# Instruction Guide

PHOTON SYSTEMS INSTRUMENTS

## PolyPen RP 410

**Please read the Guide before operating this product**

**Manual Version: 2023/04**

www.psi.cz

# TABLE OF CONTENT

# 1 INFORMATION BEFORE USING POLYPEN DEVICE

Read this manual carefully before operating the device. If you are not sure about something in the manual, contact the manufacturer for clarification.

| | |
|---|---|
|  | By accepting the device, the customer agrees to follow the instructions in this guide. |

Always follow corresponding manuals while working with the PolyPen device or doing the maintenance.
It is forbidden to interfere with the hardware or software of the PolyPen device in any way without previous agreement with the manufacturer.

**The following table presents basic highlight symbols used in this manual:**

| Symbol | Description |
|---|---|
|  | Important information, read carefully. |
|  | Complementary and additional information. |

**Tab. 1 Used symbols.**

# 2 GENERAL DESCRIPTION

**PolyPen RP400 & RP410** (in further text - PolyPen) is a portable, handheld spectroradiometer. 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.
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.
The built-in GPS module and splash-proof case are ideal for field use of the PolyPen and make this device well suited for wide scope of environmental, agricultural and ecological applications such as monitoring of artificial lighting used in horticulture industry or light source testing.

**PolyPen versions:**

| | |
|---|---|
| PolyPen RP 410 UVIS | Spectral response range: 380 to 790 nm. |
| PolyPen RP 410 NIR | Spectral response range: 640 to 1050 nm. |

**PolyPen measures:**

| |
|---|
| **Transmittance – calculated using the following formula**<br>***T= I/$I_0$***<br>Where: $I_0$ is reference light intensity<br>I is measured light intensity |
| **Absorbance – calculated using the following formula**<br>***A=log ($I_0$/I)***<br>Where: $I_0$ is reference light intensity<br>I is measured light intensity |

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 vegetation indices:

| |
|---|
| **Normalized Difference Vegetation Index (NDVI)**<br>Reference: Rouse et al. (1974)<br>Equation: NDVI = ($R_{NIR}$ - $R_{RED}$) / ($R_{NIR}$ + $R_{RED}$) |
| **Simple Ratio Index (SR)**<br>Reference: Jordan (1969); Rouse et al. (1974)<br>Equation: SR = $R_{NIR}$ / $R_{RED}$ |
| **Modified Chlorophyll Absorption in Reflectance Index (MCARI1)**<br>Reference: Haboudane et al. (2004)<br>Equation: MCARI1 = 1.2 * [2.5 * ($R_{790}$ - $R_{670}$) - 1.3 * ($R_{790}$ - $R_{550}$)] |
| **Optimized Soil-Adjusted Vegetation Index (OSAVI)**<br>Reference: Rondeaux et al. (1996)<br>Equation: OSAVI = (1 + 0.16) * ($R_{790}$ - $R_{670}$) / ($R_{790}$ - $R_{670}$ + 0.16) |
| **Greenness Index (G)**<br>Equation: G = $R_{554}$ / $R_{677}$ |
| **Modified Chlorophyll Absorption in Reflectance Index (MCARI)**<br>Reference: Daughtry et al. (2000)<br>Equation: MCARI = [($R_{700}$ - $R_{670}$) - 0.2 * ($R_{700}$ - $R_{550}$)] * ($R_{700}$ / $R_{670}$) |

| |
|---|
| **Transformed CAR Index (TCARI)**<br>Reference: Haboudane et al. (2002)<br>Equation: $TSARI = 3 * [(R_{700} - R_{670}) - 0.2 * (R_{700} - R_{550}) * (R_{700} / R_{670})]$ |
| **Triangular Vegetation Index (TVI)**<br>Reference:Broge and Leblanc (2000)<br>Equation: $TVI = 0.5 * [120 * (R_{750} - R_{550}) - 200 * (R_{670} - R_{550})]$ |
| **Zarco-Tejada & Miller Index (ZMI)**■<br>Reference: Zarco-Tejada et al. (2001)<br>Equation: $ZMI = R_{750} / R_{710}$ |
| **Simple Ratio Pigment Index (SRPI)**<br>Reference: Peñuelas et al. (1995)<br>Equation: $SRPI = R_{430} / R_{680}$ |
| **Normalized Phaeophytinization Index (NPQI)**<br>Reference: Barnes et al. (1992)<br>Equation: $NPQI = (R_{415} - R_{435}) / (R_{415} + R_{435})$ |
| **Photochemical Reflectance Index (PRI)**<br>Reference: Gamon et al. (1992)<br>Equation: $PRI = (R_{531} - R_{570}) / (R_{531} + R_{570})$ |
| **Normalized Pigment Chlorophyll Index (NPCI)**<br>Reference: Peñuelas et al. (1994)<br>Equation: $NPCI = (R_{680} - R_{430}) / (R_{680} + R_{430})$ |
| **Carter Indices**<br>Reference: Carter (1994), Carter et al. (1996)<br>Equation: $Ctr1 = R_{695} / R_{420}$; Ctr2■ $= R_{695} / R_{760}$ |
| **Pigment specific normalized difference a (PSNDa)**<br>Reference: Blackburn (1998)<br>Equation: PSNDa■ $= (R_{790} - R_{680}) / (R_{790} + R_{680})$ |
| **Structure Insensitive Pigment Index (SIPI)**<br>Reference: Peñuelas et al. (1995)<br>Equation: $SIPI = (R_{790} - R_{450}) / (R_{790} - R_{650})$ |
| **Gitelson and Merzlyak Indices**<br>Reference: Gitelson & Merzlyak (1997)<br>Equation: $GM1 = R_{750} / R_{550}$; GM2 ■$= R_{750} / R_{700}$ |
| **Anthocyanin Reflectance Indices (ARI1; ARI2)**<br>Reference: Gitelson et al. (2001)<br>Equation: $ARI1 = 1/R_{550}-1/R_{700}$; $ARI2 = R_{790}*(1/R_{550}-1/R_{700})$ |
| **Carotenoid Reflectance Indices (CRI1; CRI2)**<br>Reference: Gitelson et al. (2002)<br>Equation: $CRI1 = 1 /R_{510}-1 /R_{550}$; $CRI2 = 1 /R_{510}-1 /R_{700}$ |
| **Renormalized Difference Vegetation Index (RDVI)**<br>Reference: Roujean & Breon (1995)<br>Equation: $RDVI = (R_{780} - R_{670}) / ((R_{780} + R_{670})^{0.5})$ |

■ indices measured also by RP 410 NIR

## 2.1 TECHNICAL SPECIFICATION

| | |
|---|---|
| Spectral range | 380 nm – 790 nm (RP 410 UVIS)<br>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<br>Low gain: 1:13000 |
| Size of aperture | 7 mm |
| Light source | Xenon incandescent lamp |
| Light source spectral range | 380-1050 nm |
| 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 |
| 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<br>Low battery indicator |
| Sample holder | Mechanical leaf clip |
| Display | Touchscreen 240 x 320 pixel; 65535 colors |
| Built in GPS module | Ultra-high sensitivity down to -165dBm<br>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<br>Relative humidity: 0 to 95 % (non-condensing) |
| Storage conditions | Temperature: -10 to +60 °C<br>Relative humidity: 0 to 95 % (non-condensing) |
| Warranty | 1year parts and labor |

# 3 DEVICE DESCRIPTION


**Fig. 1 Device description.**

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

### Color touch screen display
PolyPen is operated via a touch screen by using a supplied stylus. The software operation instructions are available on page 17.

| | |
|---|---|
| | No sharp objects should be used when operating the PolyPen via touch screen. It is recommended to use provided stylus when making selections on the touch screen. |

### 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.

**Optical sensor and light source**

The optical sensor of the PolyPen and the light source, are placed inside of the device. See schematic drawing of the principle of reflectance measurement in PolyPen in Fig. 2. The light source is oriented in 35° to the normal line intersecting the detector.

| | |
|---|---|
|  | The sensor should be always dust and dirt free. |

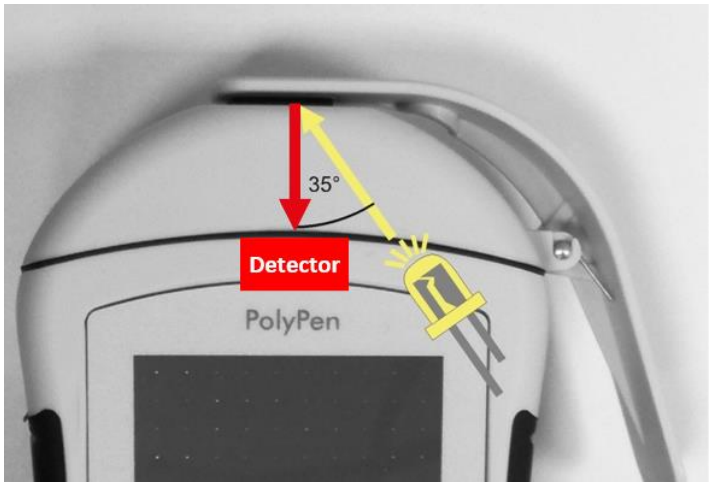



**Fig. 2 Schema of reflectance measurement.**

## 3.1 LIST OF EQUIPMENT AND CUSTOMER INFORMATION

**Standard version of the PolyPen device package consists:**

- PolyPen
- Reflectance standard (Spectralon®)
- Stylus
- Carrying Case
- Textile Strap for Comfortable Wearing
- PolyPen Operating Manual (on a USB flash disc)
- SpectraPen software and driver (on a USB flash disc)
- USB cable
- Other Accessories or Optional Features (according to your specific order)

| | |
|---|---|
|  | For data download via USB connection, the USB driver needs to be installed on the PC. It can be found on the installation disk (USB driver folder).<br>If any item is missing, please, contact the manufacturer. Also check the carton for any visible external damage. If any damage is found, notify the carrier and the manufacturer immediately. The carton and all packing materials should be retained for inspection by the carrier or insurer.<br>For customer support, please write to: support@psi.cz |

## 3.2 CARE AND MAINTENANCE

**PolyPen device**

- Never submerge the device in water!
- The device should not come in contact with any organic solvents, strong acids or bases.
- Keep the optical sensor clean and dry. If cleaning is needed, use soft, non-abrasive tissue.
- Do not use sharp objects for touch screen operation.

