



AvaRaman Operating manual

AvaSoft Raman-USB2 version 7.6.1

June 2011





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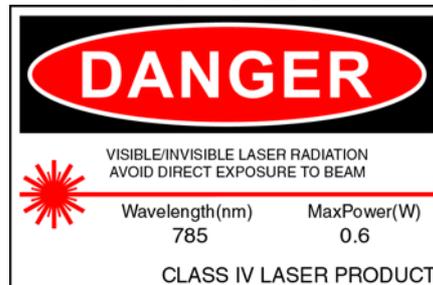


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0 SAFETY PROCEDURES AND WARNINGS

FOR YOUR SAFETY, READ AND UNDERSTAND ALL SAFETY AND OPERATING INSTRUCTIONS BEFORE USING THIS PRODUCT.



Optical Safety

The laser beam emerging from the AvaRaman laser output port or from the fiber optic probe is a Class IV laser. This laser product produces visible and/or invisible laser radiation. It is capable of causing serious eye injury and blindness to anyone who looks directly into the beam or its specular reflections. Laser safety eyewear (AVARAMAN-GL-532/785) must be worn before applying power to the unit. Laser safety eyewear must be worn at all times while operating the AvaRaman. The laser will operate at full power at 785nm within 2 seconds of applying power to the unit and it operates in continuous wave (cw) mode at 785nm with a 500mW-output power.

The backside power switch controls the power to the system. When the system is on, the *green* Spectrometer LED will be on. The key switch on the front panel of the AvaRaman labeled LASER ON | OFF controls the power to the laser. When the laser is on, the *red* Laser Power Indicator Lamp will be on.

Due to the dangers associated with operating lasers, the AVARAMAN-GL-785 Safety Goggles are specified with every AvaRaman order. It is the customer's responsibility to supply the correct laser safety eyewear to anyone who could be exposed to the laser radiation. Reputable distributors of laser safety eyewear can recommend the best product for a user's specific needs.

Laser light presents special safety hazards not associated with other light sources. People present while a laser is in operation need to be aware of the special properties and dangers involved in laser radiation. Familiarity with the AvaRaman and the properties of intense laser radiation will aid in the safe operation of this product. AvaRaman users must read and understand all of the information presented in the Raman Systems AvaRaman Operating Instructions before operating the Raman System.

The AvaRaman System has following internal laser safety protection installed:

1. Key-switch, please remove the key, such that unauthorized operators cannot switch on the laser
2. Interlock, connect the interlock to a door switch, such that the laser is automatically switched off when the door is opened
3. SMA connector micro-switch, the laser is automatically switched off when no SMA coupled fiber probe is inserted into the laser exit.



AvaRaman users must adhere to the following regulations:

1. Never look directly into the laser light source.
2. Never stare at the diffuse reflected beam.
3. Never sight down the beam into the source.
4. Do not turn the laser on unless the fiber-optic probe is connected to the AvaRaman.
5. Do not disconnect the fiber-optic probe from the AvaRaman unless the laser is turned off.
6. Restrict the use of the AvaRaman to qualified and well-trained users knowledgeable in laser safety practices. In addition, inform all personnel working in the area of these regulations.
7. Before the laser is in operation, notify all personnel in the room or others who might be exposed to the laser beam that a laser is about to be used.
8. Illuminate warning lights and post warning signs in the area when the laser is in operation.
9. People requiring access to areas within the nominal hazard zone must wear protective eyewear designed for 785nm lasers with the 785 nm system and 532 nm with the 532 nm system. The eyewear designation should permit observation of the emission indicator.
10. Position the beam path and optical components used in the operation of the AvaRaman at an elevation low enough to prevent inadvertent beam-to-eye contact.
11. Reflections from shiny surfaces, such as watches, rings, window glass, polished surfaces, etc., can redirect light in dangerous directions. Whenever the laser light can possibly illuminate a shiny object, consider where the reflected light could go and make sure that a hazardous situation is not created.
Even a diffused reflection of a Class IV laser product is dangerous.
12. User should consult with their laser safety division, if applicable.
13. Use of a Class IV laser product requires power interlocks installed on every door leading to the lab.

Upgrades

Customers sometimes find that they need Avantes to make a change to or to upgrade their system. In order for Avantes to make these changes, the customer must first contact us and obtain a Return Merchandise Authorization (RMA) number. Please contact the Avantes Technical Services for specific instructions when returning a product.

If you still have problems with your installation, do not hesitate to contact us:

Avantes Technical Support

Soerense Zand Noord 26

NL-6961 RB Eerbeek

The Netherlands

Tel. +31-(0) 313-670170, Fax. +31-(0) 313-670179

www.avantes.com, info@avantes.com

1.0 AvaRaman System

The AvaRaman Raman System is a fully integrated, low-cost system for applications requiring Raman techniques. The AvaRaman system consists of a laser diode, an AvaSpec 2048TEC TE-cooled CCD-array spectrometer and an expanded range of fiber optic probes. The AvaRaman System is available for 532 and 785 nm excitation wavelengths in 2 basic versions:



1. The low-cost non-cooled version, standard built-in solid state laser .
2. The high performance, TE-cooled version with a stabilized Laser.

All AvaRaman systems come with special AvaSoft-Raman software (see software section). The AvaRaman System is optimized for maximum sensitivity. The maximum integration time is 60 seconds.

The AvaRaman is especially useful for analysis, such as reaction monitoring, product identification, remote sensing, and the characterization of highly scattering particulate matter in aqueous solutions, gels and other media.

The AvaRaman System is available with different Laser types than the standard 785nm, such as solid-state 50 mW green (532 nm) lasers or HeNe lasers 633nm.

1.1 Parts included in the shipment

In your shipment box you will find following, please check carefully that all items are present:

- AvaRaman spectrometer, depending on the model a 19" rackmount or 9.5" desktop
- Safety goggles
- Power cord (standard EUR, also -US, -UK or -AUS version available)
- USB interface cable
- AvaRaman Product CD-rom
- Wavelength Calibration Data Sheet
- AvaRaman probe (needs to be ordered separately)



1.1.1 AvaRaman Spectrometer

Depending on the model, a 19" rackmount (for the high-end AvaRaman-TEC system) or 9.5" desktop. A detailed description of all connections is given in paragraph 1.2.

On the backside a sticker is located with spectrometer type, serial nr, installed options date and customer name.

Please follow instructions in chapter 1.4 and 2 for installation.

1.1.2 Safety Goggles

Safety goggles should be included in the shipment and have to worn at all times when installing the system and having the laser switched on.

1.1.3 Power cord

The supplied power cord is standard equipped with EUR connection and is suitable for 100-240 VAC. If you need different socket connection, please contact us for US, UK or Australian power cords. Please follow instructions in chapter 1 or 2 before connecting the power supply.

1.1.4 USB interface cable

Standard a USB interface cable is included in the shipment. For connection RS-232 an IC-DB26/DB9-2 interface cable should be separately ordered the instrument.

under with



1.1.5 AvaSpec Product CD-rom

The AvaRaman CD-ROM includes the installation software for the AvaRaman system. It also includes a PDF version of this manual and a PDF version of the Avantes catalog.

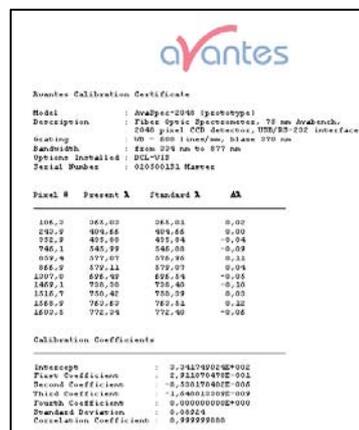
1.1.6 Wavelength Calibration Data Sheet

This calibration sheet is unique to your spectrometer; it includes the wavelength calibration coefficients, installed grating, wavelength range and options as well as the spectrometer serial nr.

Please make sure to save this document in a secure place.

1.1.7 AvaRaman Probe

A number of AvaRaman probes can be ordered with the AvaRaman system, depending on the wavelength range and application. Please section 1.2.3 for more information.



Avantes Calibration Certificate

Model : AvaSpec-2048 (prototype)
Description : Fiber Optic Spectrometer, 75 nm AvaRaman, 2048 pixel CCD detector, USB/RS-232 interface
Grating : 600 lines/mm, blaze 370 nm
Bandwidth : 2200 nm to 877 nm
Options Installed : DCL-V12
Serial Number : 020500211 Name:

| Pixel # | Present λ | Standard λ | $\Delta\lambda$ |
|---------|-------------------|--------------------|-----------------|
| 106.0 | 365.00 | 365.00 | 0.00 |
| 202.0 | 404.65 | 404.65 | 0.00 |
| 302.0 | 432.00 | 432.04 | -0.04 |
| 405.1 | 465.99 | 465.00 | -0.09 |
| 509.8 | 517.07 | 516.94 | 0.13 |
| 666.0 | 579.11 | 579.07 | 0.04 |
| 807.0 | 656.40 | 656.54 | -0.14 |
| 1009.1 | 732.30 | 732.40 | -0.10 |
| 1216.9 | 810.42 | 810.39 | 0.03 |
| 1458.0 | 892.62 | 892.54 | 0.08 |
| 1600.5 | 972.04 | 972.00 | 0.04 |

Calibration Coefficients

| | |
|-------------------------|-------------------|
| Intercept | 2.241749024E+002 |
| First Coefficient | 2.923704912E-001 |
| Second Coefficient | -6.201376480E-006 |
| Third Coefficient | 1.648013392E-009 |
| Fourth Coefficient | 0.000000000E+000 |
| Standard Deviation | 0.00024 |
| Correlation Coefficient | 0.99999888 |

see



1.2 Technical Data

1.2.1 Technical Data Spectrometer

| | AvaRaman-532 | AvaRaman-532TEC | AvaRaman-785 | AvaRaman-785TEC |
|--|---|---|--|---|
| Signal to noise Ratio | 200:1 for Benzene | | | 300:1 for Benzene |
| Resolution | 10 cm ⁻¹ | 10 cm ⁻¹ | 16 cm ⁻¹ | 8 cm ⁻¹ |
| Spectrometer | AvaSpec-2048 with grating NC (535-752nm), slit-25, DCL-UV/VIS | AvaSpec-2048TEC with grating NC (535-752nm), slit-25, DCL-UV/VIS, TE cooled | AvaSpec-2048 with grating IB (780-1100nm), slit-50, DCL-UV/VIS | AvaSpec-2048TEC with grating NC (780-930nm), slit-25, DCL-UV/VIS, TE cooled |
| Spectral Range | 100-5400 cm ⁻¹ | 100-5400 cm ⁻¹ | 100-3600 cm ⁻¹ | 100-2100 cm ⁻¹ |
| Temperature cooled CCD | n.a. | Regulated, ΔT = ca. -20 °C versus ambient | n.a. | Regulated, ΔT = ca. -20 °C versus ambient |
| Time to stabilize | Depending on integration time | 30-60 seconds | Depending on integration time | 30-60 seconds |
| Dynamic Range improvement for it > 5 seconds | n.a. | > Factor 10 | n.a. | > Factor 10 |
| Dark Noise improvement for it > 5 seconds | n.a. | Factor 2-3 | n.a. | Factor 2-3 |
| Peltier cooling internal Power supply | n.a. | Regulated, 0- 3.0 V, 4A | n.a. | Regulated, 0- 3.0 V, 4A |
| External Power supply | 100-240 VAC, 30W | 100-240 VAC, 30W | 100-240 VAC, 30W | 100-240 VAC, 30W |
| Dimensions | 310 x 235 x 135 mm Desktop | 320 x 450 x 135 mm Rackmount | 310 x 235 x 135 mm Desktop | 320 x 450 x 135 mm Rackmount |

1.2.2 Technical Data Laser

| | AvaRaman-532 (TEC) | AvaRaman-785 (TEC) |
|----------------------|--------------------|--------------------|
| Laser output (785nm) | 50 mW, Class 3b | 500 mW, Class 3b |
| Laser Wavelength | 532 nm | 785 nm |
| Laser Bandwidth | < 0.1 nm | < 0.2 nm |
| Connection | 100μm, SMA905 | 100μm, SMA905 |

1.2.3 Technical Data Probes

Since there are a variety of probes available, please find below some of the standard probes and their specifications:

AvaRaman-PRB-532/785*

3/8" SS low-cost focusing probe with excitation fiber and 200 μ m read n.a. 0.22.

Multiple focal lengths available (5 7.5mm(standard), 10mm).

Manual shutter included, 1.5 m standard SMA905 connectors.

Filter Specs OD>6 @ 532/785*nm.

Temperature up to 80°C.

This probe cannot be used directly in fluids, NOT IMMERSIBLE.



a 100 μ m
fiber,
mm,
cable,

AvaRaman-PRB-FP-532/785*

1/2" SS focusing probe with a 100 μ m excitation fiber and 200 μ m read n.a. 0.22.

Multiple focal lengths available (5 mm(standard), 7.5mm, 10mm).

5 m cable, standard SMA905 connectors.

Filter Specs OD>6 @ 532/785*nm.

Temperature up to 80°C.

This probe cannot be used directly in NOT IMMERSIBLE.



fiber,

fluids,

AvaRaman-PRB-FIP-532/785*

5/8" SS focusing immersible probe for measurements with a 100 μ m excitation fiber and 200 μ m read n.a. 0.22.

Focal length 7.5mm (5/10mm available).

5 m cable, standard SMA905 connectors.

Filter Specs OD>6 @ 532/785*nm.

Temperature up to 200°C.



in-situ
fiber,



AvaRaman-PRB-FC-532/785*

3/8" SS focusing process industrial for in-situ measurements with a excitation fiber and 200 μ m read n.a. 0.22.

Focal length 7.5mm (5/10mm available), manual shutter.

5 m cable, standard SMA905 connectors.

Filter Specs OD>6 @ 532/785*nm.

Temperature up to 400°C and pressure up to 200 bar.

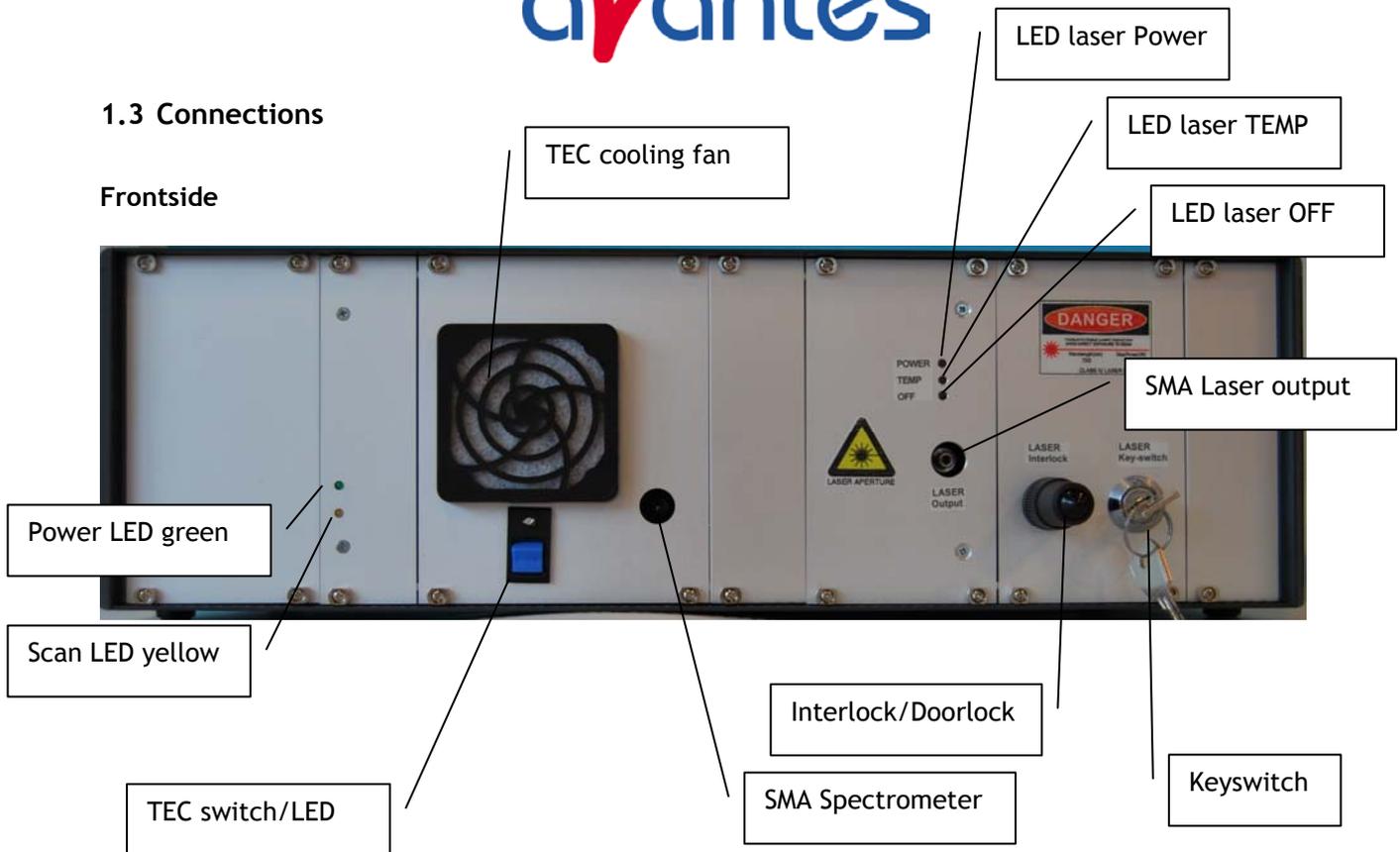


probe
100 μ m
fiber,

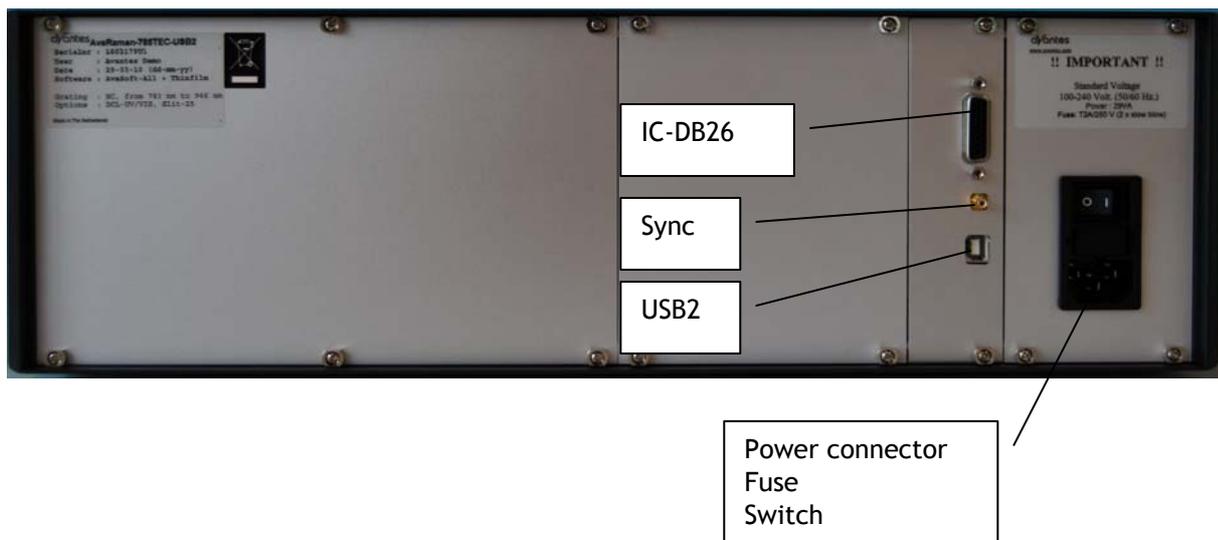
- Specify wavelength range upon ordering

1.3 Connections

Frontside



Backside





Power LED green and scan LED yellow

The green and yellow LED's act as status LED's for the micro controller with following meaning:

Green LED = off, power is not connected

Green LED = on, power is on, micro controller ready, no errors

Green LED = blinking, permanent error detected by micro controller

Yellow LED = on, when scan is transmitted to PC

TEC switch and indicator

The blue switch is used to switch on the CCD detector cooling, the green LED=on indicates that the CCD detector cooling is switched on.

Switch in down position Cooling is on

Switch in up position Cooling is off

SMA Spectrometer

This is the optical entrance that the fiber optic probe SMA connector return leg should be connected to. Please rotate SMA connector clockwise to fasten.



SMA Laser output Spectrometer

This is the optical exit that the fiber optic probe SMA connector illumination leg should be connected to. Please rotate SMA connector clockwise to fasten. The optical laser output is protected by a microswitch, so only when the SMA connector is fully fastened the laser will switch on.

