



# NeoSpectra™ SWS62221 Product Manual

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## Contents

<b>ABOUT THIS MANUAL .....</b>	<b>4</b>
<b>PART I - BACKGROUND INFO.....</b>	<b>6</b>
CHAPTER 1    PRODUCT OVERVIEW .....	7
1. <i>The function</i> .....	7
2. <i>Working principle</i> .....	7
3. <i>Usage model</i> .....	8
CHAPTER 2    THE HARDWARE.....	10
1. <i>Interfaces</i> .....	10
2. <i>Host</i> .....	10
3. <i>Conditions</i> .....	10
4. <i>Mechanical drawings</i> .....	11
CHAPTER 3    PERFORMANCE OPTIMIZATION .....	12
1. <i>Measurement parameters</i> .....	12
2. <i>Advanced settings</i> .....	13
<b>PART II - EVALUATING NEOSPECTRA .....</b>	<b>15</b>
CHAPTER 4    THE EVALUATION SOFTWARE - SPECTROMOST .....	16
1. <i>Installation</i> .....	16
2. <i>Description of the GUI</i> .....	18
CHAPTER 5    RECOMMENDED SETUPS .....	21
1. <i>Transmission measurements</i> .....	21
2. <i>Diffuse reflection measurements</i> .....	22
CHAPTER 6    EVALUATION USAGE GUIDE.....	23
1. <i>Transmission measurements</i> .....	23
2. <i>Diffuse reflection measurements</i> .....	24
3. <i>Advanced settings</i> .....	26
CHAPTER 7    RECOMMENDED TESTS .....	33
1. <i>Spectral range</i> .....	33
2. <i>Signal-to-Noise Ratio (SNR)</i> .....	34
3. <i>Resolution</i> .....	36
4. <i>Wavelength errors</i> .....	37
<b>PART III - DEVELOPING WITH NEOSPECTRA.....</b>	<b>40</b>
CHAPTER 8    THE SOFTWARE DEVELOPMENT KIT (SDK) .....	41
1. <i>Description of the package</i> .....	41
2. <i>Software architecture</i> .....	41
3. <i>Quick description of the APIs</i> .....	42
CHAPTER 9    USAGE GUIDE FOR DEVELOPMENT OF END-USE APPLICATION .....	44
1. <i>The hardware</i> .....	44
2. <i>The software (SDK)</i> .....	44
<b>PART IV - MISCELLANEOUS .....</b>	<b>46</b>
CHAPTER 10    DISCLAIMERS.....	47
1. <i>Precautions &amp; Limitations</i> .....	47
2. <i>Known issues</i> .....	47
CHAPTER 11    TROUBLESHOOTING .....	49
1. <i>System performance</i> .....	49
2. <i>SpectroMOST</i> .....	50
3. <i>SDK</i> .....	50
REFERENCES .....	51

## About this manual

Thank you for choosing NeoSpectra™ SWS62221 for your spectral sensing application. This product has been built to be used as a spectral sensing module in a wide variety of applications. This manual will help in facilitating the integration of SWS62221 into your unique application environment. The manual describes the different components of the product and their requirements. It also instructs on how to install, use, and troubleshoot the product. You can refer to this document at different stages of your application development starting from the evaluation of the fit of SWS62221 to the final integration in the end-use application system.

### Summary of chapters

It is understood that different teams will be working on the development of the end-use application system. It is recommended that different teams are familiar with the various features and attributes of the product. The table below provides a brief summary of the different chapters of this product manual, and highlights the foreseen audience for the information provided.

#	Chapter name	Summary of the content	Who can benefit from reading
1	Product overview	Background information about the product, its working principle, and usage model.	All teams working on the development of the end-use application system
2	The hardware	Information related to the sensor module: the interfaces, requirements on optical power level, the dimensions, and conditions of operation.	Developers of the end-use application system, and integrators into final physical form
3	Performance optimization	Guidelines for the selection of basic measurement parameters (scan time, resolution, gain settings), and advanced settings (setting gain settings, apodization functions, and zero padding).	Evaluators of NeoSpectra, and developers of the end-use application system
4	The evaluation software	Installation procedure and description of SpectroMOST Graphical User Interface (GUI)	Evaluators of NeoSpectra
5	Recommended setups	Description of evaluation setups and their requirements for transmission and diffuse reflectance measurements	Evaluators of NeoSpectra
6	Evaluation Usage guide	Step by step instruction to perform transmission and reflection measurements using SpectroMOST	Evaluators of NeoSpectra
7	Recommended tests	Definitions and characterization methods of different performance parameters	Evaluators of NeoSpectra
8	The Software Development Kit	A brief description about the SDK and its components	Developers of the application software
9	Usage guide for development of end-use system	Guidelines to develop the sampling setup and to integrate NeoSpectra on computer boards	Developers of the end-use system

10	Disclaimers	Precautions when using NeoSpectra	All teams working on the development of the end-use application system
11	Troubleshooting	Common errors in the hardware, software, and performance. Description of the root cause of these errors, and how to solve them.	All teams working on the development of the end-use application system

## Related documents

Some complementary information can be found in other documents provided by Si-Ware Systems. Please make sure you have the latest version of the documents listed in table that correspond to the release delivered to you.