**Li-ion battery**

- Avoid fully discharging of the battery.
- Do not keep the battery at full charge for long periods of time. Allow for it to discharge.
- High temperatures shorten battery life.
- If the battery can no longer be charged, please contact PSI for replacement battery.

# 4 GETTING STARTED

To **switch ON** the PolyPen, 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 battery.

| | |
|---|---|
|  | The measurements with the PolyPen cannot be made until the calibration is performed. |

## 4.1 CALIBRATION

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).


**Fig. 3 Reflectance standard Spectralon.**

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

| | |
|---|---|
|  | Spectralon® standard is spectrally flat over UV-VIS-NIR spectrum and optically flat to +/- 1 % over the photopic region of the spectrum. |

**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 will change into Get reflectance (Fig. 4). Get Reflectance – shows up after successful calibration, measures and stores reflectance spectrum.
- The device is now ready to measure other samples.

## 4.2 MEASUREMENT

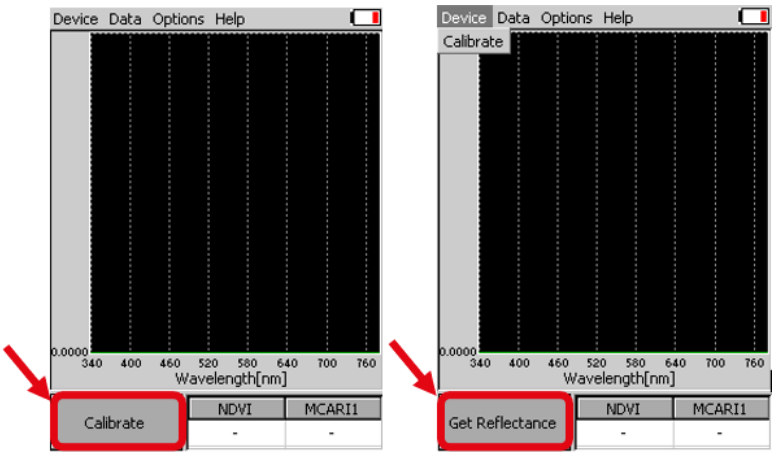



**Fig. 4 PolyPen calibration.**

PolyPen is a complex system 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.
- 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 5).

**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/I0, where I means the signal measured from the sample and I0 is the ideal reflectance signal from the standard.
**Absorbance** data are normalized to the white calibration standard as the logarithmic ratio: A = log(I0/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** displays a group of selected indices calculated for actual measured data (Fig. 5). 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 30).

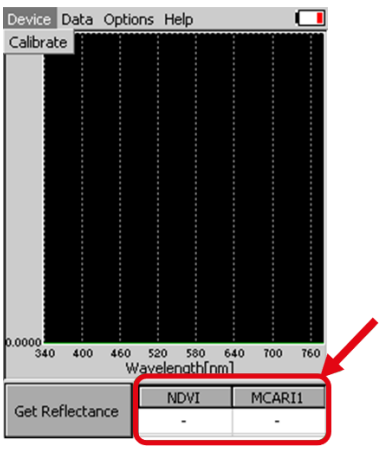



**Fig. 5 Indices table.**

# 5 MENU DESCRIPTION

### Device

- **Calibrate** – calibration can be run any time by pressing Device > Calibrate after inserting appropriate standard in the leaf clip. (Fig. 6).

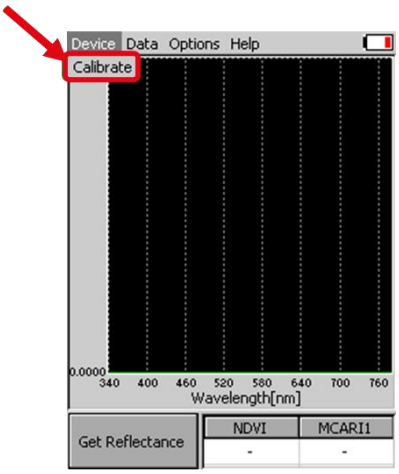



**Fig. 6 Calibration of the device.**

### 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.

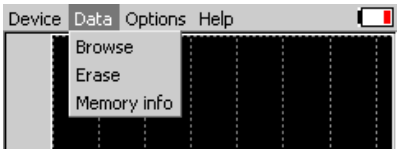



**Fig. 7 Menu - Data.**

### Options

- **Settings** – function is used to set various variables for the light measurements and for the device settings.
  - **Indices** - Select indexes to be calculated and displayed on the main screen (Fig. 8).

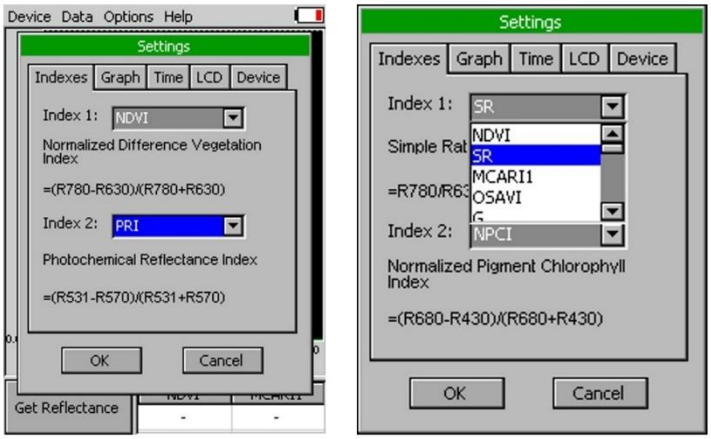



**Fig. 8 Settings - Indices selection.**

- **Graph** – displays options for setting the wavelength range and graph features (Fig. 9).
  - 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.
- **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. 9).

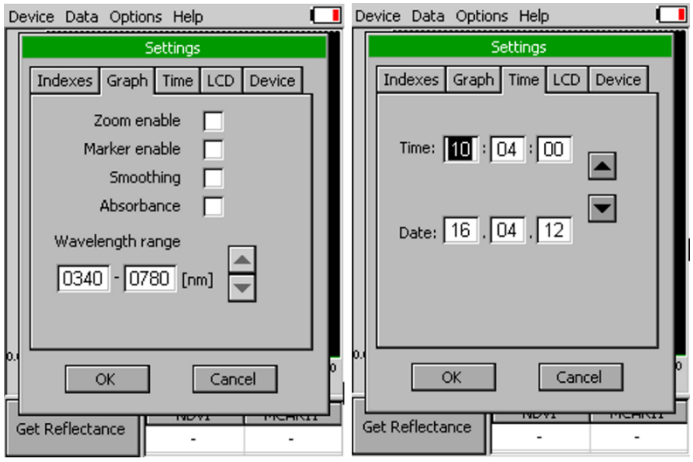



**Fig. 9 Settings – Graph ant Time**

- **LCD** – is used to adjust LCD display control settings (Fig. 10).
  - 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).
- **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 measurements to be acquired for averaged values (Fig. 10). Data are affected.

- GPS – enables the GPS module (Fig. 10). The GPS coordinates cannot be displayed at the device display, but they are exported together with data and visualized in SpectraPen software.

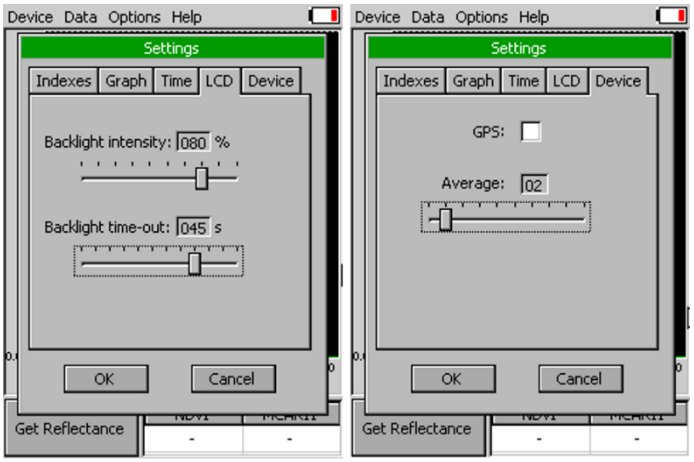



**Fig. 10 Settings – LCD and Device**

### Help

- **About…**- information about the device, hardware and software version (Fig. 11).