DO NOT LOOK IN THE (REFLECTED) LASER BEAM, WEAR SAFETY GOGGLES AT ALL TIMES.

Interlock/doorlock

For a safe operation of the instrument it is required that interlocks are connected on every door to the lab that the Raman is operated in. The delivered interlock will operate the laser without the need for interlocks on the doors, but has to be replaced by interlocks on the doors.

Keyswitch

A keyswitch with 2 keys is delivered with the instrument, you can switch on the laser unit by rotating the key clockwise. Make sure the key is stored in a safe place, so that only authorized personel can operate the instrument.

LED Laser Power

Green LED is on when the Laser power module is switched on

LED Laser TEMP

Yellow LED is off when Laser diode is temperature stabilized, when yellow LED=ON, laser diode is not temp stabilized yet (may take 10-20 seconds)

LED Laser OFF

Red LED indicates that the laser is switched off, so no output light will come out of the laser. When LED is switched off, the laser diode will output will be on



Power connector with Fuse and switch (rear panel)

The power connector for 100-240 VAC is located on the rear of the AvaSpec-2048TEC. Be careful to use for designated power range only, please use included power cord with the instrument. For UK, US and Australian power cords, contact Avantes Technical Support. The Fuse is a 2A slow blowing Fuse.



Disconnect power before opening housing or replace Fuse.
The installation category for this equipment is Class 2, it is not permitted to connect equipment to the AvaRaman with a power supply without SELV or class II qualification.

USB connector

The USB interface has the following physical characteristics:

- USB version 2.0
- high speed, 480Mbps
- endpoint node, no HUB function
- 5VDC power supply

| Pin | Description |
|-----|-------------|
| 1 | V+ |
| 2 | D- |
| 3 | D+ |
| 4 | Common |

Synchronization connector

SMB miniature 50R coax synchronization connector to synchronize to other AvaSpec-USB2 spectrometers only, order code for SMA cables is IC-COAX-SMB-0,25 for 250mm coax cable.



External I/O connector

The external I/O connector is a female high density 26 poles Sub-D connector.

| Pin | Name | Connect to | Comment |
|-----|-----------|------------------------------|---|
| 1 | GND | GND(DB26/DB15-p10) | |
| 2 | DO2 | | general purpose TTL output, PWM |
| 3 | DO5 | | general purpose TTL output, PWM |
| 4 | DO8 | FOS (DB26/DB15-p15) | general purpose TTL output, AvSoft FOS control |
| 5 | STROBE | AVALIGHT-XE (DB26/DB15-p1) | Output, one ore more TTL pulses per scan |
| 6 | Trig In | Ext. trigger | TTL Input, external hardware trigger |
| 7 | DI2 | | TTL input, AvaSoft-Save spectrum |
| 8 | GND | GND | |
| 9 | AI1 | | Analog input, 0-5VDC |
| 10 | RX | RS-232-RX (DB26/DB9-p3) | RS-232-RX |
| 11 | DO1 | AvaLight-LED (DB26/DB15-p14) | general purpose TTL output, PWM, AvaSoft-PWM |
| 12 | DO4 | shutter(DB26/DB15-p13) | Output, used to close shutter for AvaLight-HAL-S, AvaLight-DHc and AvaLight-DHS |
| 13 | DO7 | | general purpose TTL output, PWM |
| 14 | GND | GND | |
| 15 | 5VDC | DB26/DB15-p3 | 5VDC output, max xx mA |
| 16 | DI3 | | TTL input, AvaSoft-Save reference |
| 17 | AO1 | | Analog output, 0-5VDC |
| 18 | AI2 | | Analog input, 0-5VDC |
| 19 | TX | RS-232-TX (DB26/DB9-p2) | RS-232-TX |
| 20 | DO3 | | general purpose TTL output, PWM |
| 21 | DO6 | | general purpose TTL output, PWM |
| 22 | DO9 | | general purpose TTL output, PWM |
| 23 | LASER OUT | LASER TTL for LIBS | TTL output, AvaSoft programmable delay and duration |
| 24 | DI1 | | TTL input, AvaSoft-Save dark |
| 25 | DO10 | | general purpose TTL output |
| 26 | AO2 | | Analog output, 0-5VDC |



1.4 Hardware Installation

1. Unpack all items and carefully
2. First install the Software on the PC, follow instructions in paragraph 2.0
3. Put on the Laser Safety Goggles.
4. Now connect the power cable to the backside of the AvaRaman unit.
5. Connect the fiberoptic probe with the corresponding legs to the SMA connector of the Spectrometer and the SMA connector of the Laser
6. Connect the probe to the experimental setup or other accessories, such as sample holder, etc.
7. Switch on the power supply
8. Now connect the USB cable to the PC and follow instructions under 2.0.
9. Start the AvaSoft-Raman Software
10. Switch on the TE Cooling, wait 1-2 Minutes until the signal stabilizes.
11. Connect the Interlock/doorlock
12. Insert the Key in the keyswitch and turn it on
13. Now the laser should be on.



DO NOT LOOK IN THE (REFLECTED) LASER BEAM, WEAR SAFETY GOGGLES AT ALL TIMES.



2 AvaSoft Installation

AvaSoft-RAMAN-USB2 version 7 is a 32-bit application and can be installed under the following operating systems:

- Windows 95/98/Me
- Windows NT/2000
- XP/Vista x32 (32-bit O/S)
- XP/Vista x64 (64-bit O/S)

If the operating system is Windows 95 or Windows NT4.0, use a standard RS-232 cable (with male and female DB-9 connectors) to connect the AvaSpec to the serial port of the computer.

Installation program

With each new spectrometer system, an AVANTES PRODUCT CD-ROM is included. To install AvaSoft-RAMAN from the CD-ROM, the file setup.exe on the CD-ROM needs to be executed.

Installation Dialogs

The setup program will check the system configuration of the computer. If no problems are detected, the first dialog is the “Welcome” dialog with some general information.

In the next dialog, the destination directory for the AvaSoft software can be changed. The default destination directory is C:\AvaRaman7USB2. If you want to install the software to a different directory, click the Browse button, select a new directory and click OK. If the specified directory does not exist, it will be created.

After this, the “Start Installation” dialog is shown. After clicking the “next” button, the installation program starts installing files.

During this installation, the installation program will check if the most recent USB driver has been installed already at the PC. In previous AvaSoft versions, the Avantes kernel USB driver was installed for the as5216 on all 32bit Windows O/S. On the 64bit Windows O/S, the winusb USB driver has been installed. AvaSoft now supports the winusb USB driver also on 32bit Windows O/S.

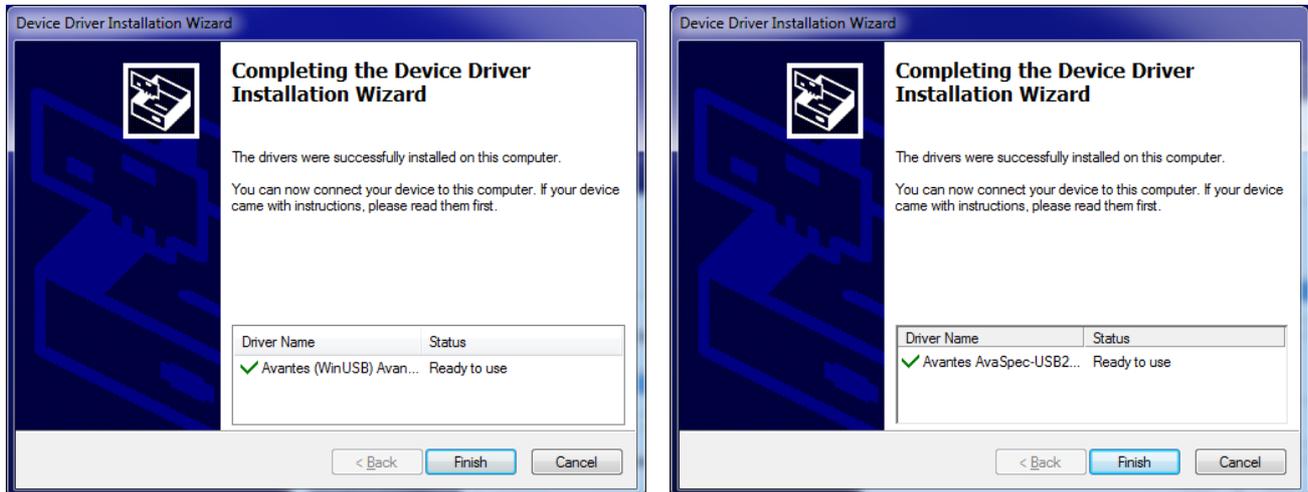
If the installation program detects that a USB driver has been installed before for the as5216, the dialog at the right will be displayed.





At modern PC's, we have seen some communication problems under 32bit versions of Vista and Window7, which were solved by upgrading to the WinUSB driver. If the Avantes driver has been installed before, and no communication problems were noticed, you can also keep this driver by selecting the "Avantes driver" option. See Appendix A for more details about updating the USB driver.

The Device Driver Installation Wizard will be launched automatically. The last dialog in the Device Driver



Installation Wizard displays the USB driver that has been installed. In the lower left figure, the WinUSB driver has been installed. The lower right figure is displayed after installing the Avantes kernel driver.

After all files have been installed, the "Installation Complete" dialog shows up. Click Finish.

Connecting the hardware

Connect the USB connector to a USB port on your computer with the supplied USB cable. Windows XP will display the "Found New Hardware" dialog. Select the (default) option to install the software automatically, and click next. After the Hardware Wizard has completed, the following dialog is displayed under Windows XP:



Click Finish to complete the installation.

Please note that if the spectrometer is connected to another USB port to which it has not been connected before, the "Found New Hardware Wizard" will need to install the software for this port as well. For this reason, this Wizard will run "NrOfChannel" times for a multichannel AvaSpec-USB2 spectrometer system. This happens because inside the housing, the USB ports for each spectrometer channel are connected to a USB-Hub.

Windows Vista and Windows7 will install the driver silently, without displaying the "Found New Hardware Wizard" dialogs.



Launching the software

AvaSoft can be started from Windows Start Menu. Under Start-programs, the group “AVANTES Software” has been added. This group contains icons. With the red “V” AvaRaman-USB2 icon, AvaSoft is started. The AvaSoft-Raman help icon can be used to show this manual in pdf format.

After starting the AvaSoft software, the connected spectrometers will be recognized automatically. The number of detected spectrometers and their status will be displayed in the welcome dialog. After a few seconds, the main window will be displayed and the spectrometer names (default serialnr) will appear in the legend at the right hand of the screen. More detailed information about the spectrometer(s) is shown after clicking the menu option Setup-Hardware. In this dialog, a user defined name can be defined for each spectrometer.

After clicking the start button, the spectra for all connected spectrometers will be displayed in the main window.

After clicking the OK button, the main window is displayed. Refer to section 4 for a description about the main window components. A “Quick Start” can be found in section 3, if you want to start measuring immediately. Detailed information about the menu options is found in section 5. Depending on the extra add-on modules that were ordered for your spectrometer, up to three applications are available, which are described in sections 6.1 to 6.3:

- History (standard in AvaSoft-Raman)
- Process Control (add-on module)
- Excel Output (add-on module)



3 Quick Start: Measuring and saving a spectrum

1. After starting AvaSoft Raman, the green Start button needs to be clicked to start measuring.
2. Connect the probe to the laser and to the Spectrometer input port(s).
3. Adjust the Smoothing Parameters in the Setup menu to optimize smoothing for the Fiber/Slit diameter that is used. In most Raman systems, the slit is 25 micron, and the smoothing parameter should be set to 0. Setting the smoothing parameter to 1 will show a smoother spectrum against the price of a little less resolution (see also section 5.2.3)
4. Before switching on the laser, be sure to avoid direct eye contact via the probe tip. Turn on the laser. Usually some sort of spectrum may be seen on the screen. A lot of experiments with a Raman system require a long integration time, e.g. 10000 milliseconds for ethanol measurements. A progress bar (section 5.3.9) can be enabled to visualize the progress of a measurement cycle. The integration time can be changed in the main window, in the white box below the start/stop button. If the integration time is changed when measuring, the next scan will be started with the new integration time after pressing the enter key.
5. When a good spectrum is displayed, turn off the laser.
6. Now save the Dark data. This is done by File-Save-Dark from the menu or by clicking the black square on the left top of the screen with the mouse. Always use Save Dark after the integration time has been changed.
7. Turn on the laser again. Subtract the dark data that has been saved by clicking the 'Subtract Saved Dark' button, next to the dark button. To have a better look at the amplitude versus wavelength, the cursor button can be clicked. A vertical line is displayed in the graph. If the mouse cursor is placed nearby this line, the shape of the mouse cursor changes from an arrow to a 'drag' shape. If this shape is displayed, the left mouse button can be used to drag (keep left mouse button down) the line with the mouse towards a new position. Moving this line shows the corresponding values of wavelength and amplitude in the main screen. By clicking the red stop button, the data acquisition is stopped and the last acquired spectrum is shown in static mode. The data acquisition can be started again by clicking the same button, which now shows a green 'Start'.
8. To save the spectrum, choose File-Save-Experiment from the menu, or click the Save Experiment button from the button bar.
9. Other options to save a spectrum can be found under Setup-Options-Autosave Spectra Periodically. With this option, spectra can be saved automatically according to instructions entered in "Time delay before first scan", "Time delay between scans" and "Number of scans to save".
10. To improve the Signal/Noise ratio, a number of spectra may be averaged. To do this, the value in the white average box in the main window (next to integration time) can be increased. If the number of averages is changed when measuring, the next scan will be started with the new number of averages after pressing the enter key.

4.1 Menu bar

File Setup View Application

The menu's and submenu's are described in section 5.

4.2 Button bar



Start Start/Stop button

The Start/Stop button can be used to display data real-time or to take a snapshot



Cursor button

After clicking the cursor button, a vertical line is displayed in the graph. If the mouse cursor is placed nearby this line, the shape of the mouse cursor changes from an arrow to a 'drag' shape. If this shape is displayed, the left mouse button can be used to drag (keep left mouse button down) the line with the mouse towards a new position. Moving this line shows the corresponding values of wavelength and amplitude in the main screen. As an alternative for dragging the line, the small step and big step arrow buttons may be used, or the left and right arrow keys on the keyboard. The step size for the arrow buttons can be changed by holding down the CTRL-key while clicking at a (single or double) arrow button.



Save Dark button

This is the black button at the left top of the screen. It needs to be clicked to save the dark data. The same result can be achieved with the option File-Save Dark.



Subtract Saved Dark button

After Dark data has been saved or loaded, the subtract saved dark button becomes enabled. After clicking this button, the dark spectrum will be subtracted from the measured data. The same result can be achieved by selecting the "Subtract Saved Dark" menu option under the setup menu.



Save experiment button

By clicking the Save Experiment button an experiment is saved. The same result can be achieved with the option File-Save Experiment.



Print button

By clicking the Print button a graph that is displayed on the monitor will be printed. The same result can be achieved with the option File-Print.



Autoscale Y-axis button

By clicking this button, the graph will be rescaled on-line. A maximum signal will be shown at about 75% of the vertical scale. The same result can be achieved with the option View-Autoscale Y-axis



Change Graph Scale button

By clicking this button, a dialog will be shown in which the range can be changed for both X- and Y-axis. This range can be saved as well and restored any time by clicking the Goto Preset Scale button (see below). The menu option with the same functionality is View-Change Graph Scale.



Goto Preset Scale button

By clicking this button, the scale for X- and Y-axis will be set to a range that has been set before. The same result can be achieved with the menu option View-Goto Preset Scale



Graphic Reset button

By clicking this button, the X- and Y-axis will be reset to their default values. The same result can be achieved with the option View-Graphic Reset



H.C.F. button

The History Channel Function button allows you to switch directly to the history channel function screen to start measuring immediately. Of course first the functions need to be defined.



4.3 Edit bar

| | | | | | |
|------------------------|------------------------------------|----------|--------------------------------|--------------------|-------------------------------------|
| Integration time [ms]: | <input type="text" value="10000"/> | Average: | <input type="text" value="1"/> | Raman Shift[1/cm]: | <input type="text" value="880,74"/> |
|------------------------|------------------------------------|----------|--------------------------------|--------------------|-------------------------------------|

When AvaSoft is acquiring data, the integration time and average values can be changed, but the enter key needs to be pressed to confirm the new setting for the next scan. By clicking the red STOP button, data acquisition is stopped. The edit bar shows the following parameters:

Integration time[ms]

This option changes the CCD readout frequency and therefore the exposure- or integration time of the CCD detector. The longer the integration time, the more light is exposed to the detector during a single scan, so the higher the signal. If the integration time is set too long, too much light reaches the detector. The result is that, over some wavelength range, the signal extends the maximum counts (65535) or in extreme case shows as a straight line at any arbitrary height, even near zero. Entering a shorter integration time can usually solve this.

Average

With this option, the number of scans to average can be set. A spectrum will be displayed after every # scans. This spectrum is the average of the # scans.

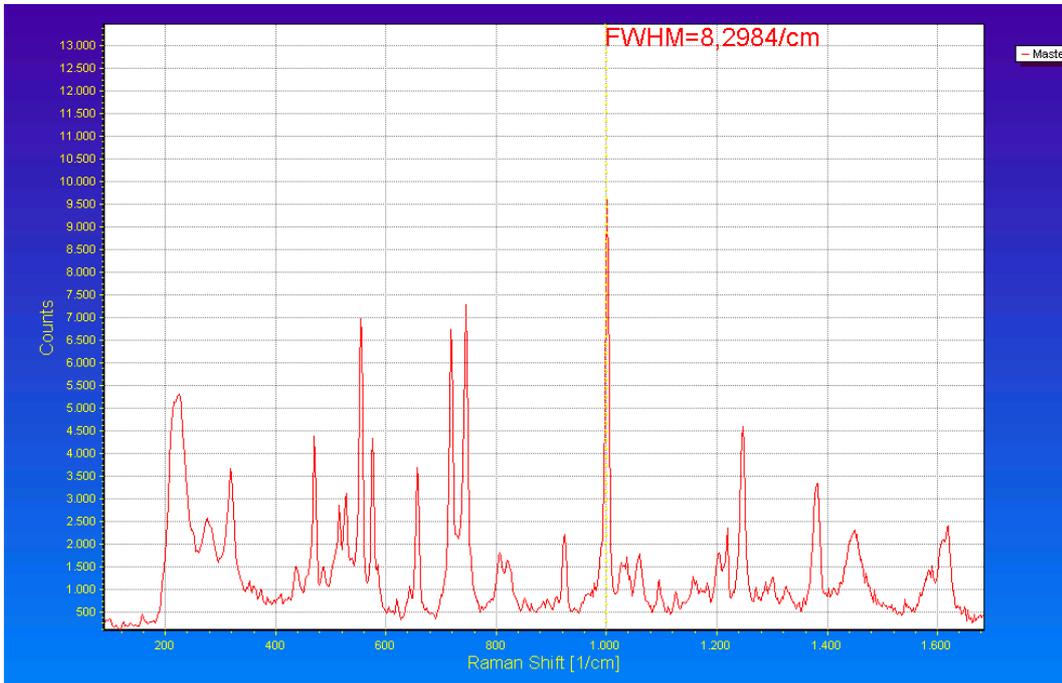
Raman Shift[cm⁻¹] or Wavelength[nm]

The wavelength shows the position of the cursor, which becomes visible if the cursor button is down. The amplitude of the signal, which is given in the statusbar at the bottom of the main window, is the amplitude at the wavelength shown in this field.

Default, the spectral data are shown versus Raman Shift in cm⁻¹. After the menu option 'View -Display wavelength (nm) at X-axis' is clicked, the wavelength in nanometers is shown at the X-axis and the Raman Shift[cm⁻¹] in the edit bar changes to Wavelength [nm]:

| | | | | | |
|------------------------|------------------------------------|----------|--------------------------------|------------------|-------------------------------------|
| Integration time [ms]: | <input type="text" value="10000"/> | Average: | <input type="text" value="1"/> | Wavelength [nm]: | <input type="text" value="843,30"/> |
|------------------------|------------------------------------|----------|--------------------------------|------------------|-------------------------------------|

4.4 Graphical region



The graphical region displays the data in an XY-diagram, with at the X-axis (default) the Raman Shift in cm^{-1} , and at the Y-axis the detector counts.

Display saved Graph and Line style editor

By clicking on the legenda with the right mouse button, multiple spectra, that were saved earlier can be displayed.

New in AvaSoft 7 is that displayed graphs can be deleted or properties of the displayed graphs, such as line style or color or comments can be changed. This is done by clicking with the right mouse button on the line in the graphical display. A small line edit box will occur.



Now the line can be deactivated or the line properties can be changed as depicted in the border editor or the comments can be edited.



