POLYPEN
RP400 & RP410

Manual and User Guide

Please read this manual before operating this product

Photon Systems Instruments

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3 TECHNICAL SPECIFICATION

Spectrum measurement	
Spectral range	380 nm - 790 nm (RP 410 UVIS) 640 nm - 1050 nm (RP 410 NIR)
Spectral response half width	8 nm
Spectral Straylight	-30 dB
Scanning Speed	About 100 ms
Dynamic Range	High gain: 1:4300 Low gain: 1:13000
Size of Aperture	7 mm
Light source	
Type	Xenon incandescent lamp
Spectral range	380-1050 nm
Data storage and transfer	
Internal memory capacity	Up to 16 Mbit
Internal data logging	Up to 4,000 measurements
Data transfer	USB cable
PC software	SpectraPen 1.1 (Windows 7 and higher)
Battery	
Type	Li-Ion rechargeable battery
Capacity	2600 mAh
Max. charging current	0.5 A
Charging	Via USB port - PC, power bank, USB charger, etc.
Battery life	48 hours typical with full operation Low battery indicator
Other	
Sample holder	Mechanical leaf-clip
Display	Touchscreen 240 x 320 pixel; 65535 colors
Built in GPS module	Ultra-high sensitivity down to -165dBm High accuracy of <1.5 m in 50% of trials
Size	150 x 75 x 40 mm
Weight	300 g
Operating conditions	Temperature: 0 to +55 °C Relative humidity: 0 to 95 % (non-condensing)
Storage conditions	Temperature: -10 to +60 °C Relative humidity: 0 to 95 % (non-condensing)
Warranty	1 year parts and labor

4 GENERAL INFORMATION

PolyPen RP400 & RP410 (in further text - PolyPen) is a portable, handheld spectro-radiometer. The PolyPen features a complete system primarily designed for a measurement of spectral reflectance of leaves or other planar samples. The system is convenient for both, indoor as well as field applications owing to an inbuilt GPS module.

The PolyPen is a self-contained instrument powered by a Lithium-ion battery which is rechargeable via a PC and a USB cable. However, it does not require a PC for operation. Reflectance spectra and calculated reflectance indices are instantly displayed on the PolyPen touch screen and all stored in the device internal memory. Integrated USB communication allows data transfer to a PC at a later time. Measured spectra and calculated indices are stored as full spectrum and individual values (respectively).

The PolyPen device integrates an internal light source (Xenon incandescent lamp) with radiation range 380 – 1050 nm. Two versions of detectors are available for UV/VIS and NIR spectral regions.

VERSIONS

- POLYPEN RP 400(410) UVIS
  Spectral response range: 380 to 790 nm.
- POLYPEN RP 400(410) NIR
  Spectral response range: 640 to 1050 nm.

The PolyPen device incorporates formulas of commonly used reflectance indices (e.g. NDVI, NDGI, PRI etc.) directly in its software and displays values of the selected indices instantly. The PolyPen allow calculation of the following pre-defined parameters:

Transmittance – calculated using the following formula

$T = I / I_0$

Where: I_0 **is reference light intensity**

I **is measured light intensity**

Absorbance – calculated data using the following formula

$A = \log(I_0/I)$

Where: I_0 **is reference light intensity**

I **is measured light intensity**

List of vegetation indices are automatically calculated for the measured sample based on the reflectance spectra.

LIST OF CALCULATED VEGETATION INDEXES:

- **Normalized Difference Vegetation Index (*NDVI*)**

Reference: Rouse et al. (1974)

Equation: $NDVI = (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED})$

- **Simple Ratio Index (*SR*)**

Reference: Jordan (1969); Rouse et al. (1974)

Equation: $SR = R_{NIR} / R_{RED}$

- **Modified Chlorophyll Absorption in Reflectance Index (*MCARI1*)**

Reference: Haboudane et al. (2004)

Equation: $MCARI1 = 1.2 * [2.5 * (R_{790} - R_{670}) - 1.3 * (R_{790} - R_{550})]$

- **Optimized Soil-Adjusted Vegetation Index (*OSAVI*)**

Reference: Rondeaux et al. (1996))
Equation: $OSAVI = (1 + 0.16) * (R_{790} - R_{670}) / (R_{790} - R_{670} + 0.16)$

- **Greenness Index (*G*)**

Equation: $G = R_{554} / R_{677}$

- **Modified Chlorophyll Absorption in Reflectance Index (*MCARI*)**

Reference: Daughtry et al. (2000)
Equation: $MCARI = [(R_{700} - R_{670}) - 0.2 * (R_{700} - R_{550})] * (R_{700} / R_{670})$

- **Transformed CAR Index (*TCARI*)**

Reference: Haboudane et al. (2002)
Equation: $TCARI = 3 * [(R_{700} - R_{670}) - 0.2 * (R_{700} - R_{550}) * (R_{700} / R_{670})]$

- **Triangular Vegetation Index (*TVI*)**

Reference:Broge and Leblanc (2000)
Equation: $TVI = 0.5 * [120 * (R_{750} - R_{550}) - 200 * (R_{670} - R_{550})]$

- **Zarco-Tejada & Miller Index (*ZMI*)**

Reference: Zarco-Tejada et al. (2001)
Equation: $ZMI = R_{750} / R_{710}$

- **Simple Ratio Pigment Index (*SRPI*)**

Reference: Peñuelas et al. (1995)
Equation: $SRPI = R_{430} / R_{680}$

- **Normalized Phaeophytinization Index (*NPQI*)**

Reference: Barnes et al. (1992)
Equation: $NPQI = (R_{415} - R_{435}) / (R_{415} + R_{435})$

- **Photochemical Reflectance Index (*PRI*)**

Reference: Gamon et al. (1992)
Equation: $PRI = (R_{531} - R_{570}) / (R_{531} + R_{570})$

- **Normalized Pigment Chlorophyll Index (*NPCI*)**

Reference: Peñuelas et al. (1994)
Equation: $NPCI = (R_{680} - R_{430}) / (R_{680} + R_{430})$

- **Carter Indexes**

Reference: Carter (1994), Carter et al. (1996)
Equation: $Ctr1 = R_{695} / R_{420}$; $Ctr2 = R_{695} / R_{760}$

- **Lichtenthaler Indexes**

Reference: Lichtenthaler et al. (1996)
Equation: $Lic1 = (R_{790} - R_{680}) / (R_{790} + R_{680})$; $Lic2 = R_{440} / R_{690}$

- **Structure Intensive Pigment Index (*SIPI*)**

Reference: Peñuelas et al. (1995)
Equation: $SIPI = (R_{790} - R_{450}) / (R_{790} + R_{650})$

- **Gitelson and Merzlyak Indexes**

Reference: Gitelson&Merzlyak (1997)
Equation: $GM1 = R_{750} / R_{550}$; $GM2 = R_{750} / R_{700}$

- **Anthocyanin Reflectance Indexes**

Reference: Gitelson et al. (2001)
Equation: $ARI1 = 1/R_{550} - 1/R_{700}$; $ARI2 = R_{800} * (1/R_{550} - 1/R_{700})$

- **Carotenoid Reflectance Indexes**

Reference: Gitelson et al. (2002)
Equation: $CRI1 = 1/R_{510} - 1/R_{550}$; $CRI2 = 1/R_{510} - 1/R_{700}$

Note: Besides the pre-defined vegetation indices, the user has the possibility to define own formula based on specific wavelengths identified. The calculation of the designed formula can be specified in the Config file of the device and subsequently automatically calculated and displayed among routinely calculated indices (please refer to page 35 for explanation).

5 COMPONENTS OF THE POLYPEN DEVICE

Carefully unpack the carton. You should have received the following items, as described in table below:

1.	**PolyPen RP400**
2.	**Reflectance standard (Spectralon®)**
3.	**Stylus**
4.	**Carrying Case**
5.	**Textile Strap for Comfortable Wearing**
6.	**This Operation Manual (PDF file on a USB flash disc)**
7.	**USB flash disc with SpectraPen software and driver**
8.	**USB Communication Module**
9.	**Other Accessories or Optional Features** (according to your specific order)

Note: If any item is missing, please, contact the manufacturer. Please check the carton for any visible external damage. If you find any damage, notify the carrier and PSI immediately. The carton and all packing materials should be retained for inspection by the carrier or insurer. For customer support, please contact us at: **support@psi.cz**

6 DESCRIPTION OF THE POLYPEN DEVICE

PolyPen is a compact, durable and lightweight device operated by single Turn ON/OFF button and touch screen (Fig. 1). PolyPen device is optimized for photo-biological applications and easy rapid measurements inside of the controlled environment as well as outside in the field. It features an innovative user interface with an integral computer, a full color touch screen display and an in-built light source. The PolyPen is equipped with a non-destructive leaf-clip sample holder. For data collection and analysis, a comprehensive software package is provided. PolyPen RP400 can be connected to PC for further data collection and analysis via USB connector.

An integral part of the PolyPen is broad-spectrum internal light source (Xenon incandescent lamp) with radiation range 380 – 1050 nm. The light beam strikes the sample under the fixed angle of incidence 35° (Fig. 2). The PolyPen system is optimized particularly for a measurement of planar samples such as leaves. Please note the variability and reproducibility of the measurement performed with more structured samples like conifer needles can be affected simply by the geometry of the measurement.

Fig. 1 PolyPen device

LEAF CLIP

PolyPen is equipped with a non-destructive leaf-clip sample holder.

COLOUR LCD DISPLAY

PolyPen is operated via a touch screen by using a supplied stylus. The software operation instructions are available on page 24.

Please note: No sharp objects should be used for touch screen operation. It is recommended to use the provided stylus.

USB CONNECTOR

USB connector is used for operation of the PolyPen device directly from PC via the SpectraPen software and for re-charging the device batteries. Please note that PolyPen device is automatically re-charged when connected to the PC via the USB connector.

POWER BUTTON

Power button is the main Switch ON/OFF button.

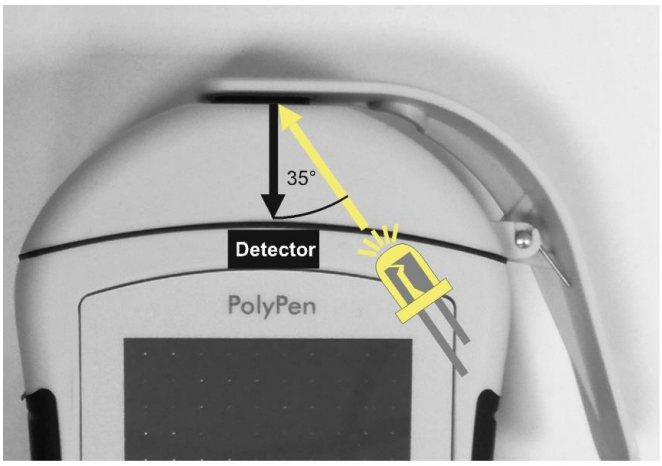


Fig. 2 Schematic drawing of the principle of reflectance measurement in PolyPen RP400 & RP410. The light source is oriented in 35° to the normal line intersecting the detector.

7 CARE AND MAINTENANCE

- Never submerge the device in water!
- The device should not come in contact with any organic solvents, strong acids or bases.
- Battery life is approximately 48 hours when the PolyPen is operated continuously.
- Use the provided stylus for the touch-screen operation. Avoid usage of any sharp objects.

8 OPERATION INSTRUCTIONS

This chapter provides instructions on an initial set-up operation of the PolyPen RP400 device as well as detailed, step-by-step description of a measurement procedure.

To switch the PolyPen ON, press the POWER BUTTON until the device logo shows up. Follow next steps to perform the measurements. In case the device battery is not charged, connect the PolyPen with USB cable via USB port to the PC and charge the batteries.

8.1 CALIBRATION

Calibration pf the PolyPen device MUST be done prior measurement after the turning on of the device. The calibration of the white reflectance standard is an indispensable part of a correct calculation of reflectance spectrum. The calibration scan must be performed always after the device switched ON or it should be periodically repeated upon certain time period of the device operation. The calibration is not needed for a simple measurement of spectra of external light sources.