Document title	Highlights about the content
Datasheet	Technical specifications
SDK Description	List of APIs, data format, errors, etc., for the Software Development Kit

## Part I - Background Info

## Chapter 1 Product overview

*NeoSpectra SWS62221 is a spectral sensing module whose working principle is based on the standard Fourier Transform Infra Red (FT-IR) spectroscopy technique commonly used in conventional spectrometers. The core engine of FT-IR spectrometers is a Michelson interferometer. In NeoSpectra, the whole Michelson interferometer is integrated on a single silicon chip.*

*This chapter gives an overview about the main function of NeoSpectra SWS62221, its working principle, and the typical usage model.*

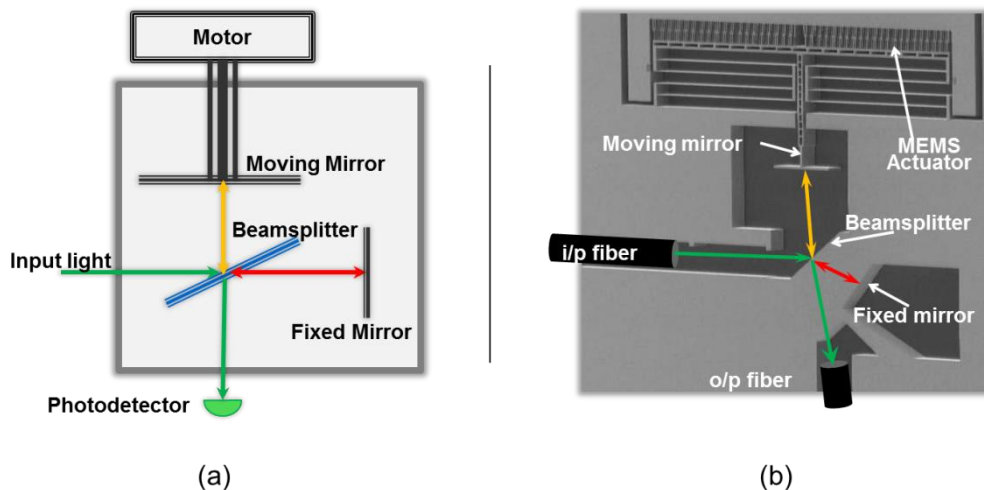
### 1. The function

NeoSpectra SWS62221 spectral sensor determines the spectral content of the input light in NIR range (selectable options between 1,250 – 2,500 nm). The input light can be either transmitted through a sample material, or reflected from it using external sampling accessories. The post-analysis of the output spectra, enables delivering same functionality as standard bench top FT-IR spectrometer instruments: quantification, qualification, or identification of materials .

### 2. Working principle

#### 2.1. Fourier-Transform Infra Red (FT-IR) Spectroscopy

The core of any FT-IR spectrometer is a two-beam optical interferometer named the Michelson interferometer. The basic block diagram of a Michelson interferometer's discrete components is shown in Figure 1.1.



**Figure 1.1: (a) Block diagram of Michelson Interferometer (b) Monolithic Michelson interferometer MEMS chip used in SWS62221**

A beamsplitter splits the incident beam into two paths: one of the beams is reflected by a moving mirror, and the other is used as a reference when reflected by a fixed mirror. The moving mirror controls the Optical Path Difference (**OPD**) between the two reflected beams, which interfere to produce a pattern that corresponds to the spectral content of the input light. The latter is captured by the single photo detector generating

\*Post-analysis of the measured spectra can be done by using an external software. Post-analysis software is not provided with NeoSpectra SWS62221 package.

an interferogram. The spectrum of the input light is directly generated by applying a Fourier Transform to the interferogram.

## 2.2. Measurement steps

The spectrum  $S$  of a sample is given by the ratio of the spectrum of the beam transmitted or reflected from the sample  $I$  to the spectrum of the beam at the front face of the sample  $I_o$  over the spectral range of interest

$$S_{(\lambda_1 \rightarrow \lambda_2)} = \frac{I_{(\lambda_1 \rightarrow \lambda_2)}}{I_o_{(\lambda_1 \rightarrow \lambda_2)}}$$

Hence, in practice, in order to measure sample's spectrum  $S$ , the background spectrum should be measured  $I_o$  (background measurement), as well as the light transmitted or reflected from the sample  $I$  (sample measurement). SpectroMOST software enables the acquisition of the background measurement and stores it to be used as a reference spectrum in further sample measurements. (A guide for SpectroMOST usage to perform spectrum measurement is described in Chapter 6).