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Zoom features

Zoom in: select a region to be expanded to the full graph. To select this region, click the left mouse button in the white graphical region and drag it downwards and to the right. After releasing the left mouse button within the graphic display, both the X- and Y-axis will be rescaled to the new values of the selected region.

Zoom out: drag with the left mouse button within the white rectangle, but instead of dragging the mouse downwards and to the right, drag it into another direction. After releasing the mouse button, both the X- and Y-axis will be reset to their default values.

Move X-Y: dragging with the right mouse button results in moving the complete spectrum up or down and to the left or right.

Move-Y: if a mouse-wheel is available on the mouse being used, then the spectrum can be moved up or down by moving the mouse wheel.

4.5 Status bar



For each selected spectrometer channel, a statusbar at the bottom of the main window shows information about the file to which the data will be saved, amplitude at current wavelength, and the current settings for the smoothing and spline parameters. The field at the right of the Spline setting is used to indicate that the spectrometer is receiving too much light at a certain wavelength range (=65535 counts before correcting for dynamic dark, smoothing or averaging), in which case the label “saturated” will become visible. See also section 5.2.7.1: check on saturation.

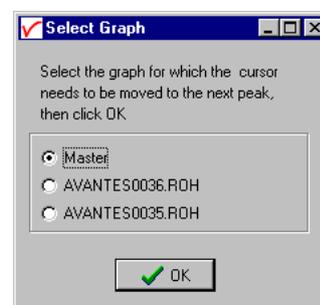
4.6 Find peaks or valleys by CTRL or SHIFT + left mouse button click

This option can be used for all displayed graphics. When the left mouse button is clicked in the graphical region, while the CTRL key is down, AvaSoft will follow the following procedure to run to the closest peak:

1. The wavelength is determined from the position the mouse click occurred.
2. The data from closest pixel is retrieved
3. The direction to search for the peak is determined from the neighbor pixels. If both neighbor pixels have a lower value at the Y-axis than the current pixel, the current pixel is already a peak. If only one of the neighbor pixel values is higher than the current pixel value, the peak will be searched in the direction of this higher pixel. If both neighbor pixels have a higher value at the Y-axis than the current pixel, the current pixel is in a valley. The peak will in this case be searched in the direction of this neighbor pixel with the highest value.
4. The cursor starts moving in the direction, as determined under 3), until it reaches a pixel of which the value is not higher than the last one evaluated. At this pixel the cursor stops.

By holding down the SHIFT key instead of the CTRL key, the same procedure will be used to move to the closest valley.

If more than one spectrum is being displayed, a dialog, as shown at the right, pops up in which the spectrum for which the peakfinder needs to be activated can be selected out of all displayed spectra.

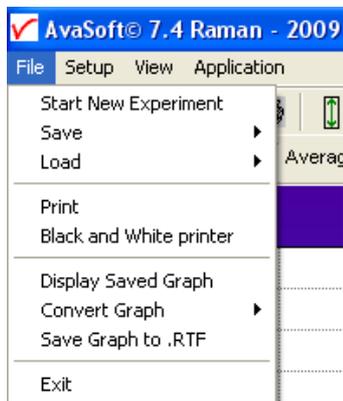


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5 Menu Options

In sections 5.1 to 5.3 the three main menu options (File, Setup and View) and their submenu's are described in detail. The applications menu (History, Process Control, Excel) are described in sections 6.1 to 6.3.

5.1 File Menu



5.1.1 File Menu: Start New Experiment

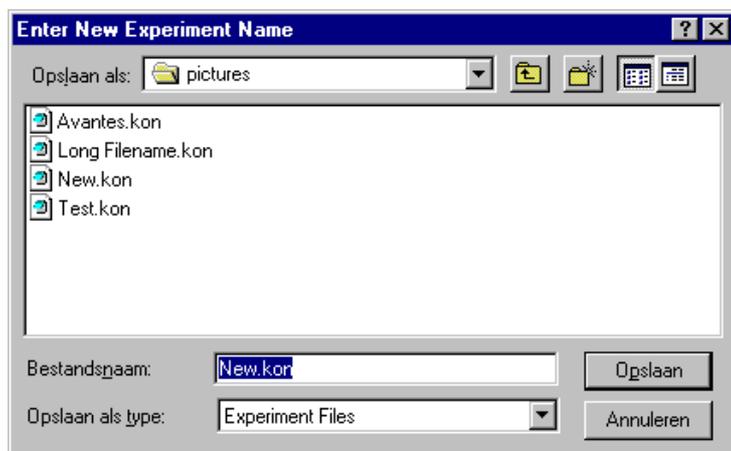
After selecting this option, a dialog box appears in which a new experiment name can be entered. The experiment name will be saved as a filename with the extension *.kon. extension does not need to be entered.

After clicking the save button, the current filename will be built up from experiment name that has been entered, and a sequence number, starting at 0001.

Example: if the experiment name is the first graphic file that will be in scope mode, will be called TOP0001.ROH, the sequence number be automatically incremented, so the file that will be saved in scope mode be called TOP0002.ROH etc.

For detailed information on graphic filenames, see File-Save Experiment. Note that the dialog allows you to select different folders or drives to save the experiments to, as well as creating a new folder name for the new experiment.

After closing the dialog box by clicking the save button, the new experiment name, followed by its sequence number, is displayed in the lower left of the status bar. By clicking the cancel button, the old experiment name will be restored.



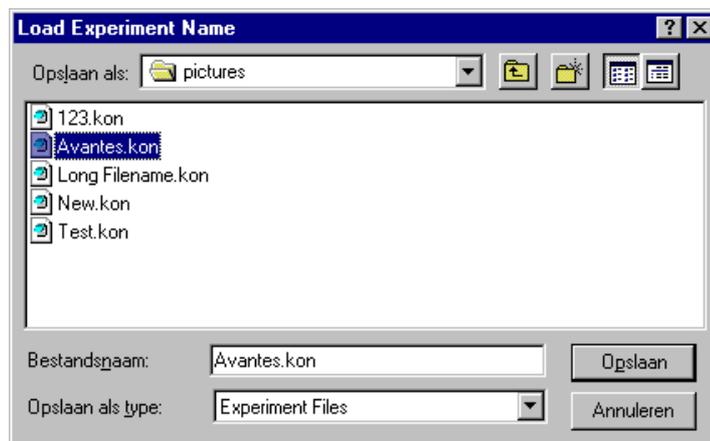
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5.1.2 File Menu: Load Dark

With this option, dark data can be loaded, that have been saved before. If AvaSoft is not scanning, the dark data that will be loaded are shown on the screen first.

5.1.3 File Menu: Load Experiment

With this option, an experiment can be loaded, that has been used before. This more spectra can be saved to an existing experiment. An experiment name has the file extension ".kon". After choosing this option, a dialog box shows all experiments that were saved earlier in the current experiment directory. If the experiment name that needs to be loaded is in this directory, select it and click the save button. If experiment name that needs to be loaded is in another drive and/or



directory, move to this directory by clicking the  behind the current folder name. For detailed information on graphic filenames, see File-Save Experiment.

5.1.4 File Menu: Save Dark

With this option, dark data are saved. The name of the dark data file is "<serialnr>.DRK". The dark data files will be saved in the experiment directory that has been picked by the option File-Load-Experiment or File-Start New-Experiment.

5.1.5 File Menu: Save Experiment

With this option, spectral data is saved. All graphic files will be saved in the experiment directory that has been picked by the option File-Load-Experiment or File-Start New-Experiment.

First, a window appears in which a line of comments can be entered to the saved graph. Next two files will be saved: the first file contains the saved spectrum data. The name of this first file starts with the experiment name, directly followed by the sequence number of the saved spectrum. The extension of this first file is *.ROH

The second file contains the line of comments, which may have been added to this graph. The name of this second file is, except for the extension, the same as the name of the first file (experiment name and sequence number). The extension of this second file is *.RCM

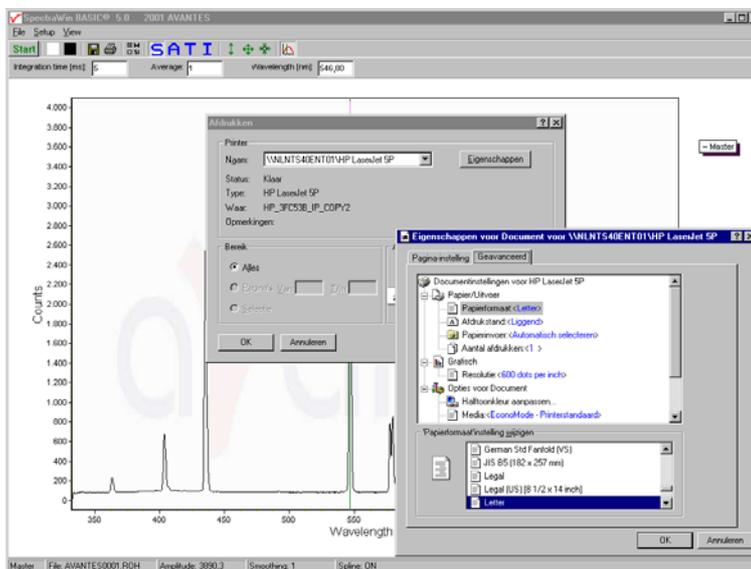
Example: suppose the name of our experiment is "top". Then, saving two spectra, results in the following files: top0001.roh, top0001.rcm, top0002.roh, top0002.rcm

After leaving the application and opening AvaSoft the next time, saving a new spectrum will then result in respectively the data-files top0003.roh and top003.rcm.

Before saving, the name of the graphic file is displayed in the statusbar at the bottom of the screen. After saving, the sequence number is automatically incremented by one.

5.1.6 File Menu: Print

After selecting the print menu option, the background colors in the graphical region will become white. the menu option “Black and White printer” (see next section) has been marked, the line style for the spectra will also change from colored to black. A dialog will be shown in which the title for the printout can be entered. In the next window, the printer settings can be changed (e.g. portrait or landscape printing, printing quality etc.). After clicking OK in the printer settings dialog, the graph will be printed, and the original graph colors will be restored on the monitor.

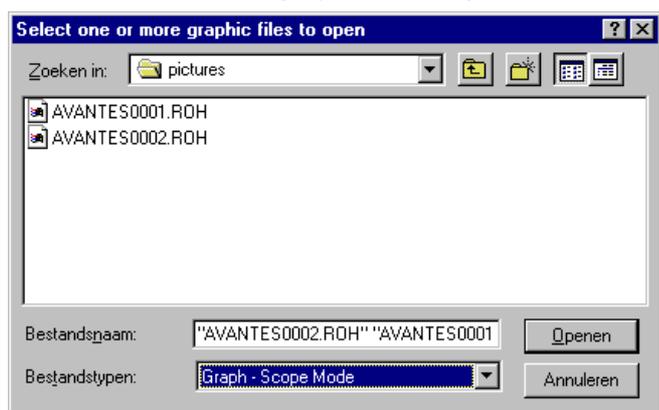


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5.1.7 File Menu: Black and White printer

The default setting in AvaSoft is to print the spectra in the same color as they appear on the monitor. However, if a color printer is not available, the menu option “Black and White printer” can be enabled. If this option is enabled, different line styles will be printed if more than one spectrum is displayed, e.g. dash-dash, dot-dot, dash-dot. To enable this option, click the menu option and a checkmark appears in front of it.

5.1.8 File Menu: Display Saved Graph



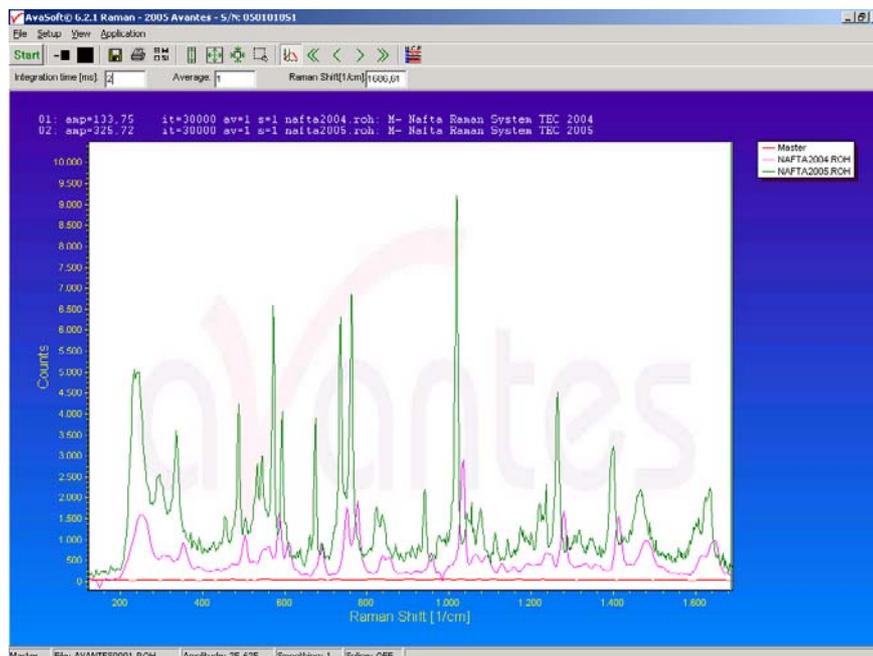
This option requires that graphic files were saved earlier by using the option File-Save Experiment. After choosing this option, a window shows all files that were saved before.

If a graphic file is marked by a (single) mouse click on the filename, the comment line for this file appears at the top of the graphical region in the main window. Selecting multiple filenames can be realized by using the CTRL or SHIFT key in combination with the mouse. If the CTRL key is pressed, all the files that are clicked by the mouse

will be selected for displaying. If the SHIFT key is pressed, all the files in between two clicked files will be selected for displaying.

Select the name of the file(s) to be displayed and click the Open button. To leave this dialog without displaying graphic files, the CANCEL button.

In the figure at the two graphic files were selected in scope. The comments that saved with these graphs displayed at the top of graphical region, together with information about amplitude at current wavelength (amp), integration time (it) smoothing (s) settings moment that the file saved and the name of graphic file. The actual for the online measurements can be displayed in the same graph as the selected graphic files. By clicking the green start button, the online measurements can be compared directly to the graphics that were saved before.



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New in AvaSoft 7 is that displayed graphs can be deleted or properties of the displayed graphs, such as line style or color or comments can be changed. This is done by clicking with the right mouse button on the line in the graphical display. A small line edit box will occur.



Now the line can be deactivated or the line properties can be changed as depicted in the border editor or the comments can be edited.



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The menu option File-Display Saved Graph is preceded by checkmark as long as the earlier saved graphics are displayed. To clear these earlier saved graphics, select again the menu option File-Display Saved Graph, after which the checkmark disappears, and only the spectra for the active spectrometer channel(s) will be displayed.

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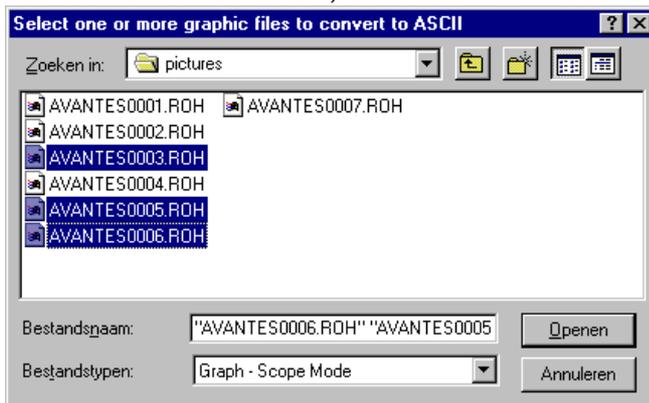
5.1.9 File Menu: Convert Graph - to ASCII



The binary files with extension .roh can be exported to a text file with or without header. By default, the header is included, but if the text file should be created without header, deselect the “include ASCII Header” by clicking this menu option.

Convert Graph to ASCII requires that graphic files were saved earlier by using option File-Save Experiment. After choosing this option, a window shows all that were saved before

If a graphic file is marked by a (single) click on the filename, the comment line this file appears at the top of the graphical in the main window. Selecting multiple filenames can be realized by using the or SHIFT key in combination with the mouse.



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If the CTRL key is pressed, all the files that are clicked by the mouse will be selected for conversion. If the SHIFT key is pressed, all the files in between two clicked files will be selected for conversion.

Select the name of the file(s) to be converted to ASCII and click the Open button. To leave this dialog without converting files, click the CANCEL button. The extension of the text files will be *.TRT.

The text files that start with a header include information for the graphic file that has been converted. The header shows:

- the comment line
- the integration time
- the number of scans that has been averaged
- the number of pixels used for smoothing
- the serialnumber of the spectrometer that was used to save the data
- a timestamp in 10 microseconds ticks

The data in a *.TRT file is given in three columns, separated by a “;”. The first column gives the wavelength in nanometers, the second the corresponding Raman Shift in cm^{-1} and the third column the detector counts at that wavelength / Raman Shift.

5.1.10 File Menu: Save Graph to .RTF

This option allows you to save the graph to a file in Rich Text File (.RTF) format. After clicking this menu option, a comment can be added and the filename can be entered in a standard Windows “Save As” dialog.

5.1.11 File Menu: Exit

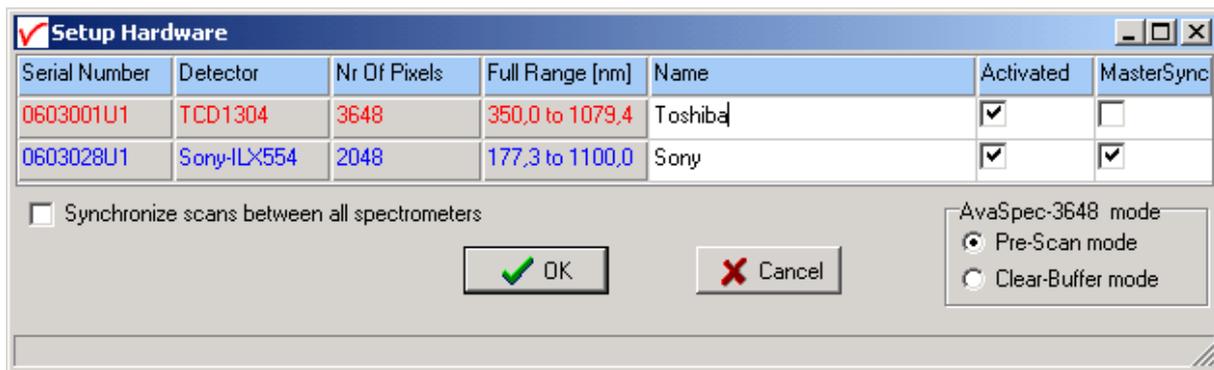
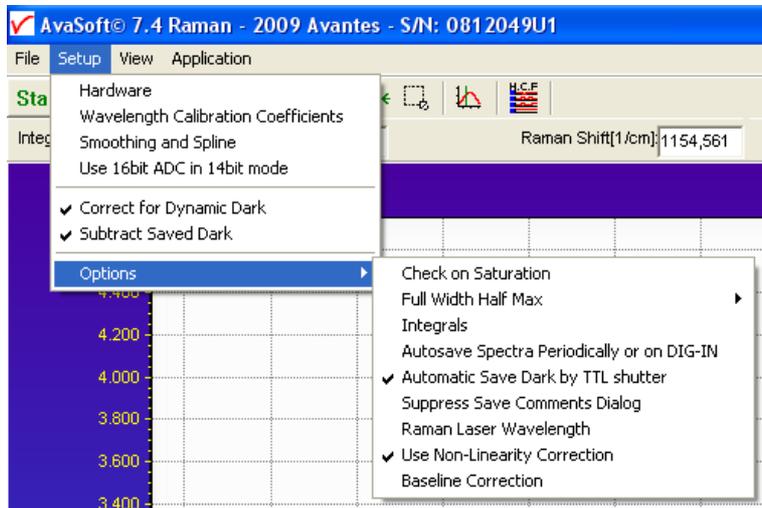


Closes AvaSoft.

The measurement settings are saved to EEPROM before the software is closed. During the process of saving it is very important that the spectrometer is not powered off. A dialog as shown at the right will become visible as long as data are saved (< 1 sec for USB2), about 8 sec for RS232 connection.



5.2 Setup Menu



5.2.1 Setup Menu: Hardware

This option shows all connected spectrometers and allows you to change the name of the channel and to deactivate and activate spectrometers. For a single channel Raman system, only one spectrometer will be visible. For the TE Cooled Raman, the Setpoint temperature can be entered at which the detector will be held constant.