For calibration of device use special reflectance standard **Spectralon®*** (Fig. 3). Calibration is required every time the device is turned ON.

** Spectralon® is a registered trademark of Labsphere.*

Please follow the instructions below for device calibration:

- In the main window go to > **Calibrate >press OK** (Fig. 4).
- Use the **Spectralon®** standard (Fig. 3) for white calibration. For dark calibration close the leaf clip only ("standard" is on bottom part of the leafclip).
- Close leaf clip.
- Press OK and wait until the calibration step is completed.
- Calibration is automatically stored into the device memory.
- After the calibration step is performed, Main window icon **Calibrate** (Fig. 4) will change into **Get reflectance** (Fig. 5). Get Reflectance – shows up after successful calibration, measures and stores reflectance spectrum.
- **Spectralon®** standard is spectrally flat over UV-VIS-NIR spectrum and optically flat to +/- 1 % over the photopic region of the spectrum.
- The device is now ready to measure other samples.

Fig. 3 Reflectance standard Spectralon®

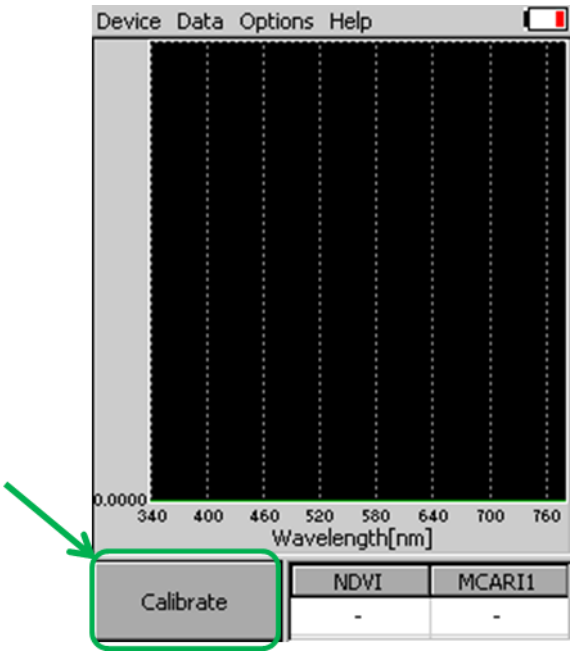


Fig. 4 Calibration of device

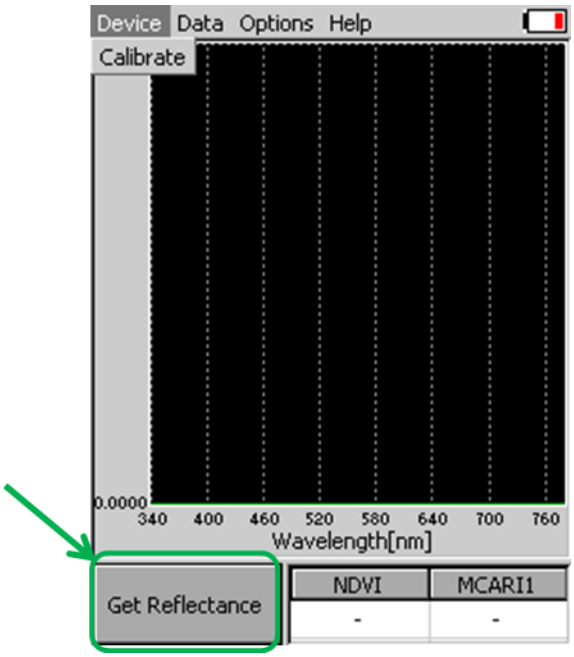


Fig. 5 Getting reflectance values

8.2 MEASUREMENT

PolyPen RP400 and RP410 are a complete systems for a measurement of **reflectance spectra** of planar samples such as leaves.

Besides the whole spectrum information, the PolyPen incorporates pre-defined formulas for calculation of commonly used plant **reflectance indices** (e.g. NDVI, NDGI, PRI, Greenness Index, etc.) directly in its software. The measured data are instantly displayed in graphs or data sheets on the device screen display. They are also stored in the device memory for later re-collection or transfer to a PC.

Please follow these instructions to perform a measurement:

- Insert a leaf sample into the leaf clip. The leaf clip is important for the sample stabilization.
- In the main window select > **Get Reflectance > press OK** (Fig. 5).

- Press OK and wait until the measurement is completed.
- Measurements are automatically stored into the device memory and displayed on the screen.
- Currently displayed graph represents **transmittance** data. Displayed graph would be switched to absorbance data in Options menu (more information in chapter 8.3).
    - **Transmittance:** the transmittance mode corresponds with reflectance in case of PolyPen device. The measured spectral data are normalized to the white calibration standard by the linear calculation: $T = I/I_0$, where I means the signal measured from the sample and I_0 is the ideal reflectance signal from the standard.
    - **Absorbance:** The measured data are normalized to the white calibration standard as the logarithmic ratio: $A = \log(I_0/I)$. This visualization mode does not have a special meaning in case of PolyPen device, as this function is important for the trans-illumination geometry measurement in PolyPen-Aqua.

INDICES TABLE

- The table displays a group of selected indices calculated for actual measured data (Fig. 6). To define the indices of interest, go to **Options > Settings > Indexes**. You can select **two indices** that are currently displayed. However all indices are calculated and stored in the device memory. Entire list of the indices can be displayed after a data download to PC. The software also allows a calculation of custom indices defined by user (please refer to page 35).

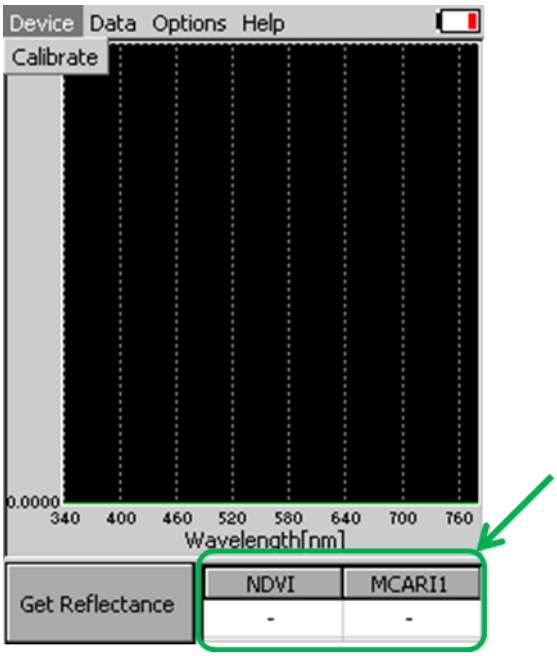


Fig. 6 Indexes table

8.3 MAIN MENU

In this chapter the settings of the optimal device parameters and features of displayed data are described.

DEVICE

Calibrate – calibration can be run any time by pressing **Device > Calibrate** after inserting appropriate standard in the leaf clip. (Fig. 7).

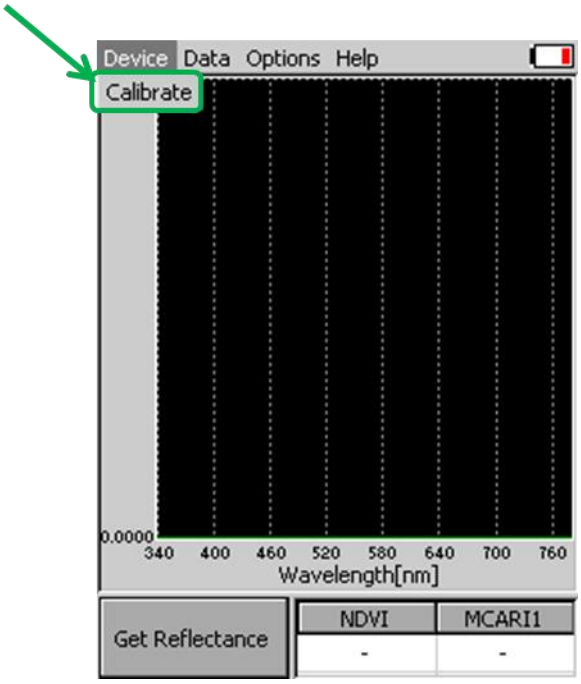


Fig. 7 Calibration of device

DATA

- **Browse** – displays data browse dialog box. The user can browse the list of stored data, select the set of data files and view the light spectra in ***Transmittance*** or ***Absorbance*** mode (**Options > Settings > > Graph**). Color classification of each data file helps user to discriminate between individual modes. Up to 3 sets of collected data can be displayed at once by checking off the last column in the data table.
- **Erase** – erase function is used to delete the internal data memory.
- **Memory info** – displays info on amount of used internal memory of the PolyPen RP400 or RP410 devices.

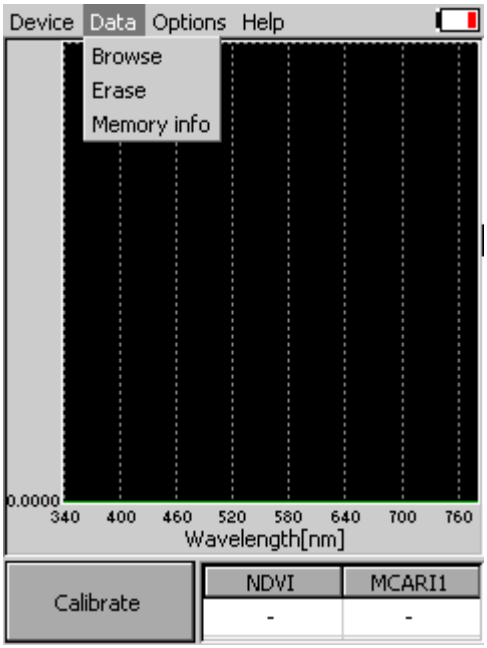


Fig. 8 Menu Data

OPTIONS

- **Settings** – function is used to set various variables for the light measurements and for the device settings (Fig. 9).
  - **Indexes -** Select indexes to be calculated and displayed on the main screen (Fig. 10).

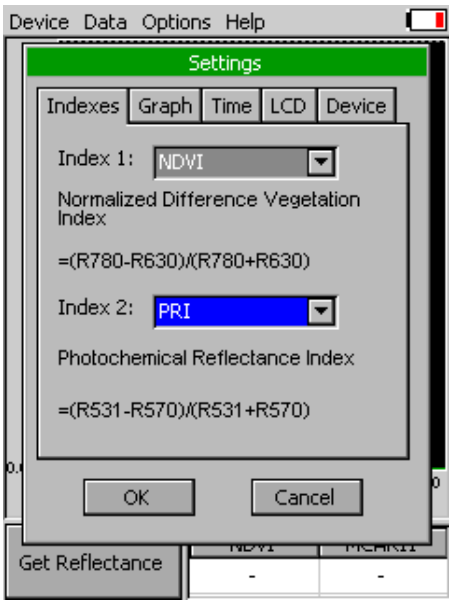


Fig. 9 Settings → Indexes

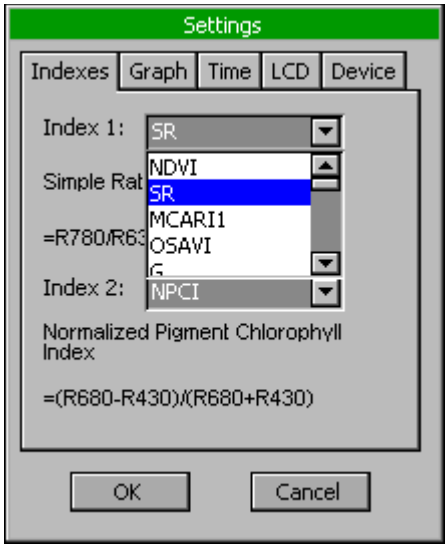


Fig. 10 Index selection

- **Graph –** displays options for setting the wavelength range and graph features (Fig. 11).

