Operation Manual

sIRoLine/sIRoCube

Online Spectrometer

GUT
Environmental Technologies

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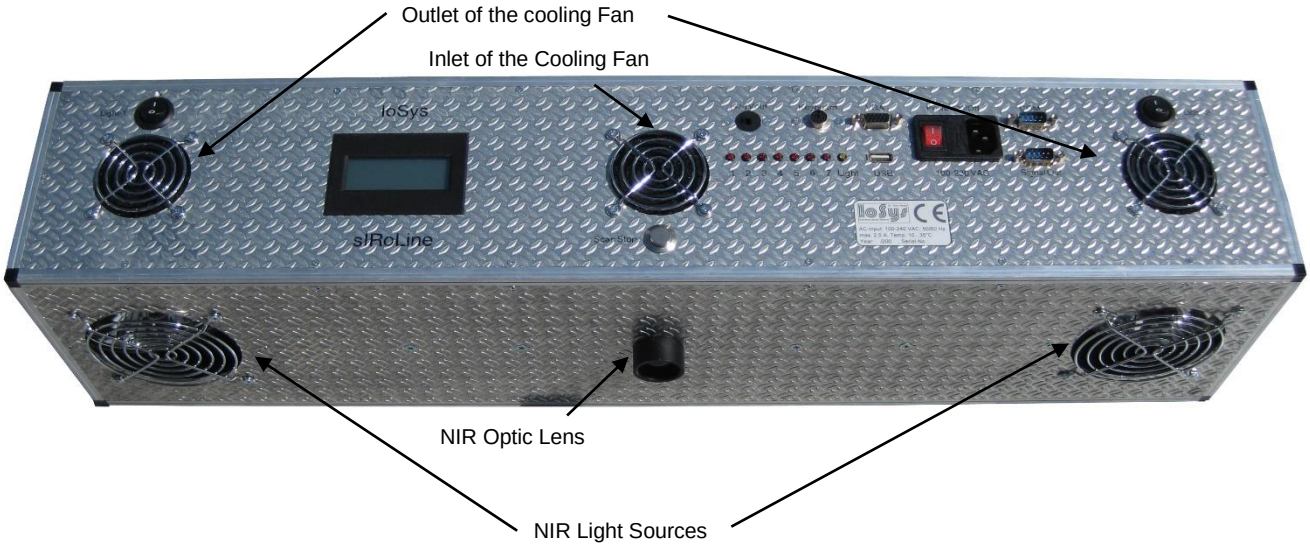
1 Setup of the stationary Infra-Red optic Online- sIRoLine



The stationary online device mainly consists of three function groups

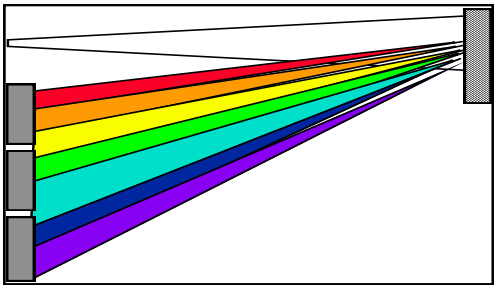
- Near Infrared light source (NIR)
- NIR spectrometer optic
- Computer with control and measurement electronics

1.1 The Near Infrared Light Source

The exchangeable NIR light sources are mounted in a moveable Alu-reflector in the mid part of the unit. The halogen spot light can be easily exchanged when burnt out (see: Exchanging the NIR-spot light). Both light sources must be adjusted in such a way that a sharp focusing spot in the middle of the reflection tile appears thus max. light intensity is measured.

1.2 The Spectrometer Optic

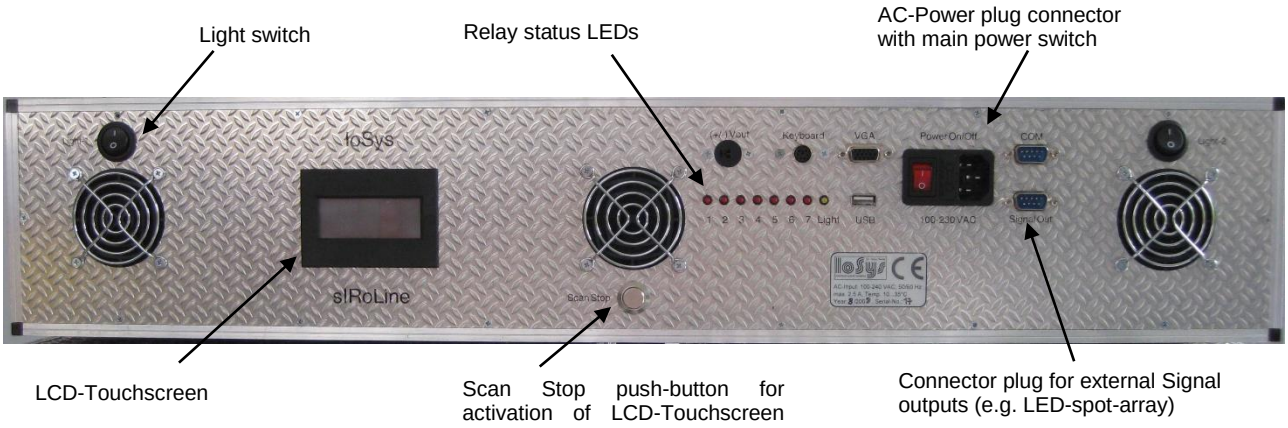
The basic principle of the method is the diffuse near infrared reflection and transmission spectroscopy whereby characteristic absorption behaviors of different polymer types are used in the NIR wavelength region.



The diffuse near infrared reflected radiation is transported via the optical fiber to the slit of the multi-channel spectrometer to be scattered into its different wavelengths. From the end of the optical fiber the beam of light falls on an imaging diffraction grating. The light reflected by the grating falls on a sensor array. This photo-detector converts the light into electric analog signals. 32 pixels of the optical spectrum are scanned simultaneously, whereby an almost complete overview spectrum in the observed spectral range is recorded.

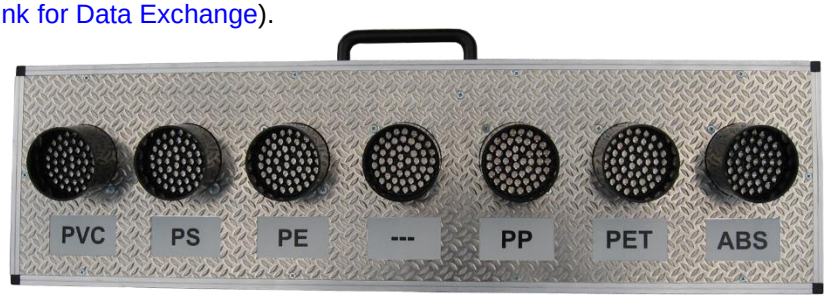
The signals are read opto-electronically after each scan. The analog signals are digitized on an interface board. The 12 bit digitized data then are transferred to the evaluation computer. To improve the signal/noise (S/N) ratio, the signals are accumulated by the software after each individual scan (runs) and then arithmetically averaged by the number of measuring cycles that has been set to give the spectral representation following. The dynamic range extends from 0 to 4096 arbitrary counts for a scan (12 bit intensity resolution). For an improved scaling the dynamic range is rounded to 4100.

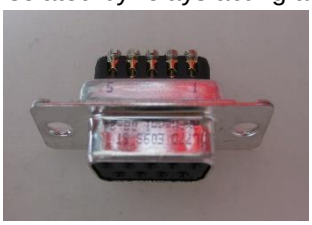
1.3 The Computer with Control and Measurement Electronics



Functional tasks of the computer are to transmit the parameters to the spectrometer electronics and further to process and evaluate the signals received before displaying them on the external VGA display. Direct operating of the software is possible with a connected external keyboard. The user enters the parameters via the menu-guided sIRoLine software. A serial interface (9 pole SUB-D plug) and an USB interface are provided for the transmission of data (see: PC-Link for Data Exchange).

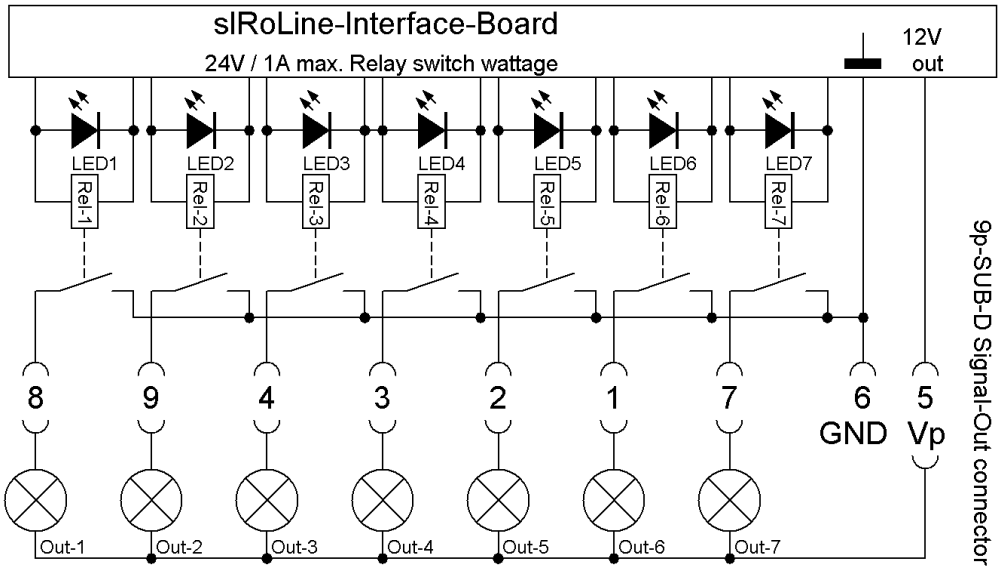
The sIRoLine-interface electronics of the system generates external signal outputs depending on preset parameters (see: The Initialization File). All signals are galvanically isolated by relays acting as closers.





Maximally 7 signal outputs can be used. The signal outputs are available at the 9p-SUB-D Signal-Out connector plug. As an optional feature a LED-Spot-Array can be connected to visualize the identification result. Besides this solution an external terminal-connector is available for individual cabling. Connection must be made according to the wiring guide shown below. Furthermore a 12VDC power output is supplied.

Only use the terminal connectors for external signals in low voltage circuits (max. 24V/1A). The connection of 100 –230 VAC line voltage is not permitted!



Example: 7 external signal light cabling

2 Hints and Instructions

2.1 Warnings and Safety Instructions

! In order to ensure that the device can operate properly, set it up in a manner so that it cannot slip and will not be subject to vibrations. Do not shake the device!

! Ensure that there is an adequate circulation of air for the device. The slits are for ventilation purposes and may not be covered over or otherwise blocked. The openings are designed to ensure that the device can function properly.

! Take care that no liquid (water, rain etc) gets into the device. This can lead to internal components being damaged or to a short-circuit.

! Never wipe the ceramic reflection tiles with a wet dripping cloth or water. This changes their reference reflection behavior thoroughly and will disturb further measurements! The material is hygroscopic and will incorporate the water within its pores, changing its NIR behavior.

! To avoid short-cuts, do not use the device near water or in moist ambient surroundings.

! This measuring device consists of sensitive electronic components. Use not in accordance with the instruction may result in their destructions. Electrostatic discharges, induces voltage peaks and balance currents between different voltage potential are particularly harmful.

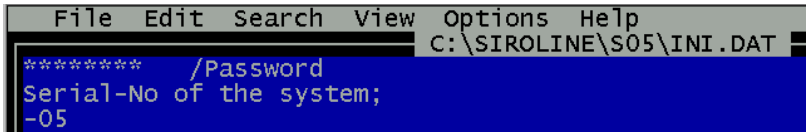
! Take care not to touch the surface of the bulb with fingers. Use a paper or tissue for protection. Contamination with fingerprints reduces the lifetime of the light source!

2.2 Technical Data

Rated voltage:	100-240 V AC
Rated current:	2.5 A max.
Protection class:	I
Type of protection:	IP 20
Dimensions (WxHxD):	720 x 120 x 150 mm
Height of measurement:	50-100 cm
Weight:	5 kg
Ambient temperature:	15...35°C
Max. relative air humidity:	Operating: 10%...90%

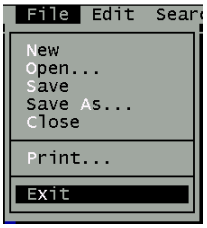
2.3 Enter new Password

The system is secured with a password which activates the program. In case the message: ***Program deactivated!…*** is displayed, please contact info@gut-stuttgart.de to obtain the actual password for the device.



To edit once the new password please proceed as following:

1. Connect an external keyboard and a VGA screen to the system.
2. Edit on the DOS-prompt level of the given sub-directory the command line *edit ini.dat.*
3. Replace the 8 stars (*) in the first line of the *ini.dat* with the new password (8 small characters!).
4. Save the ini.dat file (ALT+F(ile), ALT+ S(ave)) and close the Text-editor (ALT+X(exit)).
5. Edit on the DOS-prompt level mIRo.exe to start the program again.