It is recommended that the "background spectrum" be measured as frequent as possible, and ideally before each sample measurement. This ensures the most accurate results from the device.

### 2.2.1. Transmission measurements:

Practically, the background measurement  $I_o$  is obtained by measuring the spectrum of the beam at the input of the module without placing any material in the light path (e.g. an empty cuvette), under the same conditions at which the measurement of the sample will be conducted.

The sample measurement  $I$  is obtained by applying the measurement after placing the material inside the sample holder.

### 2.2.2. Reflection measurements:

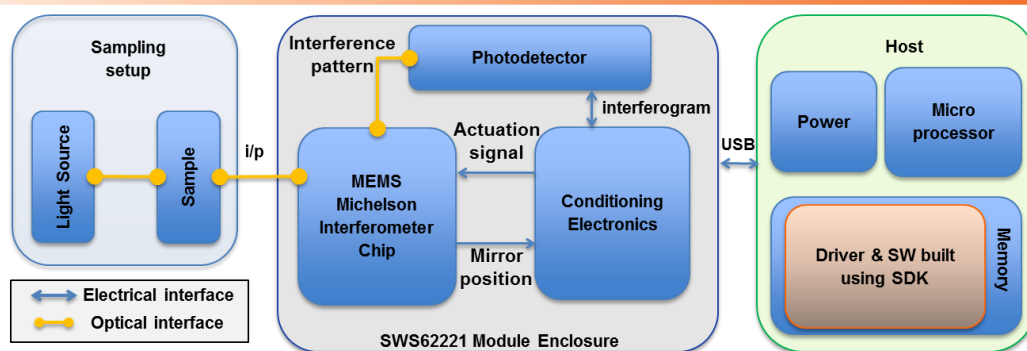
Practically, the background measurement  $I_o$  is obtained by measuring the spectrum of the beam at the input of the module while placing a reference material with nearly flat spectral response across the spectral range of interest with 95% reflectance instead of the sample, under the same conditions at which the measurement of the sample will be conducted.

The sample's spectral response  $I$  is obtained by applying the measurement after placing the material at the collection fiber's interface.

## 3. Usage model

NeoSpectra SWS62221 is delivered as an OEM module that can be integrated in different environments and for different applications. The light is coupled via an optical fiber, and spectrum data are transferred to an external host computer via USB cable. Figure 1.2 shows a block diagram of the internal components of SWS62221, as well as interconnections with external components in a typical end-use system.





**Figure 1.2: Block diagram of typical usage model of NeoSpectra SWS62221**

### 3.1. The core module (SWS62221)

The core module is the sensing elements of the system. It contains the following components:

- The MEMS chip: a monolithic single-chip Michelson interferometer (shown in Figure 1.1). The chip produces a light pattern with the motion of the moving mirror that corresponds to the spectral content of the input light (the interferogram).
- The photodetector: it captures the interferogram and generates electrical signal corresponding to light intensity.
- The electronic circuitry: a set of dedicated electronics board that contain an Application Specific Integrated Circuit (ASIC) chip. The ASIC operates the following functions:
  - Optical signal handling
  - MEMS actuator positioning (determination of the moving mirror's position in the interferometer) using self-calibrated circuitry
  - MEMS chip actuation
  - Data processing

### 3.2. The sampling setup

The requirements and the design of the sampling setup differ by application. Therefore, it is expected that instrument developers will be making their own setups that fit best in their unique application and environment. However, it is recommended to use the default accessories (listed in Chapter 5) for initial evaluation.

### 3.3. The software

SpectroMOST is a software package that interfaces with SWS62221. The evaluation kit contains a basic software edition with a simple GUI that serves to measure, plot, save, and load spectra. Details of the SpectroMOST are described in Chapter 4.

A Software Development Kit (SDK) is also provided to enable the creation of the end use application software. Details of the SDK are provided in Chapter 8.

## Chapter 2 The hardware

*NeoSpectra SWS62221 is designed to be an OEM module that can be used for the development of various applications and environments.*

*In this chapter, we summarize the interface and handling requirements of NeoSpectra spectral sensing modules.*

### 1. Interfaces

- Optical interface: light can be coupled to SWS62221 via an optical fiber with standard FC-PC connector
- Data and power interface: communication with NeoSpectra is established through USB2.0 interface. NeoSpectra has a Mini-B receptacle USB connector for the interface with other devices. The USB connector is also used to supply NeoSpectra with its required Power for operation.