  - Zoom enable – enables the zoom feature. Select an area (in the right-down direction) of the displayed graph, which you want to zoom in. Reverse these steps if you want to return to the original graph size.

  - Marker enable – enables to display exact numeric value for the point selected in the Scope graph window. Exact wavelength and light irradiance are displayed for the point, which is selected by touching on the display. In top right corner of the LCD display the exact value of wavelength in nm is shown for the user selected position in spectra. In addition, light irradiance for the given nm is shown.

  - Smoothing – enables noise reduction of the graphical display (only on display) by smoothing the noise in the spectrum at the expense of spectral resolution. Data are not affected (calculated as moving average).
  - Absorbance – switches to absorbance mode of spectrum visualization, the raw spectral data are calculated according to the formula ($A = \log(I_0/I)$).

  - Wavelength range – defines the range of wavelengths considered for light scope and light meter measurements. Desired wavelength range can be adjusted by selecting the wavelength and by using the arrows up and down.

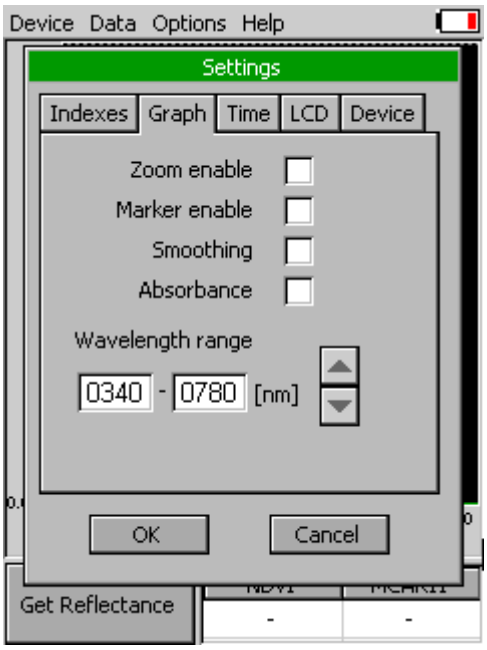


Fig. 11 Graph features

- **Time -** Set the actual time and date (all data files are stored by time and date signature).To change time, touch on one of the values and adjust it using the arrows (Fig. 12).

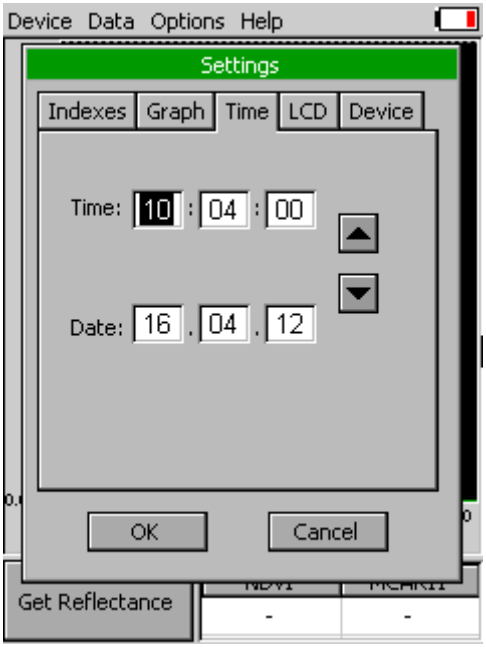


Fig. 12 Time setting

- **LCD –** is used to adjust LCD display control settings (Fig. 13).
  - *Backlight intensity* – move slider to adjust backlight intensity.
  - *Backlight time-out* – move slider to adjust backlight time-out (time of inactivity required before backlight will dim out to save battery life).

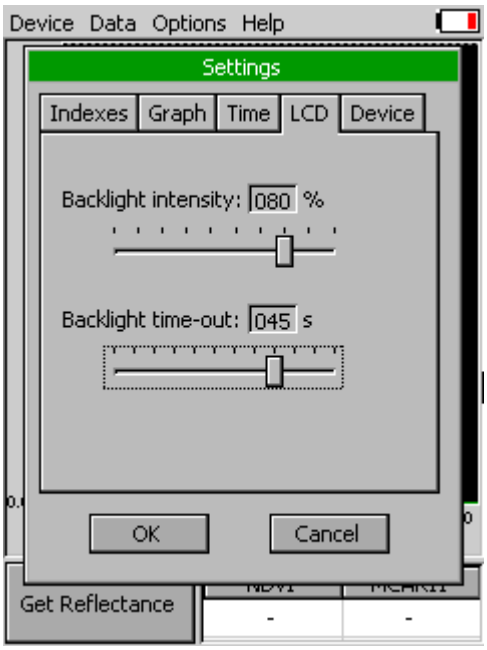


Fig. 13 Display intensity and time-out settings

- **Device**
  - *Average* – Average function is used for adjusting the number of scans for each reading. Averaging of more scans results in a higher signal-to-noise ratio but increases the time required for each reading that appears on the screen. Move slider to set the number of measurement to be acquired for averaged values (Fig. 14). Data are affected.
  - *GPS* – enables the GPS module. The GPS coordinates cannot be displayed at the device display, but they are exported together with data and visualized in SpectraPen software.

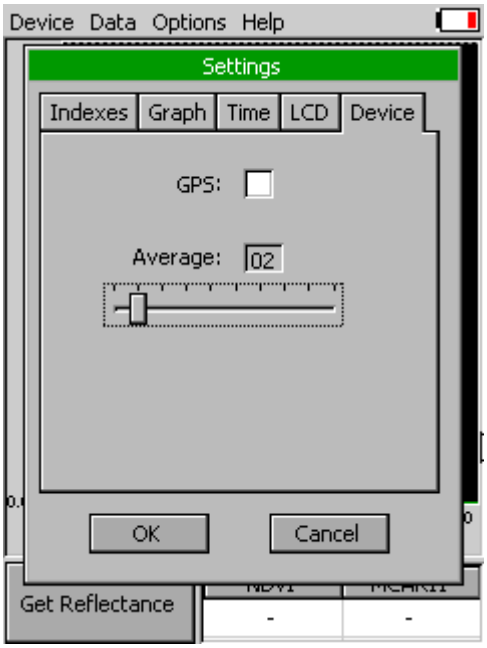


Fig. 14 Number of reading scans and GPS module function

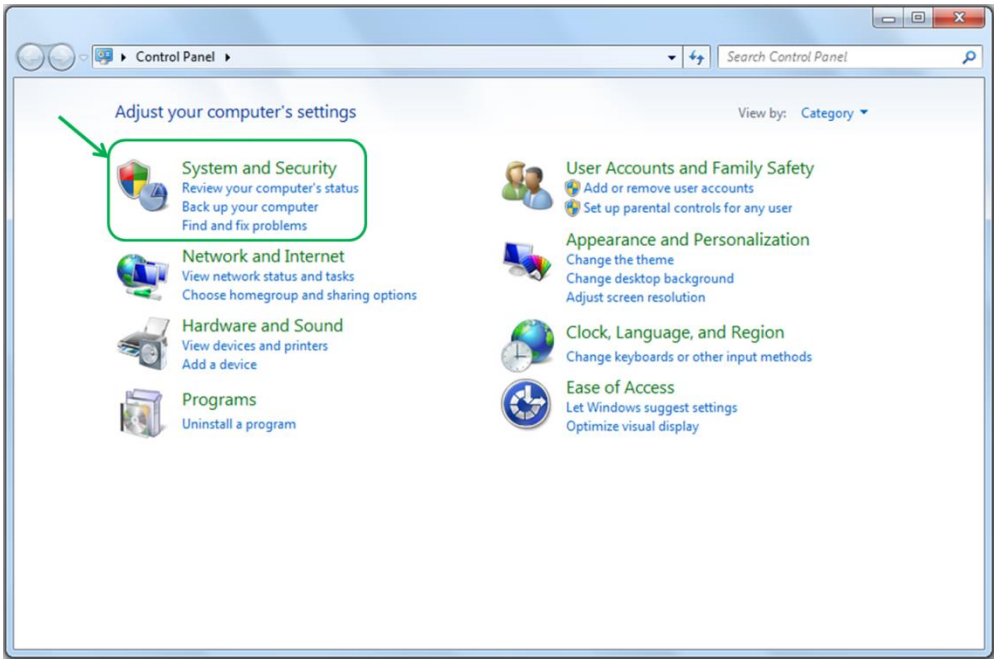
9 SPECTRAPEN SOFTWARE

PolyPen device can be connected to the PC by USB cable. For working with the data (export, check,..) the SpectraPen software is used.

9.1 DRIVER INSTALLATION

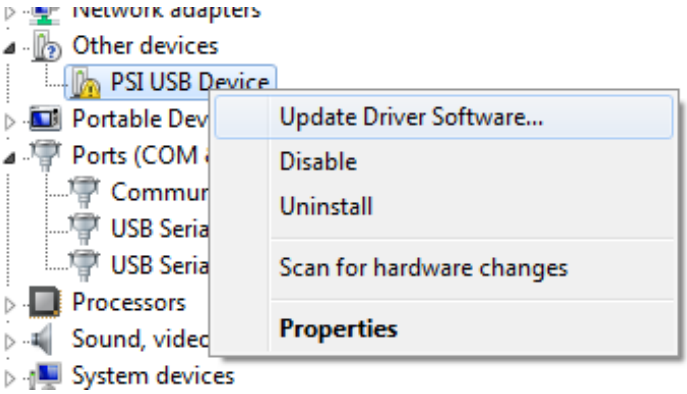
Install driver to your computer before first connection of PolyPen device to your computer. If you do not install driver to your computer, your device is not be recognized.

1. Press Start and Select **Control Panels**

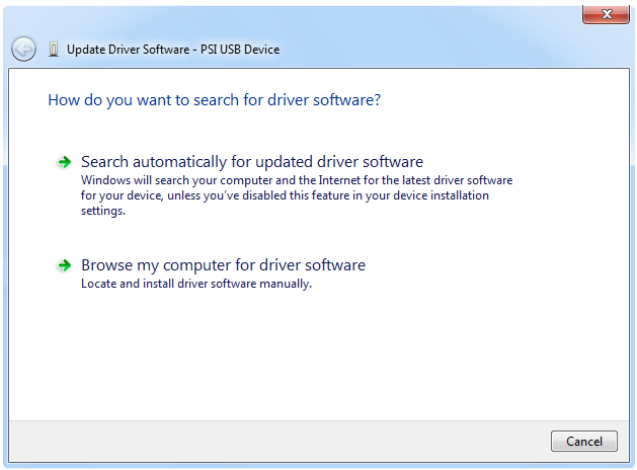


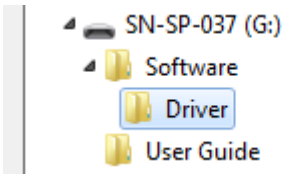
2. Navigate through **System and security and System** to **Device manager**

3. Connect the PolyPen to the PC. You should see that **PSI USB Device** appears in the list. Right click on it and select **Update Driver Software…**

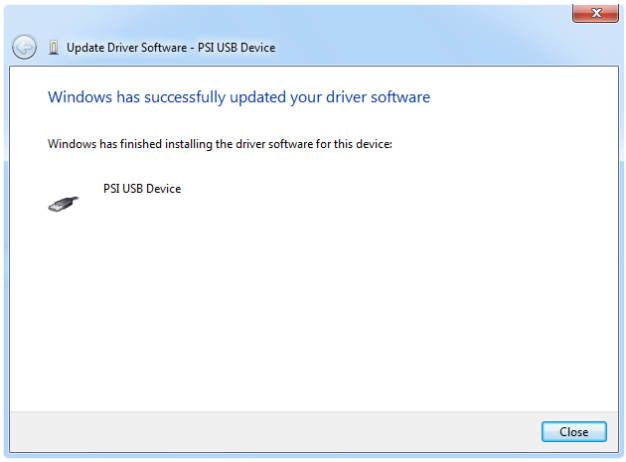


4. Click Browse my computer for driver software and select Driver folder on the PolyPen installation disk. Allow the installation even the warning table appears.