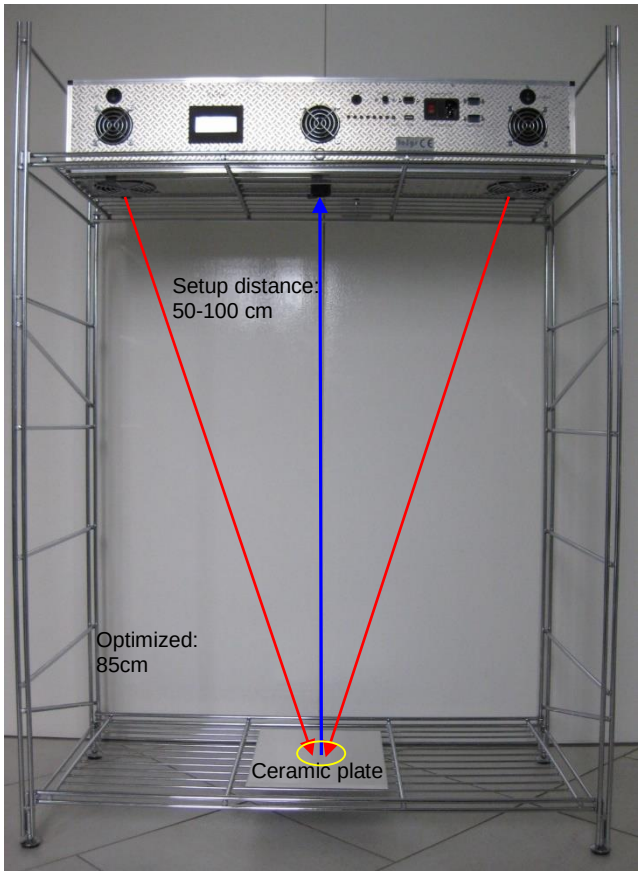
2.4 Time and Date Setting

To enter a new Time and/or Date please do as follows:

1. Connect an external keyboard to the system.
2. Enter on the DOS-prompt level of the given sub-directory the command *time* or *date*, resp..
3. Edit new date or time values and confirm/quit with **<ENTER>.**

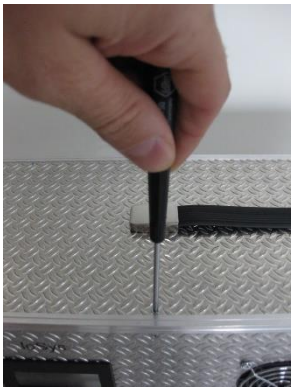
3 Setup of the system

The basic principle of the method is the diffuse near infrared reflection spectroscopy. The polymer sample is radiated with a infrared light generated by halogen bulbs and the reflected light of the measuring place is collected by an optical lens and analyzed using a near infrared detector 16- or 32 Pixel-array.



To measure transparent materials, a white ceramic is needed which must be placed under the sample as a kind of reflection mirror. The sIRoLine system should be placed onto a rack for easy operation. Measuring heights (distance between ceramic plate and lens) of 50-100 cm are possible. The system is optimized for operation using IoSys' metal rack for the height of ca. 85cm. After setting up the device in the center of the shelf the focusing spots of beach halogen bulb must be almost in the middle of the reflection tile to achieve maximum light reflection (see also instructions for Exchanging the NIR-spot light).

If not, adjust both focusing spots as following:



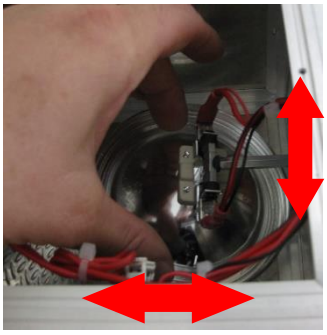
1. Remove carefully all M2.5-screws in the top plate using a screwdriver (size: PH1) and put the plate aside.

2. Connect an external VGA and a keyboard and the power supply cord to the AC socket and switch on the unit with the Power-On/Off switch. In the normal operation mode both Light-switchers should be ON (1).

3. When ready, both NIR-Light sources are automatically powered on. The system starts automatically the Auto-Gain-Recalibration. Interrupt this procedure by pressing **<F1>** entering to the SPC-mode and press **<SFT+F4>** (???-Onln) to stop the Result-Online mode and then **<F1>** (NetD/NirD) to activate the NirD mode displaying the 0-100% intensity range.

4. Power off one NIR light thus only one light is shining (Light-1 switcher ON (1), Light-2 switcher OFF (0)).

5. Adjust the focusing spot by moving the Alu-reflector with its 12VDC halogen light source to its maximum light intensity displayed.

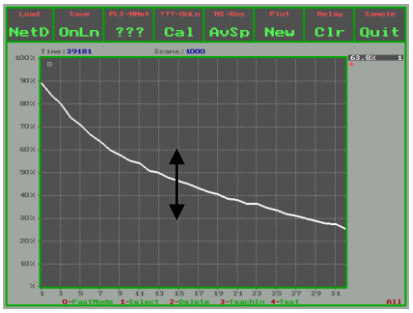


Take care not to touch any contacts at the 100-240VAC power supplies!

6. Switch on the other light and power down the other one resp. (Light-1 switcher OFF, Light-2 switcher ON). Adjust the light focus in the same manner.

7. Switch on both light sources and carry out a recalibration by pressing **<F4>** to adjust gain level automatically.

8. Insert cover plate and fix all screws[1] carefully again. Please beware not to fix the screws too much in its thread.



[1] In case of lost or damaged screws, some spare parts (like relay, screws, spot light) are located inside a small plastic box fixed on the right side of the interface board.

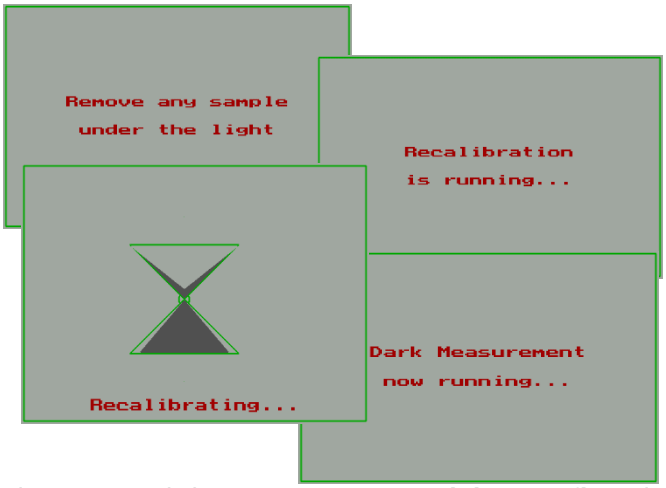
4 Operating Instructions with VGA Screen and Keyboard

4.1 Starting

1. Connect the power supply cord to the AC socket on the left side and to the mains and switch on the unit with the Power-On/Off switch <u>In the normal operation mode all switches should be on.</u>

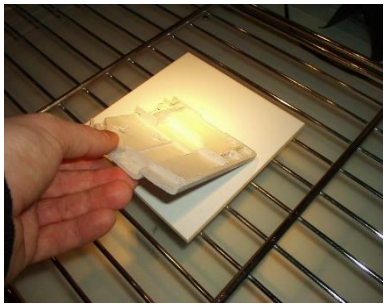
2. During the boot up sequence the integrated Relay-Interface-Board will be initialized. The initialization is indicated by switching on and off the relay from 1 to 7.

3. When Ready, the yellow *Light* LED illuminates and the NIR-light sources are automatically powered on. The system sets the Auto-gain level to maximum and automatically starts the Online-mode. After 10 times beeping and displaying the message ***Light Overflow*** sIRoLine automatically carries out the recalibration process.



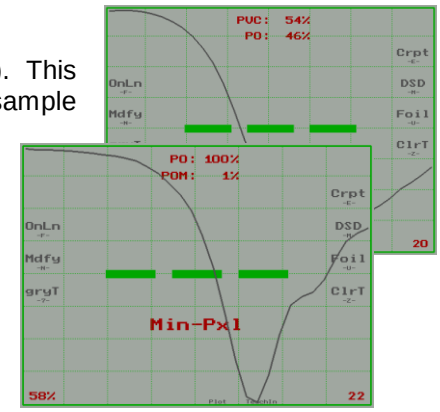
4. In case there is no sample placed on the focusing spot and the error message: ***Light Overflow!*** is frequently displayed, the gain level of the electronics is drifted due to powering and warming-up[2]. Either a manually recalibration (pressing **<F4>**) could be carried out again or if this message is running 10 times successively then the Auto- Recalibration procedure will be started automatically. sIRoLine starts the recalibration procedure with the message: ***Remove any sample under the light*.** No sample must be on the focusing spot. The next message: ***Recalibrating…***, indicates the automatic gain adjustment. If the electronics are adjusted the NIR light source is powered down automatically for few seconds to carry out the dark measurement. The message: ***Saved as new reference spectrum*** signals the end of the recalibration procedure. The NIR-Light source is powered on again and the program switches back to the Online-Mode.

4.2 Measuring



1. Hold the sample to be measured about 0-10 cm above the focusing spot on the lower ceramic tile. Best results will be obtained when the surface of the sample is inclined downwards towards the back reflection tile as to be seen on the picture at the right. Immediately after the positioning the result will appear on the screen.

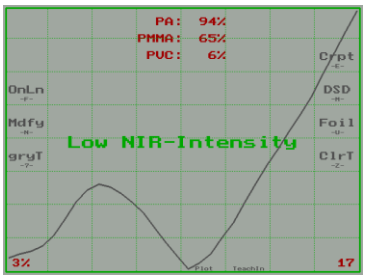
2. If desired, activate the restriction of the plastic identification to specific polymer types (Mdfy-, gryT-, clrT- or Foil functions) either to the most probable ones or which appears most plausibly due their polymer similarity. The activation of these functions are signaled in red in the Result display.



3. Non-Identification is signaled with the No-Result message (---). This indicates that the neuronal network was not able to identify the sample reliably (see: Polymer Type Identification by Neuronal Networks). Either the pre-set limit values have not been exceeded (e.g. 1st place less than 70 %, 2nd place greater than 30 % probability) or the minimum of the NetD curve is not in the range of the pre-set Min-/Max-Pixel values. In both cases repeat the measurement until a reliable statement appears. If repeated measurements still are producing this message, the sample might be unknown (not calibrated) or the wrong net model was selected for identification or new recalibration is necessary.

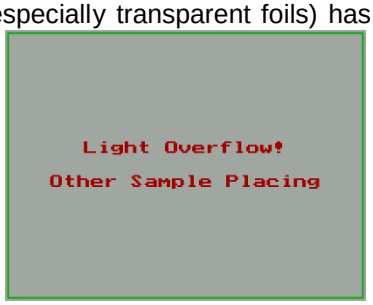
[2] Usually the sIRoLine identification devices reaches it thermal equilibrium within 2 hours and thus the resulting signals become stable and reproducible.

4. If the measured light intensity level is low then the message shown at the left is displayed. The Low NIR-Intensity message appears if the measured NIR-light intensity does not exceed the pre-set threshold value for the minimum light intensity (standard: 5%, see: The Initialization File). Reasons may be that the sample is too dark[3] for the reflection principle or the plastic part is a kind of a diffuse scattering material and thus unsuitable[4] for the diffuse near infrared reflection or transmission measuring method.



5. The sIRoLine unit operates in transmission as well as in reflection mode in parallel. Nevertheless for a correct identification of foils and transparent materials it always is advisable to switch on the respective special Foil Model or clearType model. In general for the identification of such materials these models should be activated with the respective keys **<U>** or **<Z>**. Due to the variable thickness of foils the absorption characteristic differs in comparison to solid materials. The typical minimum of the measured NIR curve (Min-Pxl) is usually different to solid materials. Thin foils should be folded several times thus a thickness at least 50-100 µm is achieved otherwise the result might not be reliable. Plastic parts thicker than 500 µm should be measured with the Standard or clear Type.

6. The shown error message may indicate that a shiny sample surface (especially transparent foils) has been placed in an unsuitable position for the NIR optics where the reflected light back to the NIR lens is higher than the white reference spectrum. Place the sample in other position. Best results will be obtained when the surface of the sample is inclined downwards towards the back reflection tile. On the other hand if no sample is placed on the focusing spot and this message is displayed then the system is heated up with operation, thus causing a sensitivity gain drift of the electronics gain level. If more than 10 times the ***Light Overflow*** signal is measured (shown by a counter on the right top side of the screen) then the message ***Starting autom. Recalibration*** is displayed. It indicates the beginning of the automatic gain adjustment.



If either incorrect identification results are showing up with known samples or the system condition has been changed after the last recalibration a new recalibration might be necessary to ensure the stability of the electronic environment!

5 The *sIRoLine*-program

5.1 Conventions in this Manual

The device is designed in such a way that it can be operated from the touchscreen and/or from an external keyboard. In general a keyboard permits the menu-guided software to be handled more easily.

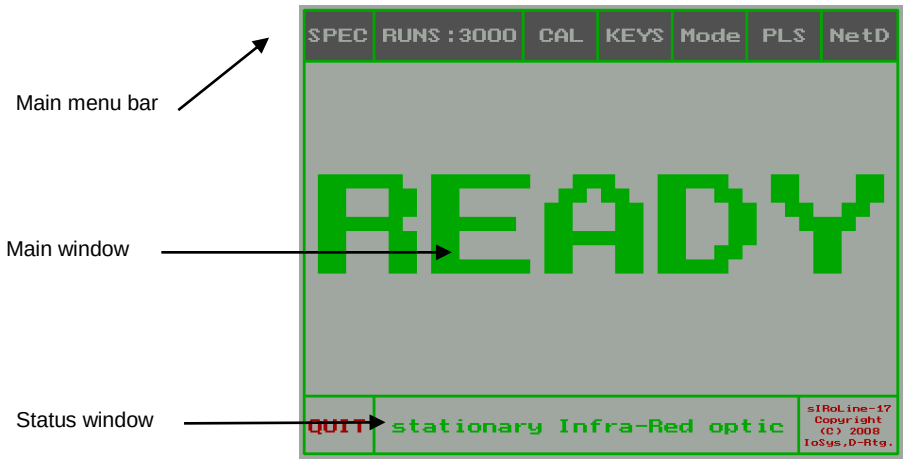
The following paragraph gives the writing conventions used in these operating instructions:

Operations to be carried out via the LCD touch screen are given with the legend on the particular touch field and the word **<Display>**. For the operation with a VGA monitor it defines only the display on the screen. The operations to be carried out with the external keyboard with the legend of the keyboard key and the word **<Key>.** Usually small characters should be entered. A touch field on the display only has to be touched briefly. If a number of keys or, as the case may be, touch fields have to be pressed simultaneously, then this is indicated with a plus sign (+) between the individual key or touch field legends, e.g. SHIFT+F1.