### 2. Host:

The requirements of the host system are listed in Table 2.1

**Table 2.1: Requirements for host system**

Parameter	Requirements
Operating systems	<ul style="list-style-type: none"> <li>• Microsoft Windows XP (both x86 and x64)</li> <li>• Microsoft Windows Vista (both x86 and x64)</li> <li>• Microsoft Windows 7 (both x86 and x64)</li> <li>• Microsoft Windows 8 (both x86 and x64)</li> <li>• Microsoft Windows 10 (both x86 and x64)</li> <li>• Ubuntu 12.04 (both x86 and x64)</li> <li>• Debian 32 bit (ARM architecture)</li> </ul>
CPU Specs	<ul style="list-style-type: none"> <li>• Processor: Core 2 Duo, 2 GHz or higher</li> <li>• RAM: 2 GB or higher</li> </ul>
SDK Coding language	<ul style="list-style-type: none"> <li>• Java JDK1.7</li> </ul>

### 3. Conditions

#### 3.1. Temperature

The NeoSpectra module should be kept in the environments that maintain the temperature conditions listed in Table 2.2

**Table 2.2: Operating and storage temperature of SWS62221**

Parameter	Value	Units
Operating temperature	-5 – +40	°C
Storage temperature	- 20 - +85	°C

### 3.2. Warm up

Upon connecting the Neospectra module to the host via USB, the system takes 15 to 20 minutes to become thermally stabilized. The module is operational during warm-up. However, repetitive measurements of the same sample may lead to slightly different spectra. If measurements are to be taken during warm up time, it is recommended to apply a background measurement right before each sample measurement.

## 4. Mechanical drawings

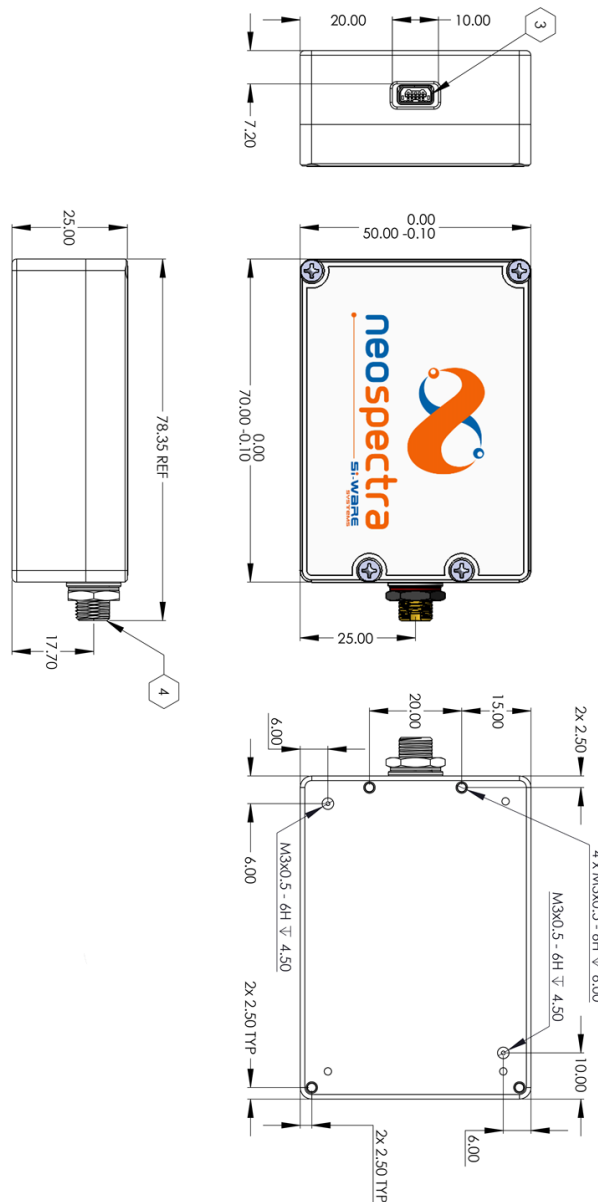


Figure 2.1: Mechanical drawings for SWS62221

## Chapter 3 Performance optimization

*The performance of spectral sensors is commonly characterized by different parameters that are usually interdependent. The software enables optimization of performance by allowing a set of values for some parameters to be changed and certain hardware settings to be adjusted.*

*This chapter describes the effect of the different parameters on the Signal to Noise Ratio (SNR), as well as some advanced settings that can be used to optimize the overall performance of the system.*

### 1. Measurement parameters

NeoSpectra is based on FT-IR, so the independencies between the different performance parameters are governed by the same relationships as conventional FT-IR systems. Scan time and resolution are two parameters that can be set with the software to optimize the performance of the system depending on target requirements. In this section, we summarize the main elements that need to be considered when adjusting these two parameters.

#### 1.1. Scan time

Scan time is defined as the time taken by the interferometer to scan input light signal. Higher scan time implies higher number of scan cycles to be averaged, hence higher SNR.