5. Installation of the driver is now complete.

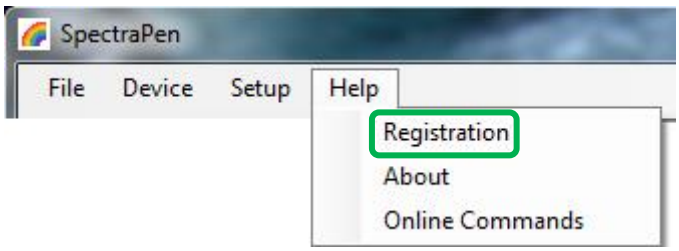


9.2 SOFTWARE INSTALLATION

1. Save the SpectraPen software provided on the USB flash disk to your computer and launch the SpectraPen program (for PolyPen is the same software like for SpectraPen).

2. To connect and recognize your PolyPen device in the SpectraPen software proceed with the registration of your SpectraPen software first.

   Go to **Help > Registration.**



   Enter your serial (registration) number. Please note that you will find your serial (registration) number in the file **SN.txt**, which is included on the enclosed USB flash disk (Fig. 15).

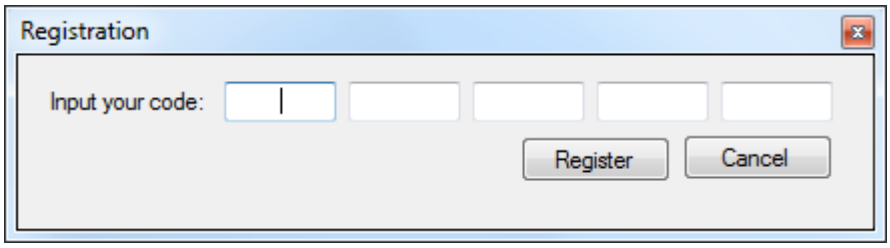


Fig. 15 Device registration step

3. Connect the USB cable with the PolyPen device. Please note that connector lock system is used.

   IMPORTANT: Be careful when connecting the USB cable with PolyPen outlet connector. It is easy to damage the cable connector if it is not positioned well in the PolyPen inlet connector. Please follow the next steps on Fig. 16:

   A) Outlet connector on PolyPen device. B) Inlet part on the USB cable. C) – E) Position the cable horizontally, plug in the inlet and screw the securing screw. F) Correct connection of the USB cable and Pen device.

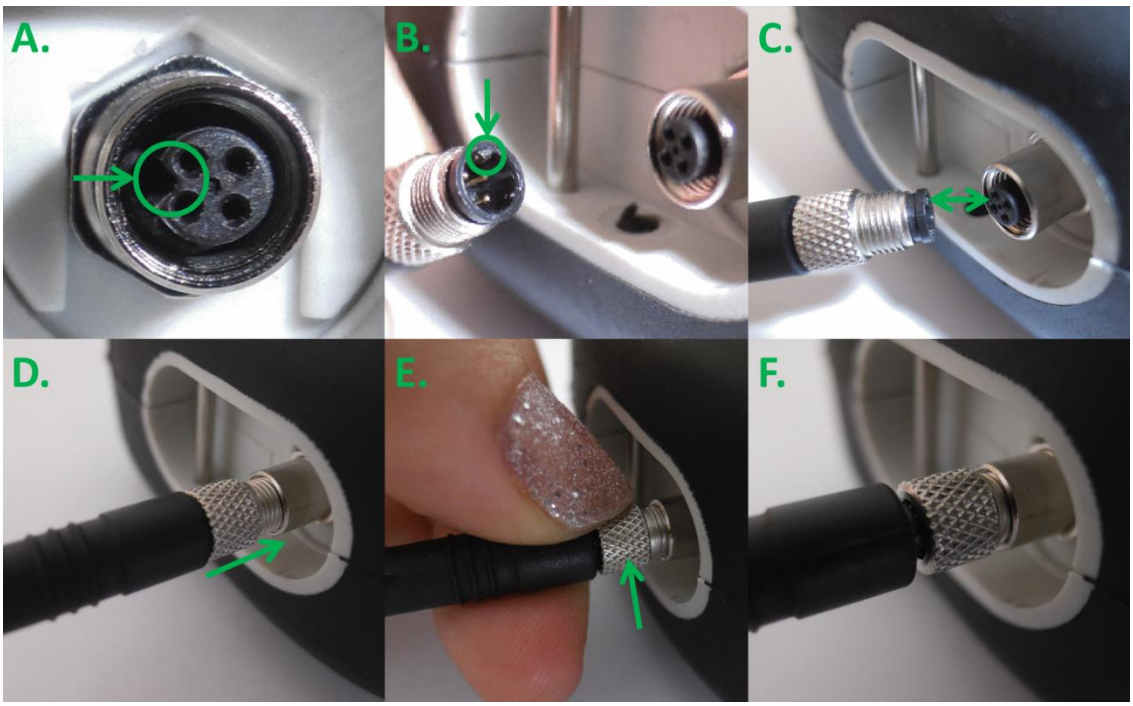


Fig. 16 PolyPen connection with PC

4. Connect the USB cable to the computer. Then switch on the PolyPen by pressing the Power button for couple of seconds.

5. Connect PolyPen device in SpectraPen software, **Device > Connect.**

6. When the device is connected properly, message "**PolyPen**" appears in the bottom left part of the screen (please note the green rectangle in the picture below) and a small USB icon will appear in the top right corner of the PolyPen device display (Fig. 17).

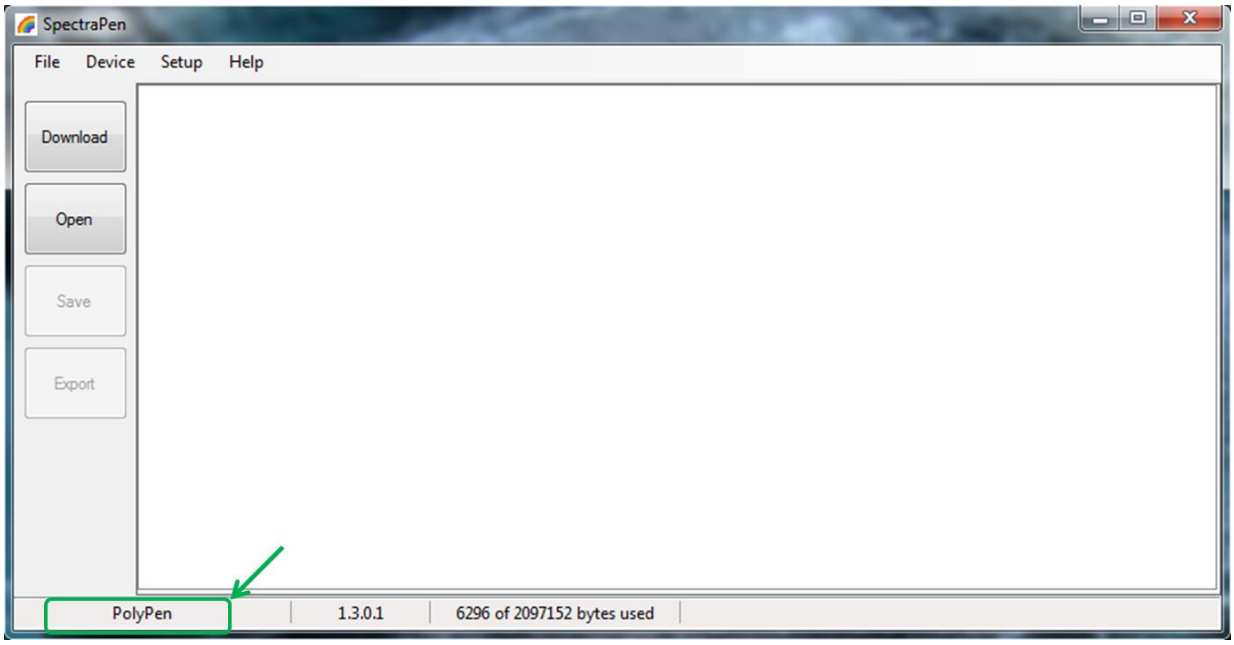


Fig. 17 PolyPen device connection in SpectraPen software

7. In case, that PolyPen device is not recognized, message **Device: Not connected** will occur in the bottom left corner (Fig. 18). Repeat the entire procedure again first and if it does not solve the problem please contact our customer support at support@psi.cz.

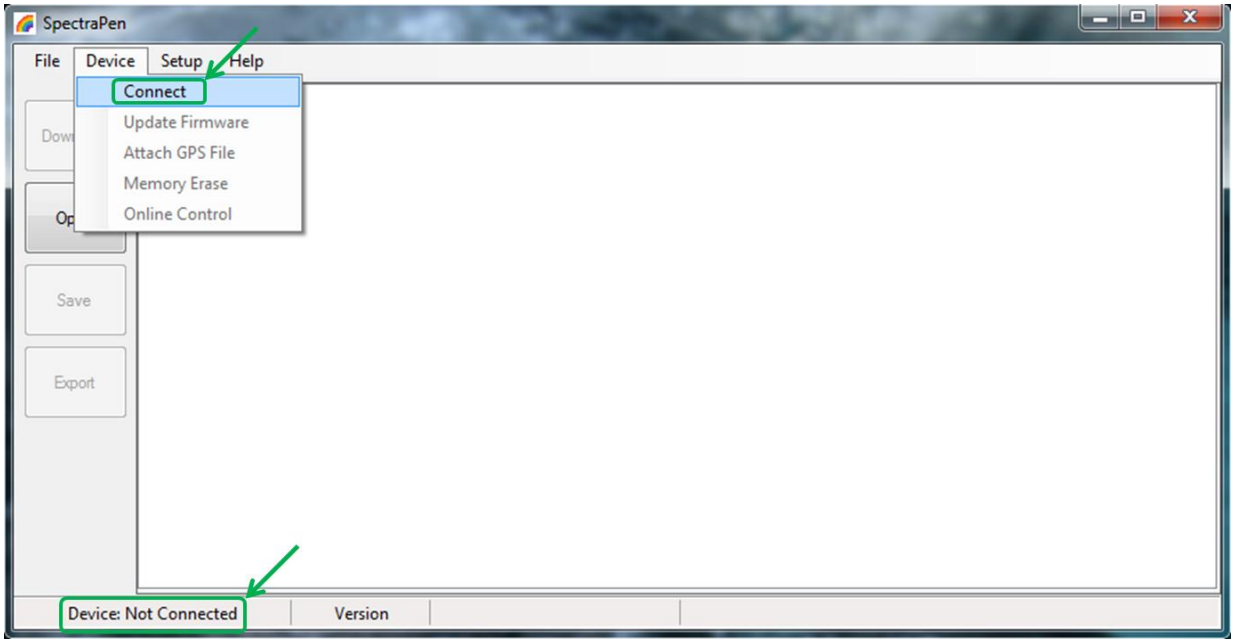
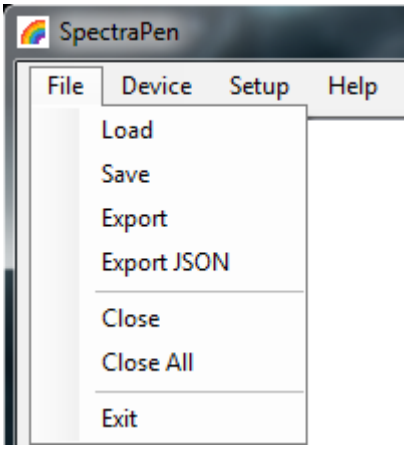


Fig. 18 Failed PolyPen connection

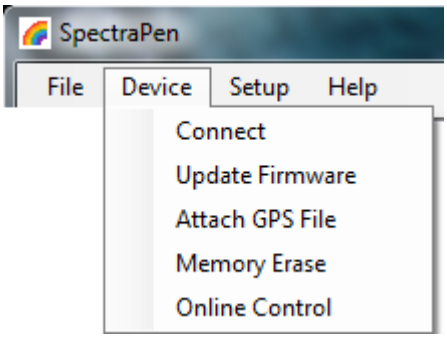
9.3 SPECTRAPEN SOFTWARE MENU

Menu: File



Load	Loads previously saved data files.
Save	Saves data to hard disc.
Export	Exports data in .txt format.
Export JSON	Exports data in JavaScript Object Notation.
Close	Closes the current experiment.
Close All	Closes all running experiments.
Exit	Exits the program.