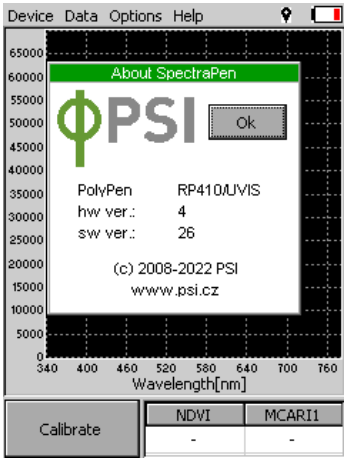



**Fig. 11 About**

# 6 PC COMMUNICATION

## 6.1 USB CONNECTION

PolyPen comes with the USB cable that is required for charging of the Li-ion battery and can also be used for data transfer to the PC after completion of measurements. To connect the USB cable with the PolyPen device follow the picture instructions below. Please note that a lock in system is used to secure the USB cable to the PolyPen and extreme caution has to be used when setting up this connection to avoid damage to the cable pins.

| | |
|---|---|
| ⚠ | When connecting the USB cable take extra caution to prevent damage to the cable connector pins. Ensure correct orientation of the cable as shown in the pictures below so the circled portion of the plug and the cable in photo A and B are perfectly lined up prior to pushing them together. Once this connection is achieved the cable may be secured in position by turning the metal cover of the cable and locking the cable in position. |

To connect PolyPen with your computer please follow steps below in Fig. 12:


**Fig. 12 How to connect PolyPen with PC.**

**A) connector on the PolyPen device. B) Portion of the USB cable with pins. C – E) Position the cable horizontally and line up the green circled parts of the cable and the connector, plug in the inlet and screw the securing screw. F) Correct connection of the USB cable and Pen device.**

## 6.2 DRIVER INSTALLATION

For successful USB connection of the PolyPen to the PC computer the USB driver and the SpectraPen software, included on the USB disk, need to be first installed on the PC. Without the driver installed the PolyPen device will not be recognized by the computer and the connection to the software will be not possible.

- Press **Start** and Select Control Panels (Fig. 13)

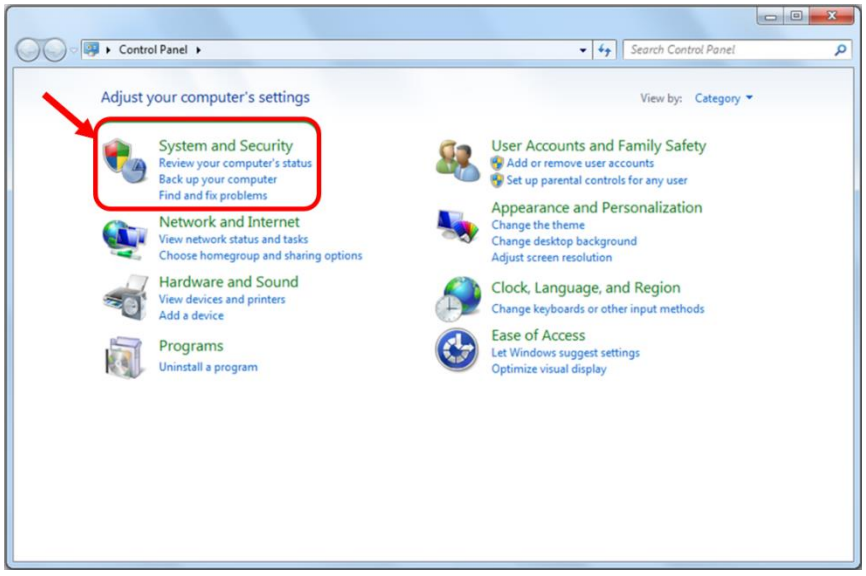



**Fig. 13 Control panel.**

- Navigate through System and security, System to Device manager (Fig. 14).

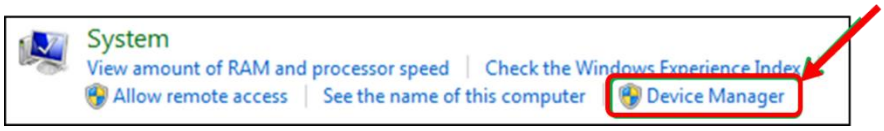



**Fig. 14 System window.**

- 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 (Fig. 15)

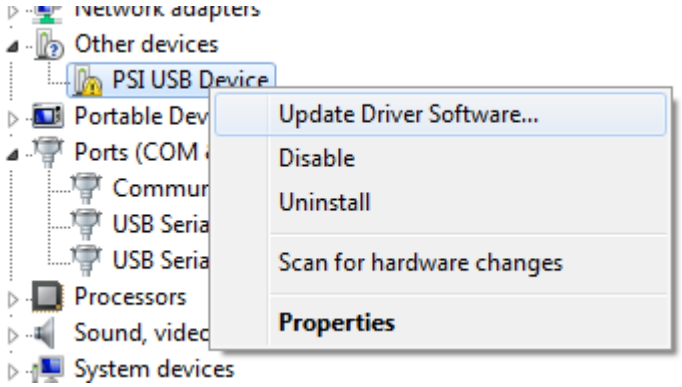
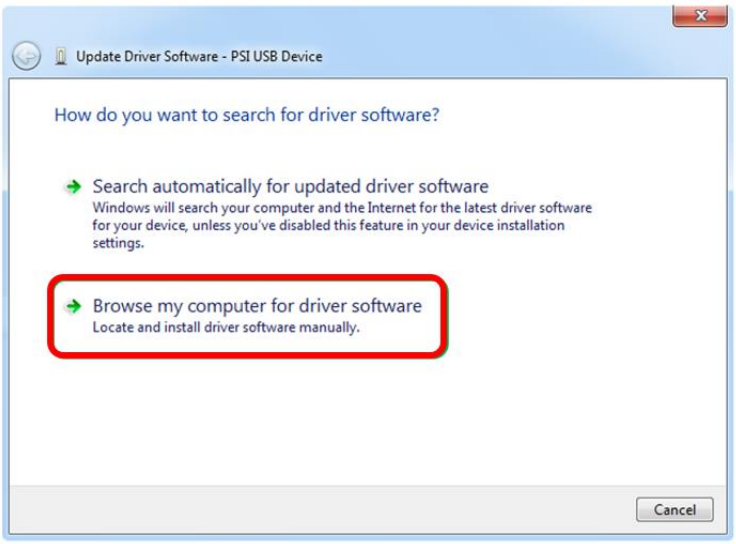



**Fig. 15 PSI USB device.**

- Click Browse my computer for driver software and select Driver folder on the PolyPen installation disk. Allow the installation even if the warning message appears (Fig. 16).



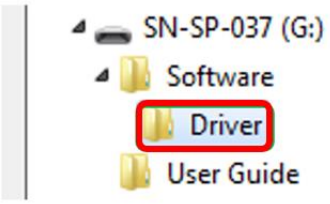




**Fig. 16 Choose the driver from the USB disc.**

- Installation of the driver is now complete (Fig. 17)

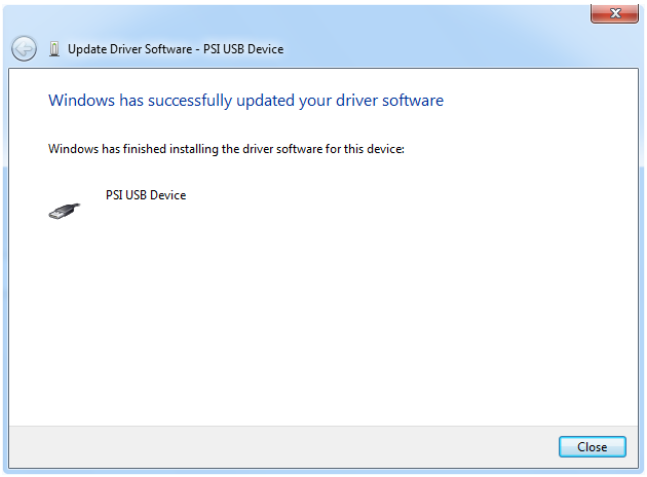



**Fig. 17 Complete installation.**

| | |
|---|---|
| | In case this driver installation is not successful the driver may be downloaded directly from PSI websites www.psi.cz. |

Once the device is properly connected to the computer, the indicating icon appears in upper right corner on the PolyPen display (Fig. 18).

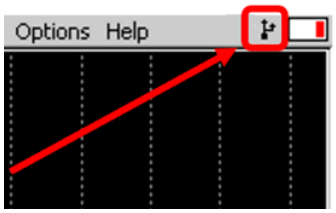



**Fig. 18 Device connect.**

# 7 SPECTRAPEN SOFTWARE

## 7.1 SOFTWARE INSTALLATION

1. Copy the SpectraPen software provided on the USB flash disk to your computer and launch the SpectraPen program.
2. To connect and recognize the PolyPen device in the SpectraPen software, proceeds first with the registration of the SpectraPen software (Fig. 19).