5.2.2 Setup Menu: Wavelength Calibration Coefficients

After clicking this option, a dialog is shown in which the wavelength calibration coefficients can be changed manually. This should not be necessary, because the spectrometers are very accurately calibrated. The wavelength calibration can be found at the datasheet that comes with the Raman

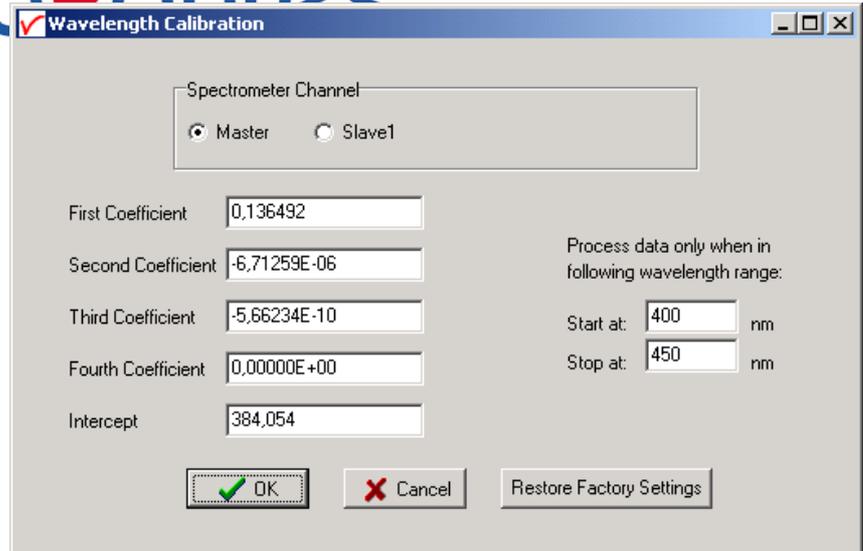
Background

The wavelength λ that corresponds to a pixel number (pixnr) in the detector in the spectrometer can be calculated by the following equation:

$$\lambda = \text{Intercept} + X1*\text{pixnr} + X2*\text{pixnr}^2 + X3*\text{pixnr}^3 + X4*\text{pixnr}^4$$

in which Intercept and X1 to X4 correspond to Intercept and First to Fourth Coefficient in the figure at the right. For example, if we want to calculate the wavelength at pixel number 1000, using the numbers in the figure at the right, the wavelength becomes:

$$\lambda = 384,054 + 0,136492 \cdot 1000 - 6,71259E-6 \cdot 1E6 - 5,66234E-10 \cdot 1E9 = 513,267 \text{ nm.}$$



The 'Restore Factory Settings' button restores for all spectrometer channels the original wavelength calibration coefficients that were saved to the EEPROM during factory calibration.

The "Process data only when in following wavelength range" option can be used to transfer only a limited number of pixels from the spectrometer to the PC. An advantage is data reduction, because only the spectral data will be saved at the pixels for which the wavelength is in the specified wavelength range.

5.2.3 Setup Menu: Smoothing and Spline

The Cubic Spline Interpolation Algorithm can be applied to better estimation for the spectral data between the pixels the detector array.

Smoothing is a procedure, which averages the spectral data a number of pixels on the detector array. For example, if the smoothing parameter is set to 2, the spectral data for all x_n on the detector array will be averaged with their neighbor x_{n-2} , x_{n-1} , x_{n+1} and x_{n+2} .



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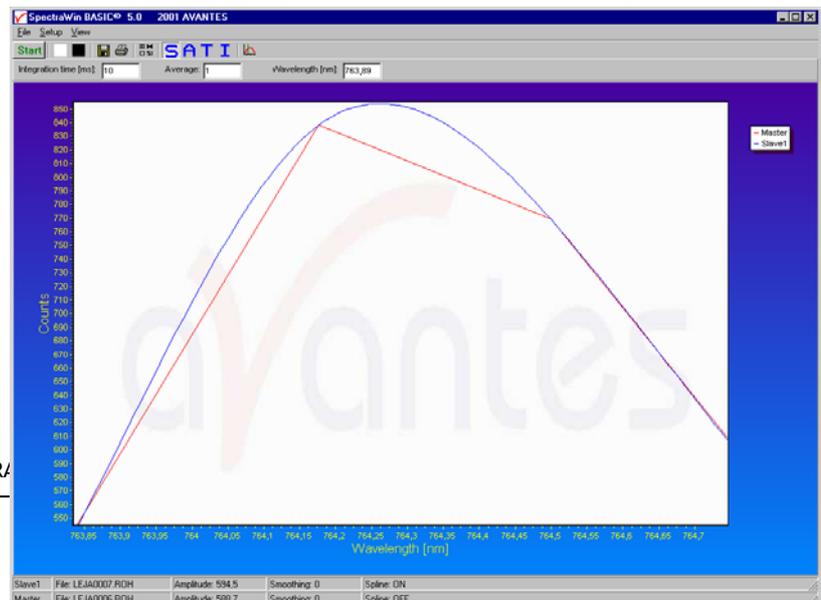
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Cubic Spline Interpolation

In the figure below, the effect of spline interpolation is illustrated. The Master data shows the AD counts for 4 pixels, connected by a straight line (linear interpolation). The Slave1 data is for these 4 pixels exactly the same as for the Master data, but this time the cubic spline interpolation algorithm has been applied, resulting in data which is smooth in the first derivative and continuous in the second derivative.

The spline interpolation can be useful for applications in which the output of line sources, like laser diodes is displayed, or for other applications, which require a high resolution. Note that for the AvaSpec-2048 with 2048 pixels, the effect of spline interpolation is not visible if the data is shown at full scale. The monitor resolution is much less than 2048 pixels. The effect of spline interpolation can only be visualized if





the number of detector pixels that are displayed is smaller than the number of monitor pixels at the x-axis.

Smoothing

To get a smoother spectrum without losing information it is important to set in the software the right smoothing parameter. The optimal smoothing parameter in a standard AvaRaman system with 50 micron slit is 1, in which case the data at each pixel will be averaged with one neighbor pixel at the left and one at the right. This can be done without losing resolution, because the 50 micron beam will cover at least 3 detector pixels (the distance between the pixels at the CCD detector is 14 micron). The AvaRaman-TEC includes a 25 micron slit in which case the smoothing should be set to zero.

If resolution is not an important issue, a higher smoothing parameter can be set to decrease noise against the price of less resolution.

5.2.4 Setup Menu: Use 16bit ADC in 14bit mode (HW rev 1D and later)

The 14bit AD Converter used with the as5216 boards revision 1B and 1C inside the AvaSpec-USB2 has been replaced by a 16bit ADC since the release of the as5216 board revision 1D. Therefore, the default range in Scope Mode for an AvaSpec-USB2 has changed from a 14bit range (0..16383) to 16bit (0..65535). All AvaRaman-USB2 systems include the 16bit AD Converter.

If the menu option "Use 16bit ADC in 14bit mode" is enabled (preceded by a checkmark), the 16bit range AD Counts will be converted to a 14bit range by the as5216.dll (divide by 4.0). This option has been added for customers who have been already working with earlier versions of the AvaSpec-USB2 with 14bit ADC (or with a AvaRaman system for the USB1 platform) and want to be able to compare the data in scope mode between both spectrometers. Note that by setting the 16bit ADC into 14bit mode, you will not lose resolution because the numbers are not truncated or rounded to integer numbers, e.g. 5 counts in 16bit mode will become 1.25 counts in 14-bit mode.

5.2.5 Setup Menu: Correct for Dynamic Dark

The pixels of the CCD detector (AvaSpec-2048) are thermally sensitive, which causes a small dark current, even without light exposure. To get an approximation of this dark current, the signal of the first 14 optical black pixels of the CCD-detector can be taken and subtracted from the raw scope data. This will happen if the correct for dynamic dark option is enabled. As these 14 pixels have the same thermal behaviour as the active pixels, the correction is dynamic.

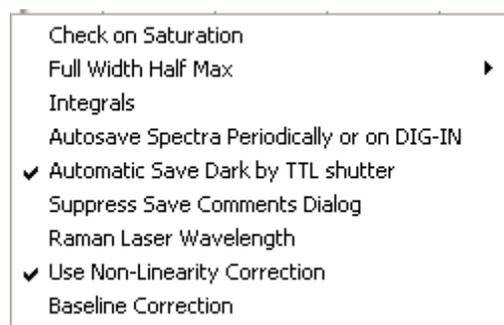
If this menu option is preceded by a checkmark, the scope data is corrected with the dynamic dark algorithm. It is recommended to leave this setting checked, which is the default state.

5.2.6 Setup Menu: Subtract Saved Dark

This option is used to subtract the dark spectrum that has been saved (File-Save Dark) from the raw scope data. After starting up AvaSoft, this menu option is always unselected, because a dark spectrum needs to be saved or loaded before it can be subtracted.

If this menu option is preceded by a checkmark, the scope data is corrected with the saved dark.

5.2.7 Setup Menu: Options



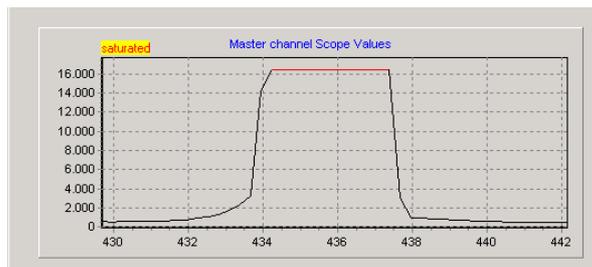
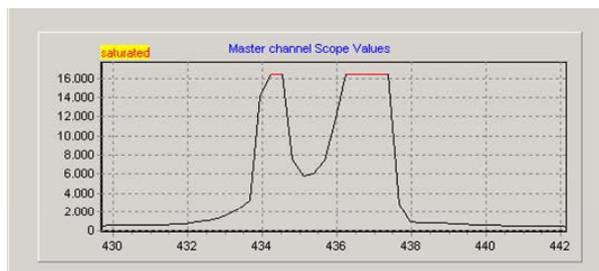
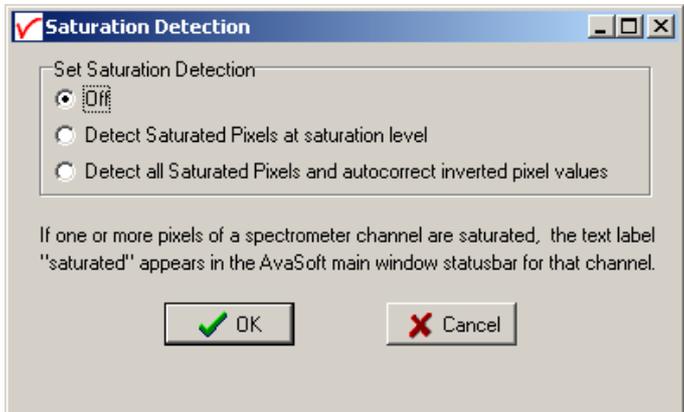
5.2.7.1 Setup Menu: Options - Check on Saturation

The range for the 16-bit A/D converter in the AvaRaman-USB2 results in Scope pixel values between 0 and 65535 Counts. The pixels are called “saturated” at 65535 counts. Since saturated pixels can disturb the measurement results, a lot of attention has been given in AvaSoft (and the interface package AS-5216.DLL) to detect saturation and to notify the user if a measurement contains saturated pixels. This notification is done in such a way that the user can always decide to ignore the saturation, for example if the saturation happens at pixels that are not in the wavelength range where the user is interested in. Saturation can usually be solved by selecting a shorter integration time. When at minimum integration the signal is still too high, an attenuator, a neutral density filter or fibers with a smaller diameter may be used.

In AvaSoft, different levels of saturation detection can be set, as shown in the figure below.

Saturation detection levels

The default level of saturation detection is “Detect Saturated Pixels at saturation level”. Only for AvaSpec-2048 spectrometers, the third (autocorrect inverted pixels) level is available. The reason for this is that if the detector type in the AvaSpec-2048 (Sony-ILX554) is heavily saturated (at a light intensity of approximately 5 times the intensity at which saturation starts), it will return values < saturation level. The other detector types in the AvaSpec-102, 256, 1024 and 3648 do not show this effect, so no correction is needed. Normally, you don’t need to use this third level for the AvaSpec-2048, but when measuring a peaky spectrum with some heavily saturated peaks, the autocorrect can be used. To illustrate this, a strong peak from the AvaLight-CAL calibration line source was heavily saturated at 435.84 nm. This caused the most heavily saturated pixels to return inverted pixel values (figure below at the left). In the right figure, the saturation detection has been set to the third level, which will not only detect the saturated pixels, but also detect and correct the inverted saturated pixels. Disadvantage of the autocorrect detection level is that processing the saturated scans by the application takes more time. Moreover, the autocorrect inverted pixel values cannot be used together with averaging. Error -110 (see Appendix B) will be displayed if you try to start a measurement with average >1 together with autocorrect inverted pixels setting



Saturation Notification

If the saturation detection has not been switched off, the spectrometer channel statusbar will show the text label “saturated” as long as one or more pixels of that spectrometer channel are saturated:

| | | | | | |
|--------|-----------------------|-------------------|--------------|-------------|-----------|
| Slave1 | File: AVANTES0003.ROH | Amplitude: 261,50 | Smoothing: 0 | Spline: OFF | Saturated |
| Master | File: AVANTES0002.ROH | Amplitude: 3613,7 | Smoothing: 0 | Spline: OFF | Saturated |

In scope mode, a spectrum can contain saturated pixels also when this is not directly obvious from the graph. Examples are:

- Smoothing. The maximum pixel value of a peak can be saturated, but is averaged with neighbor pixels which may not be saturated.
- The correct for dynamic dark algorithm subtracts the dark values that are measured at the optical black pixels from the spectral data. Therefore, the saturation level of 65535 counts will never be reached with correct for dynamic dark ON. The saturation detection in AvaSoft is done before the data is corrected for dynamic dark, so it will also detect saturation with dynamic dark ON.
- Monitor resolution. The CCD contains 2048/3648 pixels which is a lot more than the monitor pixels in the graph. Since not each CCD pixels can be drawn at the monitor, a sharp peak at one CCD pixel can be saturated although this is not visible at the monitor. Use the zoom function if you want to verify if this is the cause of saturation.

- Zoomed in. Saturation can also happen at a wavelength range that is not visible because the graph is not at full scale.

Under all these circumstances, the “saturation” label will be shown in the statusbar of the spectrometer channel for which one or more pixels are saturated.

5.2.7.2 Setup Menu: Options - Full Width Half Max

The Full Width Half Maximum of a peak is the bandwidth (in cm^{-1}) for which the intensity is higher than half of the maximum intensity of that peak. During FWHM calculations, the intensity needs to be corrected for the dark data. Therefore it is recommended to enable the option Subtract Saved Dark.

The FWHM can be displayed in two different ways:

Show all FWHM and Peaks in Table

This option allows you to open the table in which Raman Shift (in cm^{-1}), Intensity (ADC Counts) and FWHM (in cm^{-1}) are displayed and updated after each scan.



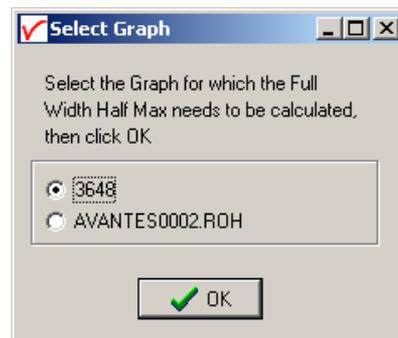
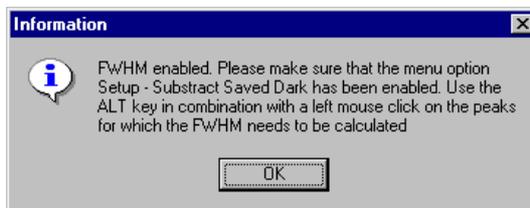
The results can be saved any time by clicking the Save As button. The file is a textfile with the file extension .fwm. It can be opened with any texteditor, e.g. notepad.

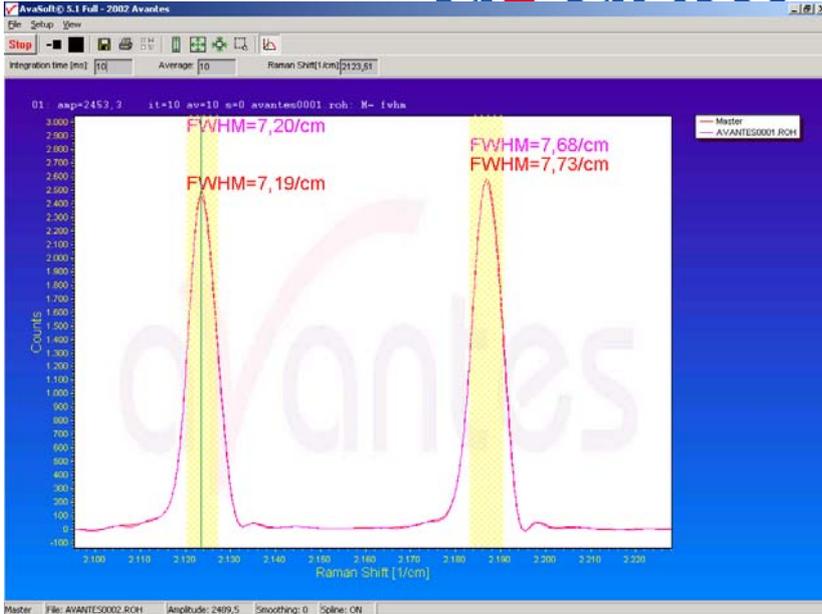
The cursor (vertical green line which is enabled/disabled by the cursor button) will be positioned automatically on a peak if one of the peaks in the FWHM dialog is clicked with the left mouse button. The cursor needs to be enabled by clicking the cursor button

Display FWHM in Graph after selection

The dialog at the right appears when clicking this option. After clicking the OK button, the Full Width Half Max values are calculated for a number of peaks. To mark a peak for which the FWHM values need to be calculated, press the ALT key, and click with the left mouse button on this peak. If only one spectrometer channel is enabled, and there are no earlier saved graphs being displayed, then the FWHM value of the marked peak will be shown directly on top of the peak. Furthermore, this peak will be yellow marked over the width of the FWHM value (it may be necessary to zoom in on the peak to be able to view that the peak is marked).

If more than one spectrum is being displayed, a dialog, as shown at the right, pops up in which the spectrum for which the FWHM needs to be activated can be selected out of all displayed spectra. In the figure below, 2 peaks have been selected for FWHM calculation. The FWHM values are given in the same color the spectrum is drawn in.





The FWHM values are given in the same color as the spectrum is drawn. To disable the FWHM calculation, the menu option (which is marked as long as the FWHM is enabled), needs to be reselected.

5.2.7.3 Setup Menu: Options - Integrals

This utility can be used for measuring the total amount of energy coming into the spectrometer. Up to 10 integrals can be displayed simultaneously. The integral calculations are enabled after they have been defined in the dialog that is shown after clicking the Setup-Options-Integrals menu.

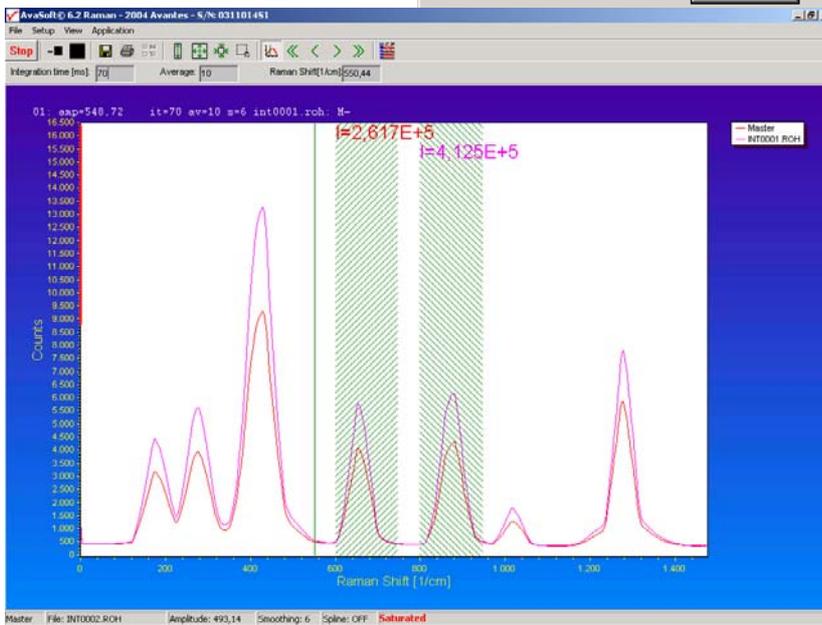
In the figure at the right, the two integrals have been defined by clicking the “Enable” checkbox in the first column. In the second column, spectrum can be chosen out of spectra that are at that moment displayed in the main window in AvaSoft. A full list of spectra to choose from (this includes earlier saved spectra integral 2 in the example) is displayed after clicking on the button at the right side of the

Integral Range

Enter wavelength range and spectrum for integral calculation:

| Enable | Spectrum | Raman Shift | | | Multiply with |
|-------------------------------------|-------------|-------------|-----------|------------------|---------------|
| <input checked="" type="checkbox"/> | Master | From 600,00 | to 750,00 | cm ⁻¹ | 1,0000 |
| <input checked="" type="checkbox"/> | INT0001.RDH | From 800,00 | to 950,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |
| <input type="checkbox"/> | Master | From 389,00 | to 935,00 | cm ⁻¹ | 1,0000 |

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second column. In the third and fourth column, the range can be entered over which the integral should be calculated. Finally, a multiplication factor can be entered for scaling purpose. After clicking the OK button, the integral values are given as shown in the figure below.