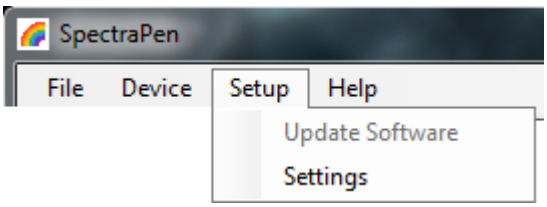
Menu: Device



Connect	Detects and connects the device.
Update Firmware	Used for firmware updates.*
Attach GPS File	Used for download data from GPS module.
Memory Erase	Erases data from the PolyPen memory.
Online control	Used for online control from PC.

** For more information on firmware updating, see Chapter Firmware Update of this Operation Manual.*

Menu: Setup



Update Software	Used for software updates.
Settings	On/off – Auto memory erase after download.
	Selection of data separator after its download.

Menu: Help

Registration	Used for the SpectraPen software registration.
About	Offers basic information about the SpectraPen application.
Online Commands	Online commands description.

9.4 DATA TRANSFER AND VISUALIZATION

To download, visualize and further process of the measured data, please follow the next instructions:

1. Perform the measurement and connect the PolyPen device to the computer.
2. Launch the SpectraPen software and **Connect** the device. Go to **Device > Connect**.
3. To visualize the stored data use the ***Download*** function to transfer your data from the PolyPen device to your PC. Select icon on left side of screen or go to ***File*** and select ***Load*** if you want to process data stored in PC.
4. All data stored currently in the PolyPen device will be shown in the main window view. The data are logged with the time of measurement.

   Please note, that if there are no data stored in the memory, the download function is not available.
5. **Visualization modes: Scope** mode window is always displayed at the first (Fig. 19). To visualize the measured data in transmittance or absorbance mode, go to **Transmittance** or **Absorbance** bookmark (Fig. 20, Fig. 21).

   - **Scope:** the measured data are normalized to dark spectrum scan. This mode is ideal for visualization of measured spectra of external light sources.
   - **Transmittance:** the transmittance mode corresponds with reflectance in case of PolyPen device. The measured spectral data are normalized to the white calibration standard by the linear calculation: $T = I/I_0$, where I means the signal measured from the sample and I_0 is the ideal reflectance signal from the standard.
   - **Absorbance:** The measured data are normalized to the white calibration standard as the logarithmic ratio: $A = \log(I_0/I)$. This visualization mode does not have a special meaning in case of PolyPen device, as this function is important for the trans-illumination geometry measurement in PolyPen-Aqua.

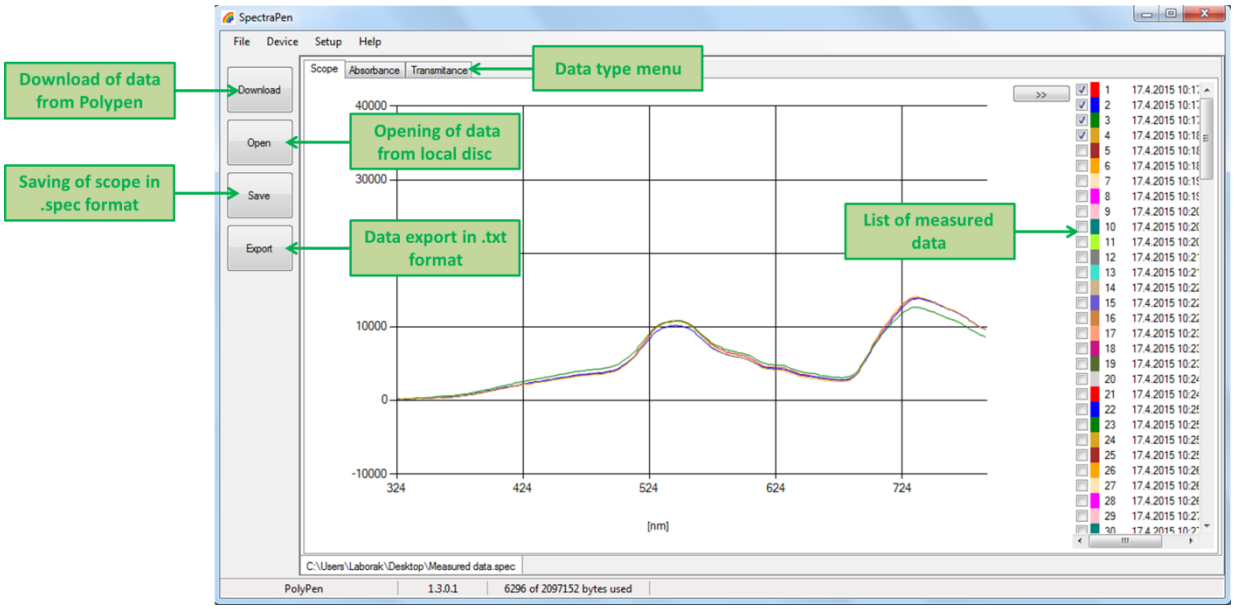


Fig. 19 Scope spectra

6. All data, that are downloaded from PolyPen device, are displayed in the Scope window. The user can select the set of measurements to be displayed by marking and unmarking the data from the selection list (see Selection of data in the right side of the Fig. 19).

7. Marker feature is available in the graph. This marker enables displaying of the numeric values for wavelength and transmittance or absorbance for the selected wavelength of the scan (Fig. 22). Use the mouse to select the given point. In top right corner of the graph is shown exact value for the selected point in nm (x-axis) and values on y-axis.

8. "Draw" rectangle by left mouse click around the area you would like to zoom in (Fig. 23). If you want to reverse these steps and return to original display, use minus icon in the corners of the zoom area as depicted by green arrows in Fig. 23.

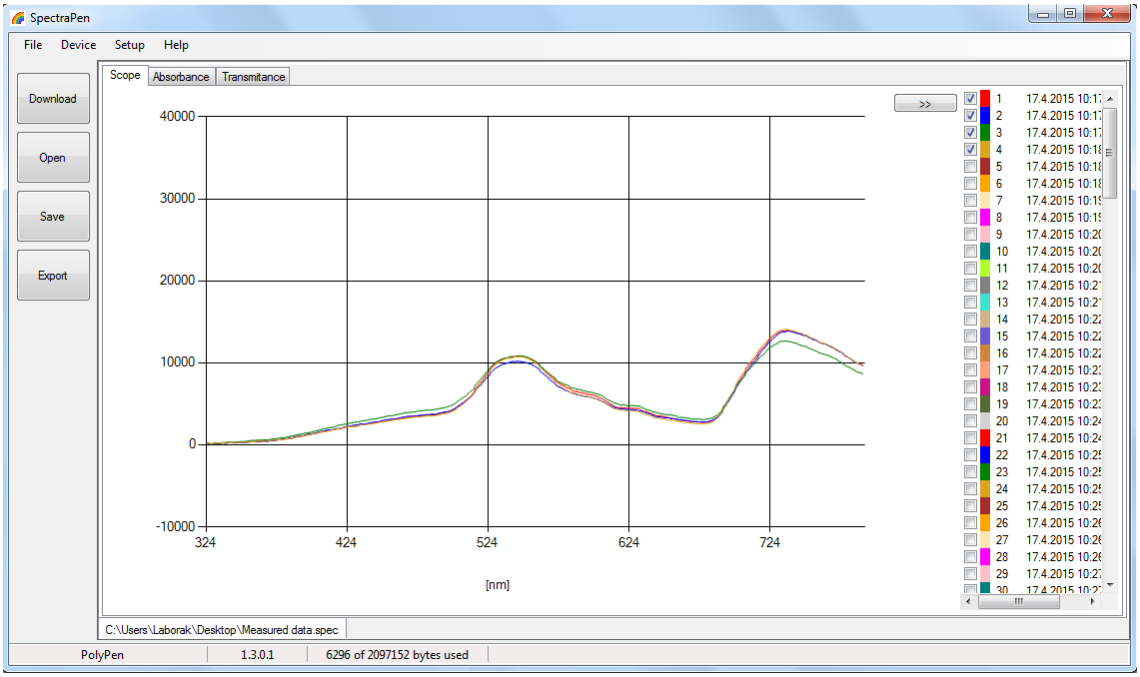


Fig. 20 Absorbance

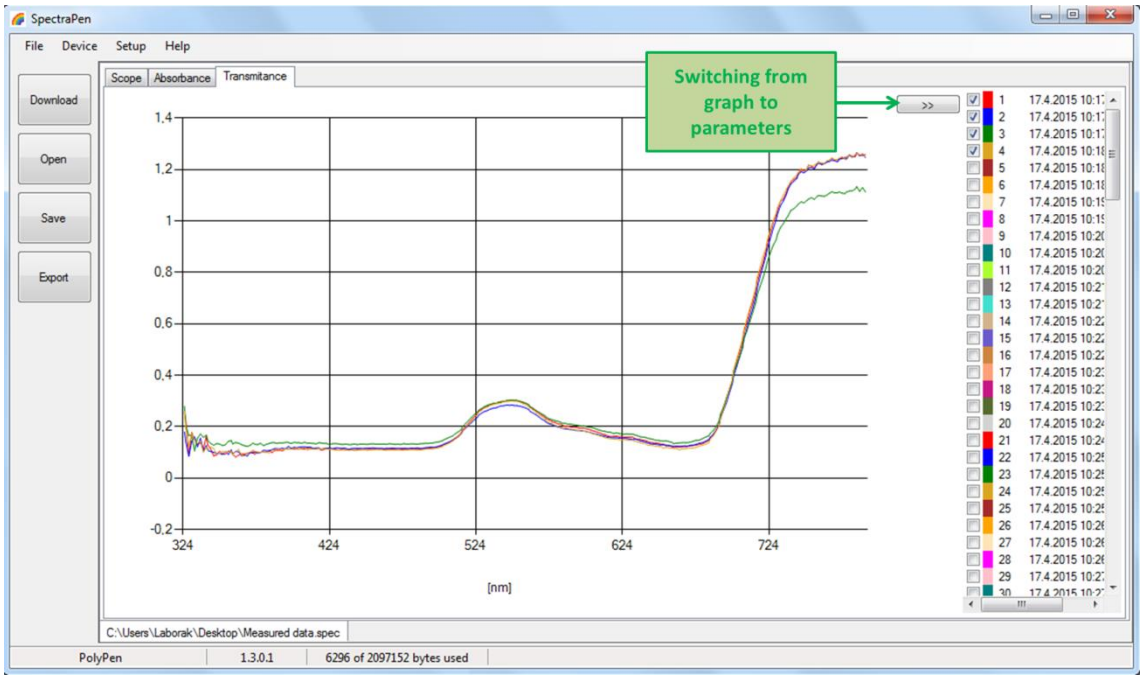


Fig. 21 Transmittance

9. Go to Absorbance or Transmittance bookmark to view the measured data.

10. To view the spectral data in parameter values (Fig. 24) click to button with two arrows (Fig. 21). If you want to calculate your own index, you can do it from the raw data in Excel or you can add this formula to the Config/Formulas.txt in the PolyPen program folder. Syntax is very simple, for example:

    Transmittance:CRI2:Caroteniod Reflectance Index 2:1/Transmittance[510nm]-1/Transmittance[700nm]

    Each parameter is separated with colon: the first one is data set, which will be used as source data (leave there Transmittance); the second is name of the created parameter; the third is description of created parameter and the last one is formula of the new parameter. After you edit the Formulas file, restart the SpectraPen software. Your index should appear in the list and also in the exported data.