- Select: Help > Register
- Enter: your serial registration number (found in a text file on the USB flash disk drive included with the device).
- Select: OK

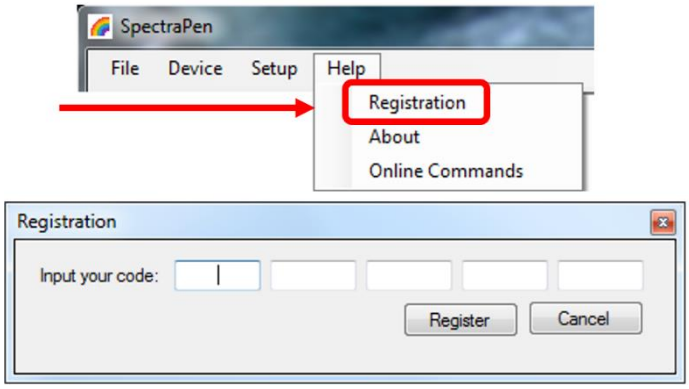



**Fig. 19 SW registration.**

| | |
|---|---|
| | Please note that the serial (registration) number for the PolyPen may be found in the file SN.txt, which is included on the enclosed USB flash disk.<br>Please Note: it is not possible to download data from the PolyPen device without software registration. |

3. Connect the USB cable to the computer. Then switch on the PolyPen by pressing the Power button for a couple of seconds.
4. Ensure the PC and the PolyPen are properly paired (see chapter 6).
5. Connect PolyPen device in SpectraPen software, **Device > Connect** (Fig. 20).

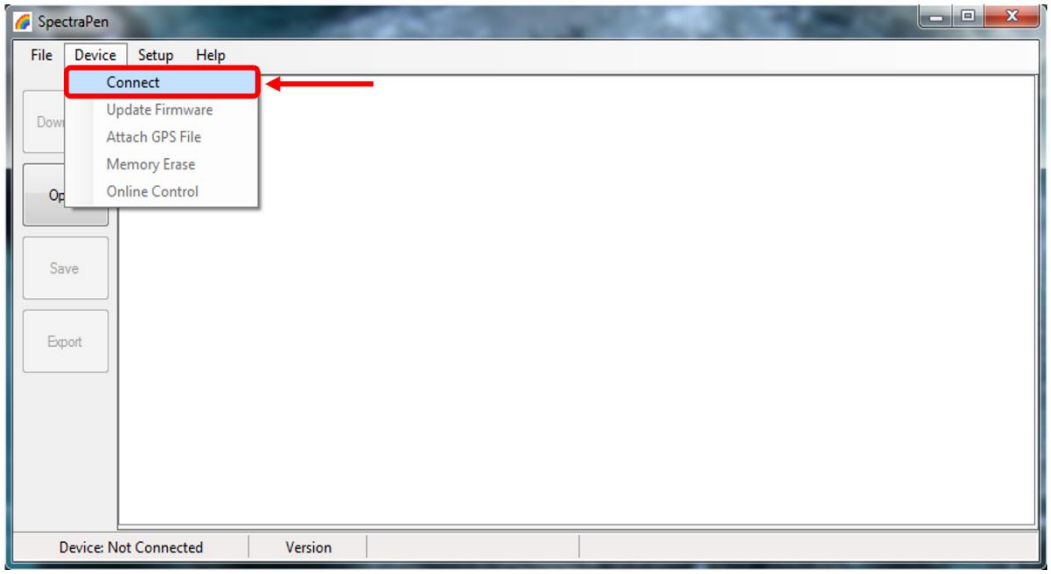



**Fig. 20 SW connection.**

6. When the device is properly connected the left bottom corner of the SW window will display **"PolyPen"** (Fig. 21). Otherwise, notification **"Device: Not Connected"** is displayed (Fig. 22).

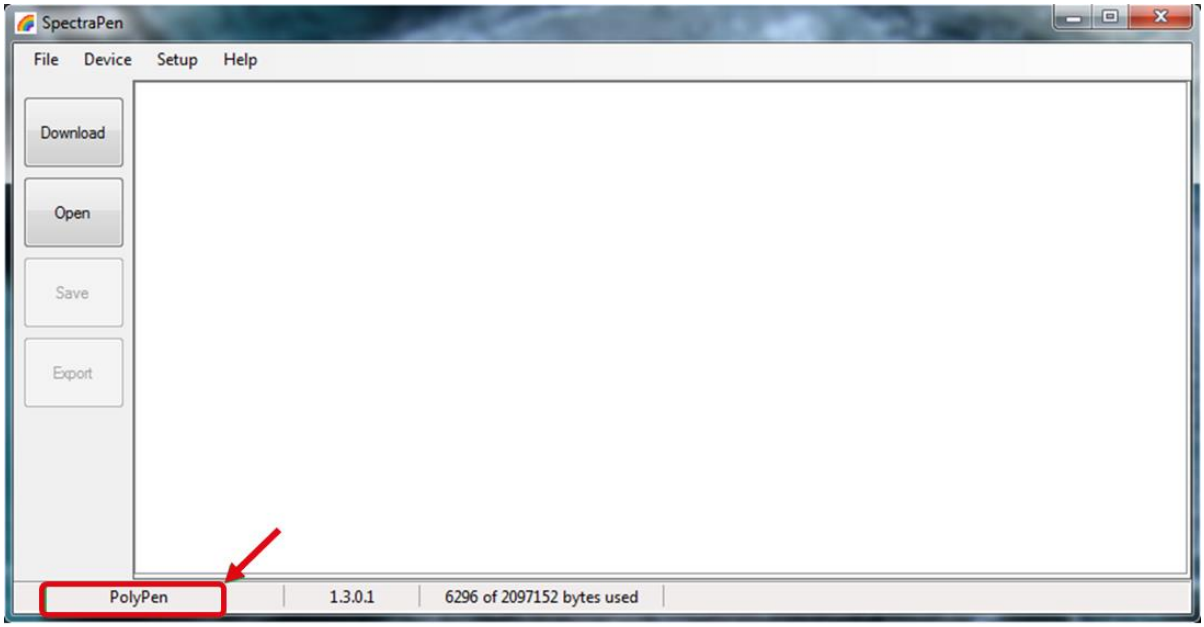



**Fig. 21 PolyPen connected.**

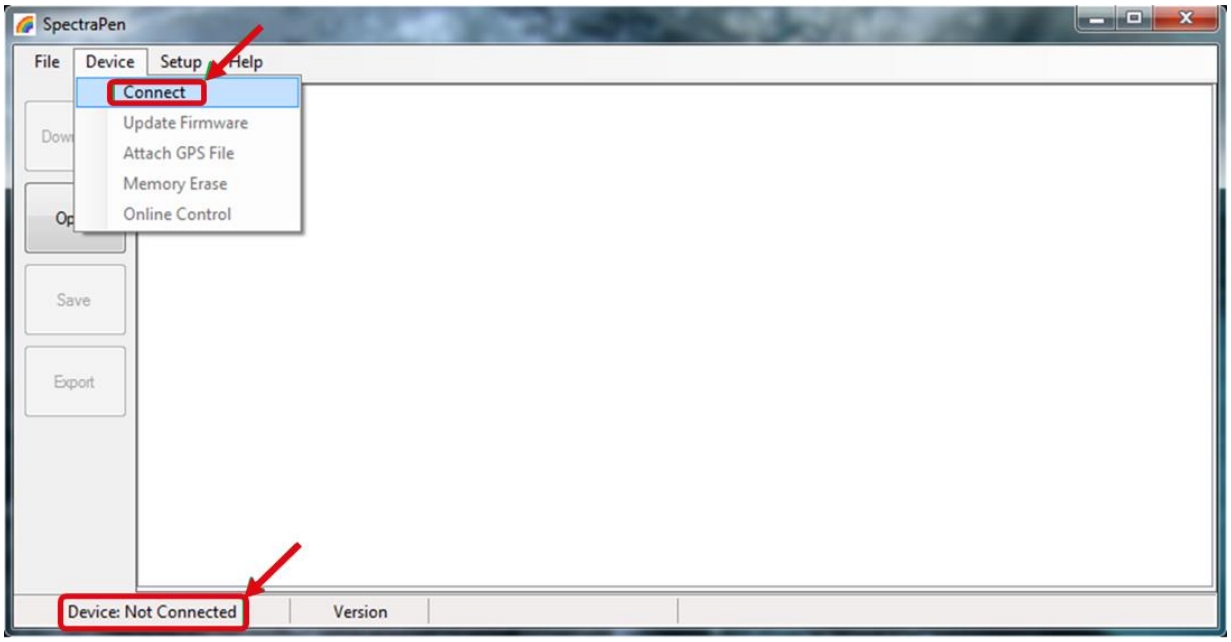



**Fig. 22 Connection failed.**

## 7.2 SOFTWARE MENU

### MENU: File

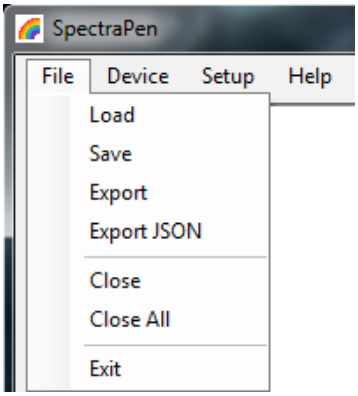



Fig. 23 Menu File.