To disable the integral calculation, the menu option (which is marked as long as the Integrals are enabled), needs to be reselected.

5.2.7.4 Setup Menu: Options - Autosave Spectra Periodically or on DIG-IN

Save Periodically

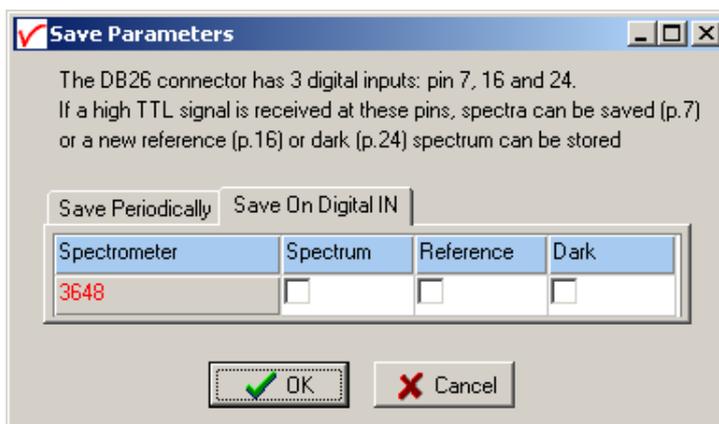
With this option complete spectra will be saved automatically in time. The following parameters can be set:

- **Time delay before first scan** needs to be entered in seconds. After clicking the OK button, AvaSoft waits for this number of seconds, before the first scan is saved.
- **Time delay between scans** needs to be entered in seconds. This defines the time between saving two subsequent spectra. If this number is set to zero, AvaSoft will save the spectra as fast as possible.
- **Number of scans to save:** the number of spectra that needs to be saved can be entered.

On top of the parameters that appear at the right, a checkbox shows: Save As Fast As Possible (no screen updates). If the white checkbox in front of this text line is marked, the Automatic Save option will always save the number of scans that have been entered as fast as possible.

Save on Digital In

The DB26 connector pins 7, 16 and 24 may be used to connect external switches, such as photoswitches, to save a spectrum, reference or dark. This is especially useful for automated sampling in a process control environment with periodical updates of dark and reference signals.



5.2.7.5 Setup Menu: Options - Automatic Save Dark by TTL Shutter

The laser can be switched off by a TTL signal. This software option can be used to switch off the laser automatically before a dark scan is saved. If “Automatic Save Dark by TTL Shutter” is enabled, the next 2-3 integration time cycles after the Save Dark event, are used to get a stable dark spectrum. Then, this dark spectrum is saved after which the laser is switched on again.

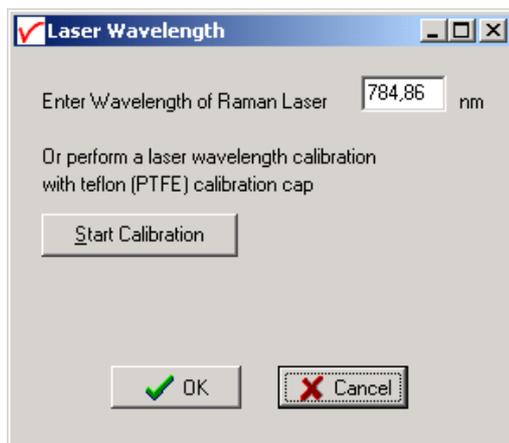
To use this feature, the menu option ‘Save Automatic Dark by TTL shutter’ needs to be clicked in the menu setup-options. To disable this option, the menu option (which is marked as long as the ‘Save Automatic Dark by TTL shutter’ is enabled), needs to be reselected.

5.2.7.6 Setup Menu: Options - Suppress Save Comments

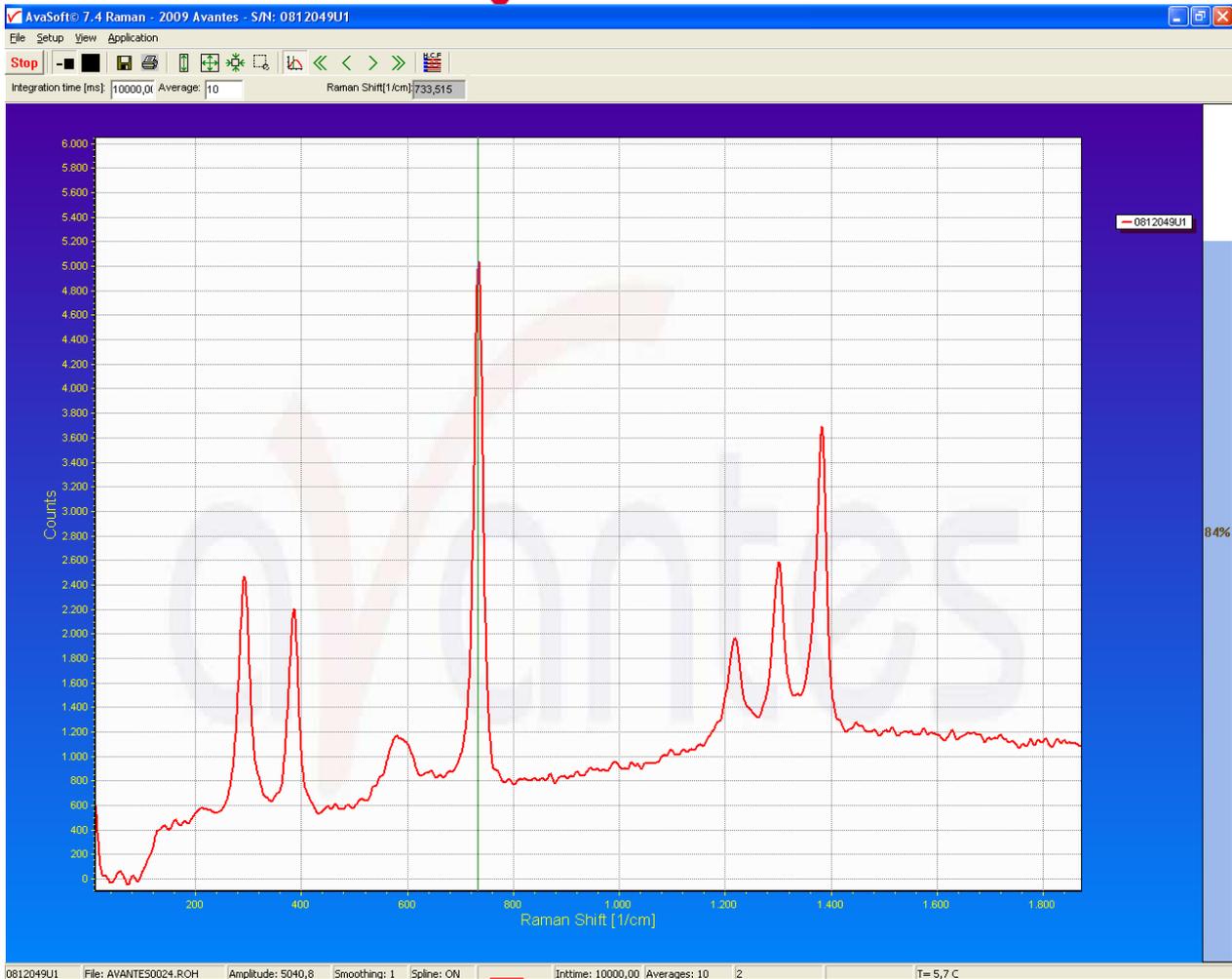
This option, if preceded by a checkmark, disables the appearance of the comments dialog box if an experiment is saved as described in section 5.1.5.

By default this option is OFF. After clicking the menu option it will be enabled (preceded by a checkmark).

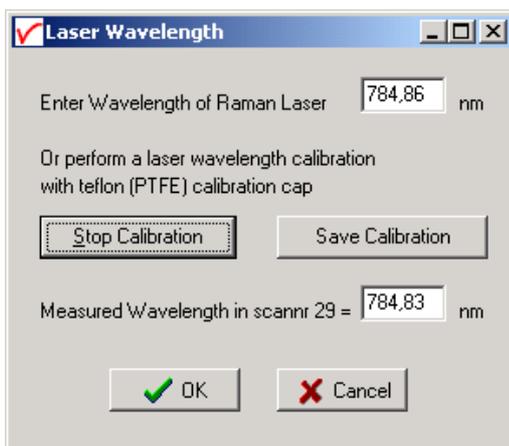
5.2.7.7 Setup Menu: Options - Raman Laser Wavelength



The wavelength of the built in Laser in the Raman System can be changed by the menu option “Raman Laser Wavelength”. A value can be entered manually or, if a teflon (PTFE) calibration cap is available, the laser wavelength can be determined by clicking the “Start Calibration” button. The PTFE spectrum has a few characteristic peaks as shown in the figure below:



The PTFE spectrum will be used to calculate and display the laserwavelength after each scan. By clicking the “Save Calibration” button in the Laser Wavelength dialog, this wavelength will be stored.



5.2.7.8 Setup Menu: Options - Use Non-Linearity Correction

This option will be available only if the Raman System has been calibrated to correct for non-linearity behavior of the detector. If a nonlinearity calibration has been performed, the NL calibration polynomial has been written to the eeprom and will be used if the menu option is enabled (preceded by a checkmark). Correcting for non-linearity can be useful if you are not only interested in the location of the peaks in a raman spectrum, but also in the (relative) intensity, compared to other peaks in the spectrum. To be able to compare the intensity between peaks, the software also needs to correct for detector sensitivity, grating sensitivity etc.. This requires an irradiance calibration of the system. See also section 5.3.1: View Normalized Counts.

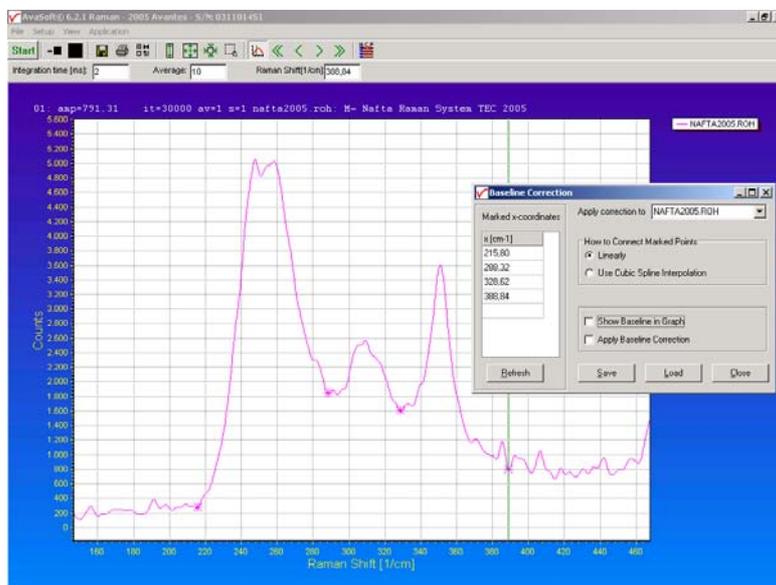
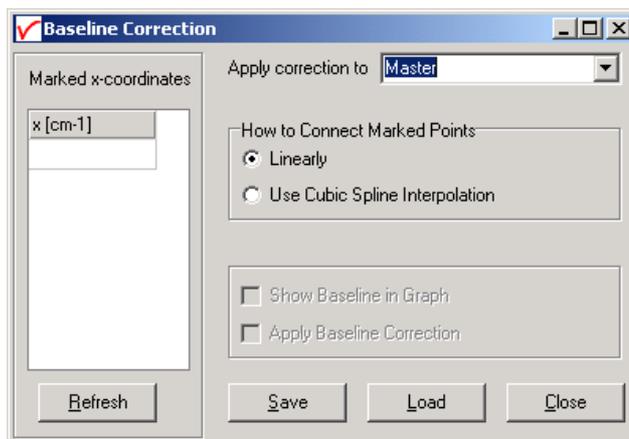
5.2.7.9 Setup Menu: Options - Use Baseline Correction

Fluorescence signal often interferes with the Raman signal of interest. In AvaSoft, the fluorescence signal can be subtracted from the measured spectrum by applying the interactive baseline correction function. Baseline correction can be applied on spectra that were saved before, but also on spectra that are measured online.

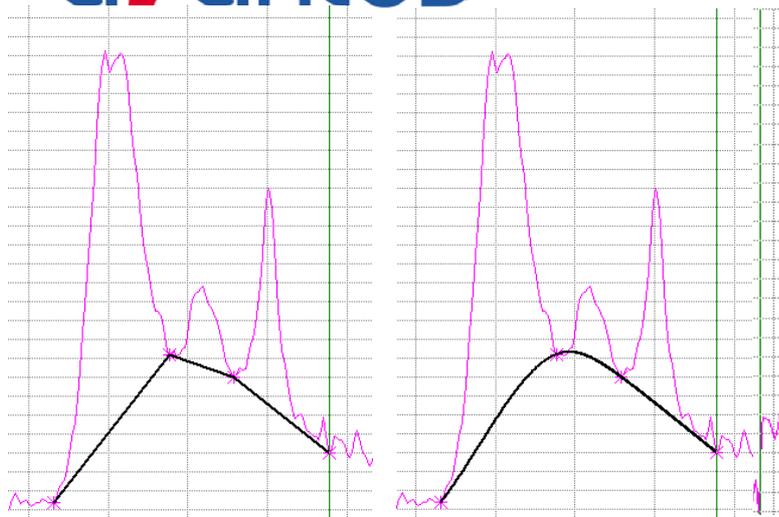
By clicking the “Use Baseline Correction” menu option, the window at the right is displayed. The dropdown box (default displaying the serial number) shows all active spectra in the main window, including the displayed spectra (File - Display Saved Graph). Select the spectrum for which the baseline correction needs to be applied in the dropdown box. In the example below we selected an earlier saved graph called NAFTA2005.ROH.

To add points in the graph that be aligned horizontally after baseline correction, just drag the vertical green cursor line to the required position, and double on this green line with the mouse. As a result, the x coordinate will be displayed in “marked x coordinates” column this point will be marked in the by a star. In the figure at the 4 points have been marked. If want to remove marked points, select the cell in the table and the delete key. To refresh the graph, click the Refresh button. sort the x-coordinates, click the cell with the text “x [cm-1]”.

The new baseline can then be displayed in the original graph by selecting the option “Show Baseline in Graph” in the baseline correction window. If the “How to connect marked points” option has been set to “Linearly”, the baseline that will be used for correction is shown in the left figure below. If “Use Cubic Spline Interpolation” has been selected, the it looks like the middle figure below.

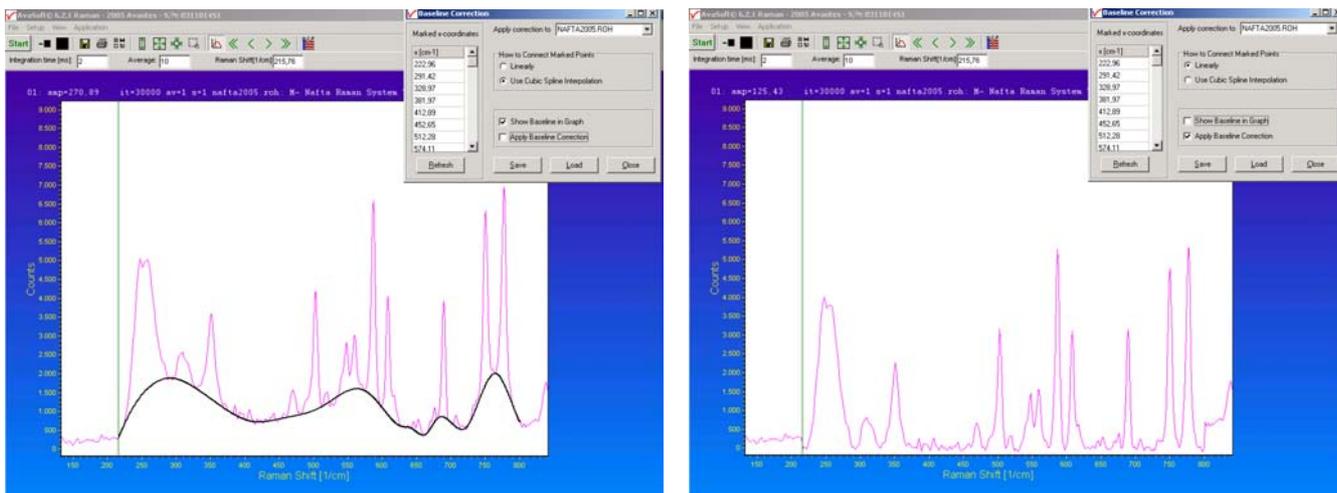


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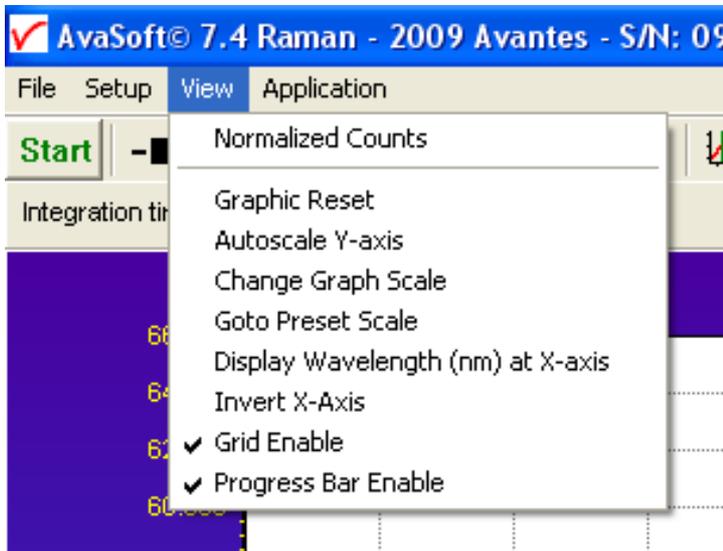
By selecting the “Apply Baseline Correction” option, the black line will be subtracted from the original spectrum. The result for the “Linear” connected points correction is shown in the above right figure: the new baseline has become zero over the range of marked points. Outside this range, the original data maintains.

The same procedure can be followed to correct the baseline for online measured data (Master). The difference is that with each arriving scan, a new baseline needs to be calculated since the y-coordinates for the marked points may change.



The figures above illustrate a baselined correction for a large range. The x-coordinates and baseline correction settings can be saved to a file with extension .bcf (baseline correction file) by clicking the “Save” button. Since only the x-coordinates will be saved, the same file can also be used to load a baseline for graphic files of the same product (but with different y-coordinates). After loading a bcf file, by clicking the “Load” button, the x-coordinates will be read from file and the points will be marked at the intersection with the selected spectrum.

