for refreshing the canvas.
The PageUp and PageDown key may show previous resp. next file.
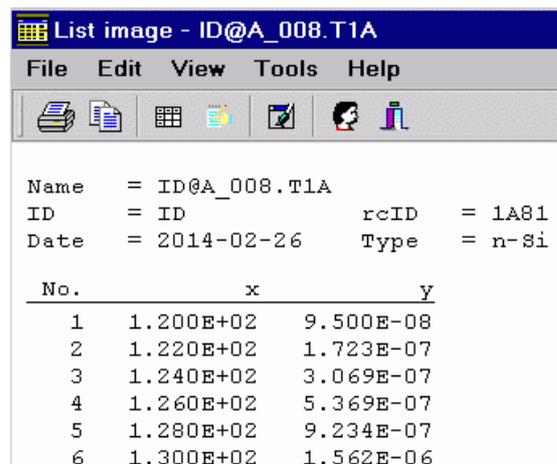
Based on the different view, the **View menu** of the image program differs from that one of the grid program.



The font, the font parameters used for the canvas, as explained in chapter 2.3.3.3, and the background color of the canvas can be selected.
If a data header or the global sample header is here available, the list can be shown without or with this header on the top. This flag is disabled when no header or no x/x-data exist.
A grid can be drawn around the lines and columns.
'Numbers of digits', 'All exponentials' and 'Numerate lines' were already be explained in chapter 5.4.1.3.
These flags and the center group is not enabled if no x/a-data exist.
'Refresh' draws again the canvas of the list image program.
If coming from a 3-dimensional plot, the menu contains three special entries as shown in chapter 5.4.1.3.

The data in the columns can be **centered** in various ways in respect to the caption:

- *Left centered:* First character of caption and column string has the same position.
- *Left sign centered:* First character of caption and column string has the same position, a minus sign will not be taken into account.
- *Right centered:* Last visible character of caption and column string has the same position, space characters at the end of the string will be deleted.
- *Auto centered:* Last character of caption and column string has the same position (default), as shown in the example above.

## 5.4.3 ASCII editor

The ASCII editor will not be used only for data but also for pure text or to list or edit ASCII files. x/y-data will be shown as a ASCII text in lines and columns, text files as saved in the file. There is no formatting, except of space (blank) characters and empty lines. The ASCII editor can be in the list or edit mode. The default data type has the extension 'Txt', but in the file dialogs you can select another one.

The ASCII editor has following **functions**:

- **Editor view** of the list/edit data program. When x/y-data exist, an additional header will not be shown, but a pure text header without x/y-data will be shown
- **Integrated editor**, in the main or tool programs, to list or edit ASCII text.
- **Separate editor** (program), which can be called from the program Tools. Here it is always in the edit mode and has the most possibilities, so an additional Tools menu.

The menus and possibilities depend on this function resp. on the origin of the text. So changing the text or reading an ASCII file is only available in the edit mode.
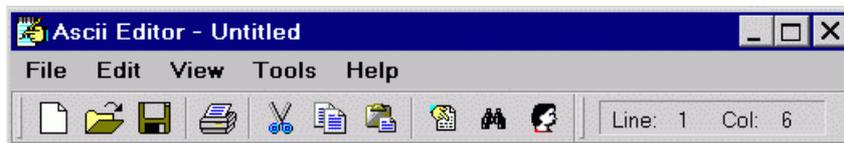


The following buttons of the **toolbar** are not visible in all cases:

**New** text, delete all text, only enabled in the edit mode.

**Open** an ASCII file, only enabled in the edit mode.

**Save** data into an ASCII file

**Print** the text on a printer.

**Cut** marked text into the clipboard, edit mode.

**Copy** marked text to the clipboard.

**Paste** text from the clipboard, edit mode.

**Mark** the full text, edit mode.

**Find** (search) a text string.

Jumps to the list **image** program, only at list/edit data program.

Jumps to the list/edit **grid** program, only at list/edit data program.

Shows **Next** file, if available.

**User button** is a user definable button, see chapter 2.3.4.

**Close** the program and goes back, not visible for the separate editor.

The current line and column number will be shown behind the toolbar, you can move the position of this display in the toolbar.

Following **shortcuts** exist for the menu, but not all are always possible:

**F1:** Help information, opens this manual at the corresponding chapter.
**F3:** Repeats the search of a text string.
**F11,F12:** Personal hot key 1 and 2, see chapter 2.3.4.
**Ctrl+A:** Marks the full text.
**Ctrl+B, E:** Marks the begin or end of a text block.
**Ctrl+C, X:** Copies or cuts the marked text into the clipboard.
**Ctrl+F:** Finds (searches) a text string.
**Ctrl+H:** Replaces a text string.
**Ctrl+N:** Deletes all text and starts a new document.
**Ctrl+O:** Opens a text file.
**Ctrl+P:** Prints the text.
**Ctrl+S:** Saves the text into an ASCII file.
**Ctrl+V:** Pastes text from the clipboard.
**Ctrl+Z:** Undoes the last new, paste or cut operation. Undo of Undo by 2. call.
**Ctrl+Del:** Deletes marked text.
**Alt+F4:** Closes the program.

The **File menu** starts a new text document, opens an existing text file or saves the current text. If no file name exist or by 'Save as', you have to input the file name before saving.

You can print the text and open the printer setup dialog. The names of the last 5 used files will be shown in the file menu. You can read one of these by clicking onto its name (here test1.txt). If the editor will be used as list/edit data program, you can jump here with the current data to the list image or grid program. When starting the editor by the Editor button of the Set_Conf program (chapter I3.6), the entry 'Cfg dirs' changes the default directory to the customer configuration directories 'Conf, 'Conf/ Base' or 'Conf/Init'. The default extension is then 'CFG'.

The **Edit menu** enables to cut or copy a marked text range. You can paste ASCII text from the clipboard, mark the full text or delete a marked text range.
'Find' opens the Windows standard dialog for searching a text and starts the search from the cursor position. 'Repeat search' starts the search without an input dialog at the current cursor position. 'Replace' replaces a text string by another one.
The entry 'Edit mode' exist only in special cases, it switches from the list to the edit mode.

In the **View menu** you can select the font and the style of the toolbar. The symbols can have a caption and the toolbar a back-ground.
'Vista file dialogs' uses the new file dialogs under Windows Vista, Seven and 8.X.
Personal shortcuts was explained in chapter 2.3.4.

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