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

### MENU: Device

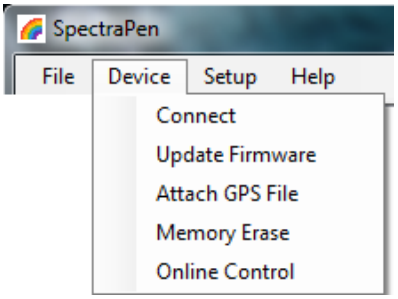



Fig. 24 Menu Device.

| | |
|---|---|
| **Connect** | Detects and connects the device. |
| **Update Firmware** | Used for firmware updates. * |
| **Attach GPS File** | Used to download data from the GPS module of the old version of the SpectraPen - LM 500. |
| **Memory Erase** | Erases data from the SpectraPen memory. |
| **Online Control** | Online control of SP device. |

** For more information on firmware updating, see Chapter 7.5 of this Operation Manual.*

### MENU: Setup

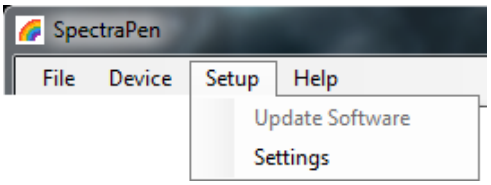



Fig. 25 Menu Setup.

| | |
|---|---|
| **Update Software** | Used for software updates. |
| **Settings** | On/Off – Auto memory erase after download.<br>Selection of separator for the csv file after its export and following opening in Excel (TAB, SEMICOLON, COMMA, SPACE). |

### MENU: Help

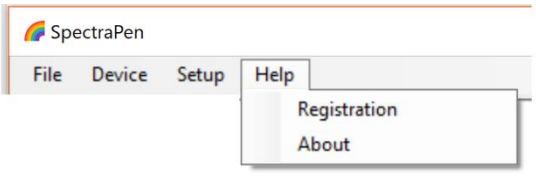



Fig. 26 Menu Help.

| | |
|---|---|
| **Registration** | Used for the SpectraPen software registration. |
| **About** | Offers basic information about the program. |

## 7.3 DATA TRANSFER AND VISUALIZATION

1. After completion of measurement PolyPen may be connected to PC for data download and further analysis.
2. Launch the SpectraPen software on the computer and **Connect** the device. Go to **Device> Connect**.
3. To transfer your data from the PolyPen device to your PC use the **Download** function. Select icon on left side of screen or go to **File** and select **Load** if you want to process data stored on PC.
4. All data stored currently in the PolyPen device will be downloaded and shown in the main window view. The data are store and displayed/listed with the time stamp of measurement.

| | |
|---|---|
|  | Please note that if there are no data stored in the memory, the download function is not active. |

5. Visualization modes: **Scope** (Fig. 27) mode window is always displayed as the default. To visualize the measured data in transmittance or absorbance mode, go to **Transmittance** or **Absorbance** bookmark.

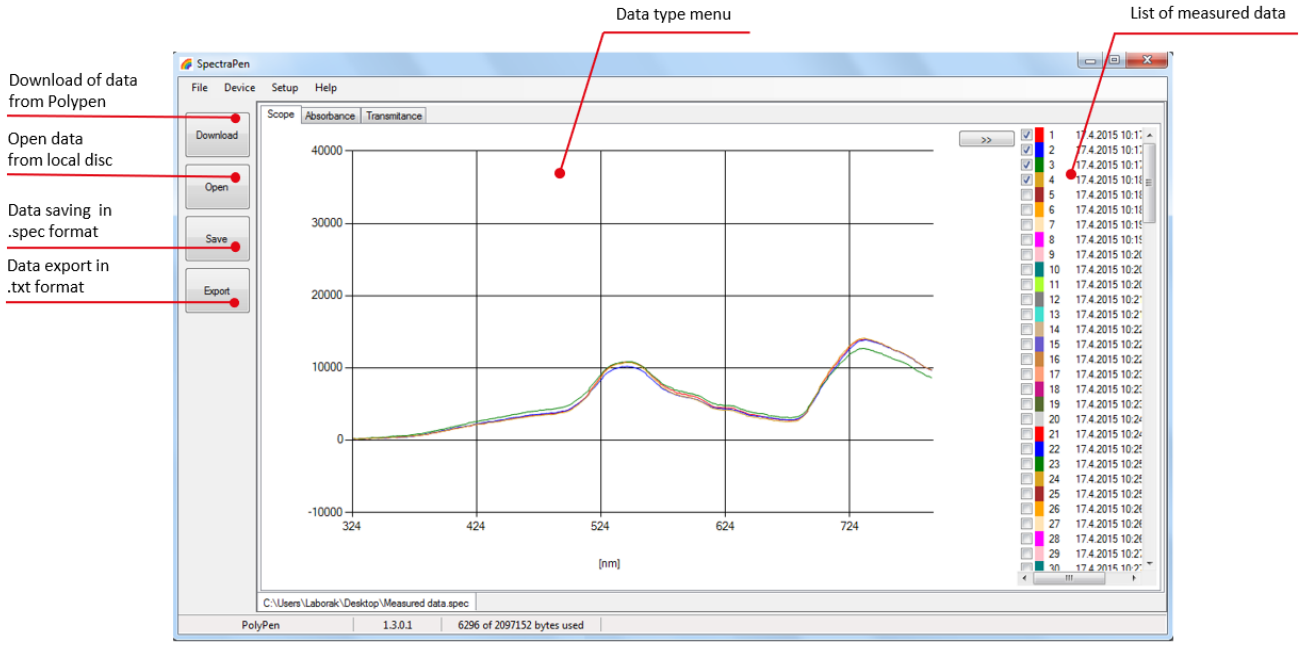



**Fig. 27 Scope spectra.**

6. All data that are downloaded are displayed in the Scope window after download from the PolyPen. The user can select the set of measurements to be displayed by marking and unmarking the data from the **selection** list. See selection in the list of measured data in Fig. 27.
7. Right click on list of measured data enables **edit data name, delete** selected measurement or **show and hide** all measured data in the graph– Select all measure and Clear all measure (Fig. 28).

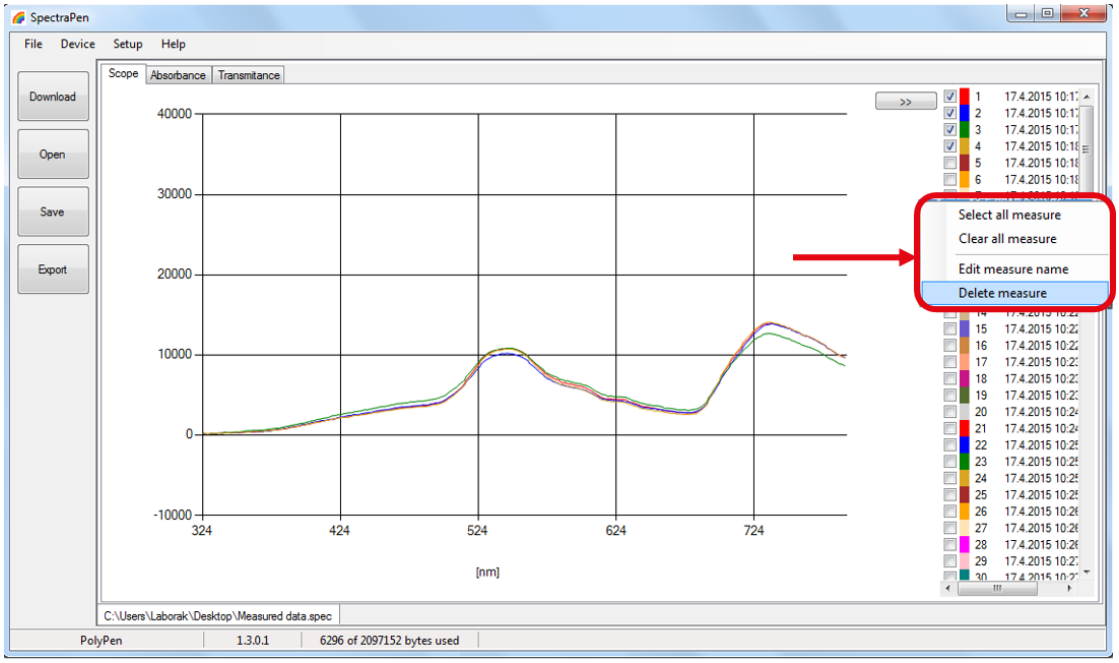



**Fig. 28 Option for list of data.**


**Fig. 29 Marker function.**

8. In the graph **marker** feature is available, which enables display of the numeric values for wavelength and transmittance or absorbance for the selected wavelength of the scan (Fig. 29). Use the mouse to select the given point. In top right corner of the graph (green rectangle) is displayed exact value for the selected point on the x-axis and y-axis.
9. To **zoom in on the data displayed in the graph** select an area of the displayed graph. To reverse these steps and return to original display use minus icon in the corners of the zoom area marked with green rectangles in Fig. 30.