5.3 View Menu

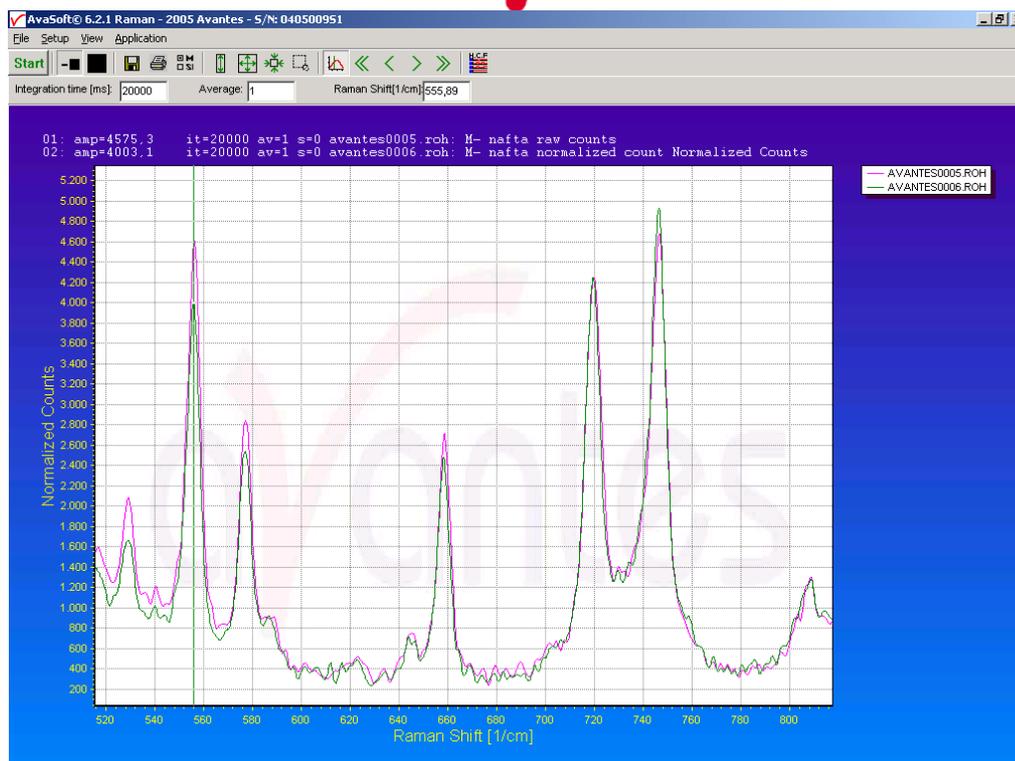


5.3.1 View Menu: Normalized Counts

The default intensity unit is AD Counts. Since a 16-bit AD Converter is used in the Raman system, the y-axis range is 0 - 65535 AD Counts. The AD Counts unit does not include corrections for wavelength dependent sensitivity curves of CCD detector, grating and other optical components like mirrors. Without corrections, the AD Counts intensity ratio's between peaks can be different from the peak intensity ratio's in raman literature or databases.

To correct for wavelength dependent sensitivity, a Raman system can be irradiance calibrated by Avantes. During this irradiance calibration, the spectrometer in the raman system is exposed to a NIST traceable standard irradiance source. The difference between the measured spectrum and known irradiance curve from the source can be used to calculate for each pixel a conversion function from AD Counts to "Normalized" Counts. The conversion function is stored in the eeprom of the spectrometer.

In the figure below, the raman spectra for nafta are displayed. One spectrum was saved in AD Counts mode, the other in Normalized Counts mode.



In the following table, the counts for the peaks at 555 cm^{-1} and 746 cm^{-1} are given for the (uncorrected) AD Counts mode and the Normalized Counts mode:

| | Peak at 555 cm^{-1} | Peak at 746 cm^{-1} |
|-------------------------|------------------------------|------------------------------|
| AD Counts (uncorrected) | 4600 | 4675 |
| Normalized Counts | 4000 | 4925 |

This result is as expected since detector and grating sensitivity decrease towards the higher (NIR) range. Therefore, the Normalized Counts increase towards the higher range.

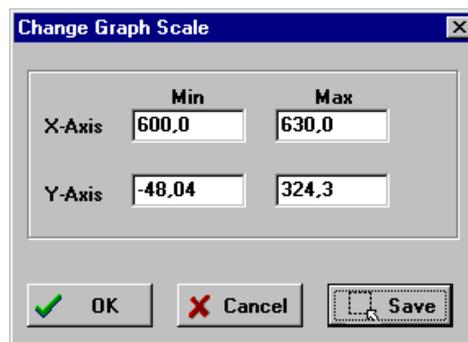
Also the nonlinear response of the CCD detector can have an influence on the peak intensity. The CCD detector response is not perfectly linear, meaning that if twice as much light falls on the detector, it will not respond with exactly twice as much AD Counts. To compensate for this nonlinearity effect, the Raman system can be calibrated by Avantes, resulting in a polynomial correction function which can be used by AvaSoft to correct the raw AD Counts. The polynomial will also be stored in eeprom.

By clicking the menu option “View - Normalized Counts”, AvaSoft will use the calibration data to convert the raw AD Counts into normalized counts. Normalized counts is an arbitrary unit in which the intensity has been corrected for wavelength dependent sensitivity and nonlinear behavior of the detector.

If the nonlinearity and/or irradiance calibration is not available, the normalized counts cannot be calculated, and an error message in which the reason is described will be displayed.

5.3.2 View Menu: Change Graph Scale

After selecting this option, a dialog is shown in which the range for both X- and Y-axis can be changed. To switch to the full scale, the View-Graphic Reset option, or the mouse zoom-out feature can be used. By clicking the Save button in this dialog, the settings for X-axis and Y-Axis will be saved to file and can be restored in the future by selecting the menu option “View-Goto Preset Scale” or by clicking the corresponding button in the button bar.



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5.3.3 View Menu: Graphic Reset

When selecting this option, the graph will be reset to the default X- and Y-axes.

5.3.4 View Menu: Autoscale Y-axis

By using this option, the graph will be rescaled on-line. A maximum signal will be shown at about 75% of the vertical scale.

5.3.5 View Menu: Goto Preset Scale

By clicking this menu option, the scale for X- and Y-axis will be set to a range that has been set before. The same result can be achieved by clicking the Goto Preset Scale Button in the button bar.

5.3.6 View Menu: Display Wavelength (nm) at X-Axis

Default, the spectral data are shown versus Raman Shift in cm^{-1} . After the menu option ‘Display wavelength (nm) at X-axis’ is clicked, the wavelength in nanometers is shown at the X-axis and a checkmark appears in front of the menu option. To return to Raman Shift, the menu option needs to be clicked again, after which the checkmark disappears and the X-axis returns to display in cm^{-1} .

5.3.7 View Menu: Invert X-Axis

Default, the spectral data are shown versus Raman Shift in cm^{-1} , increasing from left to right. After the menu option ‘Invert X-axis’ is clicked, the X-axis is inverted (increasing from right to left) and a checkmark appears in front of the menu option. To return to default mode, the menu option needs to be clicked again.

5.3.8 View Menu: Grid Enable

This option, if preceded by a checkmark, shows a grid in the graphical region. By default this option is ON (preceded by a checkmark). After clicking the menu option it will be disabled.

5.3.9 View Menu: Progress Bar Enable

If using long integration times or a high number of averages, it can take a few or more seconds before a new scan is received by the application. To get an indication about how much time it will take until the next scan arrives, a progress bar can be displayed as shown in the figure above. After enabling the progress bar by clicking the menu option, it will be displayed after the next scan has arrived. The progress bar will be shown only if the time between scans is more than one second. The time between scans is roughly the integration time, multiplied with the number of averages.

6 Applications

6.1 Applications: History Channel Functions

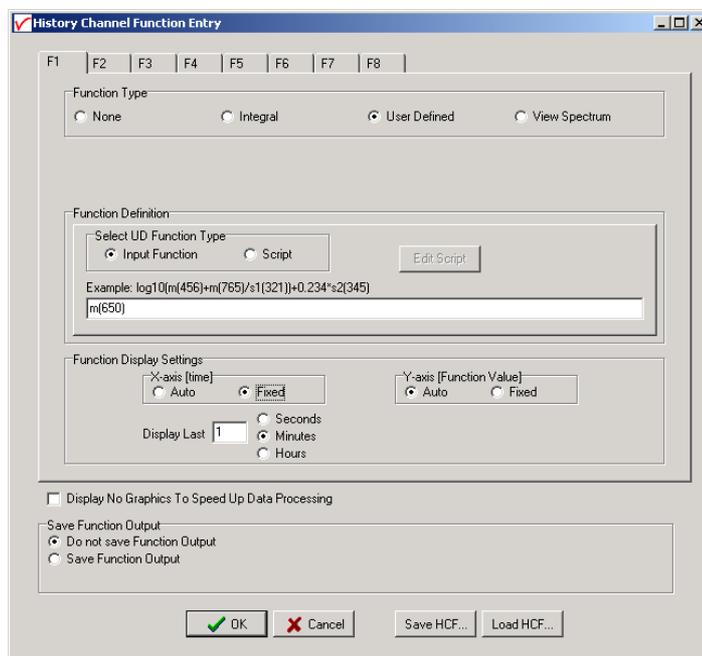
6.1.1 History Application: Function

With the History Application, the output of self defined functions or integrals can be followed in a graph against time. Up to 8 functions can be followed simultaneously.

The functions are defined in the dialog the right, which is shown after the History-Function Entry option has been chosen.

The functions F1 to F8 can be selected clicking the corresponding TAB sheet at top of this dialog.

Furthermore, a number of general (function independent) parameters can be entered, below of the function TAB sheets.



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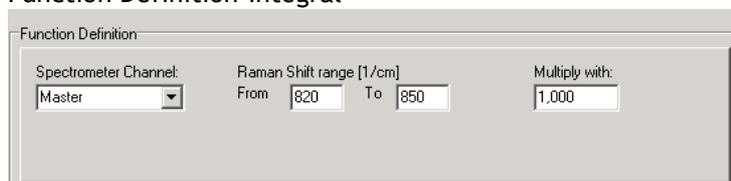
Function Type

The first time that the Function Entry dialog is activated, all 8 functions are not activated (Function Type = None). To define a function, the Function Type radio button needs to be changed from None to: Integral, User Defined or View Spectrum. After defining the function type, the Function Definition and Function Display Settings can be set.

Function Definition

The parameters that need to be entered in the Function Definition Box depend on the Function Type that has been chosen: Integral, User Defined or View Spectrum.

Function Definition-Integral



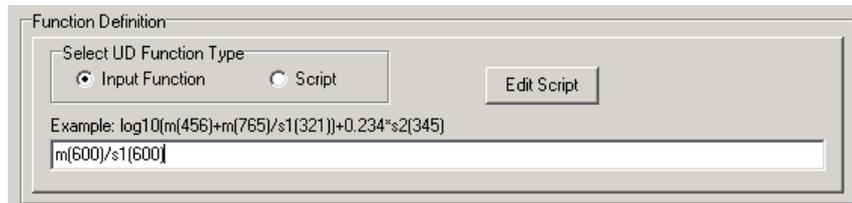
In case a function is defined to display the integral versus time, the following parameters can be set: Spectrometer Channel. The default is Master, but in case more channels are available, this can be changed to Slave1, Slave2.....up to Slave7.

The “from” and “to” edit boxes may be changed to specify the Raman Shift range in cm^{-1} over which the integral needs to be calculated.

Finally, a multiplication factor can be entered. The value entered here is multiplied with the calculated integral.



Function Definition-User Defined



If you want to display the output of a self defined function against time, a function needs to be defined first. You can either enter a user defined input function in the dialog box, or assign a script to the history channel.

Input Functions:

A comprehensive example of an input function is given in the dialog, but it illustrates only a few of the functions AvaSoft can handle. A list of allowed operators and functions is given below:

Operators: *, /, +, -

Functions:

log(x) = natural log

log10(x) = log base 10

exp(x) = e to the power of x

sqrt(x) = square root

Additionally, the wavelength signal for master and slave channel(s) can be entered by:

m(wavelength in nm) = master

s1(wavelength in nm) = slave1, s2(wavelength in nm)= slave2, etc.

For example: the function that needs to be entered to follow the intensity at 800 cm⁻¹ against time at the master channel is: m(800)

Scripts:

A scripting feature has been added to allow you to use more complicated calculations with many more mathematical and logical functions. Scripts will also allow you to combine the results of several history channels.

AvaSoft uses the Microsoft VBScript language that comes with your copy of Windows. We have included a help file for VBScript for your reference. You can open the file VBScript.chm which has been installed in the AvaSoft main directory (default AvaSoft-Raman). It lists among other things all available operators and functions.

When you edit a script, either the previous script for the channel will be shown, or a new starter script will be generated if there is no previous script. AvaSoft includes a simple script editor. The scripts are plain ASCII files, named Fx_script.txt, where x is the history channel number, from 1 to 8.

A starter script has the following contents:

Function F2(value)

F2=0

End Function

You can elaborate on this function, as long as there is a value assigned to F2 in the end. In this case, F2 will be assigned the value 0.

You can refer to the other history channels with the predefined variables F1 to F8. If you want to use data from the spectrometer, you will need to assign other history channels to e.g. wavelength values or integrals. The following script defines the function value for F3 as the quotient of F1 and F2.

Function F3(value)

F3=F1/F2

End Function

Please do not refer to the function value for the script itself. You can also not refer to other functions, if these are themselves assigned to a script. This will result in a scripting run-time error. If you want to use code from another script, please copy the necessary lines from that script into the one you are working with.

Please understand that a script is executed by an interpreter, on a line by line basis. If you make a syntax error in your script, it will usually only show at the moment the line with the error is executed, as a run-time error.

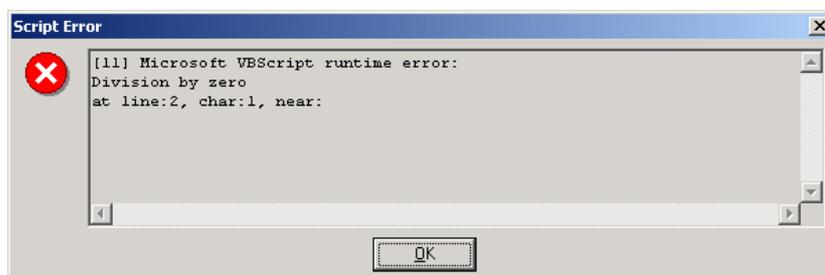
Nothing will stop you, for instance, from entering the following script for function 3:

Function F3(value)

F3=F1/0

End Function

Running this script will result in the run-time error at the right:



If you refer to channels that are undefined (Function Type 'None'), they will be handled as uninitialized variables by VBScript, with value 0. This is the case for all uninitialized variables you might use in your scripts.

Finally, a small example to monitor the integral of a peak between 522 cm^{-1} and 550 cm^{-1} , in which an offset is subtracted. The offset area is the area below of the straight line between the output at 522 cm^{-1} and the output at 550 cm^{-1} .

F1 is defined as a user defined input function: m(522)

F2 is defined as a user defined input function: m(550)

F3 is defined as the zero-based integral between 522 cm^{-1} and 550 cm^{-1} .

The script for function F4 can then be written as:

Function F4(value)

If F1 > F2 Then

offset = 28*(F2 + (0.5*(F1-F2)))

Else

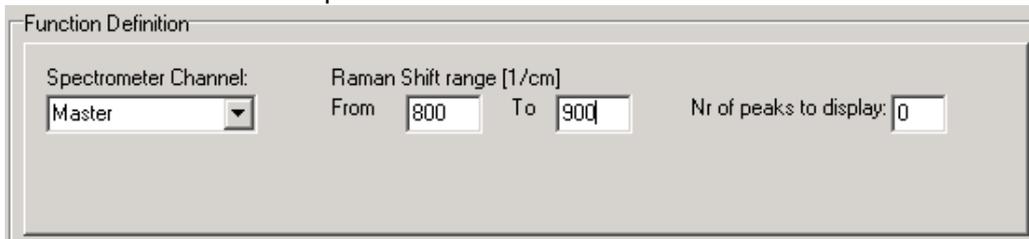
offset = 28*(F1 + (0.5*(F2-F1)))

End If

F4 = F3 - offset

End Function

Function Definition-View Spectrum



Function Definition

Spectrometer Channel: Raman Shift range [1/cm] From To Nr of peaks to display:

The View Spectrum function does not display function output against time. Instead, the Raman Shift range that has been entered in the Function Definition Box will be displayed at the X-axis. The spectrum for the selected spectrometer channel will be displayed. In combination with AvaSoft-XLS, the View Spectrum mode can also be used to export complete spectra online to Excel (section 6.2)

Function Display Setting



Function Display Settings

X-axis [time] Auto Fixed Y-axis [Function Value] Auto Fixed

Display Last Seconds Minutes Hours

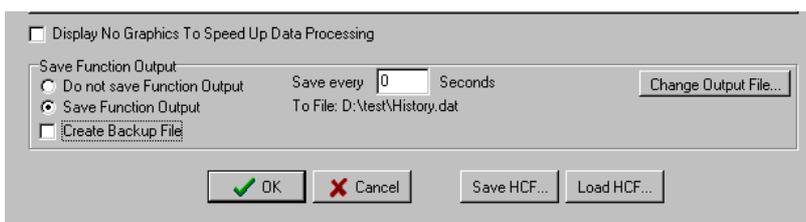
YMin YMax

For Integral and User Defined functions, the output can be displayed graphically against time. The amount of time that will be displayed at the X-axis can be set manually by clicking the “Fixed” radio button. If set to Auto, the time axis will be set to 1 minute.

This option is not available if the View Spectrum Function Type has been selected, because the X-axis range is in that case in cm^{-1} , and determined by the Raman Shift range as described above.

The Y-Axis can also be set to Fixed or to Auto. The Auto option will set the Y-axis range to the minimum and maximum function values that are in the list of measured data points.

Function Independent Parameters



Display No Graphics To Speed Up Data Processing

Save Function Output Do not save Function Output Save Function Output Create Backup File

Save every Seconds To File: D:\test\History.dat

Function Independent Parameters - Display no graphics to speed up data processing

Below the TAB sheets for function definition an option can be enabled or disabled to speed up data processing by not displaying the graphics during the measurements. If an application requires fast data processing (e.g. more than 10 scans per second), this option should be enabled. If saved to an output file, the data can be displayed graphically after the time series experiment has been ended, as described in section 3.4.3: History-Display Saved History Graph.

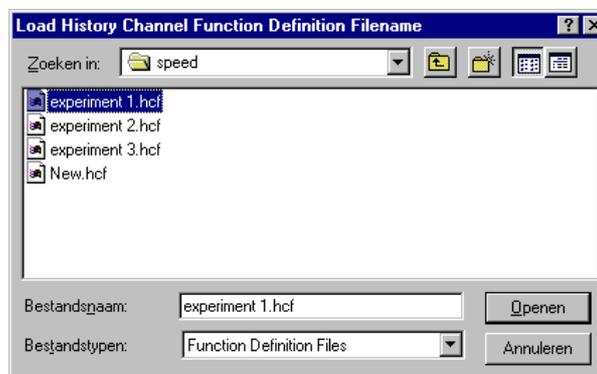
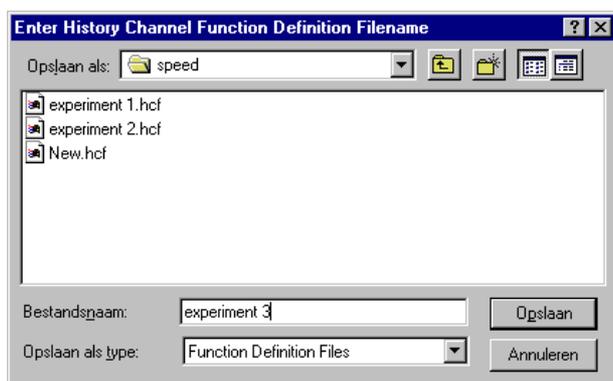
Function Independent Parameters - Save Function Output

The results of a time series experiment will be saved to an ASCII-file if the radio button “Save Function Output” has been selected.

A number of seconds between saving can be entered for data reduction, in case measurements are carried out over long periods. Entering a value of zero results in saving every scan. The name of the file to which the data will be saved, can be changed after clicking the “Change Output File...” button. Last option in the “Save Function Output” box is to enable or disable the possibility to create a backup file during the measurements. If this option is enabled, AvaSoft will create a backup file with the same filename, but with the extension *.bak (also in ASCII). This backup file is updated every scan and can be used in case the filename that has been selected has failed to save the data, for instance because of a power failure during the measurements.

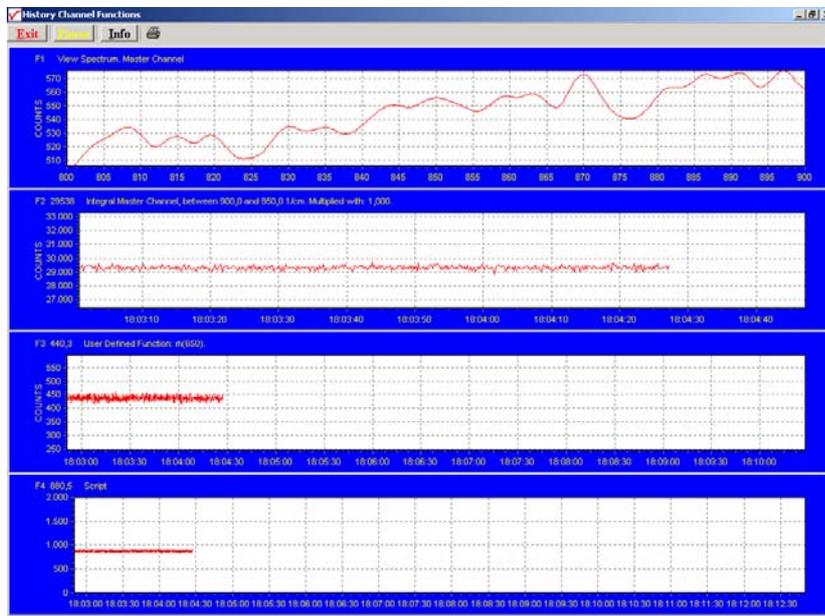
Save HCF.../Load HCF buttons

AvaSoft automatically saves all parameters (function definition, save options) to the file hcf.ini, and restores these parameters, the next time AvaSoft is started. With the Save HCF... and Load HCF... buttons, it’s also possible to save these parameter settings to (and load from) a file with the extension *.hcf. With this feature it is possible to save for each experiment a different HCF file, so it can be loaded a next time the same settings are required. The left figure below shows the dialog in which the name of the hcf file can be entered after clicking the save HCF... button. The right figure below, which is displayed after clicking the Load HCF... button, illustrates how to select an earlier saved HCF file.