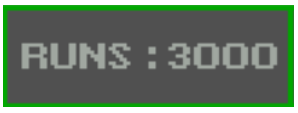
Pressing a key or touching an LCD display activates or deactivates a mode or function. In general a repeated pressing of the same key or touching the same display again deactivates/activates the operation, respectively.

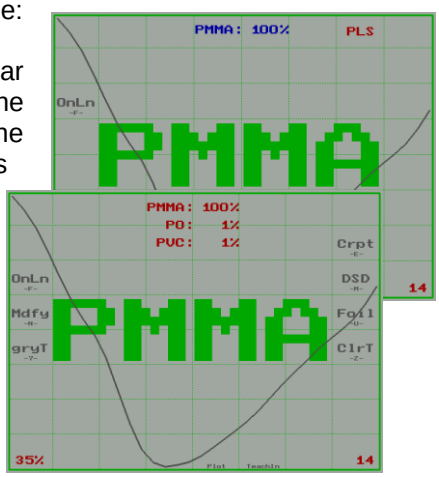
[3] In general, no dark colored and black samples or materials filled with soot can be analyzed using the NIR-technology. Soot absorbs the NIR radiation almost thus no diffuse reflection or transmission occurs.
[4] Low NIR-light reflection is observed by natural colored or milky-like Polyamides and Polyolefines (NIR-light scattering). Furthermore it must be stated due to the experiences of us that gray colored plastics (e.g. PP, PVC) which are containing lot of Talcum (20-40%) as a filling material reduces the NIR light reflection causing non reliable identification results.

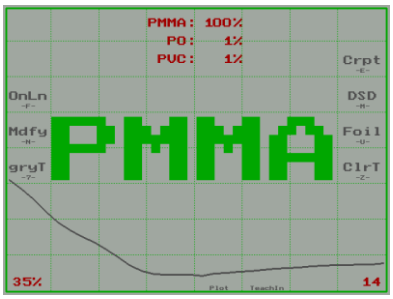
5.2 Operating Elements in the READY window



Icon	Key	Function
SPEC	**F1**	Switches to SPC mode to view the NIR-Spectra or the transformed Net-Data and to carry out further features (see: Operating Elements in the SPC Mode).
RUNS	**F2**	Increases **(<F2>)** or decreases (**<F3>**) the number of runs[5] (scan numbers) to form an average mean spectra for evaluation (see: The Bottom Menu).
CAL	**F4**	Starts the routine for the recalibration measurement with the ceramic plate reference (see: Recalibration of sIRoLine)
KEYS	**F5**	Displays the assignment of the touch panel fields and opens further menu options for testing, setting and editing systems files for the mIRo (see: Operating Elements in the Keys Window).
Mode	**F6**	Switching between the Single-Mode and the Circular Mode. In the Single-Mode the NIR-light-source inside the measuring head is switched on by a relay, the measurement is started and the identification result is displayed until the next measurement is triggered. In the Circular-Mode the NIR-light-source is continuously powered on while pressing the pistol trigger and the display shows the identification results after each measurement cycle
PLS	**F7**	Changes to the PLS model (Partial-Least-Square), where plastic identification is performed using selected Teach-In samples (see: Operating Elements in the Teach-In Menu). The activation of the PLS mode is displayed on the top and the ranking list appears now in blue letters and the icons to select the identification model are disappearing (no function). Pressing again the **<PLS>** icon switches back to the Neuronal network calculation and the hit list is displayed in red letters .
NetD	**F8**	Switches to the Result-Window. Pressing this icon again a selection of the representation view can be made (see: Operating Elements in the Result Display). In the NirD-mode (Near Infrared Data) the raw intensity data are shown. In the NetD-mode (Network Data) transformed and auto scaled intensity data are displayed. Leave the Result-window by pressing any key or by touching the middle of the touch screen briefly.
QUIT	**ESC**	Leaves the sIRoLine program and returns back to the DOS prompt level.

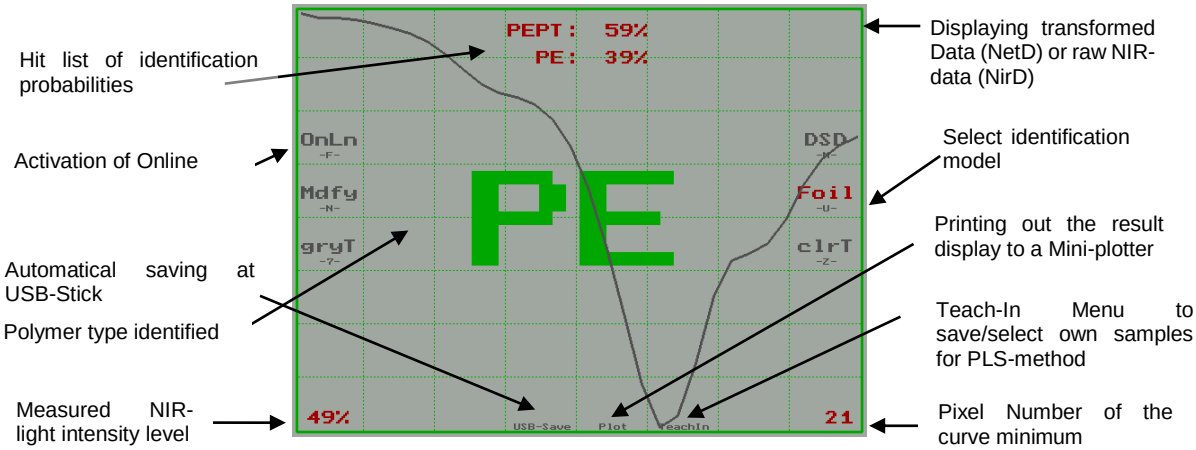




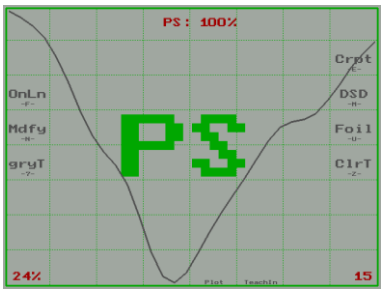


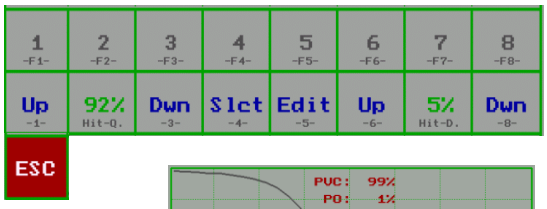
[5] The higher the scan number (RUNS), the better the resulting average spectra (improved signal/noise ratio of the calculated mean), the more stable is the identification result. However, the measuring time takes longer. On the other hand, the smaller the scan number, the more noisy the resulting spectra for evaluation, the less stable is the identification result. On the other hand the measuring time takes shorter.

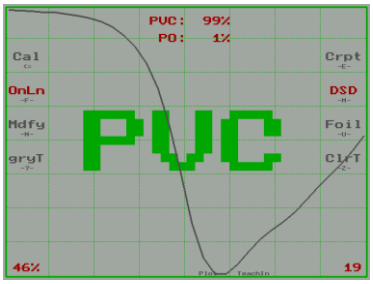
5.3 Operating Elements in the Result Display



Icon	Key	Function
./.	**F8**	Pressing this hidden[6] icon, the representation view of the data can be chosen. -intensity data are shown. In the NetD (Network Data) mathematically transformed and auto scaled data are displayed. These data are used by neuronal network or PLS processing for plastic identification. The NetD mode is recommended, because in this view differences in the curve shape can be seen more obviously. On the right bottom side of the screen the Pixel number of the curve minimum is displayed in red letters. The position of the curve minimum (e.g. 12, 15, 20 etc.) is typical[7] for a polymer type. On the left side the measured NIR-intensity[8] is shown in percentage range. If this intensity level is less then the pre-set limit value for minimum light intensity (e.g. 5%) than the message ***Low NIR-intensity*** is shown[9].
Plot	**F9**	Printing out the result as a screen dump by a Mini-Plotter (optional feature). Touching touchscreen or pressing any key on the Keyboard stops the plotting process.
TeachIn	**F10**	Opens the Teach-In menu to teach-in or to select known samples (see: Operating Elements in the Teach-In Menu) for polymer identification using the PLS algorithm. (Partial-Least-Square, best fitting curve). The PLS mode is automatically activated and the hit list (ranking) are displayed in blue letters. The advantage of the PLS method is that the user can teach-in own test samples to carry out simple rapid analysis. The disadvantage is that PLS works for NIR-spectra only which obviously have big spectral differences. Pressing the **<PLS>** icon returns back to the Neuronal network calculation (see: Polymer Type Identification by Neuronal Networks).
OnLn	**F**	Start or stops the Online-mode operation whereby the NIR light source is on continuously.
USB-Save	**BS**	Activates the USB-Save function for automatically saving the displayed identification result at the plugged USB stick (see: Using USB-Stick) in the directory path edited in the *ini.dat* file (see: The Initialization File). The result is saved if the same result is showing up two times consecutively. The temporary file name is random-like created (4 characters) and continuously counted up to –999 (e.g. 1234-1..1234-999). A new randomized file name is created if the Online mode has been stopped and then the USB-Save mode is activated again.

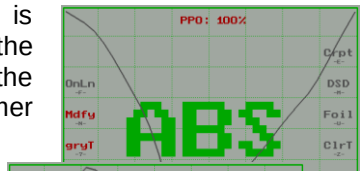


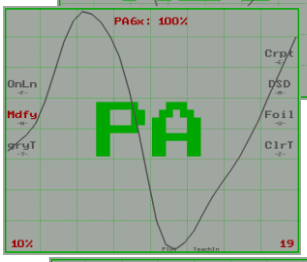


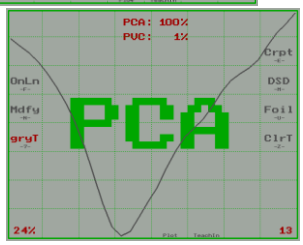


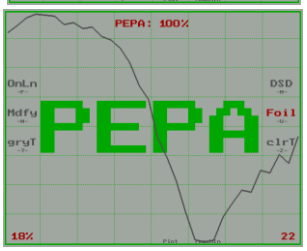
[6] The operating elements of the Ready window are also hidden but still active to quit the Result display.
[7] Depending on the spectrometer system.
[8] The measured NIR intensity is the difference of the left intensity (Pixel number 1) to the right value (Pixel number 32) in %.
[9] It means that the diffuse reflected light intensity of the sample is too weak to identify the sample reliably. The pre-set limit value for the minimum light intensity has not been exceeded. This threshold value can be altered in the Ini.dat file.

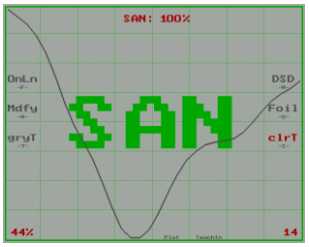
Icon	Key	Function
Mdfy	**N**	Due to spectra similarity the distinction of some polymer types is sometimes uncertain and could be random-like. To modify the identification result either means that the determined probability in the network model (1st ranking in the Hit list) is altered to the polymer which are in general more probable (PPO⇒ABS, PCPT and PCA⇒PC, SAN⇒PS or the identification will be simplified (PA6x, PA12⇒PA). The Modify function can just be activate/deactivated if one of the mentioned polymer types are displayed. A temporary modification of an identification result is signaled then in red.
gryT	**7**	This identification model is recommended when gray-coloured plastic parts coming from the electro- and electronic dissembling area (e.g. computer waste) are to be detected, because the amount of polymer types for fine differentiation of the styrene-containing sub-group is extended and other types are neglected to enhance the identification performance. Modified results Modified results **(Mdfy)** switches PPO result to ABS, PC to PCA and PCPT to PC. In this gray-Type model the identification of **PA, PP, Styr** (ABS, PS, PPO)**, PC** (PCA, PCPT)**, APVC** and **PVC** is calibrated.
Foil	**U**	This identification model is recommended when thin materials like foils are to be detected. The Thin foils should be folded several times thus a thickness at least 50 - 100 µm is achieved, otherwise the result might not be re liable. Materials which are thicker than 500 µm should be measured using the Standard model (All). Modified results **(Mdfy)** switches PEPA or PEPT to PE Identification of **PA, PP** (PPPT)**, PE** (PEPA, PEPT)**, PS, PET, PVC, PLA** and **CLLS** foils.
clrT	**Z**	Restriction of the polymer identification to few clear types which can normally occur also or only as clear, transparent plastic parts (thickness: 0.5 - 6 mm). This identification model is recommended, because the amount of polymer types for fine differentiation of the styrene-containing sub-group is extended and other types are neglected to enhance the identification performance. Modified results **(Mdfy)** switches SAN (AS) to PS. Identification of **PO, Styr** (ABS, PS, SAN)**, PET, PC, PMMA** and **PVC**.
DSD	**M**	This identification model is recommended when typical plastic parts and foils[10] coming from the household and packing area (MWS) are to be detected, because the amount of polymer types is restricted to five polymer types which normally occur as household and packaging plastics (MWS= DSD = Duales System Deutschland). In this DSD-model the identification of **PP, PE, PS, PET** and **PVC** is calibrated.
./.	**./.**	This identification[11] model is recommended when coloured, natural- or milky-like plastic parts (not gray, not black and not transparent) are to be detected. Herein the amount of polymer types for fine differentiation of the styrene-containing sub-group is reduced. Modified results **(Mdfy)** switches PA6xor PA12 to PA , PC to PCA and PCPT to PC. Identification of **PA**[12] (PA6x, PA12), **PO** (PP, PE), **Styr** (ABS, PS), **PES** (PBT, PET)**, PC** (PCA, PC, PCPT)**, PMMA, POM** and **PVC** (see: Polymer Type Identification by Neuronal Networks).
Txtl	**E**	This optional identification model is recommended when carpets or textiles are to be detected. In this model the identification of **PA**, **PP, PET, PolyCotton**, **PET+Cotton-blend, Acrylic, Silk, Wool, Cotton, Cotton+PA-blend, Cotton+PET-blend** and **Acetate** is calibrated**.**