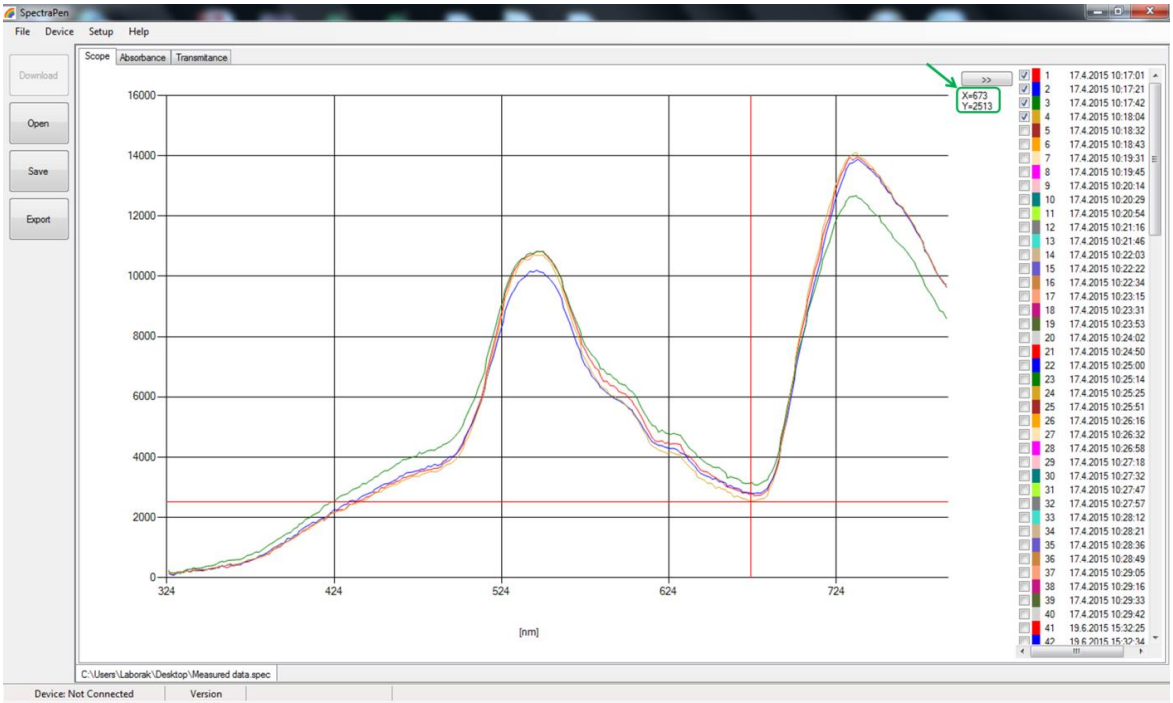


Fig. 22 Marker feature

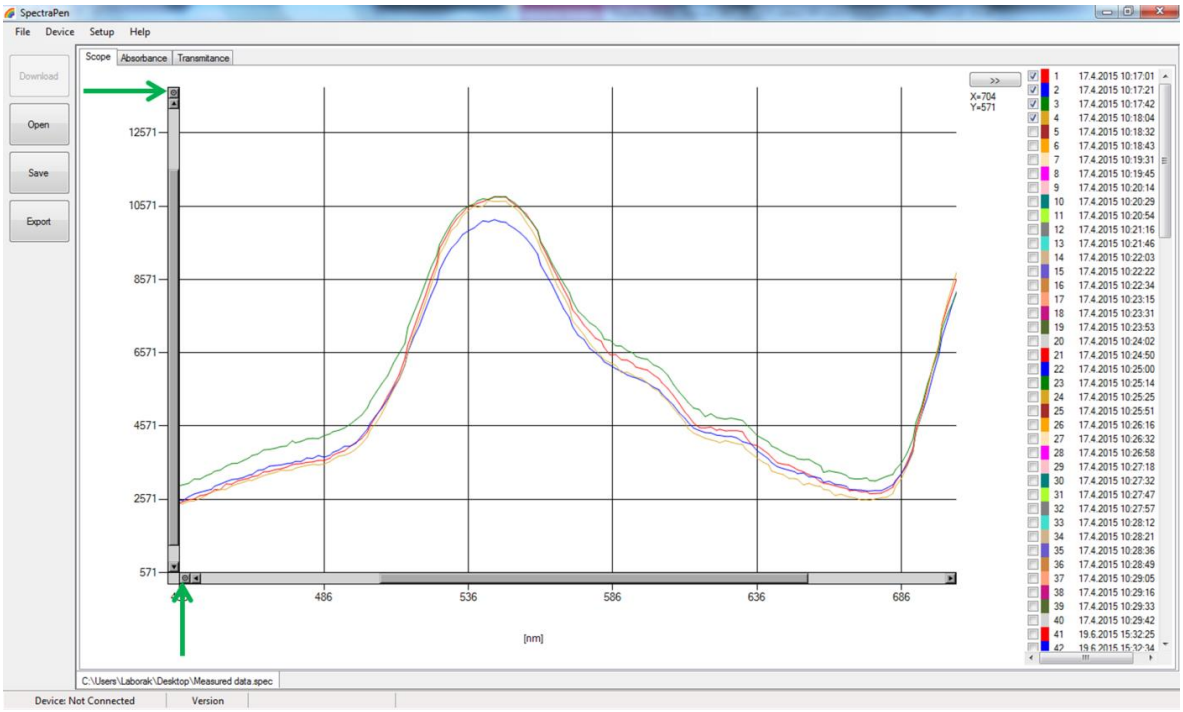


Fig. 23 Zoom feature

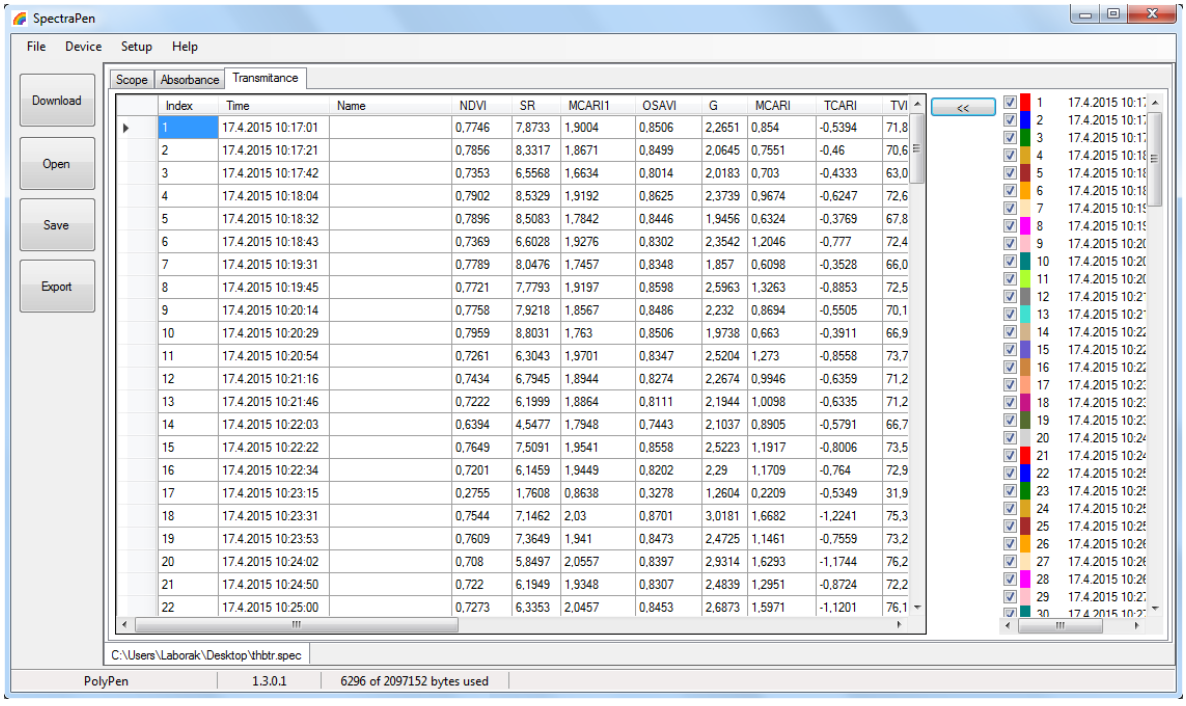


Fig. 24 Transmittance – reflectance indexes

11. To save the experiment go to **File > Save**. All data stored in the device memory will be saved irrespective of the file selection in the online window. The file will be stored in .spec format. Spec files store all Scope and Light meter data.

12. Acquired scan data and numeric data can be exported for further processing. Go to **File > Export** to export the data in .txt format.

    Export function allows the user to specify the type of data, that should be exported (Fig. 25). The options are:

Spectrum – all raw data for the whole spectral range and all wavelengths are exported including data for the dark scan.

Spectrum scope – the measured data are normalized to dark spectrum scan. Exported data can be exported for all measured scopes or only for selected scopes.

Spectrum Transmittance – transmittance data for all measurements are exported. The transmittance data are normalized to white calibration standard and thus express the reflectance from the sample.

Spectrum Absorbance – absorbance data for all measurement are exported. Data in absorbance mode are normalized to white calibration standard by logarithmic calculation.

Computed Data – export of the reflectance indices for Scope, Transmittance or Absorbance of all of the measurements.

Export interpolation – interpoled data are read every 1 nm, they are the same such as raw data.

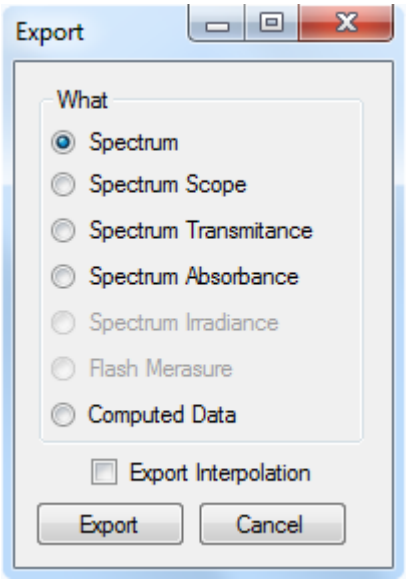


Fig. 25 Export menu

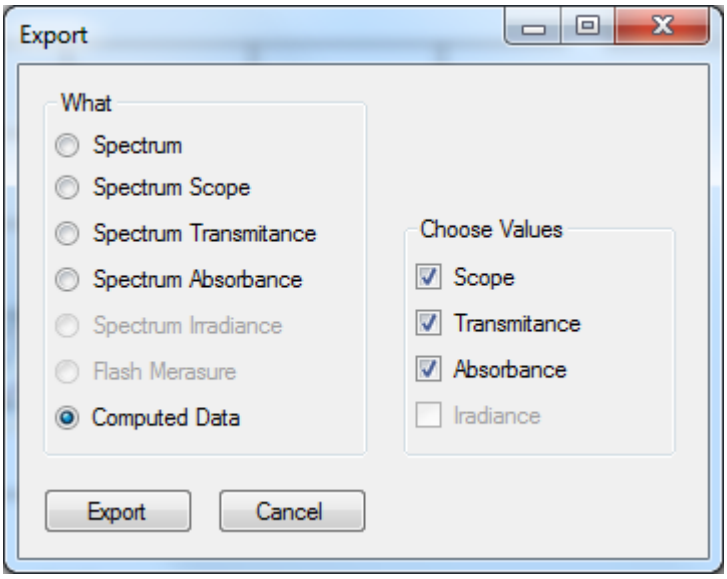


Fig. 26 Export – Computed data selection and choosing of exported values

9.5 ONLINE CONTROL

Online control serves for operation of the PolyPen device in SpectraPen software after the connection with PC. The measurement, changes in settings and measurement repetition can be set through online control.
Go to **Device > Online Control** in SpectraPen software.