After the definition of one or more functions, the OK button is clicked to confirm, the CANCEL button to leave the dialog without changes. If the OK button is clicked, AvaSoft performs a number of checks on the data that has been entered. If no warnings show up, the parameters that have been entered are accepted, and the measurement can be started by the History - Start Measuring menu option.

6.1.2 History Application: Start Measuring



This option displays the output against time for the history functions that have been defined in the History Channel Function Entry dialog box. If the option “Display no graphics to speed up data processing” has been marked in the function entry dialog, the function output will be shown by numbers only, which are updated each time a new scan is saved to the output file.

There are four buttons at the top of this window: an Exit button, a Pause/Start button, an Info button and a Print button.

If the red Exit button is clicked, the time measurements are ended and the main window and menu is activated again. The yellow Pause button can be used to stop the time measurements temporarily. After clicking the Pause button, data acquisition stops and the text on the button changes to a green Start. If the Start button is clicked, data acquisition is activated again and the text changes back to the yellow Pause.

The Info button shows the Function Entry dialog, in which all parameters can be viewed (not edited) while the measurement is running.

By clicking the Print button, the graphics that are displayed can be printed during the run. First the printer specific dialog shows up in which the print options can be set. For example, if only one graph of the four in the figure above need to be printed, this graph can be selected by the page(s) radiobutton. All graphics are printed full size on a different page.

Zoom features

In each graph the same zoom features apply as in the main window (except for scaling the Y-axis with the mouse wheel). However, zooming in over the X-axis while the measurement is running and the X-axis is already scrolling will not be possible, because in that case the X-axis is updated with each new scan.

Clicking the pause button to take a snapshot will solve this problem.

Zoom in: select a region to be expanded to the full graph. To select this region, click the left mouse button in the white graphics region and drag it downwards and to the right. After releasing the left mouse button, both the X- and Y-axis will be rescaled to the new values of the selected region.

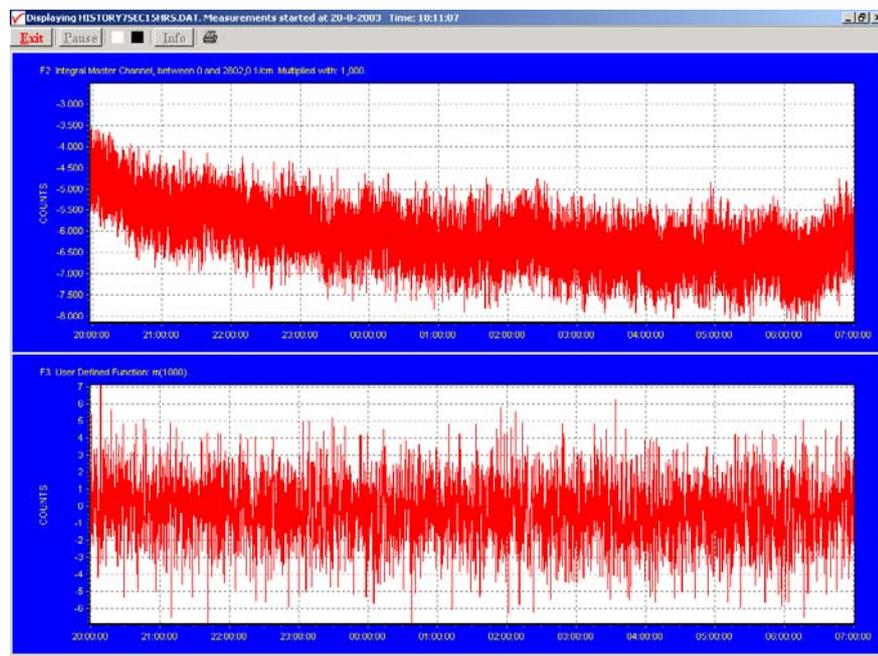
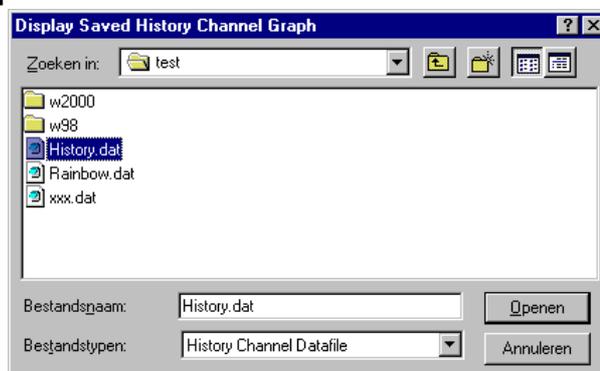
Zoom out: drag with the left mouse button within the white graphics region, but instead of dragging the mouse downwards and to the right, drag it into another direction. After releasing the mouse button, both the X- and Y-axis will be reset to their default values.

Move X-Y: dragging with the right mouse button results in moving the complete spectrum up or down and to the left or right.

6.1.3 History Application: Display Saved History Graph

If time measurement data have been saved, the resulting ASCII file can be displayed graphically by selecting this file in the dialog that is shown after clicking the “Display Saved History Graph” menu option.

After clicking the “Open” button, the function output of the functions with function type “Integral” or “User Defined” is displayed against time. Both X- and Y-axis are set to their full scale, which is determined by the minimum and maximum values in the list.



The zoom features, as described in section 6.1.2, can be applied, to zoom in on an interesting time interval. A description for the print button can also be found in section 6.1.2.

Since the History Channels Output file is in ASCII, this file can be easily imported in a spreadsheet program like Microsoft Excel. The data in the file can also be viewed with a text editor, like Microsoft Word, or with Notepad.

6.2 Applications: Excel Output

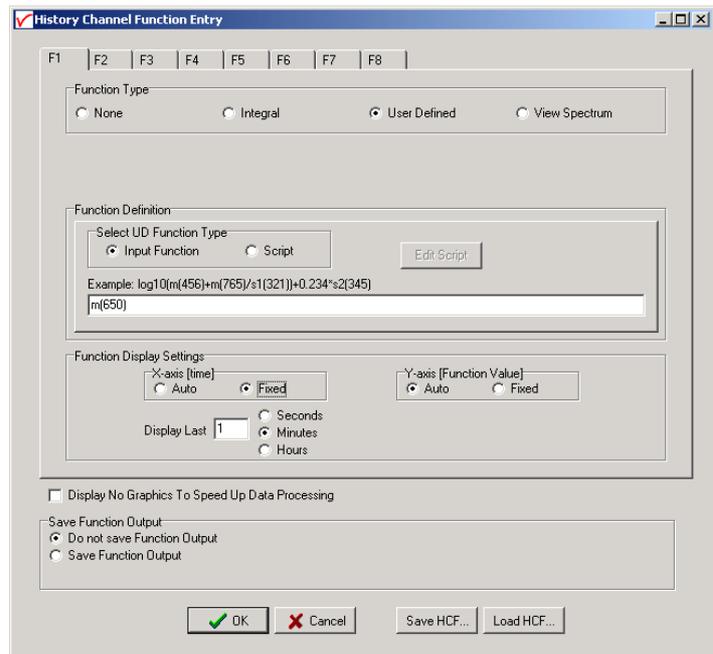
AvaSoft XLS is an add-on application that enables Avasoftware Full to output history channel data and/or complete spectra to Microsoft Excel.

It uses OLE-Automation, which is a technology that enables AvaSoft to remotely control Excel, opening sheets and copying data into cells.

6.2.1 Select Source Data

Besides enabling Excel output, you will have to select your source data. This is done in the same way it would be done without the Excel output option, with the input screens you use to define History Channel Functions.

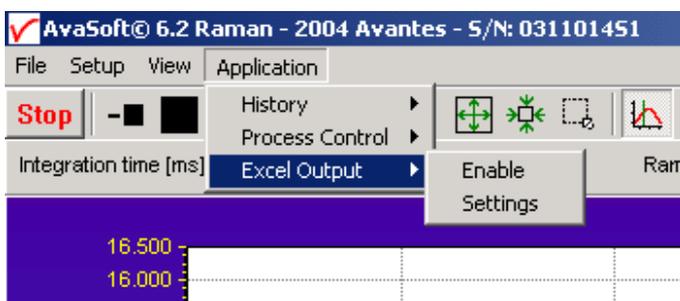
The only difference is the ‘Save Function Output’ box, which is not used by the Excel Output option. This part is replaced by a separate dialog, which will be described under ‘Settings’ in section 6.2.3.



6.2.2 Enable Excel Output

Enable the option by selecting ‘Application’, ‘Excel Output’, ‘Enable’.

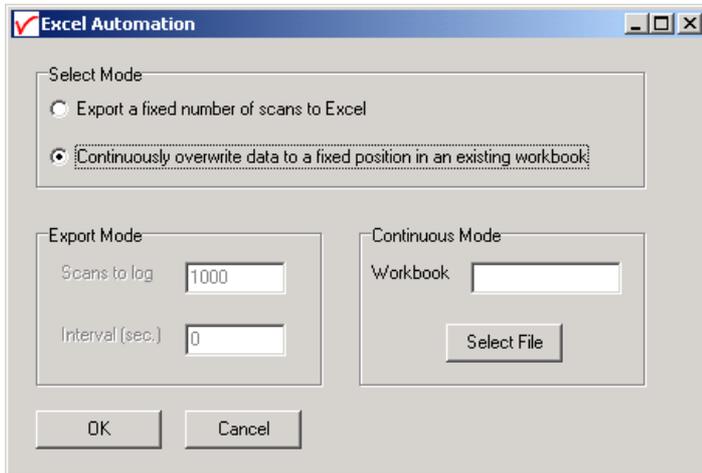
A checkmark will appear before the menu entry ‘Enable’ to show the status of the option.



6.2.3 Settings

AvaSoft will write the data to three differently formatted sheets, depending on user input in History Channel Function Entry and the Settings dialog.

You can enter the Settings dialog by selecting 'Application', 'Excel Output', 'Settings'.



First, select the mode you want.

Export mode

You can select Export Mode by selecting the top radio button. In this mode, a predefined number of scans will be logged to new worksheets that Excel will open.

Depending on your choice of history channel, one of two formats of sheet (or both) will be opened by Excel.

If you select regular history channels, without selecting 'View Spectrum', the sheet will be formatted horizontally, with the program adding a new row for each measurement written.



| 1 | Time | Elapsed msec | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | K | L | M | N |
|----|---------------------|--------------|----|----------|----|----|----|----|----|----|---|---|---|---|
| 2 | | | | | | | | | | | | | | |
| 3 | 07/03/2002 11:32:34 | 41553984 | 0 | 16.65232 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 4 | 07/03/2002 11:32:35 | 41554535 | 0 | 21.97153 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 5 | 07/03/2002 11:32:35 | 41554775 | 0 | 15.77341 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 6 | 07/03/2002 11:32:35 | 41555095 | 0 | 14.52785 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 7 | 07/03/2002 11:32:35 | 41555386 | 0 | 15.37158 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 8 | 07/03/2002 11:32:36 | 41555696 | 0 | 15.29654 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 9 | 07/03/2002 11:32:36 | 41556007 | 0 | 18.36336 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 10 | 07/03/2002 11:32:36 | 41556317 | 0 | 11.52971 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 11 | 07/03/2002 11:32:37 | 41556618 | 0 | 15.38815 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 12 | 07/03/2002 11:32:37 | 41556928 | 0 | 14.91846 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 13 | 07/03/2002 11:32:37 | 41557239 | 0 | 11.53747 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 14 | 07/03/2002 11:32:38 | 41557539 | 0 | 22.45974 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 15 | 07/03/2002 11:32:38 | 41557850 | 0 | 18.35447 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 16 | 07/03/2002 11:32:38 | 41558160 | 0 | 19.09817 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 17 | 07/03/2002 11:32:38 | 41558460 | 0 | 13.05762 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 18 | 07/03/2002 11:32:39 | 41558771 | 0 | 12.70234 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 19 | 07/03/2002 11:32:39 | 41559091 | 0 | 17.02149 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 20 | 07/03/2002 11:32:39 | 41559382 | 0 | 16.68021 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 21 | 07/03/2002 11:32:40 | 41559692 | 0 | 16.61596 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 22 | 07/03/2002 11:32:40 | 41560003 | 0 | 23.0465 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 23 | 07/03/2002 11:32:40 | 41560313 | 0 | 17.72162 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 24 | 07/03/2002 11:32:41 | 41560614 | 0 | 22.07574 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 25 | 07/03/2002 11:32:41 | 41560924 | 0 | 22.14798 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 26 | 07/03/2002 11:32:41 | 41561235 | 0 | 23.95353 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 27 | 07/03/2002 11:32:42 | 41561535 | 0 | 16.97784 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 28 | 07/03/2002 11:32:42 | 41561846 | 0 | 21.8668 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 29 | 07/03/2002 11:32:42 | 41562156 | 0 | 22.19735 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 30 | 07/03/2002 11:32:42 | 41562467 | 0 | 21.85271 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 31 | 07/03/2002 11:32:43 | 41562767 | 0 | 17.15362 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 32 | 07/03/2002 11:32:43 | 41563067 | 0 | 20.67904 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 33 | 07/03/2002 11:32:43 | 41563368 | 0 | 20.19298 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 34 | 07/03/2002 11:32:44 | 41563668 | 0 | 17.33064 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 35 | 07/03/2002 11:32:44 | 41563999 | 0 | 24.58224 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |

The sheet will be called 'AvaSoft Data', the columns contain the following data:

Column A contains a data/time value, formatted as 'dd:mm:yyyy hh:mm:ss'.

This is a floating point value, in which the integer part is the day number, starting at January 1, 1900 with day 1. The fractional part represents a decimal time value, where 0.5 is 12:00 h. noon and 0.75 is 18:00 h. This way, differences in date/time can be readily calculated by subtracting values, which would be much more difficult if this was a text representation.

Column B contains a time value, representing the elapsed milliseconds since midnight. This value does not have a one millisecond resolution. Remember that Windows is not a real-time operating system. It can, however, be used as a reasonably accurate indicator of the time that passes between scans.

Columns C through J contain the 8 different History Channel values. For unselected History Channels, a value of 0 will be entered in the sheet.

If you select 'View Spectrum' in your choice of History Channels, the sheet will be formatted vertically. As Excel only offers 256 columns per sheet, we need to write a spectrum (which can hold more than 2000 pixels) in a column instead of a row, and add more columns as time passes.



Microsoft Excel - raman full spectra at 2min inttime.xls

| | A | B | C | D | E | F | G | H |
|----|--------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 1 | Time | 19-08-2003 16:56:57 | 19-08-2003 16:58:59 | 19-08-2003 17:01:02 | 19-08-2003 17:03:05 | 19-08-2003 17:05:08 | 19-08-2003 17:07:11 | 19-08-2003 17:09:14 |
| 2 | Elapsed msec. | 61016615 | 61139480 | 61262345 | 61385221 | 61508066 | 61630911 | 61753766 |
| 3 | Raman Shift (1/cm) | | | | | | | |
| 4 | 199,38 | -4 | -3 | -5 | 0 | 0 | 0 | |
| 5 | 201,54 | -7 | 0 | -5 | -3 | -7 | -3 | |
| 6 | 203,70 | 1 | -3 | 5 | -5 | 8 | -1 | |
| 7 | 205,86 | -4 | 3 | -5 | -7 | 3 | -3 | |
| 8 | 208,02 | 7 | 3 | 3 | 3 | 3 | 3 | |
| 9 | 210,18 | 1 | -4 | -1 | 2 | -8 | 1 | |
| 10 | 212,33 | -1 | 0 | 2 | 0 | 4 | 10 | |
| 11 | 214,49 | -1 | -2 | -5 | -6 | -9 | -3 | |
| 12 | 216,64 | -15 | -8 | -13 | -5 | 5 | -8 | |
| 13 | 218,79 | -50 | -47 | -47 | -46 | -49 | -56 | |
| 14 | 220,94 | -58 | -59 | -64 | -61 | -60 | -59 | |
| 15 | 223,09 | -60 | -53 | -50 | -49 | -48 | -50 | |
| 16 | 225,24 | -51 | -44 | -54 | -47 | -53 | -53 | |
| 17 | 227,39 | -49 | -60 | -64 | -58 | -59 | -63 | |
| 18 | 229,54 | -45 | -60 | -52 | -51 | -60 | -45 | |
| 19 | 231,68 | -38 | -56 | -55 | -53 | -54 | -56 | |
| 20 | 233,83 | -45 | -48 | -55 | -46 | -45 | -50 | |
| 21 | 235,97 | -50 | -58 | -54 | -49 | -54 | -60 | |
| 22 | 238,11 | -64 | -57 | -59 | -52 | -54 | -59 | |
| 23 | 240,25 | -48 | -60 | -52 | -54 | -53 | -59 | |
| 24 | 242,39 | -47 | -57 | -51 | -45 | -46 | -43 | |
| 25 | 244,53 | -46 | -55 | -53 | -51 | -57 | -59 | |
| 26 | 246,67 | -44 | -50 | -44 | -52 | -44 | -46 | |
| 27 | 248,80 | -46 | -48 | -49 | -43 | -47 | -52 | |
| 28 | 250,94 | -56 | -54 | -52 | -46 | -49 | -59 | |
| 29 | 253,07 | -42 | -49 | -41 | -51 | -39 | -55 | |
| 30 | 255,20 | -55 | -60 | -60 | -51 | -54 | -55 | |
| 31 | 257,34 | -56 | -55 | -58 | -52 | -60 | -63 | |
| 32 | 259,47 | -50 | -57 | -47 | -52 | -51 | -57 | |
| 33 | 261,60 | -53 | -56 | -53 | -51 | -53 | -51 | |
| 34 | 263,72 | -53 | -50 | -53 | -50 | -59 | -51 | |
| 35 | 265,85 | -49 | -47 | -52 | -51 | -53 | -40 | |
| 36 | 267,98 | -56 | -55 | -53 | -52 | -48 | -57 | |
| 37 | 270,10 | -46 | -40 | -50 | -45 | -42 | -46 | |

Since there is a maximum of 256 columns per sheet, new sheets will be added after column 256 ('IV') is filled.

The first sheet will be called 'F1' for history channel 1, 'F2' for history channel 2, etc. If extra sheets are added, a suffix will be added to this name, e.g. F1_01, F1_02 etc.

Rows 1 and 2 contain the date/time stamp and the elapsed millisecond value, as described in the previous section.

Column A of the first sheet holds the Raman Shift scale. The Raman Shift range matches the Raman Shift range as specified in the History Channel Functions.

The lower left half of the Settings dialog can be used to enter the number of scans you want to export to Excel, and the time interval (in seconds) between two scans you want to log. Default values are 1000 scans and no interval, meaning as fast as possible.

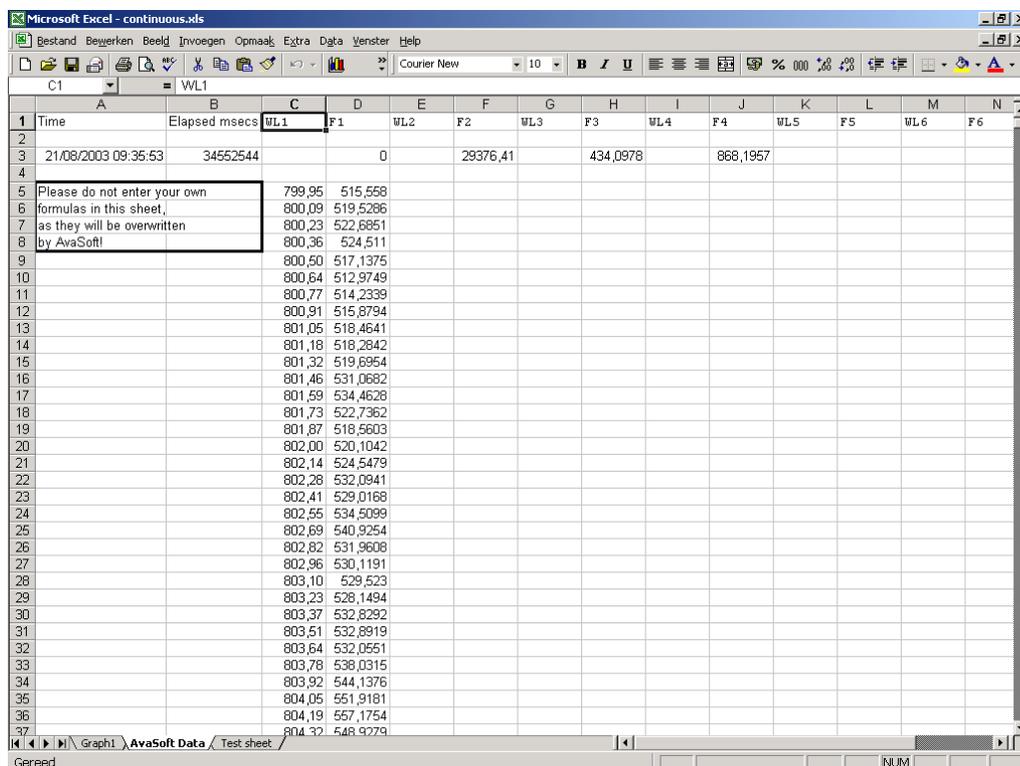
Continuous Mode

You can select Continuous Mode by selecting the bottom radio button in the settings dialog. In this mode, data will be written to a single sheet, each scan overwriting the previous one.