The scan time can be adjusted by setting a value higher than 10 ms.

The Signal to Noise Ratio (**SNR**) of the system is directly proportional to the square root of the scan time ( $t_s$ ) [ $SNR \propto \sqrt{t_s}$ ] [1]. More details about the characterization of the SNR at different scan times are explained in Chapter 7 - Section2.3.

#### 1.2. Resolution

There are several definitions for resolution. In FT-IR, nominal resolution is often defined as the reciprocal of the maximum OPD. Practically, resolution is defined as the minimum spacing between two consecutive wavelength ( $\Delta\lambda$ ) / wavenumber ( $\Delta\nu$ ) points that can be fully resolved by the module. Two neighboring spectral features of equal height and width are said to be resolved if there is a dip of at least 20% between the two maxima. More details about the characterization method of the resolution are explained in Chapter 7 - Section3.2.

The Signal to Noise Ratio (SNR) of the system is directly proportional to resolution ( $\Delta\nu$ ) [ $SNR \propto \Delta\nu$ ] [1].

## 2. Advanced settings

### 2.1. Gain settings

The Neospectra module has an internal Analog to Digital Converter (ADC) that converts the interferogram data (Analog current detected by the photodetector) to a digital signal.

The conversion ratio  $G_{opt}$  of the detected current to the voltage signal at the input of the ADC is expressed as:

$$G_{opt} = \frac{\text{Volts at the input of the ADC } (V_{ADC})}{\text{Current at the output of the photodetector } (I_{PD})}$$

$V_{ADC}$  is pre-set in the system, while  $I_{PD}$  depends on the optical power coupled into the system. Hence, it is set after acquiring a measurement (see Chapter 6 - Section3 for details on how to adjust gain settings with SpectroMOST)

NeoSpectra SWS62221 is delivered with two main gain settings:

- 1- **Transmission:** optimum gain setting corresponding to the coupled power by typical transmission setup (referred to in Chapter 6 - Section1).
- 2- **Reflection:** optimum gain setting corresponding to the coupled power equivalent to 1/32 of the coupled power by typical transmission setup.

The conversion ratio can be adjusted in order to:

- 1- Avoid saturation of the amplifiers: saturation leads to signal clipping and attenuation.
- 2- Enhance the SNR: using **Transmission** gain option for diffuse reflection signals degrades optimum SNR by a factor that ranges around 3-5 depending on the optical power coupled from the reflection setup.

### 2.2. Apodization

The interferogram can be multiplied by one of a number of different apodization functions to make a gradual decay to zero values at both sides of the interferogram, and hence to smoothe the spectrum.

It must be understood that the process of apodization affects both the resolution and the noise level of FT-IR spectra:

- **Resolution:** the information near the interferogram's centerburst determines the shape of the single-beam spectrum, and this low-resolution spectrum is largely unchanged when the interferogram is multiplied by an apodization function. Conversely, the sinusoids of narrow spectral features take much longer to decay and are therefore far more attenuated when the spectral data are apodized, leading to degradation of resolution.
- **Noise:** low-spatial-frequency noise and very broad bands are also largely unaffected by apodization. High-spatial-frequency noise is attenuated on apodization. On the average, the root mean square (rms) noise on the spectrum is decreased on apodization and the SNR increases.

The specific apodization function that should be used for a certain application is chosen by experimentation [1].

The currently available apodization function is "Tukey window" which represents a tapered cosine function with tapering factor 0.25. More apodization functions will be

added in upcoming software releases.

### 2.3. Zero Padding

Spectra being measured on FT-IR spectrometers consist of intensity values at equally spaced intervals. The discrete nature of the data leads to highly unlikely that the maximum absorption of any band will correspond exactly with one of these data points. In addition, the slope of the spectrum can appear to change markedly from one point to the next. To eliminate these problems, some form of interpolation or alternative data processing is necessary. One of the most useful of these is zero padding (also known as Zero Filling).

Considering complex Fourier transformation of an interferogram that consists of  $N$  data points, the real and imaginary spectra each contain  $N/2$  data points. Increasing the number of points by  $N$  (adding  $N/2$  zeros to each end of the double-sided interferogram) increases the number of data points per resolution element to two. This process may be continued until the data point spacing in the calculated spectrum is so small that no information is lost visually [2].

Available options of zero padding are: 0,1,3,7 corresponding to

- 0: No zero padding is applied
- 1:  $N$  zeros are added to the interferogram
- 3:  $3N$  zeros are added to the interferogram
- 7:  $7N$  zeros are added to the interferogram

Details on how to adjust zero padding on SpectroMOST are explained in Chapter 6 - Section3.4.