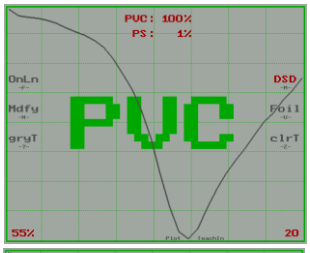


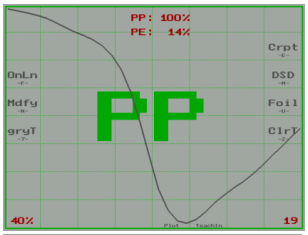


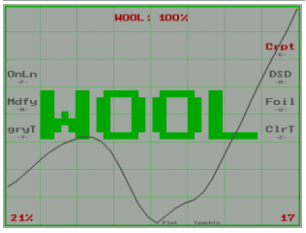










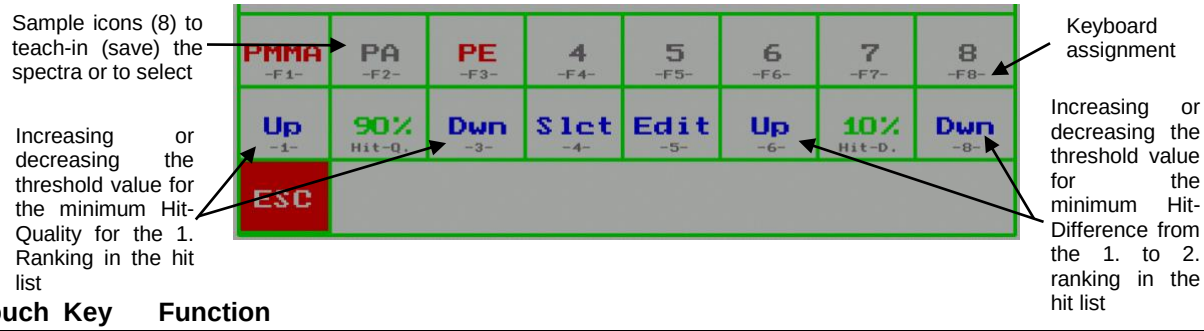


[10] No PA-, PEPT- and PLA foils are calibrated and due to the spectra similarity the multilayer foil PEPA was taught in as PE.

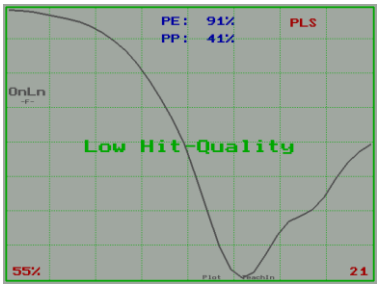
[11] IoSys uses the following abbreviations: PA=Polyamide, PO=Polyolefine, Styr=Styrene containing polymers, PES=Polyester, PCA=PC+ABS, PCPT=PC+PBT or PC+PET, APVC=ABS+PVC, PLA=Polylactoseacetate-biodegradable, CLLS= Cellulose; Multilayers: PEPA=PE+PA, PEPT=PE+PET, PPPT=PP+PET.

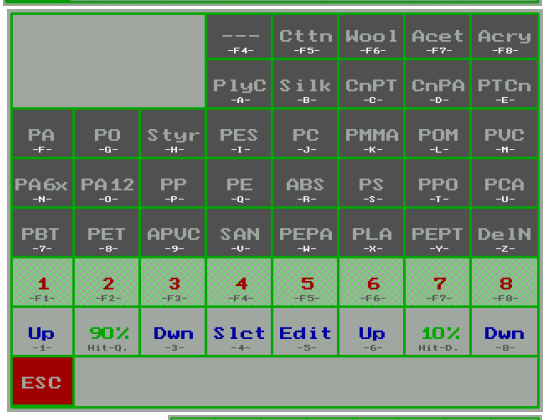
[12] Fine differentiation of PA6 and PA66 polymer types is not reliable. Therefore both types are calibrated and combined to PA6x.

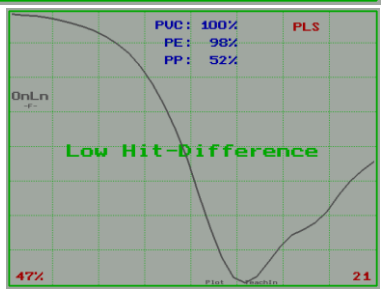
5.4 Operating Elements in the Teach-In Menu



Touch	Key	Function
1..8	**F1..F8**	By pressing one of the eight sample icons the actual spectrum will be stored as a Teach-In sample. An gray coloured touch icon indicates that in respective slot no spectrum was stored before or it was deactivated (see **<Slct>**). The PLS mode must be activated to use the Teach-In spectra for polymer type identification (see: Operating Elements in the READY window).
Up	**1**	Increases the threshold value for the minimum Hit-Quality for the 1st ranking in the hit list[13]. If the 1st ranking percentage is less than the pre-set Hit-Quality value then the message ***Low Hit-Quality*** is shown.
Dwn	**3**	Decreases (Down) the threshold value for the minimum Hit-Quality for the 1st ranking in the hit list.
Slct	**4**	Switch to the Select bar for activation/ deactivation of respective Teach-In samples for the PLS-algorithm (dotted pattern style appears and the **<Slct>** icon changes to the **<Clr>** icon). Deactivated or not available storing places are shown in gray letters Pressing the **<Clr>** icon deletes all stored Teach-In samples (Clear) and renames the referring sample to numbers 1 to 8. Repeated touch of the **<Clr>** icon confirms the deletion process.
Edit	**5**	Switch to Edit-Menu for editing of the names of given plastic types[14]. The function is only active, if a sample icon has been selected before. Other names with max. 4 characters can be edited by opening the Teach-In File (see: The Teach-In File).
Up	**6**	Increases the threshold value for the minimum Hit-Difference from the 1st to the 2nd ranking in the hit list. If percentage difference[15] from the 1st to the 2nd ranking is less than the pre-set Hit-Difference than the message ***Low Hit-Difference*** is shown.
Dwn	**8**	Decreases (Down) the threshold value for the minimum Hit-Difference from the 1st to the 2nd ranking in the hit list.
ESC	**ESC**	Leaves the Teach-In menu and returns back to the Result display. All settings are automatically saved in the system file *Teach-XX.dat* which will be loaded when starting the system (see: The System Files for sIRoLine).





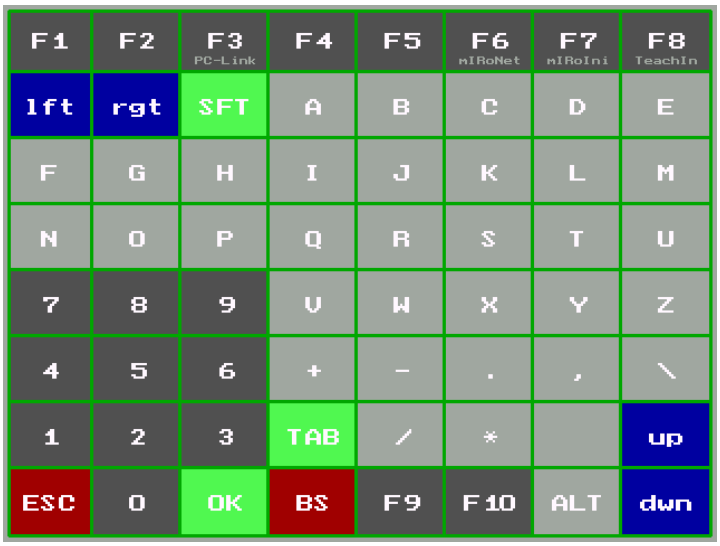


[13] The Hit-Quality is the first threshold value, which the actual spectrum must exceed (degree of spectral curve similarity in % to the trained-in and stored Teach-In samples) to be indicated. For example: the NetD curve resembles to the Teach-in sample named PE to 91% and to the PP to 41%. If the pre-set Hit-Quality value for the 1st ranking is set higher than 91% (in this example) then the message ***Low Hit Quality*** is shown.

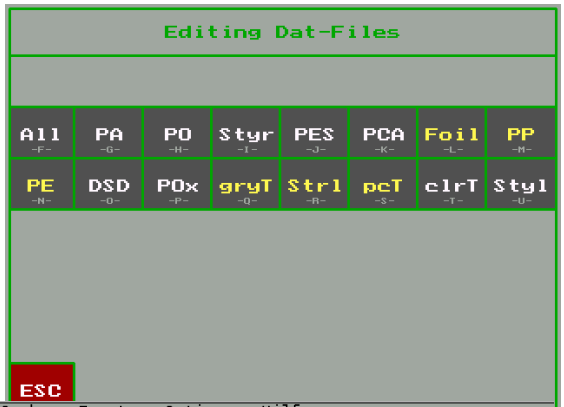
[14] The upper menu bar for the given Textile/Carpet names is only shown if the system is equipped with a Textile/Carpet model (optional feature)

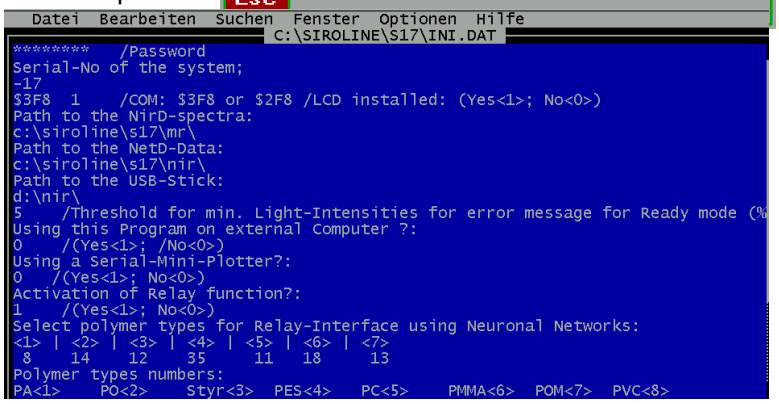
[15] The Hit-Difference is the difference-threshold value, which must be exceeded (spectra difference of 1. to 2. ranking expressed as percentage ranges). For example: the NetD curve resembles to the Teach-in sample named PVC to 100 and to the PE to 98%. If the pre-set Hit-Difference value for the 1st to the 2nd ranking is set higher than 2% (in this example 100%-98% = 2% Hit-D) then the message ***Low Hit Difference*** is shown.

5.5 Operating Elements in the KEYS Mode



Icon	Key	Function[16]
PC-Link	**F3**	Starts the PC-Link program (intersvr.exe) to enables data exchanges for updates or copying files to another computer (see: PC-Link for Data Exchange).
mIRoNet	**F6**	Opens a further window with a menu bar to select neuronal network calibration files[17] and system files Pressing an icon/key starts the text editor with automatically loading the selected Dat- or Ini-Files. (see: The System Files for sIRoLine).
mIRoIni	**F7**	Starts the text editor with automatically loading the initialization file *ini.dat)* for the mIRo part for the activation of optional accessories (e.g. serial Mini-Plotter or Relay board) and selecting polymer types either to generate external signals via the Relay board or for the counter in the FastMode function (see: The Bottom Menu).
TeachIn	**F8**	Starts the text editor with automatically loading the file *TeachIn-XX.dat* to edit sample names and pre-set threshold values (see: The Bottom Menu).
Touch	**F10**	Loading the original default touchscreen settings and overwriting the actual one for recovery the touchscreen adjustment.
mIRoTest	**t**	Starts the mIRo test program (mIRoTest.exe) for testing electronic parts on the NIR-interface board of the sIRoLine device part. In case of hardware operating malfunctions this diagnostic program helps to locate the error (see: The Bottom Menu).
QUIT	**ESC**	Leaves the KEYS mode and returns back to the READY window.





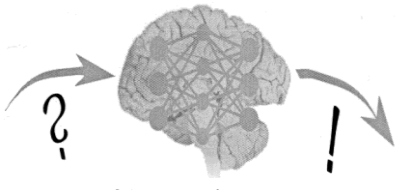
Do not make any changes to the formatting in the text files. Do not insert a decimal point with integer numbers.

[16] To operate the text editor an external keyboard should be connected. In general – if not otherwise noted - quitting the editor resets the loaded text file therefore modifications are directly taken over.

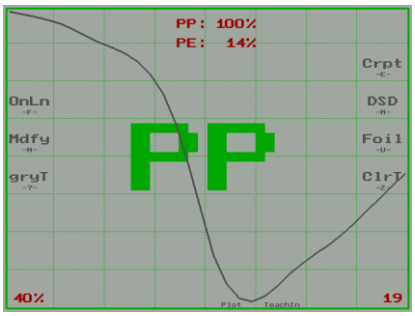
[17] The additional Dat-Files for the Textile model is only shown if the system is equipped with the optional Textile/Carpet feature.

5.6 Polymer Type Identification by Neuronal Networks

The identification of the polymer type using neuronal network is the result of a mathematical model for polymer identification This data processing simply means a comparison with a pre-set pattern recognition[18]. Different types of plastics are categorized into a main group and into a number of sub-groups for fine differentiation.