In the lower right part of the Settings dialog, you can select the workbook the sheet will be added to, thereby enabling you to use your own calculations and graphs in Excel on live data from AvaSoft.



Press the 'Select File' button to select the workbook. Please save an empty workbook using Excel if you don't have a previous workbook to open.



AvaSoft will check if a sheet named 'AvaSoft Data' is present, and will add this sheet if it is not present. This way, links to the sheet can be preserved between sessions.

The sheet contains the following data, at fixed positions:

A3 : Date / Time stamp

This is a floating point value, in which the integer part is the day number, starting at January 1, 1900 with day 1. The fractional part represents a decimal time value, where 0.5 is 12:00 h. noon and 0.75 is 18:00 h. This way, differences in date/time can be readily calculated by subtracting values, which would be much more difficult if this was a text representation.

B3 : Time in milliseconds after midnight

This value does not have a one millisecond resolution. Remember that Windows is not a real-time operating system. It can, however, be used as a reasonably accurate indicator of the time that passes between scans.

C5-C*** : Raman Shift scale (in cm^{-1}) for first History Channel spectrum

D3 : Value for first History Channel (0 if spectrum is selected)

D5-D*** : Spectrum for first History Channel.

E5-E*** : Raman Shift scale (in cm^{-1}) for second History Channel spectrum
(empty if spectrum is not selected)

F3 : Value for second History Channel

F5-F*** : Spectrum for second History Channel
(empty if spectrum is not selected)

etc.

*** : depends on the wavelength range selected.

6.2.4 Start Output

You start the output the usual way, with 'Application', 'History', 'Start measuring'.

You can also use the corresponding button on the Button Bar.

Please do not perform large alterations of the worksheet, while data is being transmitted. An error 'Call was rejected by callee' will be issued if Excel is too busy.

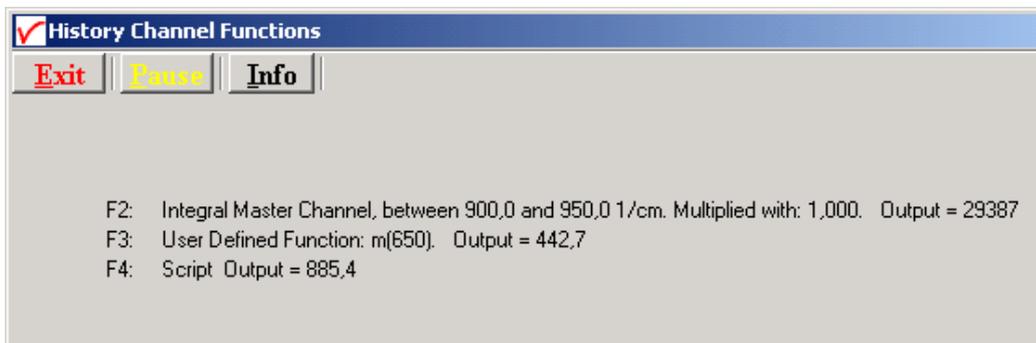
Moving around the worksheet should not pose any problems.

Save any alterations to your worksheet before starting the transfer to Excel. You do not have to close the worksheet or close Excel.



6.2.5 Stop Output

If you want to stop the transfer to Excel give focus to AvaSoft and press 'Exit'. It may take a few seconds before the buttons appear.



Excel will not be closed by AvaSoft. Save your work and close Excel the same way you would when working with Excel manually.

We have included a sample worksheet, called 'Continuous.xls', which demonstrates linking to the 'AvaSoft Data' sheet. In this case, two graphs are drawn from the Excel columns C/D and E/F. The graph and data are continuously updated while data is being transferred to Excel.



6.2.6 Limitations and Optimization Notes

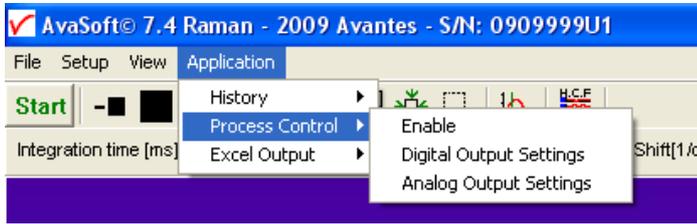
As all scans are stored in memory, it is possible to overflow internal memory with scans in Export mode. Therefore, a limit to the number of scans to store in Excel has been built in. Before a new sheet is added, the amount of memory Excel uses is determined. If this number is larger than half the physical memory installed in the machine, output to Excel will stop.

On a 128 MB machine, this corresponds with 7-8 complete sheets (of 256 columns and 2000 rows), roughly 2000 full scans. Limiting the wavelength range will extend your range of scans accordingly.

Of course, adding more Ram to your machine will also help raise this limit. On a 3.5 GB machine with Excel 2003, it is possible to save more than 100 complete sheets (of 256 columns and 2000 rows).

We have, however, seen limitations in the amount of memory that Excel can use. It looks like there is an internal limit that is hit before internal memory runs out. After this Excel issues an 'Out of Memory' message and is no longer functional. E.g. saving your data to disk is not possible anymore. For this reason, an absolute limit to the number of cells used has also been built in.

6.3 Applications: Process Control Application



Avasoft Process Control allows you to operate digital outputs corresponding with preset levels of your history channels. You can set thresholds for all eight history channel functions. The output of two History Channel Functions can be converted to analog output signals (0..5V).

6.3.1 Digital Output signals

AvaSoft supports 8 built-in digital outputs on the AvaSpec, one per history channel. The output pins on the High Density 26-pole Sub-D connector which are used for the process control application are listed in the table below.

| HD DB26 pins used by AvaSoft Process Control | |
|--|---------------|
| HCF# | connector pin |
| 1 | 2 |
| 2 | 20 |
| 3 | 3 |
| 4 | 21 |
| 5 | 13 |
| 6 | 4 |
| 7 | 22 |
| 8 | 25 |
| GND | 8 |

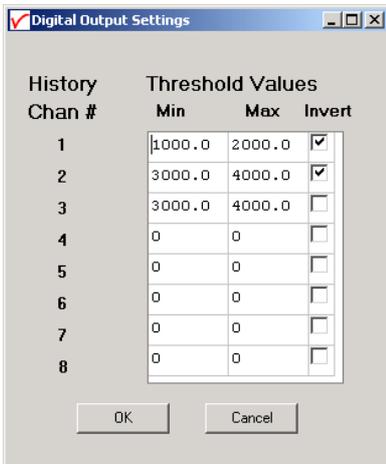
6.3.2 Analog Output signals

Pin 17 and 26 of the HD DB26 connector can be used to convert maximal two History Channel Function output signals into a 0-5V signal. The analog output resolution is 8-bit (0.02V steps)

6.3.3 Using the Process Control Application in AvaSoft

The Process Control application needs to be activated by selecting 'Application', 'Process Control', 'Enable'. A checkmark will appear before the menu entry to show that the option is enabled.

To set minimum and maximum threshold values for each of the History functions, select 'Application', 'Process Control', 'Digital Output Settings'.



The box shows 16 values, corresponding with a minimum and maximum threshold value for the 8 history channels. All 16 values can be edited by clicking them with the mouse. In addition, in the third column, you can select whether or not to invert the signal that is output. For each channel, the minimum threshold value may not exceed the maximum threshold value. You cannot leave fields blank, in that case, enter 0. After selecting OK, the settings are written to a binary file called 'digital.ini'.

The minimum and maximum threshold values are indicated in the history graphs with horizontal lines.

If 'Invert' is not selected, the corresponding output pin will be set high if the history channel output value lies between the minimum and maximum value. It will be set low if the history channel output value exceeds the maximum value OR is smaller than the minimum value.

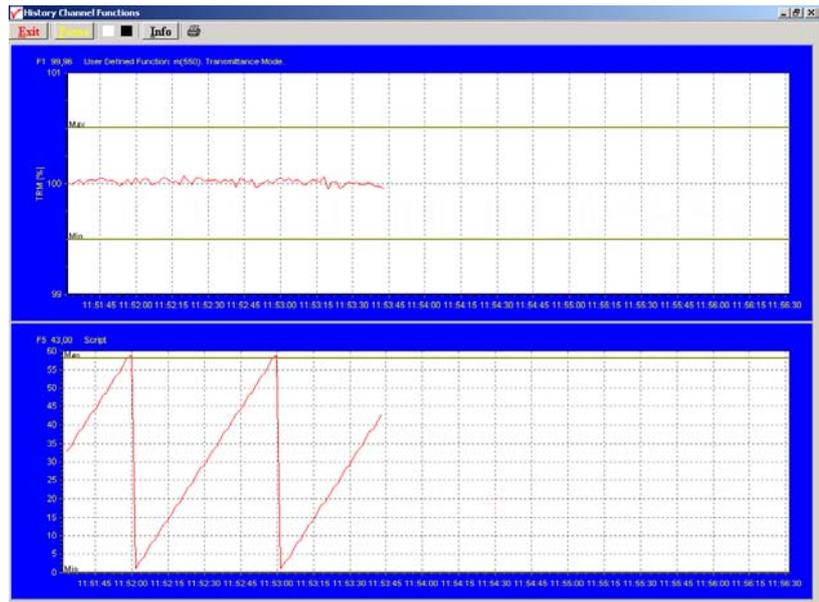
If 'Invert' is selected, the corresponding output pin will be set high if the history channel output value exceeds the maximum value OR is smaller than the minimum value. It will be set low if the history channel output value lies between the minimum and maximum value.

If you want to monitor both threshold values, you can assign two (identically configured) history channels.

To monitor a single level, set one threshold value to the desired level, and the other one to a value that is out of range, e.g. Min to -99999999 and Max to 1000, or Min to 2000 and Max to 99999999.

That way, you will only need a single channel per threshold value.

An example of running the History Channel functions together with the digital output signals in the Process Control application is shown in the figure at the right.

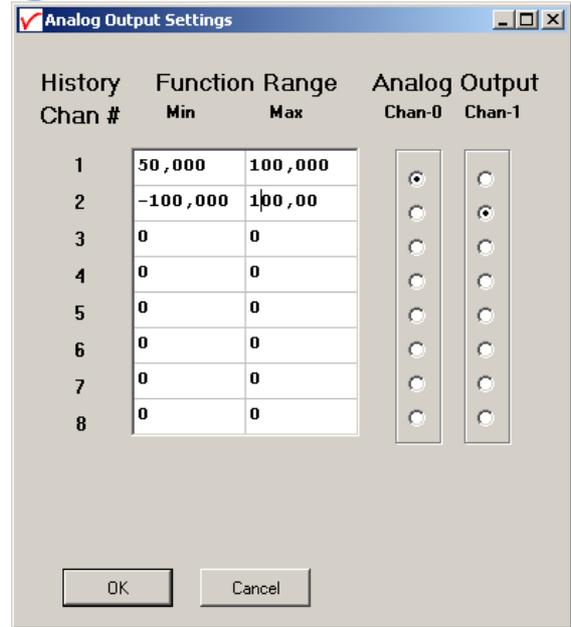


In this example, two History Channel functions were defined. The threshold values for function F1 were set at 99.5 and 100.5 percent transmittance, for function F5 at 0 and 58. These values are represented by the horizontal lines in the graphs.

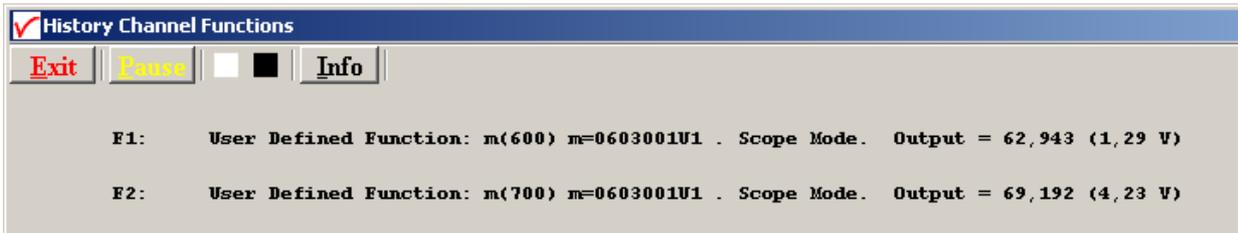


To specify the History Channel Function range(s) that should be converted into a 0-5V analog output signal, select 'Application', 'Process Control', 'Analog Output Settings'.

Two analog output signals can be assigned to any history channel. The Chan-0 output is sent to pin 17, and the Chan-1 output to pin 26 of the HD DB26 connector



The calculated voltage will be printed between parentheses after the function value in the History Channel and Time Series screens:



In this example, with the Min and Max Function Range settings according to the Analog Settings dialog above, the voltage at pin 17 and pin 26 are calculated by:

F1: Output = 62.943, corresponds to $5.0 * (62.943 - 50.0) / (100.0 - 50.0) = 1.29V$

F2: Output = 69.192, corresponds to $5.0 * (69.192 - -100.0) / (100.0 - -100.0) = 4.23V$

Appendix A USB driver installation

As mentioned in section 2 (AvaSoft Installation), AvaSoft supports under the 32bit Windows Operating Systems (XP, Vista, Windows7) two USB drivers:

- The Avantes kernel driver, which has been the standard USB driver on all 32bit O/S until May 2011.
- The MicroSoft WinUSB driver. This driver has been the standard on Windows 64bit O/S.

Installing the WinUSB driver will be the standard on all Windows O/S, except for ancient Windows versions that lack WinUSB driver support (like Windows 2000 and Windows98).

At PC's where the Avantes kernel driver was installed before, a dialog is shown in which the user can select to update to the WinUSB driver or to keep the Avantes kernel driver.

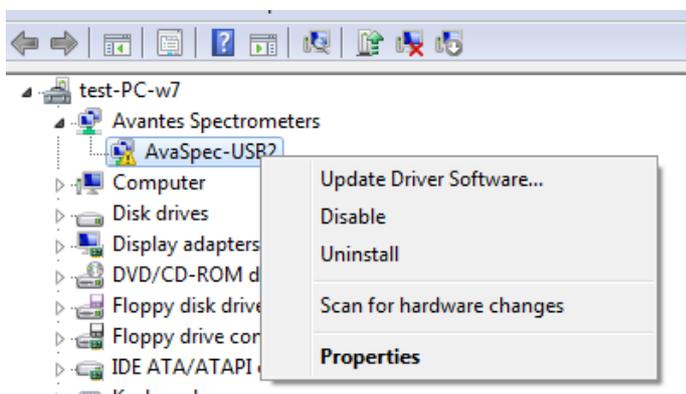
In this Appendix, some compatibility issues will be described that may occur after upgrading to winusb:

1. After installing the WinUSB driver and connecting the AvaSpec-USB2 spectrometer, the spectrometer cannot be found.
2. After installing the WinUSB driver, the spectrometers first worked fine, and the Device Manager shows a proper installation of the WinUSB driver. However, after installing some application software the spectrometer cannot be detected anymore. Also AvaSoft cannot detect an AvaSpec-USB2 anymore. The Device Manager still shows a proper WinUSB driver installation.
3. After installing the WinUSB driver, the spectrometer runs fine with AvaSoft, but not with other application software.

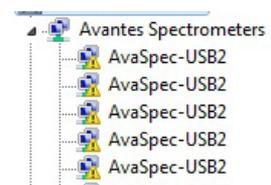
A1: Spectrometer cannot be found after update to WinUSB driver

After connecting the spectrometer to a USB port of your PC, Windows will install the device driver. If all goes well, this will be displayed in the lower right corner of your screen with the message 'Device driver software installed successfully'.

We have seen instances, where this message will not appear, and where it is necessary to open the Device Manager, to let Windows find the installed driver files. To open the Device Manager, right click 'Computer' in Windows Start menu, and select 'Properties'. Then click the "Device Manager" option.



The 'Avantes Spectrometers' entry will show a yellow triangle with an exclamation mark. Right-click the AvaSpec-USB2 line and select the "Update Driver Software" option, as shown in the figure at the left. In the next dialog, select "Search automatically for updated driver software". Windows should now find the correct files and install the driver software.



In multichannel spectrometer systems, it may be needed to repeat this step several times (once per channel)



A2: Device Manager shows a proper WinUSB driver installation, but AvaSpec-USB2 cannot be detected anymore



If the WinUSB driver has been installed properly, the Device Manager will display the connected devices without the yellow triangle with exclamation mark. AvaSoft can be executed and everything runs well. However, after installing some application software, it is possible that the spectrometer cannot be detected anymore. AvaSoft cannot detect the AvaSpec-USB2 spectrometers either. One

reason can be that the application software uses an old as5216.dll version 1.7 or earlier, as will be described below under A3.

The problem can also be caused by the installation program that installed the application software. When installing AvaSoft-Raman version 7.6.0 or earlier versions, the Avantes kernel driver (AVSUSB2.sys) will be installed, without uninstalling the winusb driver. The as5216.dll will try to communicate through the most recently installed driver (avsub2.sys), while the winusb driver is the one that is active in the Device Manager. The problem can be easily solved by reinstalling the most recent application software (AvaSoft 7.6.1, AvaSoft-Raman 7.6.1 or later). In the driver selection dialog, select the (recommended) WinUSB driver. The same situation may occur when the Avantes kernel driver is installed by other application software (AvaSoft-USB2, AvaSoft-Thinfilm-USB2, or third party applications).

A3: After installing the WinUSB driver, AvaSoft-Raman 7.6.1 (or later) runs fine, but other application software cannot detect the AvaSpec-USB2 spectrometer anymore.

Most likely, the as5216.dll version used by the other application software does not support the winusb driver. The WinUSB driver is supported by the as5216.dll since version 1.8.0.0.



Appendix B Error Messages

AvaSoft can display error messages containing a number. The following table lists these numbers and a description of the error:

| Error code | Description |
|------------|--|
| -1 | Function called with invalid parameter |
| -2 | Function called to use 16bit ADC mode, with 14bit ADC hardware |
| -3 | Opening communication failed or time-out during communication occurred |
| -4 | AvsHandle is unknown in the DLL |
| -5 | Function is called while result of previous function is not received yet |
| -6 | No answer received from device |
| -7 | Reserved |
| -8 | No measurement data is received at the point AVS_GetScopeData is called |
| -9 | Allocated buffer size too small |
| -10 | Measurement preparation failed because pixel range is invalid |
| -11 | Measurement preparation failed because integration time is invalid for selected sensor |
| -12 | Measurement preparation failed because of invalid combination of parameters (e.g. integration time > 600 seconds or averages > 5000) |
| -13 | Reserved |
| -14 | Measurement preparation failed because no measurement buffers are available |
| -15 | Unknown error reason received from spectrometer |
| -16 | Error in communication occurred |
| -17 | No more spectra available in RAM, all read or measurement not started yet |
| -18 | DLL version information cannot be retrieved |
| -19 | Memory allocation error in the DLL |
| -20 | Function called before AVS_Init is called |
| -21 | Function failed because AS5216 is in wrong state (e.g. AVS_StartMeasurement while measurement is pending) |
| -100 | NrOfPixel in Device data incorrect |
| -101 | Gain Setting Out of Range |
| -102 | Offset Setting Out of Range |
| -110 | Use of Saturation Detection Level 2 is not compatible with the Averaging function |
| -111 | Use of Averaging is not compatible with the StoreToRam function |
| -112 | Use of the Synchronize setting is not compatible with the StoreToRam function |
| -113 | Use of Level Triggering is not compatible with the StoreToRam function |
| -114 | Use of Saturation Detection Level 2 Parameter is not compatible with the StoreToRam function |
| -115 | The StoreToRam function is only supported with firmware version 0.20.0.0 or later |
| -116 | Dynamic Dark Correction not supported |