### 2.4. Wavenumber correction

Wavenumber axis of the measured spectrum may drift with aging, so two correction techniques are available:

- 1- Self-Correction: system can be auto-corrected with a smart built-in algorithm. The auto-correction is done after measuring background reference white light i.e. no sample should exist in the light path.
- 2- Correction using Reference Material: user can use a standard reference material to correct wavenumber drifts in Neospectra. User should enter the reference absorption peaks positions that correspond to the selected resolution (8 nm or 16 nm at wavelength 1,550 nm).

Wavenumber correction should be applied regularly to maintain the good performance of the module. Depending on the environment, wavenumber correction can be performed every day, week, month or year. Details on how to perform wavenumber correction using SpectroMOST are explained in Chapter 6 - Section3.

## Part II - Evaluating NeoSpectra

## Chapter 4 The evaluation software - SpectroMOST

*SpectroMOST is a software tool that can be used to evaluate NeoSpectra SWS62221. It enables plotting, saving, and loading measured spectra, as well as setting some parameters for the NeoSpectra modules.*

*In this chapter, we describe the installation steps of SpectroMOST and its Graphical User Interface (GUI)*

### 1. Installation:

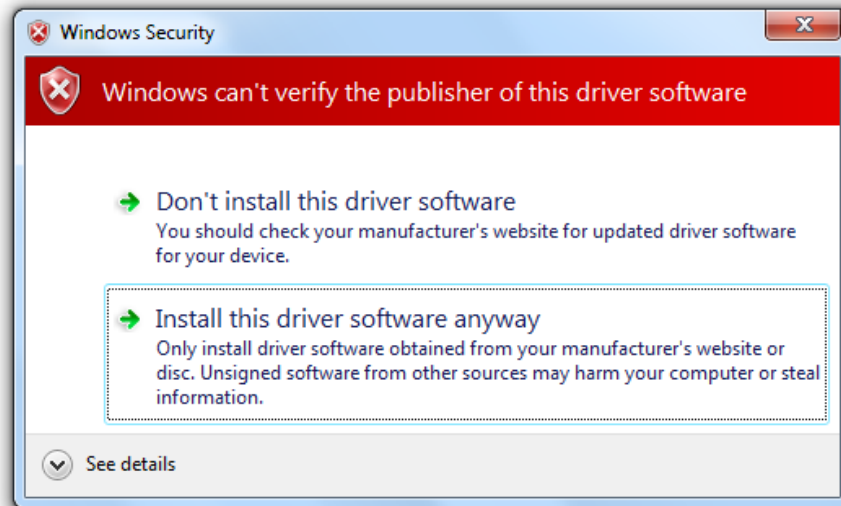
**SpectroMOST6.1\_Setup.exe** is the installation wizard for the following components:

- **SpectroMOST** software (step 1 to step 8)
- **JRE Version 7** (if not already installed on PC) (step 9)
- NeoSpectra hardware drivers (step 10)

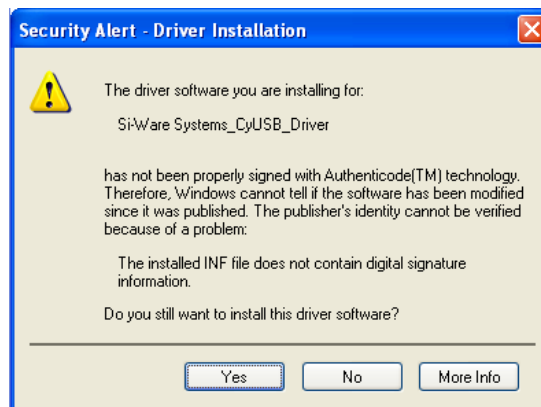
The installation procedure of SpectroMOST is as follows:

1. Run the installation wizard **SpectroMOST6.1\_Setup.exe**
2. Select the language to use during installation from the language menu. The selected language will operate during installation only. SpectroMOST uses the English language only during operation.
3. When the welcome screen appears, make sure that all other applications are closed, then click **Next**.
4. After SpectroMOST terms and conditions are read, click **Next** to proceed.
5. Browse to the SpectroMOST's installation directory then click **Next**. The path (C:\ SpectroMOST6.1) will be used as the default path.
6. Select the Start Menu folder in which SpectroMOST's shortcuts shall be created then click **Next**. The folder (SpectroMOST) will be used as the default folder.
7. Check preferences to **Create a desktop icon** then click **Next**.
8. When the wizard is ready to install, click **Install** to proceed.
9. SpectroMOST installation wizard will detect if JRE Version 7 is already installed on the computer:
  - If it exists, installation wizard will proceed to Step 10.
  - If it does not already exist, a JRE installer will be launched automatically.
10. SpectroMOST installation wizard will start preparation of the installation process of the NeoSpectra hardware drivers. A pop-up screen will give guidance for the remaining steps required to finish the installation procedure. This may require user permission for Windows Security. If the warning message in Figure 4.1 appears, select the option "**Install this driver software anyway**" on Windows Vista & Windows 7 or select "**Yes**" on Windows XP to proceed.
11. SpectroMOST installation wizard is complete.