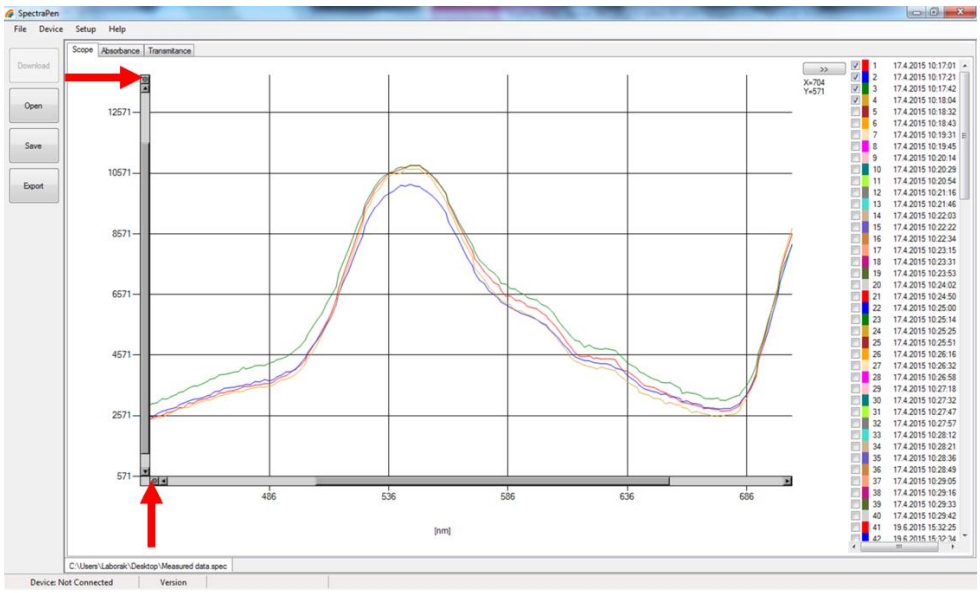


**Fig. 30 Zoom function.**

10. To view the spectral data in parameter values (Fig. 32) click to button with two arrows (Fig. 31). 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 their 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.

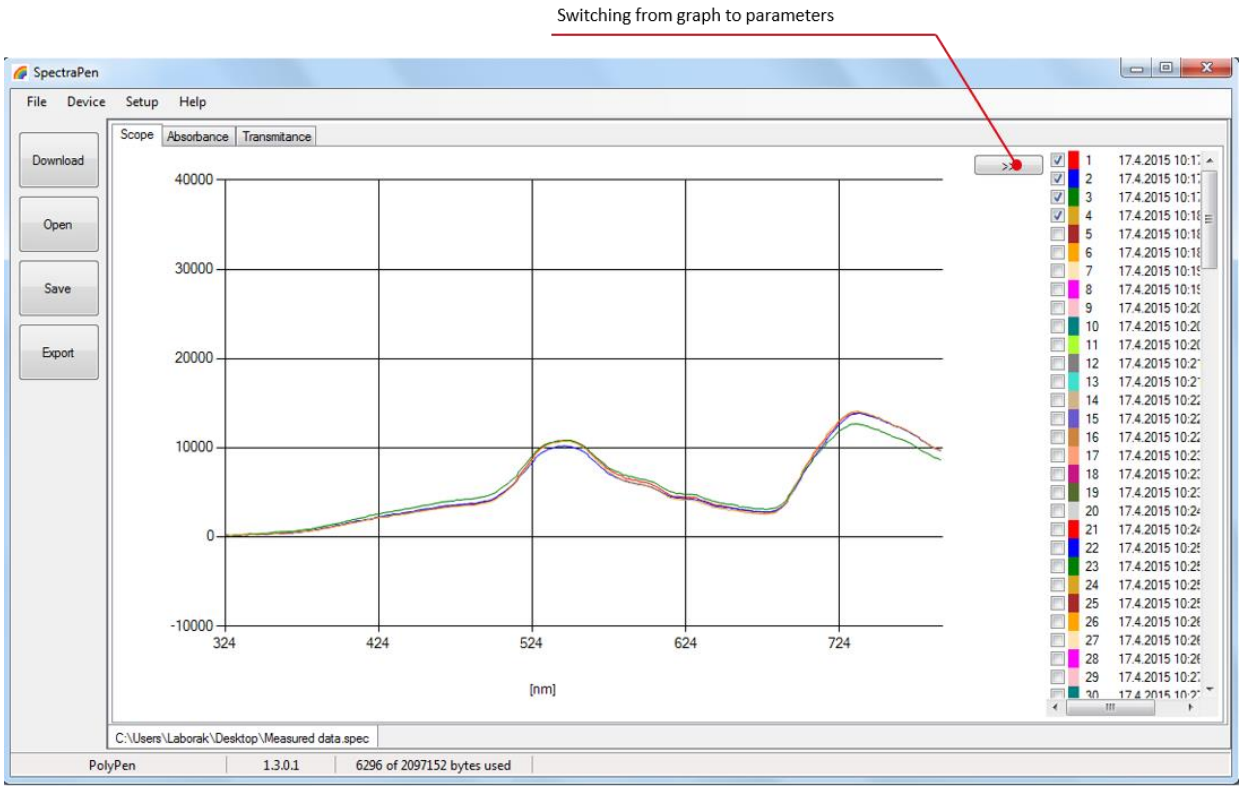



**Fig. 31 Switch to vegetation indices.**

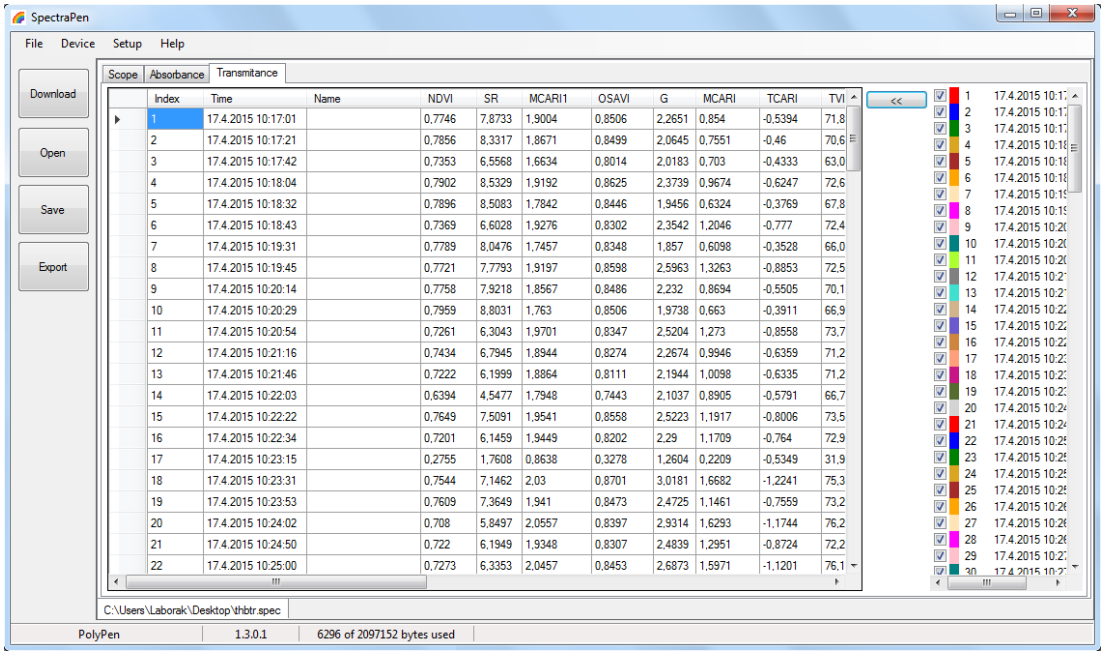



**Fig. 32 Vegetation indices.**

11. To Save the experiment select **File>Save**. All data stored in the device memory will be saved irrespective of the data selection in the SpectraPen software. The file will be stored as .spec. Spec files stores all Transmittance and numeric data.
12. Select **File>Export** to export the data in .txt format. Export function allows the user to specify the type of data. The options are:

**Spectrum** (Fig. 33) – all raw scope data for entire range of measured wavelengths are exported including data for the dark scan.
**Spectrum Scope** – scope data normalized to dark spectrum scan are exported for all acquired scans or set of selected measurements.
**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** (Fig. 34) – 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.

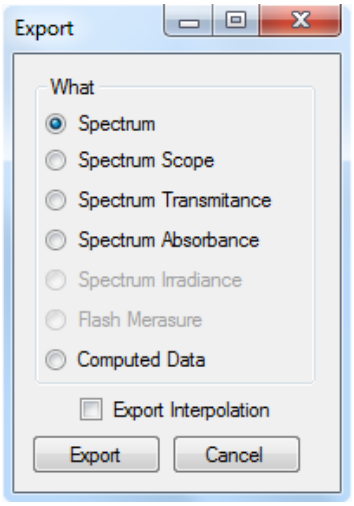



**Fig. 33 Export table.**

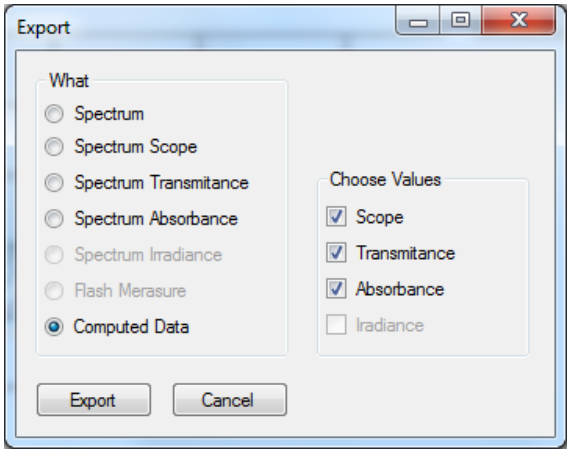



**Fig. 34 Export – Computed data selection and choosing of exported values.**

## 7.4 ONLINE CONTROL

**Menu Online Control**

This function can be used for remote - online control of the PolyPen device after connection with the PC. Online control enables to make changes in device setting and also perform remote measurement using PC.