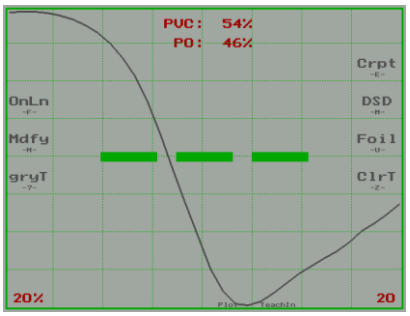


It is very important to select the right identification net model to obtain the correct identification result depending on material thickness, colour of the plastics to be measured.



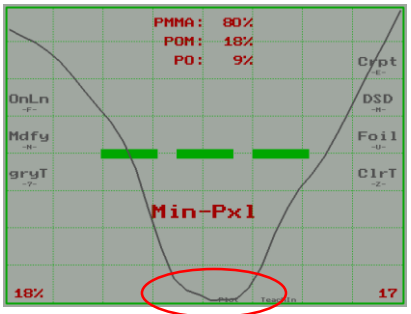
After the measurement, the near infrared intensity data (NirD) are mathematically transformed in ratio to the actual reference spectrum of the white ceramic plate and then normalized and scaled into network data (NetD). These values are processed with given weighting factors and special algorithms of the neuronal network model and stored. The pre-set data of the net model has been created, trained and stored by calibration beforehand. The result of the calculation is a ranking list of the most probable polymer type ranging between 0% and 100%. In the top of the Results window the three polymer types predicting the highest degrees of probability are displayed in red letters. The percentage value expressed the hit quality determined in the network model. It does not mean the composition of a polymer blend. If the results of the measurement for a polymer type exceed the pre-set probability threshold values, then the plastic in the first place in the hit list is additionally displayed in large green letters in the middle of the display.

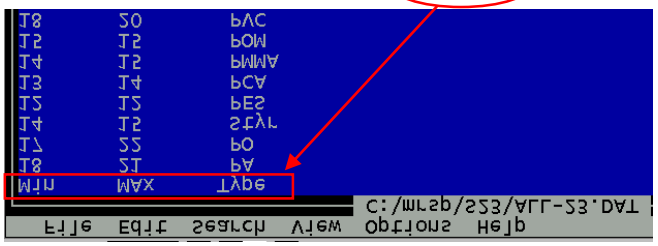
If the pre-set limit values have not been exceeded (e.g. 1st place less than 70 %, 2nd place greater than 30 %), this indicates that the neuronal network was not able to identify the sample reliably. Non-identification is signaled with the No-Result message (---). This is a request to repeat the sample measurement again. If repeated measurements still produce this message, the sample might be unknown (not calibrated) or the wrong net model was selected for identification or new recalibration is necessary (if spectrum is noisy).



5.6.1 The Min-Pxl statement

The pixel minimum of the NetD curve (Min-Pxl) is very characteristic[19] for a polymer type and can alter depending on the thickness[20] of the sample. In the file head of a Dat-file the specific Min-Pxl positions of plastics are listed as Minimum- and Maximum ranges. These values were determined during the calibration of the device for each polymer type. In case that the actual pixel minimum of the NetD curve (here: 17) is not in the range of the pre-set Min-/Max-Pixel value of a polymer identified (here: PMMA as the 1st hit list ranking of the identification probability) then the message ***Min-Pxl*** is shown (here: pre-set PMMA range 14-15). It indicates a logical restriction of the identification result due to the experiences made during the specific system calibration of the manufacture.





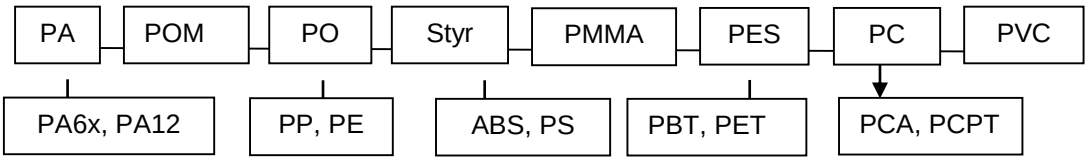
The pre-set Min-/Max-Pixel range for a polymer type should be adjusted[21] (see: Operating Elements in the KEYS Mode), if repeated measurements with known samples and correct identification probabilities for the 1st ranking still produce a No-Result message with the Min-Pxl statement.

[18] The relative disadvantage of any neuronal network algorithm is that after the production no other polymer types can be calibrated by the user. The model is only valid for the given main and sub-groups. Modifications must be carried out on demand by the manufacturer.
[19] Depending on the spectrometer system.
[20] As an example: the Min-Pxl of a thin PE foil is usually at 22 whereby the Min-Pxl of solid PE sample ranges between 20-21.
[21] Displacements of the predefined pixel positions (±1 Pxl) in the spectrometer optics can occur as a result of temperature effects.

5.6.2 Standard Model (All, for coloured, natural or milky-like plastic parts):

This identification[22] model is recommended when coloured, natural- or milky-like plastic parts (not gray, not black and not transparent) are to be detected. Herein the amount of polymer types for fine differentiation of the styrene-containing sub-group is reduced. Modified results **(Mdfy)** switches PA6x[23] or PA12 to PA and PCA or PCPT to PC.

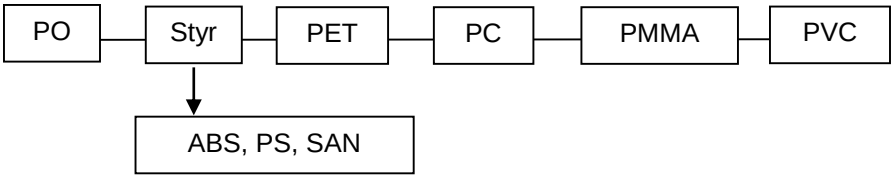
Identification of **PA** (PA6x, PA12), **PO**[24] (PP, PE), **Styr**[25] (ABS, PS), **PES** (PBT, PET)**, PC** (PCA, PCPT)[26]**, PMMA, POM** and **PVC:**



5.6.3 Clear Type Model (clrT, for clear, transparent plastic parts):

Restriction of the polymer identification to few clear types which can normally occur also or only as clear, transparent plastic parts. This identification model is recommended (thickness: 0.5 – 6 mm), because the amount of polymer types for fine differentiation of the styrene-containing sub-group is extended and other types are neglected to enhance the identification performance. Materials which are thicker than 6 mm the result for clear materials might become not reliable and for materials which are thinner than 0.5 mm the Foil model should be selected. Modified results **(Mdfy)** switches SAN (AS) to PS

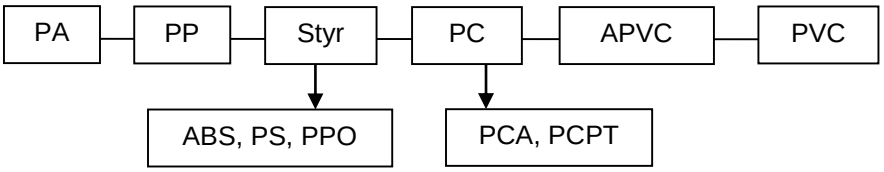
Identification of **PO**[27] (PE, PP), **Styr** (ABS[28], PS, SAN[29]), **PET**, **PC, PMMA** and **PVC:**



5.6.4 Gray Type Model (gryT, for gray-coloured plastic parts):):

This identification model is recommended when gray-coloured plastic parts[30] coming from the electro- and electronic dissembling area (e.g. computer waste) are to be detected, because the amount of polymer types for fine differentiation of the styrene-containing sub-group is extended and other types are neglected to enhance the identification performance. The restriction of the polymer identification to gray-coloured materials helps to work out the distinctive marks in the NIR spectra enhancing the NIR-identification performance for these materials. Modified results **(Mdfy)** switches PPO result to ABS and PCA or PCPT to PC.

Identification of **PA**[31]**, PP, Styr** (ABS, PS, PPO)**, PCA** (PC, PCPT)[32]**, APVC** and **PVC**

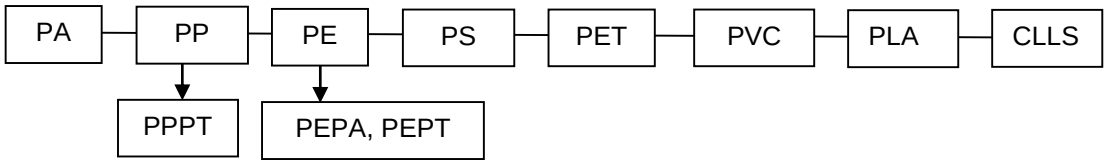


[22] IoSys uses the following abbreviations: PA=Polyamide, PO=Polyolefine, Styr=Styrene containing polymers, PES=Polyester, PCA=PC+ABS, PCPT=PC+PBT or PC+PET, APVC=ABS+PVC, PLA=Polylactoseacetate-biodegradable, CLLS= Cellulose; Multilayers: PEPA=PE+PA, PEPT=PE+PET, PPPT=PP+PET.
[23] Fine differentiation of PA6 and PA66 polymer types is not reliable. Therefore both types are calibrated and combined to PA6x.
[24] To distinguish each Polyolefine group for the neuronal network calculation IoSys uses the following abbreviations:
PO for Standard (All) and POx for DSD model.
[25] To distinguish each styrene-containing group for the neuronal network calculation and editing IoSys uses the following abbreviations: Styr for Standard (All), Styl for clear Type, Strl for gray Type model.
[26] Due to their polymer similarity the identification of colored PC, PCPT and PCA polymer types is sometimes uncertain. Blend ratios from PC/PBT or from PC/PET of 60:40, 50:50 and 40:60 are calibrated as “PCPT”.
[27] No fine differentiation of transparent polyolefine is made in ClrT. Fine identification should be done via Standard (ALL) model. Nowadays transparent PO could be a polyethylene with copolymer like Surlyn® of DuPont™
[28] Usually transparent ABS material is a blend which contains PMMA, too.
[29] SAN = Styrene-Acryl-Nitril is also named as AS = Acryl-styrene.
[30] Due to the experiences of IoSys it must be stated that gray colored plastics (e.g. PA, PP, PVC) which are containing lot of Talcum or glass fibers (20-40%) as a filling material reduces the NIR light reflection causing non reliable identification results.
[31] Fine differentiation of PA6, PA66 and PA12 polymer types is not reliable. Therefore all types are calibrated and combined to PA.
[32] Due to their polymer similarity the identification of gray colored PC, PCPT and PCA polymer types is sometimes uncertain.

5.6.5 Foil Model (Foil, for thin materials):

This identification model is recommended when transparent thin materials like foils are to be detected. Due to the variable thickness of foils the absorption and reflection characteristic differs in comparison to solid materials. These differences appear in the position number of the NIR-curve minimum for the polymer types (Min-Pixel). The Thin foils should be folded several times thus a thickness at least 50 - 100 µm is achieved, otherwise the result might not be reliable. Materials which are thicker than 500 µm should be measured using the Modified results (Mdfy) switches PEPA or PEPT to PE and PPPT to PP.

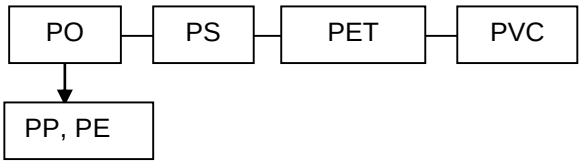
Identification of **PA, PP** (PPPT)**, PE** (PEPA, PEPT)**, PS, PET, PVC, PLA**[33] and **CLLS**:



5.6.6 DSD Model (for household and packaging plastics):

This identification model is recommended when typical plastic parts and foils coming from the household and packing area (MWS) are to be detected, because the amount of polymer types is restricted to few polymer types which normally occur as household and packaging plastics (MWS= DSD =Duales System Deutschland). To enhance the spectral variances, the database of ABS, PS are combined to PS and PBT, PET as PET. In the DSD model no PA-, PEPT-, PLA- and CLLS foils are calibrated and due to the spectra similarity the multilayer foil PEPA was taught in as PE.

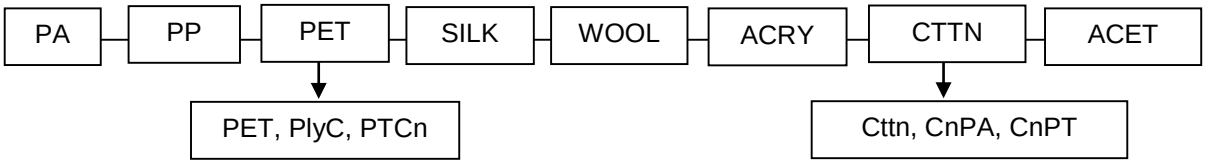
Identification of **PO** (PP, PE)**, PS, PET** and **PVC:**



5.6.7 Textile-Model (Txtl, for textile and carpet fabrics) (available as additional option):

This identification model (optional feature, sometimes named as **Crpt**) is recommended when carpets or textiles are to be detected.