(a)



(b)

**Figure 4.1: Warning message for driver installation (a) On Windows 7 and Vista (b) On Windows XP**

## 2. Description of the GUI

The GUI of SpectroMOST is depicted in Figure 4.2. The different elements of the GUI are enumerated in the figure. The functions operated by each numbered element are summarized in this section:

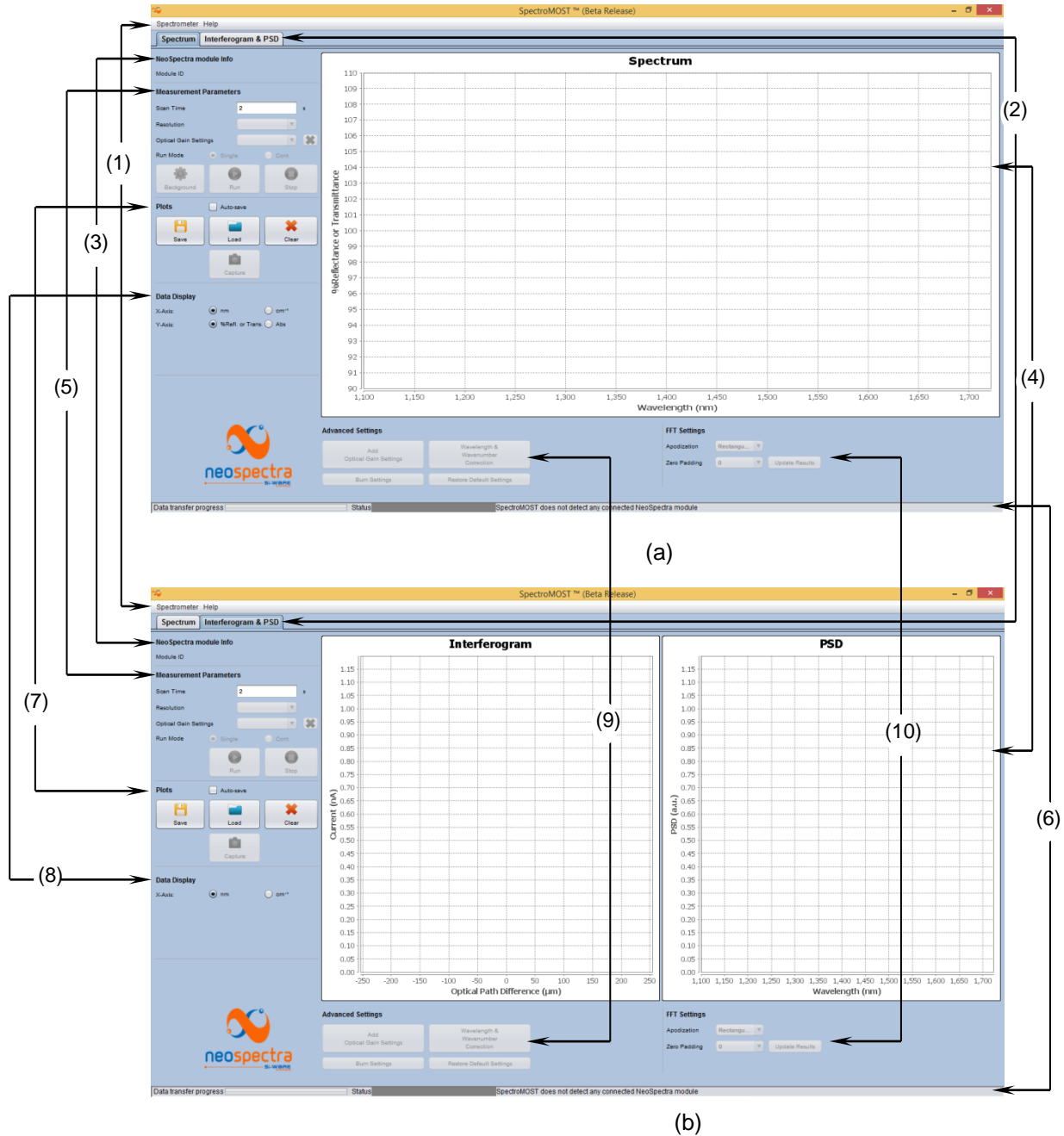


Figure 4.2: SpectroMOST GUI (a) Spectrum tab (b) Interferogram & PSD tab



- (1) **Main toolbar:**
  - SpectroMOST menu: enables to exit the software.
  - Help: enables opening the About dialog of SpectroMOST.
- (2) **Tabs selection:**
  - Toggles between the following tabs:
    - “Spectrum” tab: this tab is used to display the transmission, reflectance, or absorbance spectra of sample under test.
    - “Interferogram & PSD” tab: this tab displays the measured interferogram and its corresponding Power Spectral Density (PSD) (known as single beam spectrum)
- (3) **NeoSpectra module Info:**
  - Module ID: displays the ID of the connected spectral sensing unit.
- (4) **Display area:**
  - User can zoom in and out the graphs, save, copy, or print images of measured data.
- (5) **Measurements parameters area:** (See Chapter 3 for more details about measurements parameters)
  - Scan Time: user can specify the measurement’s scanning time
  - Resolution: user can select between different pre-set resolution values.
  - Optical Gain Settings: enables the user to select the required optical gain. The cross button allows deleting a gain setting selected in the dropdown menu.
  - Run Mode:
    - *Single:* to display the data for a single measurement with the specified scan time.
    - *Cont.:* to take continuous consecutive measurements, each measurement with the specified scan time. The latest measured data replaces the previously measured one and the plots are continuously updated.
  - Command buttons:
    - *Spectrum tab:*
      1. *Background:* applying background measurement when no material is placed in the light path. For best spectrum measurement results, background measurements should be taken as frequent as possible. It’s mandatory to take new background measurement when applying changes to measurement parameters e.g. Resolution, gain settings, etc... (Making a new measurement without updating the background is allowed if scan time is reduced)
      2. *Run:* applying spectrum measurement when material is placed in the light path. The ratioed spectra will be automatically calculated and displayed
      3. *Stop:*
        - a. Single Run Mode: Cancels displaying the measurement in progress.
        - b. Continuous Run Mode: Stops taking continuous measurements and does not display the measurement in progress.
    - *Interferogram and PSD tab:*
      1. *Run:* Initiates measurement of the interferogram and the corresponding PSD.
      2. *Stop:* Same as Spectrum tab.
- (6) **Lower bar:**
  - Status bar: displays the spectrometer module connectivity status.