Select: **Menu > Device > Online Control** (Fig. 35)

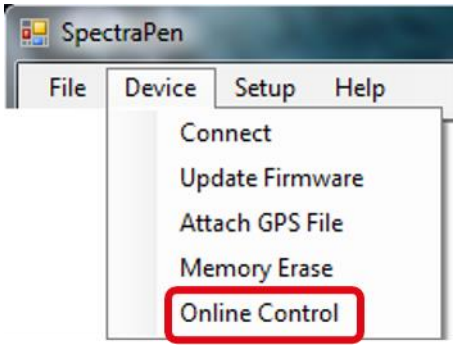



**Fig. 35 Online Control.**

**Remote measurement** (Fig. 36)

Using this function **Reflectance** and **Absorbance** can be measured.

| | |
|---|---|
| | Please note that the Calibration should be done manually prior the remote measurement. |

- For manual remote measurement click on Get button (Fig. 36 - 1).
- Setting for automated remote measurement is possible using the button with three dots (Fig. 36 - 3). Here the time interval (Fig. 36 - 5) of the measurement is set. To apply this setting use the option Use settings (Fig. 36- 4) and confirm by clicking OK (Fig. 36 - 6). The measurement stars immediately and continues until it is manually stopped (Stop button).
- Use the **export** option for exporting the data to .csv file.
- **Clear** function serves for erasing of data measured by Online Control.

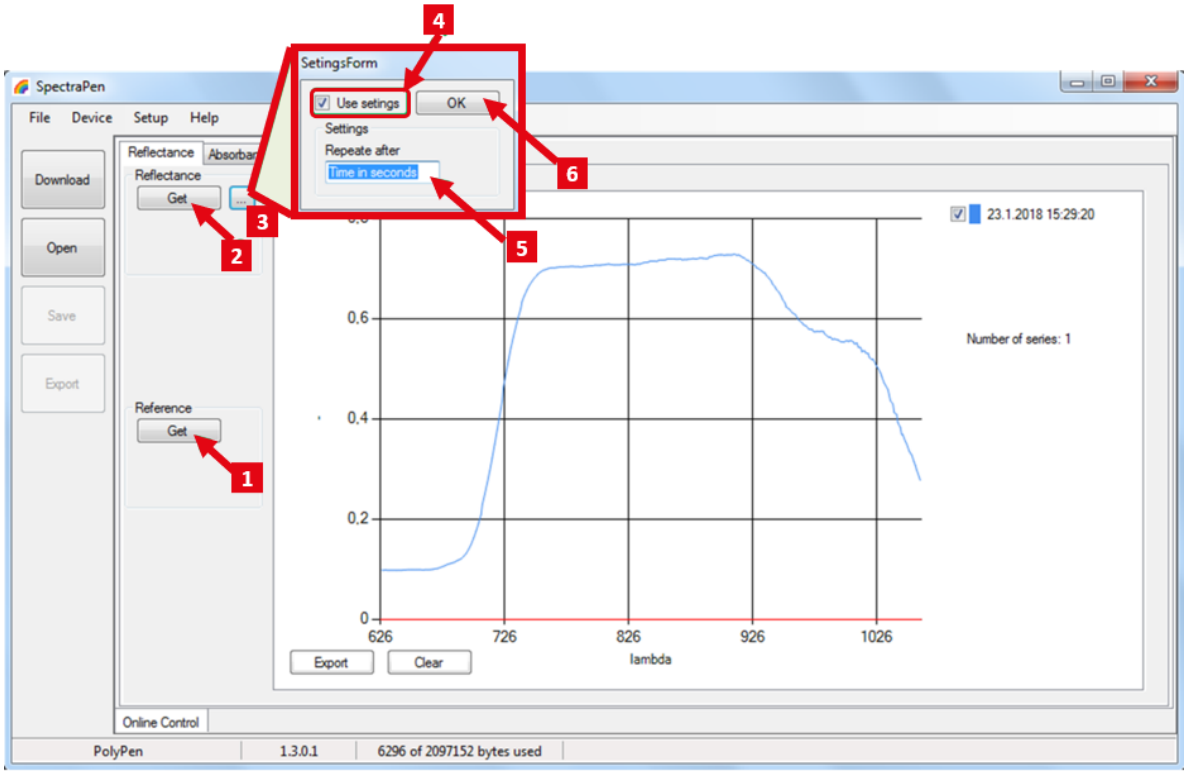



**Fig. 36 Setting of reflectance or absorbance measurements in online control.**

**Settings** (Fig. 37)
Here the following functions may be set up for remote operation of the PolyPen:

- Time synchronization of the device and PC (Fig. 37 - 1)
- GPS built-in module activation (Fig. 37 – 2; more information about the GPS module in chapter 8)
- Averaging of measurement, set from 1 to 10 measurements (Fig. 37 - 3)

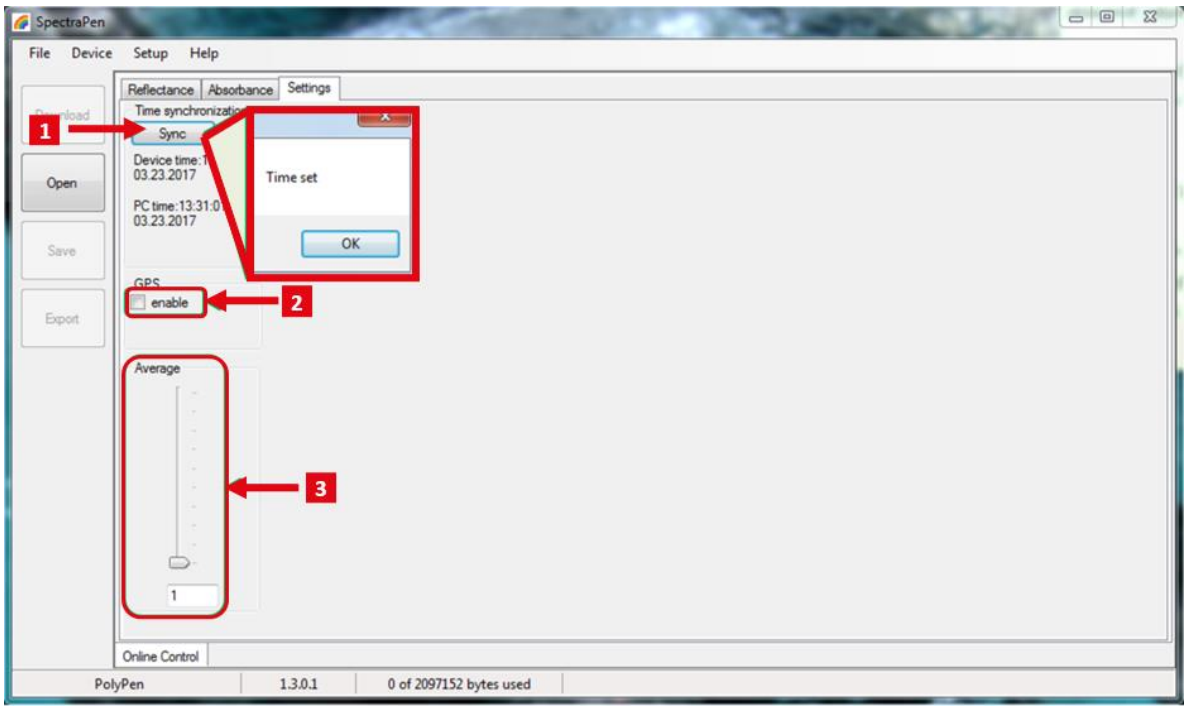



**Fig. 37 Settings of online control.**

## 7.5 FIRMWARE UPDATE

| | |
|---|---|
|  | All data in the PolyPen memory are erased during the firmware update!<br>Before starting any firmware update, download all your data from the PolyPen memory to the computer and save! |
|  | Before firmware update ask the manufacturer for appropriate version of the firmware for your particular device. Incompatible firmware version can cause device malfunction. |

1. Starting Update
- Select: Setup > Update Firmware From File

2. Selecting .bxn file
- Find firmware update file: Binary file (with the extension .bxn)
- Select: Open.

3. Finishing Upload
- Select: OK to start uploading of the update
- The bottom bar indicates the upload progress (Fig. 38)

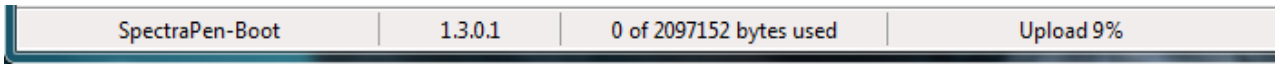



**Fig. 38 Firmware update running.**

# 8 GPS MODULE

PolyPen device has integrated GPS module which may be turned on during the measurement for mapping of the collected data to specific field position. When GPS module is turned on, the map coordinates will be automatically saved with all collected data and will be downloaded during data download.

| | |
|---|---|
|  | For proper GPS reading, the time in your PolyPen and in your computer must be synchronized. Preset time and time zone must correspond to GPS time (time zone) in your location. |

## 8.1 GPS/POLYPEN OPERATION

1. Check the time setting on the PolyPen device: **Settings > Date & Time**
2. Switch the GPS module "ON" on the PolyPen device by following these steps in the PolyPen menu:
- Select: Options > Settings > Device
- Click on the check box for GPS (Fig. 39-A)
- Wait until the GPS position is found. The GPS module is ready when the icon of the position flag, in upper menu, stops flashing (Fig. 39-B).