Identification of **PA**[34], **PP, PET** (Polyester)**, PlyC** (PolyCotton[35]), **PTCn** (PET+Cotton-blend[36])**, Acrylic, Silk, Wool, Cttn** (Cotton), **CnPA** (Cotton+PA-blend[37]), **CnPT** (Cotton+PET-blend[38]) and **Acetate.:**

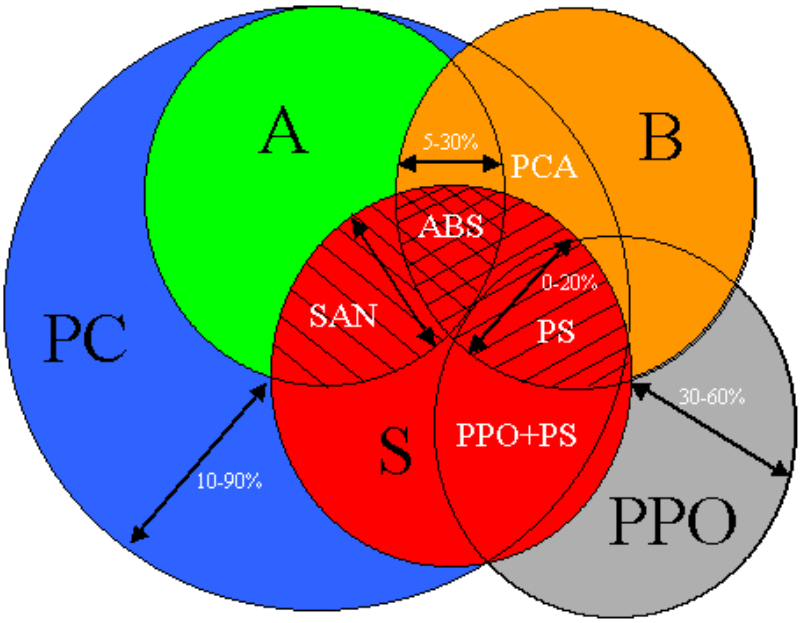


[33] PLA=Polylactoseacetate-biodegradable, CLLS= Cellulose (paper, cotton)
[34] Fine differentiation of PA6, PA66 and PA12 fabrics is not reliable. Therefore all types are calibrated and combined to PA.
[35] Blends made of Polyester-Cotton fabrics (ratio ~ 65:35 and/or 50:50). IoSys uses the abbreviation PlyC for PolyCotton
[36] Cotton fabrics which are coated with a polyester layer. IoSys uses the abbreviation PTCn for PET+Cotton-blend.
[37].Blends made of Cotton-Polyamide fabrics (ratio ~ 50:50). IoSys uses the abbreviation CnPA for Cotton+PA-blend
[38] Blends made of Cotton-Polyester fabrics (ratio ~ 80:20). IoSys uses the abbreviation CnPT for Cotton+PET-blend.

5.6.8 Composition of Styrene-containing Polymers

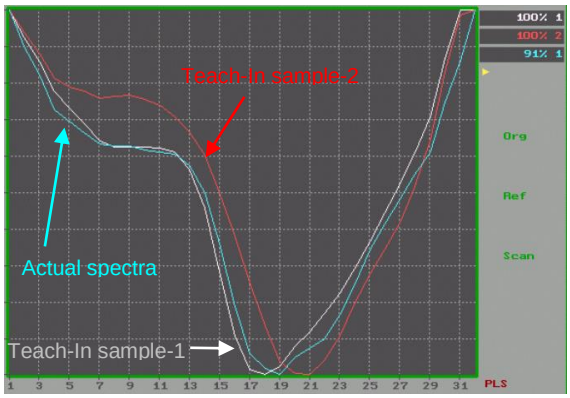
In general the differentiation of styrene-containing polymer types like ABS, PS, PPO, SAN (AS), PCA und APVC are difficult with the NIR Technology due to their polymer similarity. Most of them are blends of each other in different concentrations. But restriction of the polymer identification either to their colours (if coloured, natural- or milky-like (Standard) or if gray-coloured (gryT)) and to their material properties (if transparent (clrT) or thin (Foil)) or their characteristic fire retardant compositions helps to work out the distinctive marks enhancing the identification performance for these materials.

ABS:	Acyrilnitril-Butadien-Styrol,	A: 5-30%,	FR: Br (Cl)
PS:	Polystryrol ; HIPS = S/B;	B: 0-20%,	FR: Br, Cl
PPO:	Polyphenylenoxid+PS (S/B),	PS: 30-60%,	FR: P
PCA:	PC+ABS-Blend,	PC/ABS: 10-90%,	FR: P
SAN (AS):	Styrol-Acrylnitril (Acrylnitril-Styrol)		



5.7 Polymer Type Identification by PLS

The identification of the polymer type using the PLS[39] method (Partial Least Square) is the result of a comparison of the measured spectrum with the stored Teach-in spectra (best fitting curve). It means that an actual spectrum (here: blue curve) is compared with all teach-in sample data which are activated (here: gray & red curves). The more the blue curve resembles to one of the Teach-in curves, the higher the Hit-Quality percentage. In this case the blue curve has the best fit to the gray one. As an example: the actual curve resembles to the blue curve to 91%.

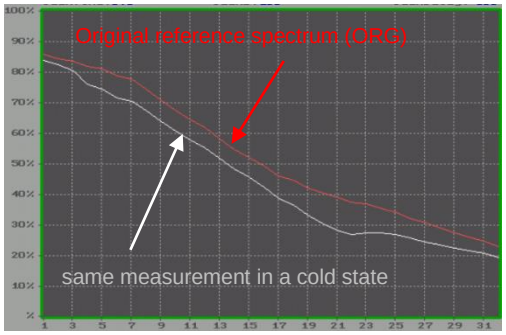


[39] The advantage of the PLS method is that the user can teach-in own test samples to carry out simple rapid analysis. The disadvantage is that PLS works for NIR-spectra only which obviously have big spectral differences.

5.8 Recalibration of sIRoLine

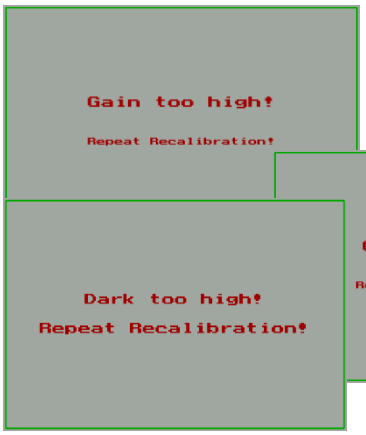
The background to the recalibration routine is that different known types of plastic have been calibrated against a reference standard (white ceramic plate). It means that the near infrared intensity data (NirD) of the known samples were mathematically transformed in ratio to this reference standard, normalized and autoscaled into network data (NetD) for modeling neuronal networks for plastic identification (see: Polymer Type Identification by Neuronal Networks). At that point of time the sIRoLine system was calibrated (the so-called Design state[40]), this reference spectrum was stored as the "original reference spectrum" (ORG).

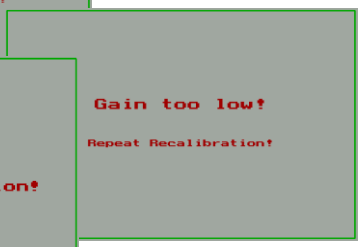
Due to temperature effects, deviations in the sensitivity of the scanning electronics are shown up and therefore the resulting intensity data differ. In general, when the device is just powered on or if the system is used in a cold environment (cold state[41]) the NIR-signals of a measurement are less intense in comparison to the design state. Through the ratio method employed, the effect of changes to the state of the system are almost eliminated through the formation of intensity ratios (sample spectrum divided by the current reference spectrum). However, the identification capabilities of the spectrometer can be reduced in the cold state. A priori, the identification performance is best when the current signal output is similar to the design state.



In order to operate the system immediately (no waiting time for warming up), a recalibration routine is programmed. The recalibration procedure for diffuse reflection and transmission measurements automatically adjusts the measurement electronics in a way that the current signal output of the reference standard closely fits to the stored original reference. Proceed as following to recalibrate the sIRoLine part of the device:

At first after pressing the **<F4>** icon the sIRoLine system starts the recalibration procedure with the message: ***Remove any sample under the light.*** No sample must be on the focusing spot. The next message: ***Recalibrating…***, indicates that the automatic gain adjustment is finished. If the electronics is adjusted the NIR light source is powered down automatically for few seconds to carry out the dark measurement. The message: ***Saved as new reference spectrum*** signals the end of the recalibration procedure.





If an error message appears like the ones shown on the right side, repeat the recalibration.

Other error messages like ***Light Overflow!*** can be displayed during operation in case that a shiny sample has been placed in an unsuitable position for the NIR optics where the reflected light back to the NIR lens is higher than the white reference spectrum. In case that the intensity data of the actual reference measurement differs from the last signal curve, error messages like ***Gain too high!*** or ***Gain too low!*** are shown up. The recalibration procedure has to be repeated.

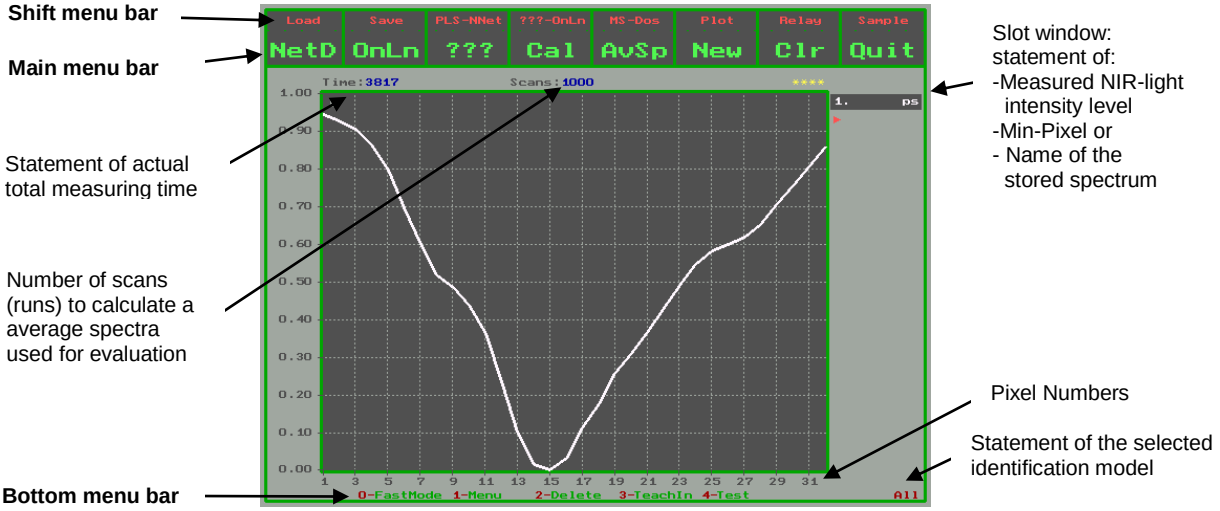
If more than 10 times a ***Light Overflow*** signal is measured (shown by a counter on the right top side of the screen) then the message ***Starting autom. Recalibration*** is displayed. It indicates the beginning of the automatic gain adjustment.

[40] Design state: For sIRoLine calibration the system was always powered on 2 hours before at a room temperature of 22 °C to ensure that the device was in a thermal equilibrium and thus the resulting signals were stable and reproducible.

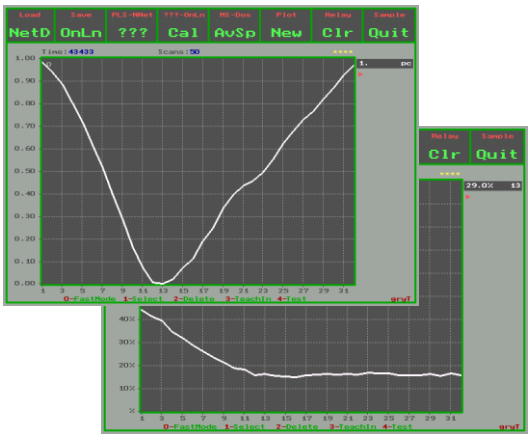
[41] Cold state: When the sIRoLine is just powered on, it is not in a thermal equilibrium. At the beginning the spectra are lower in intensity, drifting towards higher values within 2 hours, i.e. the signal outputs are unstable and non-reproducible.

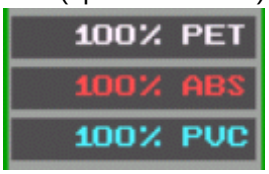
5.9 Operating Elements in the SPC Mode

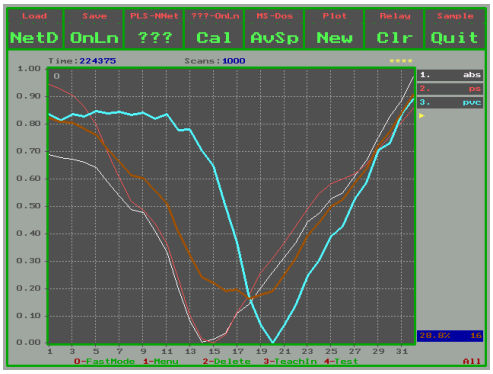
5.9.1 The Main Menu



Display	Key	Function
NirD	**F1**	Switches between the representation views. In the **<NirD>** mode the raw intensity data are shown and in the slot window the measured NIR-light intensity level and Pixel number of the curve minimum is listed (Min-Pxl). In the **<NetD>** mode mathematically transformed intensity data are displayed. In the slot window the slot number and the sample file name is listed if stored before.
OnLn	**F2**	Starts the Online mode wherein the spectrometer optic is continuously read out without triggering. The online spectrum is displayed in slot place#1. The Online mode allows to display simultaneously other spectra or permits e.g. external light sources held in front of the measuring head to be adjusted for the transmission mode (optional feature). Pressing again the **<OnLn>** Display stops the online measurement.
???	**F3**	Activates the polymer type identification (PLS or neuronal network) for all displayed spectra. In the NetD-mode the identification result and the 1st ranking percentage for each spectrum is listed in the corresponding slot window. Pressing again the **<???>** Display returns back to the statements of NIR-light intensity and Min-Pxl or sample file name.
Cal	**F4**	Starts the recalibration routine with auto-gain-adjustment (see: Recalibration of sIRoLine). In the NirD mode the original reference spectrum is automatically loaded in slot place#2 for better comparison and the actual raw intensity data are displayed in slot place#1 If the **<Cal>** function is unintentionally pressed the recalibration routine can be stopped pressing the **<Clr>** key.
AvSp	**F5**	Forms an average spectrum (not auto scaled) from all the spectra which are displayed and plots it in slot place#20 as a brown dotted line (or as a thick brown line if **<t>** press) with a blue colored slot window. Pressing the key again cancels arithmetic forming of an average mean.
New	**F6**	Opens the New-window to delete the representation of a spectrum at a slot place. The next spectrum now appears at the slot place marked with „ ▸ ".
Clr	**F7**	Deletes all the spectra represented at the slot places.
ESC	**F8**	Leaves the program and returns back to the DOS prompt level.