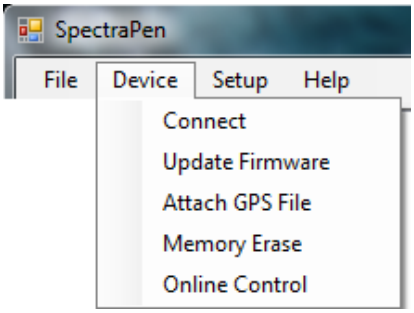


Fig. 27 Online Control

Reflectance/Absorbance

You can use button **Get** for obtaining the reference information (Fig. 27-1) and button Get for immediate measurement (Fig. 27-2) of reflectance or absorbance. In online control can be set measurement repetition. Click to button **…** (Fig. 27-3), select Use settings (Fig. 27-4), fill the pause between the measurement in seconds (Fig. 27-5) and confirm it by button **OK** (Fig. 27-6). Measured data can be exported to the .csv file by button **Export** placed under the reflectance scope or be deleted by button **Clear**.

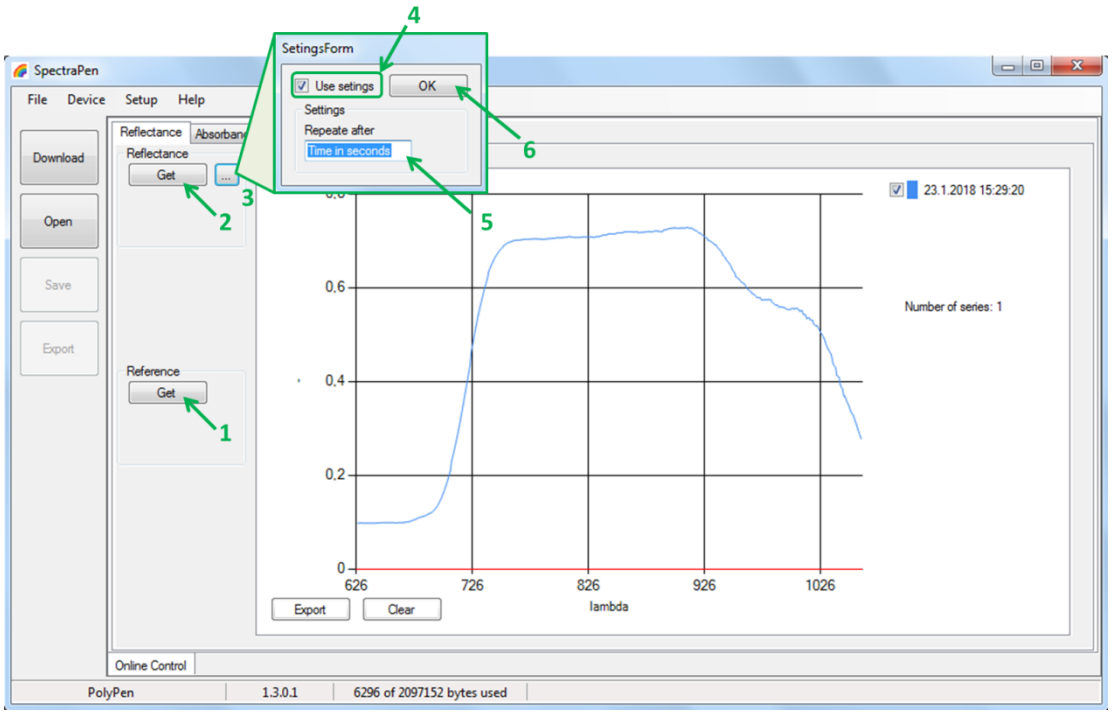


Fig. 27 Setting of reflectance or absorbance measurements in online control

Settings

- Time synchronization with computer time (Fig. 28-1).
  Device > Online Control > Settings > Sync > OK
- GPS – After GPS module is enabled, it begins acquiring satellite signals. Exported data then has GPS coordinates mark (Fig. 28-2).
- Average – Average function is used for adjusting the number of scans for each reading (Fig. 28-3).

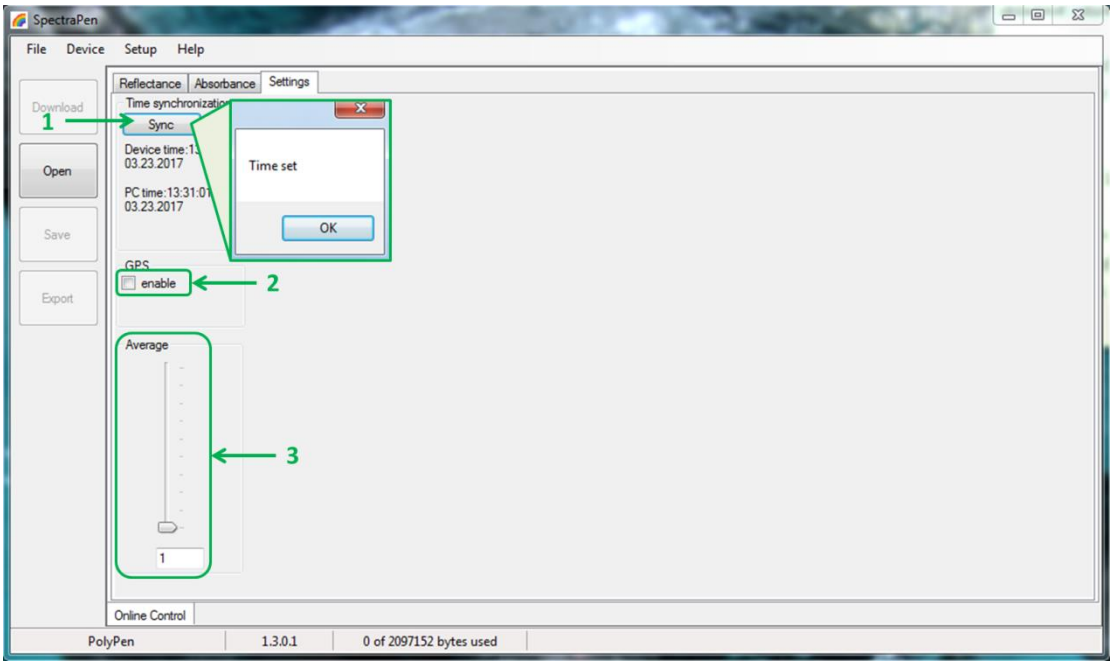


Fig. 28 Settings of online control

9.6 FIRMWARE UPDATE

Important note!

All data in the PolyPen memory are erased during the firmware update!

Before starting any firmware update, export all your data from the PolyPen memory into your computer!

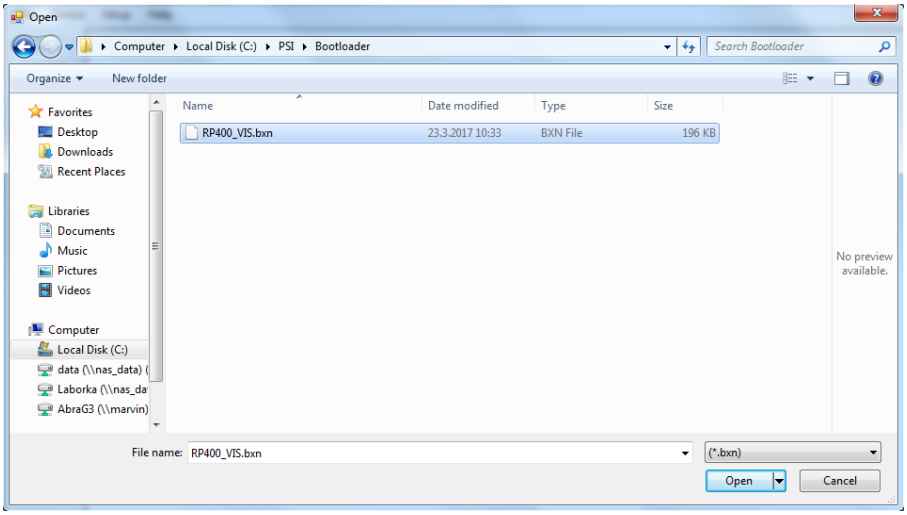
Step 1: Starting Update

Select: Device > Update Firmware

Step 2: Selecting .bxn File

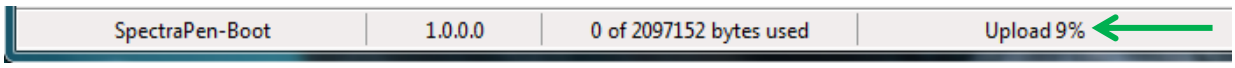
Find: Binary file (with the extension .bxn)

Select: Open



Step 3: Finishing Upload

Select: “OK” to start uploading of the update. Upload progress is indicated in the status bar.



10 GPS MODULE

PolyPen device has integrated GPS module which can be turned on during the measurement and the GPS coordinated will be added to the exported data in *txt file.

10.1 GPS / POLYPEN OPERATION

Step 1: Setting Time

Check the time setting: **Options > Settings > Time**. If there is a wrong time and date, set the actual time and date according to your time zone (Fig. 12).

Step 2: GPS Positioning

Switch the GPS module on: (Fig. 29) **Options > Settings > Device**

Wait until the GPS position is found. The GPS module is ready when the icon of the position flag, in upper panel, stops flashing (Fig. 30).

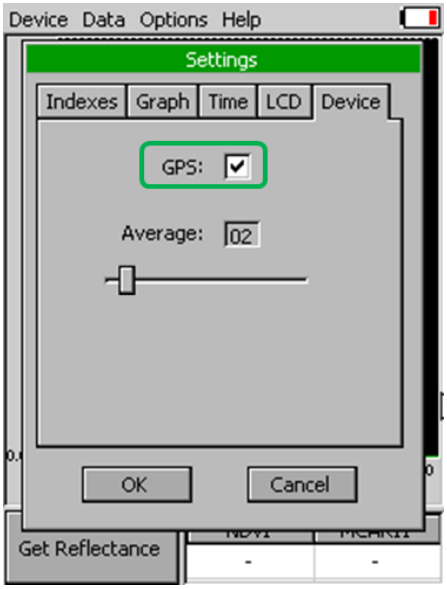


Fig. 29 Switching on the GPS module

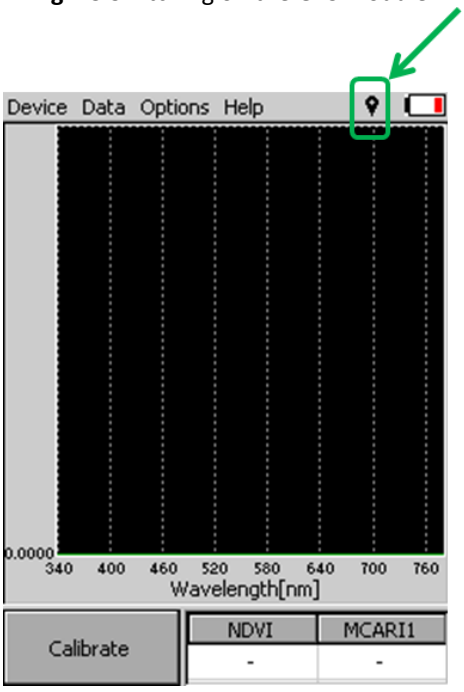


Fig. 30 GPS icon

Step 3: Measurement

Provide the calibration of the device (if not done previously) and measure the reflectance indexes and scopes of your sample.

Step 4: Export the data with GPS coordinates

Export the computed data from the SpectraPen software. All the measured data will have GPS coordinate mark (Fig. 31).