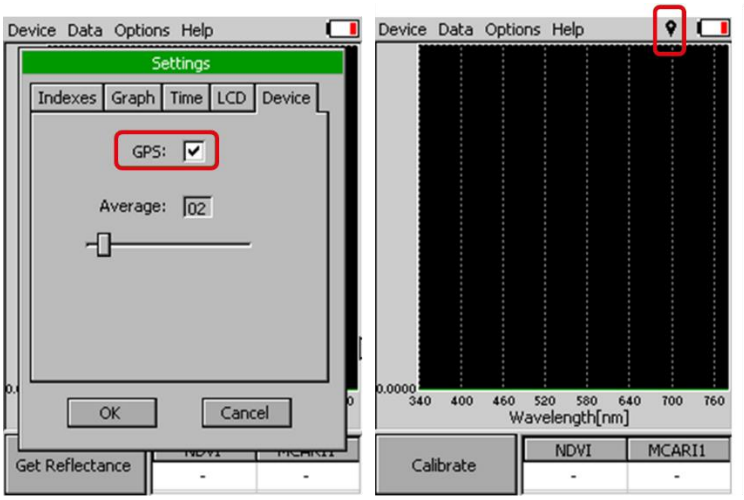



**Fig. 39 GPS activation and Active GPS**

| | |
|---|---|
|  | For proper function of the GPS module the PolyPen device may need a clear view of the sky to acquire satellite signal. |

1. Perform the selected measurements.
2. Connect the PolyPen to the computer and open the SpectraPen software to proceed with download of the measured data. Data measured with activated GPS module are downloaded with GPS coordinates (Fig. 40).

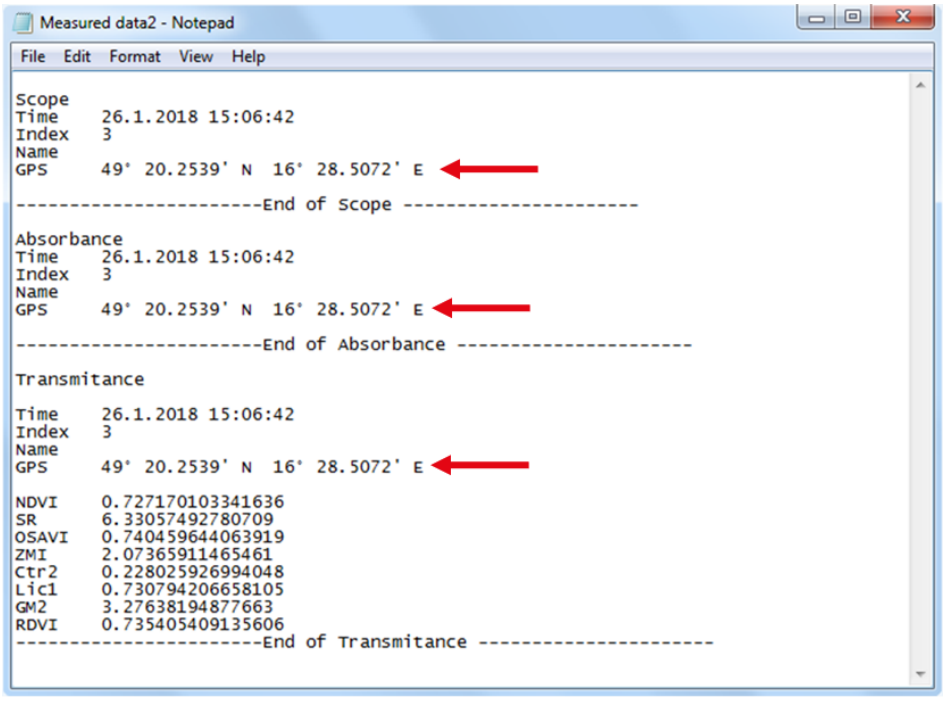



**Fig. 40 Data with GPS coordinates.**

# 9 WARRANTY TERMS AND CONDITIONS

- This Limited Warranty applies only to the PolyPen device. It is valid for 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 at 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 sufficiently 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.

# 10 TROUBLESHOOTING AND CUSTOMER SUPPORT

In case of problems with the PolyPen visit **FAQ** on our websites (http://psi.cz/support/faq) or contact customer support by email to **support@psi.cz** , or contact your local distributor.

# 11 APPENDIX

## 11.1 PROGRAMMING CUSTOM INDEX IN POLYPEN

The SpectraPen software enables programming custom indexes, which can be used for wide range of calculation based on the measured spectrum.

1. Go to the main **SpectraPen folder** in your PC (Usually in Program Files).
2. Open the file **Config > Formulas.txt.**
3. Write your index into this .txt file and save it (Fig. 41).

Index example:
Transmitance:SAVI:Soil-Adjusted Vegetation Index:
(1+0.5)*(Transmitance[780nm]-Transmitance[670nm])/(Transmitance[780nm]+Transmitance[670nm]+0.5)
Transmitance – source data
SAVI– name of the index in the SpectraPen software and in exported data
Soil-Adjusted Vegetation Index – full name of the index (not showed)
(1+0.5)*(Transmitance[780nm]-Transmitance[670nm])/(Transmitance[780nm]+Transmitance[670nm]+0.5)– equation for calculation; calculated from 670 and 780 nm of Transmittance spectra)


**Fig. 41 Formulas configuration file – adding new index.**

1. Restart the SpectraPen Software.
2. The new index appears in the selected bookmark in the data (Fig. 42).
3. For export of this index choose the option “Computed values” and selected spectrum in the export table.

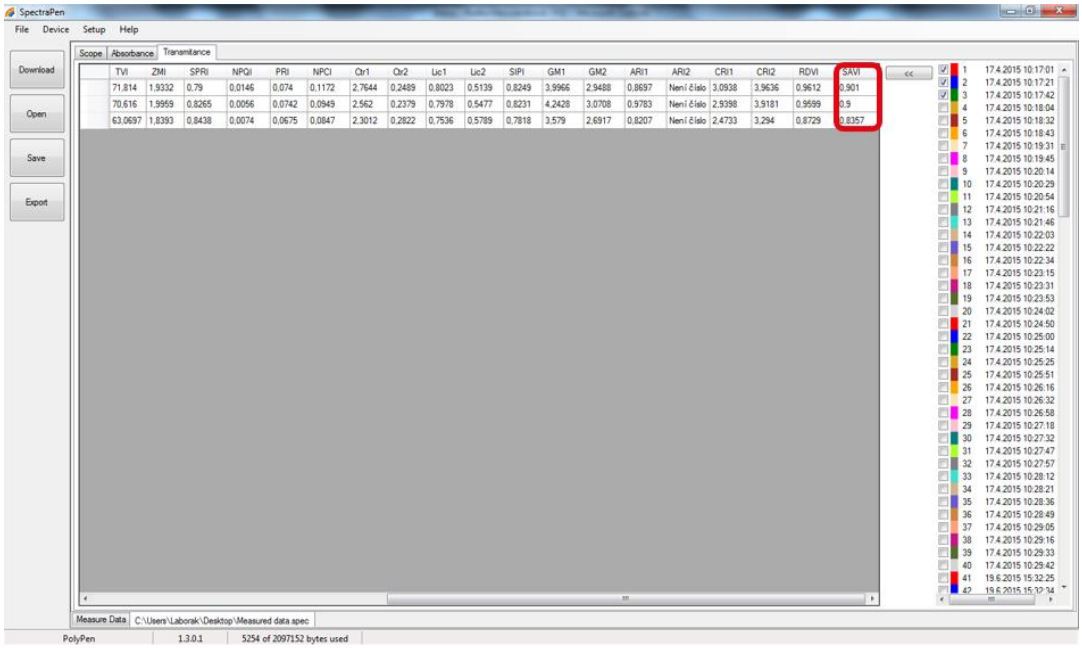



**Fig. 42 Downloaded data with newly defined index.**

### 11.1.1 FUNCTION DESCRIPTION

Different mathematical functions can be used in SpectraPen software syntax to create new custom formulas.

**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]))
**example4:** 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])
**example3:** ln(max(Transmitance[550nm], Transmitace[480nm]))
**example4:** 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)

---

**^** - specified 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 LIST OF FIGURES