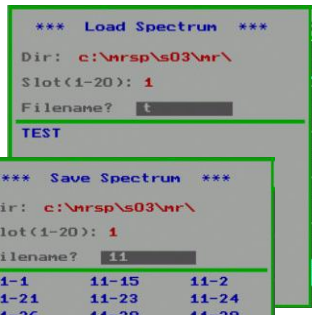


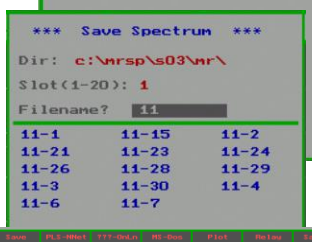


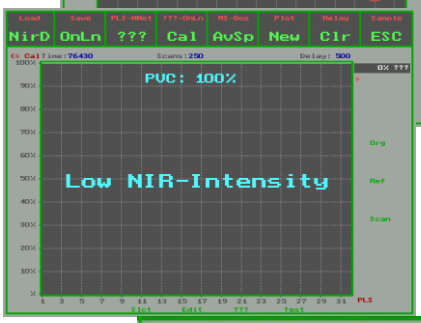


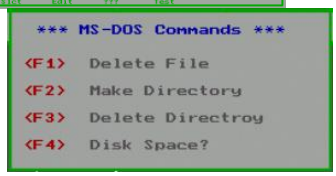
5.9.2 The Shift Menu

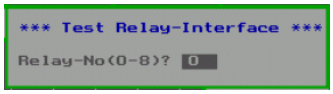
Display	Key	Function
Load	**Sft+F1**	Opens the Load-Spectrum window to open spectra which were saved in the directory path edited under Dir (max. 22 letters). A temporary change to the pre-set directory (edited in the Initialization File) and path can be carried out under Dir. The files are listed in filtered form in accordance with the characters[42] entered. Moving within the window can be done with the Enter or Cursor up/down key. Loaded spectra are shown in different colors after quitting the menu.
Save	**Sft+F2**	Opens the Save-Spectrum window to permit spectra to be stored in the directory path edited under Dir (max. 22 letters). A saved spectrum file gets the file suffix „*.spc“ and are written in a Flat ASCII text format.
PLS-NNet	**F3**	Switches between the PLS model (Partial-Least-Square) or the Neuronal Network calculation. To actualize the identification results for all displayed spectra after changing the algorithm the **<???>** key must be pressed again.
???-OnLn	**Sft+F4**	Starts/stops the Result-Online identification mode which continuously displays the identification result with the hit list ranking (automatically activated for sIRoLine). The hit list is displayed in red letters for neuronal network and in blue letters for the PLS mode. Pressing the **<OnLn>** or **<Clr>** Display stops the online identification measurement.
MS-Dos	**Sft+F4**	Opens the MS-Dos menu for carrying out given MS-Dos operation commands:
Plot	**Sft+F6**	Prints[43] out the actual display as a screen dump to a Mini-Plotter (optional feature). Pressing any key on the Keyboard stops the plotting process.
Relay	**Sft+F7**	Opens the Relay testing menu to switch relays of the relay-interface circuit[44] on or off in accordance to their relay number. Quit the Test menu with **<ESC>.**
Sample	**Sft+F8**	Loads all activated Teach-in samples (max. 8 spectra with the edited file names in the slot #1 up to slot #8. This function allows to give an overview of the stored Teach-In sample data set.
./.	**Sft+F9**	Starts the recalibration routine without auto-gain-adjustment (not displayed in the Shift menu bar). This procedure is recommended if own application (analysis method) is created whereby the reference spectrum should not have the same intensity level as the stored original reference spectrum (e.g. reference signal as blank signal).

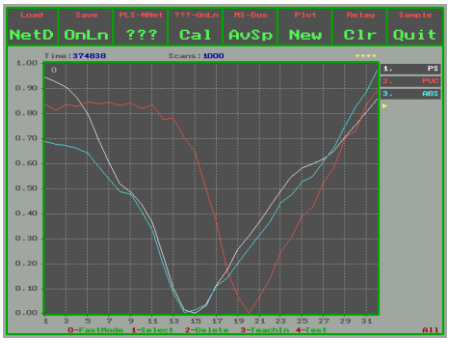








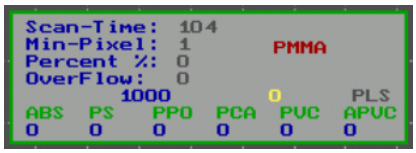


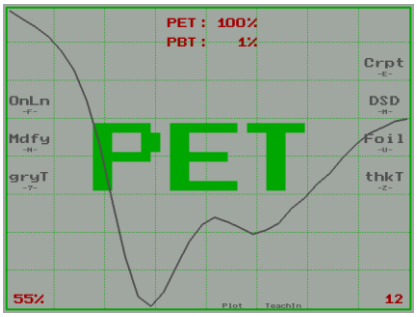


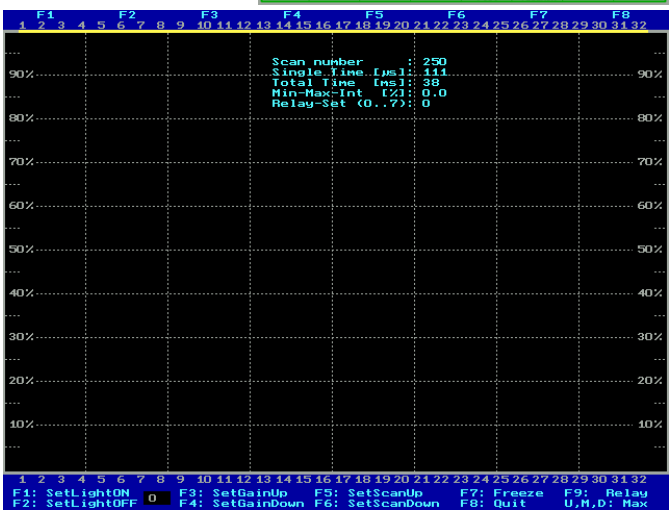
[42] A backslash (\) edited at first of the file name activates the loading/saving of a file series. For example, the entry \kal-0 loads/saves all spectra beginning with the file from kal-1; an entry \kal-1 loads/saves all spectra beginning from kal-11.
[43] Only active if a the Mini-Plotter is connected and the hardware is activated in the initialization file Ini.dat.
[44] By means of this testing menu each relay part can be tested. The 7 red ones and one yellow LED are controlled by the software where else the terminal connectors and the halogen spots are controlled by the relays. In case a selected LED illuminates but no external signal is generated (or the halogen light spots do not shine if relay #8 is selected) than the given relay might be damaged (sticking contacts) and should be exchanged (spare parts are inside the sIRoLine housing).

5.9.3 The Bottom Menu

Display	Key	Function
FastMode	**0**	Opens and closes (also with **<ESC>**) the function for the fastest Online identification option. No time consuming graphics for spectra displaying is needed and therefore deactivated. In the FastMode up to 6 preset polymer types (see: The Initialization File) can be counted[45] with corresponding external signal generation. If a value exceeds 9999 or by selecting another identification model the counter is reset. In the FastMode the following functions exist: **<s>**: Standard model (All) activated **<g>**: gray Type (gryT) activated **<c>**: clear Type model (clrT) ac tivated **<f>**: Foil model (Foil) activated **<a>**: Setting the amount of scans/runs **<t>**: Setting of letter thickness **<p>**: Selection of PLS or Nnet model **<r>**: Relay function activated
Menu	**1**	Opens the menu bar (also with **<ENTER>**) to select either a net model for polymer type identification **(<F1>..<F6>**) and/or to open the another window to select and to edit Dat- and Ini-files of the system. A text editor opens with automatically loading the file chosen for editing.
Delete	**2**	Deletes the last displayed spectrum (also with **<Backspace>)** with the highest slot number.
???	**3**	Switches to the Result-window for 2 sec. Always an average spectrum is evaluated. It means, if several spectra are shown then a corresponding mean of all displayed spectra is calculated and this result is displayed for a short time.
Test	**4**	Starts the test program (sIRoTest.exe) for testing electronic parts on the NIR-interface board of the device part (also with **<F10>**). In case of hardware operating malfunctions this diagnostic program helps to locate the error. For example: the NIR-lights are switched on and off by using **<F1>** or **<F2>**. The relay functions for the external signal generation are tested by **<F9>**. The gain adjustment function of the electronics are checked by using **<F3>** or **<F4>** or with the means of the Hotkeys **<d>** (gain down), **<m>** (gain mid) and **<u>** (gain up).



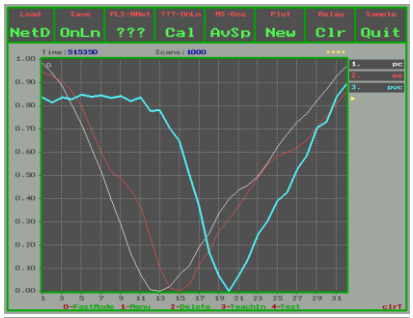


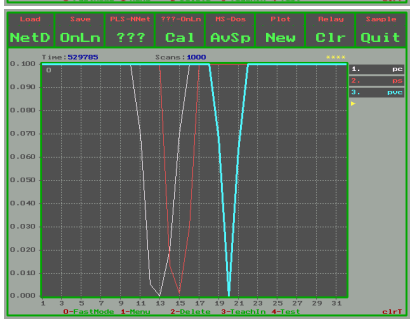


[45] Due to the very fast online measurements in the FastMode the identification result is only shown and counted and the external signal by relay is only generated if the identification result is two times the same successively.

5.9.4 Additional Operating Elements

Key[46] Function





⇑ Zooms the representation view of the displayed data curves. In the **<NetD>** mode the intensity percentage ranges then from 0-0.1% which makes it easier to see peak minima (e.g. to detect abnormal curve shapes). In the **<NirD>** mode the spectra is auto-scaled between the first and last Pixel value. Pressing the **<Cursor-up>** again returns back to the full image representation

A Sets the scan numbers[47] (scans/runs) in steps of 100, 250, 500, 1000, 2000, 3000, 4000 and 5000. The scan numbers can be changed by pressing the **<a>** repeatedly. The default value is 3000 scans, a priori, to obtain a stable average spectrum for evaluation.

O Loads the original-reference spectrum into the next vacant slot.

R Loads the current reference spectrum into the next vacant slot.

‘ ‘ Pressing the **<SPACE>** key starts single scan/measurement. The spectrum appears at the slot place marked with „ ▸ " before.

P Activates the polymer type identification (PLS or neuronal network) for all displayed spectra (same as **<???>**).

L Opens the SaveData (L=Learning) menu to save data for calibration purposes (menu for the manufacturer only).

T Displaying the last NIR-curve (highest Slot-number) as a thick curve. Otherwise this key activates the textile identification model (optional feature).

S Activates the Standard (All) model (see:). This identification model (**PA** (PA6x, PA12), **PO** (PP, PE), **Styr** (ABS, PS), **PES** (PBT, PET), **PC** (PCA, PCPT), **PMMA**, **POM** and **PVC**) is recommended when colored, non-transparent plastic parts (thickness 0.5 – 6mm) are to be detected. Each selected model is displayed in red at the right bottom side of the display.

G Activates the gray Type (gryT) model. This identification model (**PA**, **PP**, **Styr** (ABS, PS, PPO), **PC** (PCA, PCPT), **APVC** and **PVC**) is recommended when gray-colored plastic parts coming from the electro- and electronic dissembling area (e.g. computer waste) are to be detected.

C Activates the clear Type (clrT) model. This identification model (**PO**, **Styr** (ABS, PS, SAN), **PET**, **PC**, **PMMA** and **PVC**) is recommended when only as clear-transparent plastics are to be detected. The fine differentiation of the styrene-containing sub-group is extended and other types are neglected to enhance the identification performance. Materials which are thicker than 6 mm the result for clear-transparent materials might become not reliable.

F Activates the Foil model. This identification model (**PA**, **PP** (PPPT), **PE** (PEPA, PEPT), **PS**, **PET**, **PVC** **PLA** and **CLLS**) is recommended when transparent thin materials like foils are to be detected. Due to the variable thickness of foils the absorption and reflection characteristic differs in comparison to solid materials. These differences appear in the position number of the NIR-curve minimum for the polymer types (Min-Pixel). The Thin foils should be folded several times thus a thickness at least 50 - 100 µm is achieved, otherwise the result might not be reliable. Materials which are thicker than 500 µm should be measured using the Standard model.

D Activates the DSD model. This identification model is recommended (**PO** (PP, PE), **PS**, **PET** and **PVC**) when typical plastic parts and foils coming from the household and packing area (MWS) are to be detected, because the amount of polymer types is restricted to five polymer types which normally occur as household and packaging plastics (MWS = DSD = Duales System Deutschland).

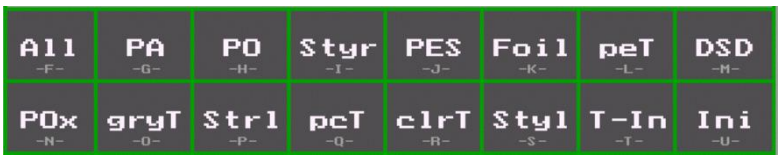
M Activates the Modify function (Mdfy). Due to NIR-spectra similarity the distinction of some polymer types is sometimes uncertain and could be random-like PA6x and PA12 in the Standard model, ABS and PPO or PCA, PCPT and PC the gray Type model, PS and SAN in the clear Type model, PEPA and PEPT in the Foil model. To modify the identification result either means that the determined probability in the network model (1st ranking in the Hit list) is altered to the polymer types which are in general more probable (in gryT: **PPO** ⇒ **ABS, PCA** and **PCPT** ⇒ **PC**, in clrT: **SAN** ⇒ **PS**, in Foil: **PEPA**, **PEPT** ⇒ **PE**) or the identification will be simplified (in All (Standard): **PA6x**, **PA12** ⇒ **PA**). The Modify function can just be activate/deactivated if one of the mentioned polymer types are displayed. A temporary modification of an identification result is signaled then in red at the right bottom side of the display.