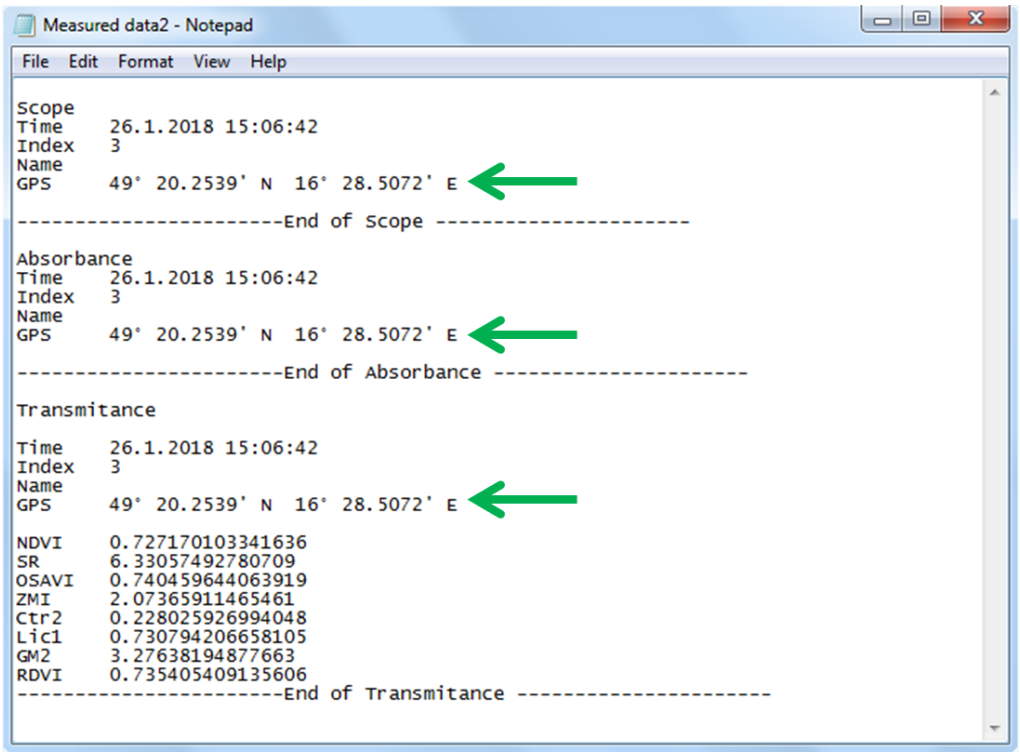


Fig. 31 Exported data with the GPS mark

11 HOW CAN I PROGRAM MY OWN INDEX IN THE POLYPEN RP 400

Two possibilities exist to define a custom index:

1. Offline calculation of the desired index from raw spectral data in Excel (independently on SpectraPen software).
2. Adding the custom formula to the list of pre-defined parameters in the PolyPen software.
    a. Write a custom formula in the file Formulas.txt located in folder Config (Fig. 32) in the main PolyPen program folder.
    b. Please follow the parameter syntax. For example - the definition of SAVI index:

    Transmitance:SAVI:Soil-Adjusted Vegetation Index:(1+0.5)(Transmitance[780nm]-Transmitance[670nm])/(Transmitance[780nm]+Transmitance[670nm]+0.5)*

    - Each index description part is separated with colon.
    - The first part is a data set source data (e.g. *Transmittance*).
    - The second part is a name/title of the index (e.g. *SAVI*).
    - The third part is a detailed description (e.g. *Soil-Adjusted Vegetation Index*).
    - The last part is a formula of the defined parameter (e.g. *(1+0.5)*(Transmitance[780nm]…)*).

    c. Restart the SpectraPen software after editing of the Formulas.txt file.
    d. New index appears in the list and also in the exported data (Fig. 33).

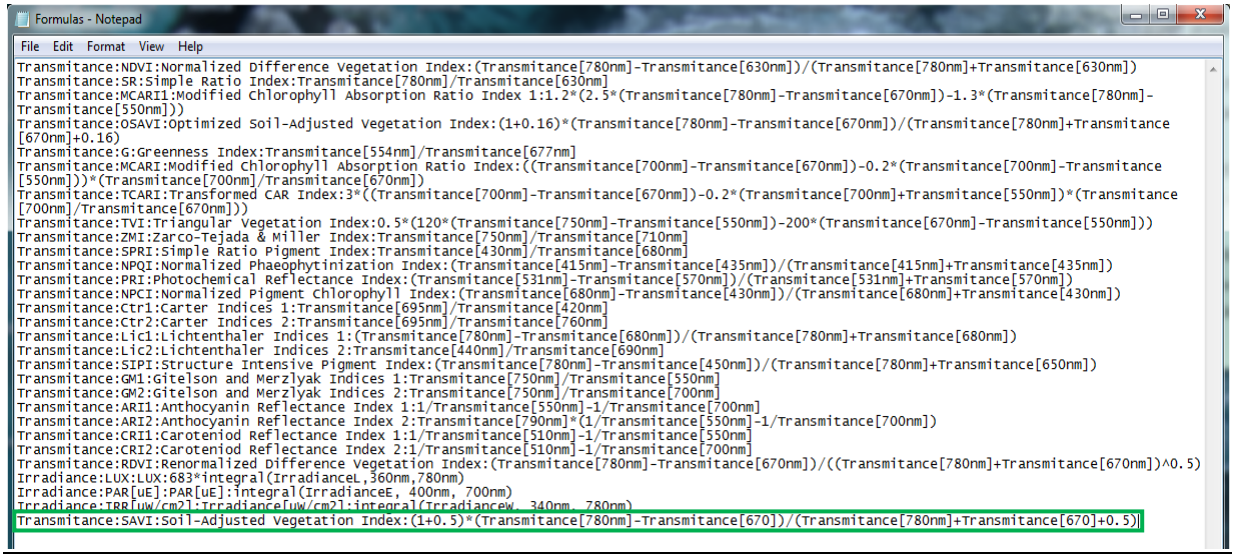


Fig. 32 Formulas configuration file – adding new index

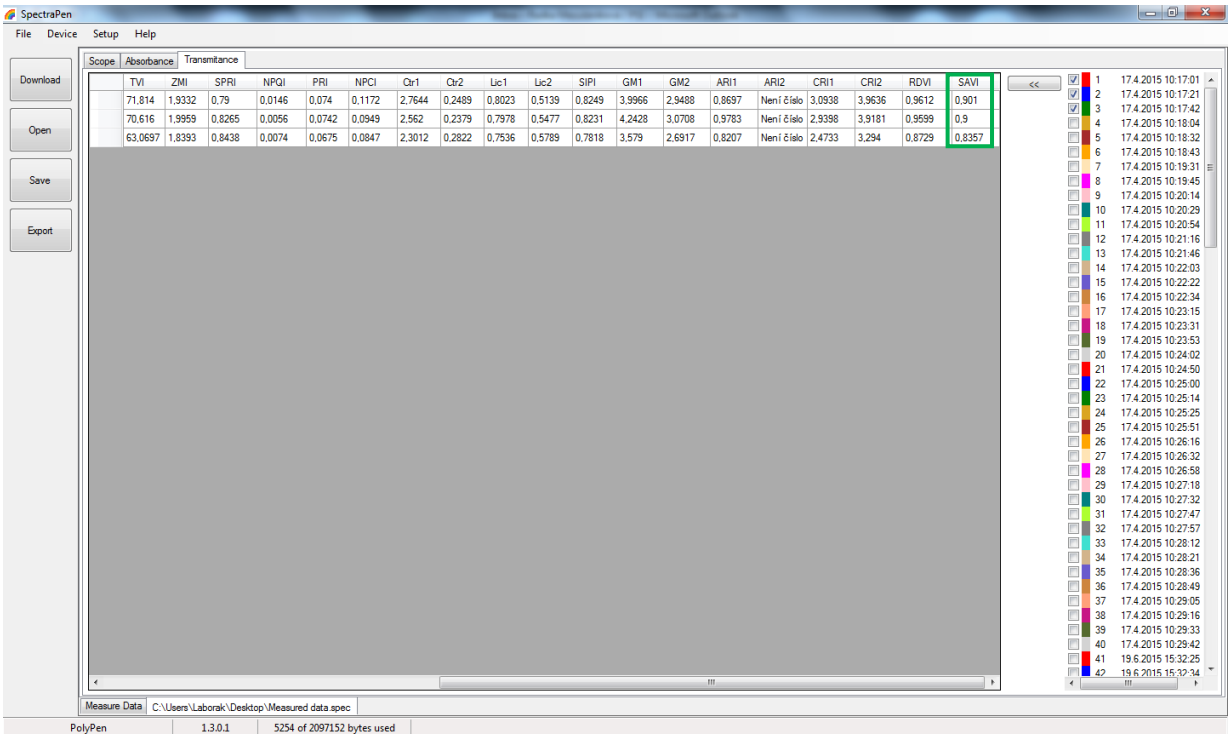


Fig. 33 Downloaded data with new index

11.1 FUNCTION DESCRIPTION

It is possible to use different mathematical functions for definition of new indices:

min, max -

min(value1, value2)

value1 - number, variable, function

value2 – number, variable, function

- only one value can be function!

min(array)

array – array of numbers

example1: max(Transmitance)
example2: min(Irradiance)
example3: min(Transmitance[760nm], max(Transmitance[450], Transmitance[680]))
example5: max(Transmitance[550nm], (5+4)*4)

---

ln – the natural (base e) logarithm of specified number

ln(value)

value – number, variable, function

example1: ln(5)
example2: ln(Transmitance[760nm])
example2: ln(max(Transmitance[550nm], Transmitance[480nm]))
example5: ln((5+4)*4)

---

log – the logarithm of specified number in a specified base.

logB(value)

B – base - number

value – number, variable, function

example1: log2(5)
example2: log5(Transmitance[760nm])
example3: log10(max(Transmitance[550nm], Transmitance[480nm]))
example4: log10((5+4)*4)

---

sqrt – the square root of a specified number
sqrt(value)
value – number, variable, function

example1: sqrt(5)
example2: sqrt(Transmitance[760nm])
example3: sqrt(max(Transmitance[550nm], Transmitance[480nm]))
example4: sqrt(((5+4)*4) + 6)

---

^ - spedified number raised to the specified power
value^power
value – number, variable, function
power – number, variable, function

example1: Transmitance[760nm]^Transmitance[550nm]
example2: min(Transmitance[760nm],Transmitance[550nm])^max(Transmitance[435nm], Transmitance[430nm])
example3: Transmitance[760nm]^0.5

---

integral - express the area under the curve of a graph of the function in the interval
integral(function_values, from, to)
function_values – input values for integral compute
from,to – limit values

example1: integral(IrradianceL, 360nm, 700nm)
example2: integral(IrradianceE, 360nm, 700nm) * IrradianceE[450]

12 STATEMENT OF LIMITED WARRANTY

- This Limited Warranty applies only to the PolyPen device and its accessories (**excluding** any batteries). It is valid one year from the date of shipment.
- If at any time within this warranty period the instrument does not function as warranted, return it and the manufacturer will repair or replace it with no charge. The customer is responsible for shipping and insurance charges (for the full product value) to PSI. The manufacturer is responsible for shipping and insurance on return of the instrument to the customer.
- No warranty will apply to any instrument that has been (i) modified, altered, or repaired by persons unauthorized by the manufacturer; (ii) subjected to misuse, negligence, or accident; (iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions supplied by the manufacturer.
- The warranty is return-to-base only, and does not include on-site repair charges such as labor, travel, or other expenses associated with the repair or installation of replacement parts at the customer's site.
- The manufacturer repairs or replaces faulty instruments as quickly as possible; the maximum time is one month.
- The manufacturer will keep spare parts or their adequate substitutes for a period of at least five years.
- Returned instruments must be packaged well and protected so as not to assume any transit damage. If damage is caused due to insufficient packaging, the instrument will be treated as an out-of-warranty repair and charged as such.
- PSI also offers out-of-warranty repairs. These are usually returned to the customer on a cash-on-delivery basis.
- *Wear & Tear Items* (such as sealing, tubing, padding, etc.) are excluded from this warranty. The term *Wear & Tear* denotes the damage that naturally and inevitably occurs as a result of normal use or aging even when an item is used competently and with care and proper maintenance.

*For customer support, please write to: **support@psi.cz***