[46] Use small keyboard characters.

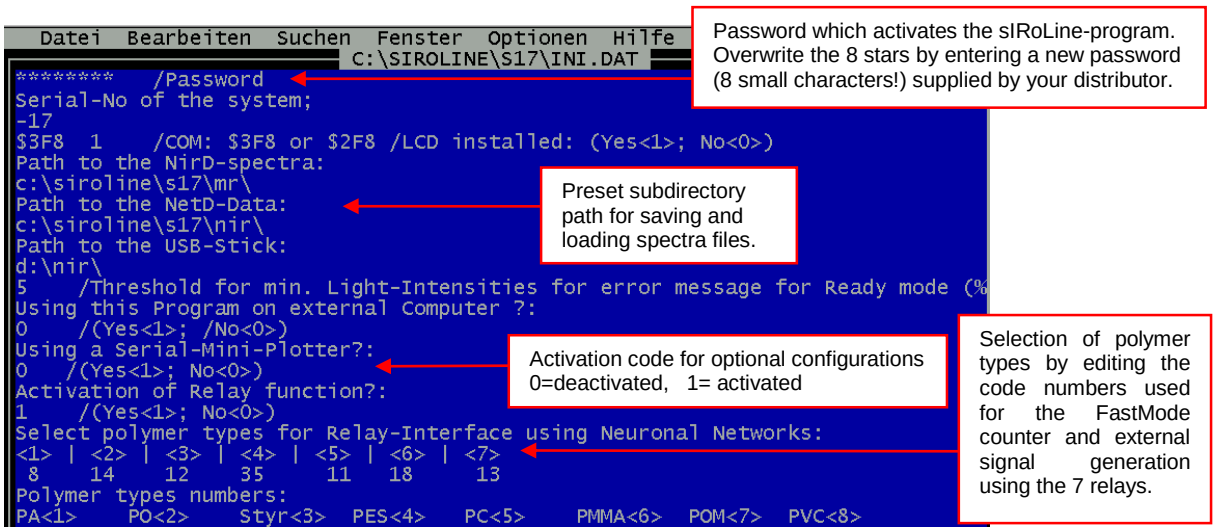
[47] The higher the scan number (RUNS), the better is the resulting average spectra (improved signal/noise ratio of the calculated average) and the more stable the identification result. However, the measuring time is longer. On the other hand, the smaller the scan number, the more noisy is the resulting spectrum for evaluation, the less stable is the identification result, but the measuring time is shorter.

6 The System Files for sIRoLine

6.1 The Initialization File

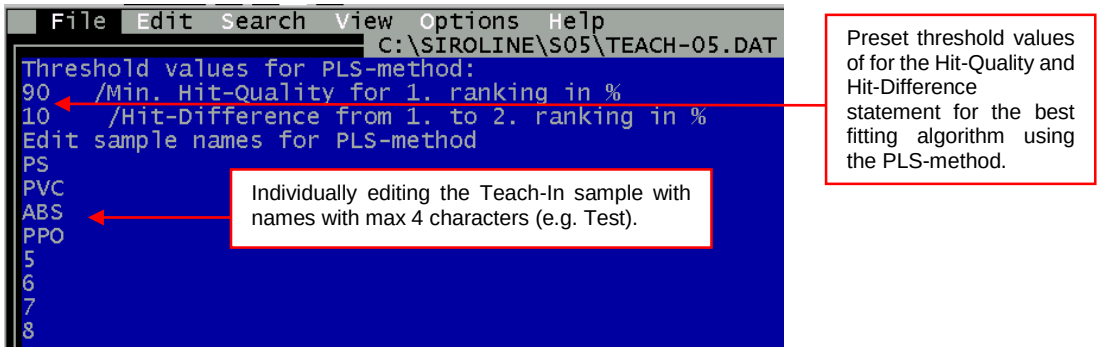


Pre-set parameters like the serial number of the unit, hardware address, directory paths and the activation of optional features are stored in the file Ini.dat. This text file can be opened by pressing the **<1>** or **<ENTER>** key to open the Select menu and then **<F7>** switching into the NetM menu. The **<u>** key opens the *Ini.dat* file. As an example a typical initialization file is listed[48]: (data always differ depending on the system!).



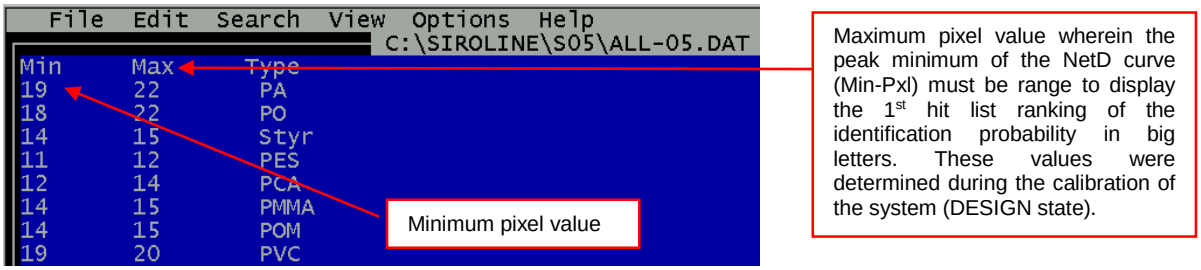
6.2 The Teach-In File

Sample names and pre-set threshold values edited in the Teach-In menu are stored in the file: *teach-XX.dat* (XX=series number). This text file can be opened as describe before and pressing the **<F8>** key. As an example a typical Teach-In file is listed:



6.3 The Dat-Files

The Min-/Max-Pixel range of the NetD curve minimum and given values of the neuronal network models (weighting factors) are stored in the Dat-files Modelname-XX.dat (XX=series number). These text files can be opened as described before and pressing the **<f>… <s>** keys. As an example for a typical Dat-file of the Standard (All) model is listed (data always differ depending on the actual individual unit!).



[48] As an example the following polymer types are selected to the corresponding relay number of the optional external relay board: Relay#1 is switched on if PVC (polymer type number=8) is identified by setting polymer type number #8. Using code number 0 for a polymer type means that the counter and relay is deactivated.

7 PC-Link for Data Exchange

7.1 Using PC-Link cable

For communication with other computers and the update of software the MS-DOS communication system Interlink/Interserver is used for the communication between the device system and other computers (only working for computers equipped with Windows95® or Windows98®) for with the aid of the serial interface, a zero modem cable (Laplink-cable, 9p-SUB-D).

Copy the interlnk.exe file (supplied by Floppy-Disk or e-mail) to a directory on the computer (e.g. your Desktop or Laptop computer) where you want to make the communication with the systems. The interlnk.exe file should be placed in the main root c:\ of the external computer and should get an entry in the config.sys file[49] as following.

device=c:\interlnk.exe /com /noprinter /auto.

1. Connect a serial zero modem cable to the COM interfaces of the device (acts as Server) and the external computer (acts as Client).
2. Switch off the integrated Mini-Plotter (optional feature) with the rocker switch locate aside before to avoid data transfer malfunctions.
3. Press the **<PC-Link>** icon (or **<F3>**) in the KEYS-Menu to start data exchange program (intersvr.exe).
4. Reboot the external computer (e.g. your Laptop or Desktop-PC) to start the data exchange program. The drives of the measuring device (e.g. A:\, C:\) will appear now as additional drives (e.g. F:\, G:\) at your external computer which you can now access to copy files for updates or to copy stored spectra to your .
5. If no computer link could be established then restart the external computer again and press repeatedly **<F8>** to enter the Microsoft Window 98 Start Menu. Press **<5>** to select the Dos prompt level.
6. Power down the device to quit the PC-Link-program.

7.2 Using USB-Stick

For data exchange with other computers and software updates an USB stick can be connected to the USB port of the mIRoPort system to read from and write to this removable mass storage device. The USB drivers are already incorporated into the MS-DOS based operating system.

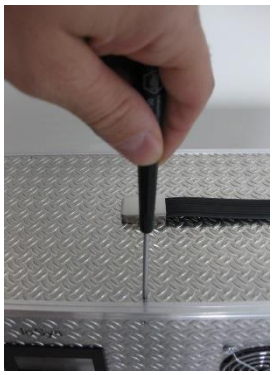
Before booting up the mIRoPort system the USB-Stick must inserted correctly into the USB slot. It will only fit properly one way round. Do not try to force it.

The USB stick will be recognized by the MS-DOS system at time of booting only! When the USB stick is disconnected while system operation and connected again then it will not recognize the USB stick again. The unit must be restarted again.

[49] Please recognize that there might be some config.xxx files on your computer in the root directory (usually c:\) depending on the operating system you may have for initial starts or the later change to MS-DOS. In such a case all files named config.xxx should be altered accordingly with the above mentioned line. Please make sure that also the lastdrive command is giving enough figures for the deviated disks on your computer when connecting to the sIRoLine. Always place the new command at the end of the config.xxx files to avoid conflicts with other commands redirecting drives. Then either from the Windows Explorer or alternatively starting the MS-DOS mode, updates for the unit can be easily copied.

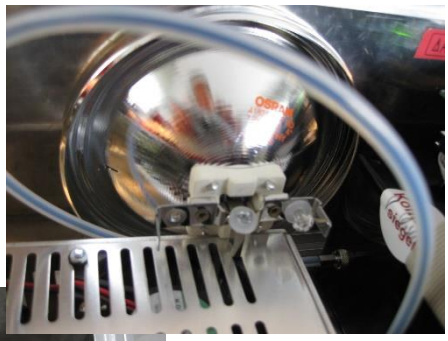
8 Exchanging the NIR-spot light

The lifetime of the NIR light source is about 3000–4000 hours. Therefore an exchange can be necessary from time to time. Needed spare parts like relays, screws and new halogen spot light (type: Osram QRB111, 50W, 12V, 4°) are located and fixed inside the unit.



1. To do so, switch off the device and remove carefully all M2.5-srews in the top plate using a screwdriver (size: PH1) an put this cover plate aside.

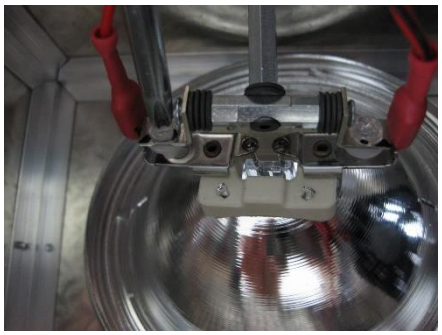
2. Loose the M3-screw which fixes the spot light spare and take it out carefully.

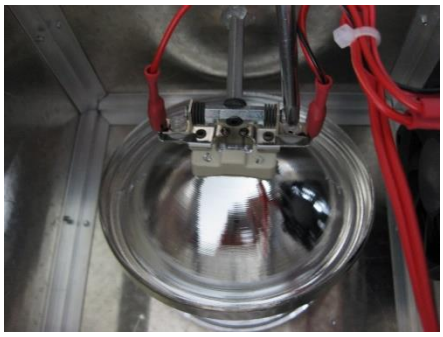


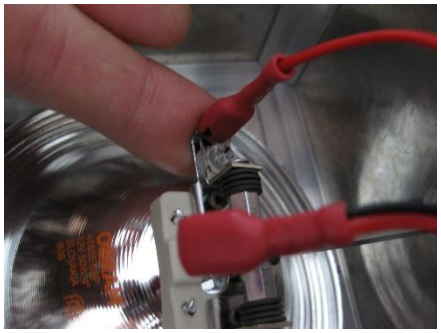
3. At the broken spot light, remove both M4-plastic screws a little by at one side and a little at the other side using a screwdriver (size: PH2) to avoid tilting. Repeat this procedure until the alu-reflector is loosened.

4. Disconnect carefully both red female headers out of the pins. Do not pull at the cables!

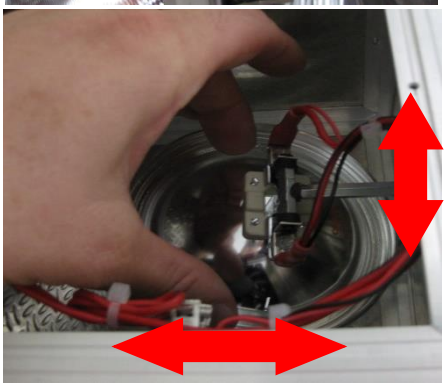
5. Take the new NIR-spot light and fix both M4-plastic screws a little by at one side and a little at the other side (avoid tilting). Repeat this procedure until the alu- reflector is fixed again. Please inform GUT (info@gut-stuttgart.de) about the spot light exchange. Please keep broken spot if not otherwise noted.



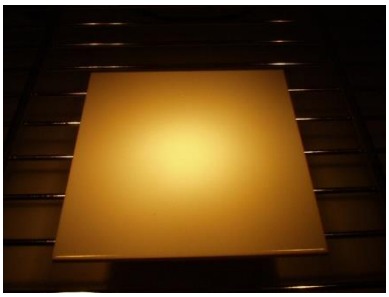




6. Connect carefully both red female headers in the pins again. A black mark at the header indicates the inside orientation.



7. After the exchange the focusing spot be almost in the middle of the reflection tile to achieve maximum light reflection. If not, adjust the both focusing spots by moving the Alu-reflector. Please proceed as described in chapter: Setup of the system.



8. After the light source exchange a new recalibration must be carried out.