  - Progress bar: displays the data transfer progress between the software



- and the spectrometer device.
- (7) **Graph manipulation area:**
- **Save:** user can save all data sets (X- and Y-axis values of plotted graphs) shown in the display area in readable formats (\*.Spectrum for data in spectrum tab, and \*.InterPSD & \*.Interferogram in interferogram and PSD tab). User will create a folder where all data sets shall be saved. User identifies a prefix which will be used with the measurement number, shown in the legend below the display area, to save the file<sup>†</sup>.
  - **Load:** user can load previously saved data in \*.Spectrum, \*.InterPSD or \*.Interferogram formats.
  - **Clear:** clears all displayed data sets in a display area.
  - **Capture:** (useful only in continuous run mode) keeps the latest plotted graph and does not replace it by the next measurement.
  - **Auto Save check box:** if enabled, it automatically saves measured data.
    - Single run mode: saves each plotted graph.
    - Continuous run mode: saves only the captured and the last plotted graphs.
- (8) **Data display control area:**
- **Spectrum tab:** user can select units of the Y-axis of displayed data (either absorbance or percentage transmittance/reflectance)<sup>‡</sup>. User can also select units of the X-axis of displayed data (either nm or cm<sup>-1</sup>)<sup>§</sup>.
  - **Interferogram & PSD tab:** user can select units of the X-axis of displayed data (either nm or cm<sup>-1</sup>).
- (9) **Advanced Settings area:** (see Chapter 3 - Section2 for more details about advanced settings)
- **Gain Adjustment:** opens a wizard that enables the creation of new gain settings that suits the optical power coupled at the input of the module. The newly created gain settings are stored on the PC on which the measurement is being performed. The gain settings will not be transported when the module is used on another host unless the settings are burnt into the module.
  - **Wavelength/Wavenumber Correction:** opens a wizard that allows to correct measurement errors that may occur due to long term drifts.
  - **BurnSettings:** opens a wizard that enables burning the advanced setting changes to the module to be able to use them on other hosts.
  - **Restore Default Settings:** reloads to the default settings with which the module was delivered.
- (10) **FFT Settings:** (see Chapter 3 - Section2 for more details about FFT settings)
- **Apodization:** user can select one of the filter techniques
  - **Zero Padding:** user can select one of the zero padding options to smoothen the curve
  - **Update Results:** apply the selected FFT Settings to the measured spectrum

<sup>†</sup> To read the saved plots in text or other formats, user may change the file extension.

<sup>‡</sup> Relation between absorbance (A) and percentage transmittance or reflectance (S) is:  $A = -\log_{10} S$

<sup>§</sup> Relation between wavenumber ( $\nu$ ) and wavelength ( $\lambda$ ) is:  $\lambda(\text{nm}) = \frac{10^7}{\nu(\text{cm}^{-1})}$

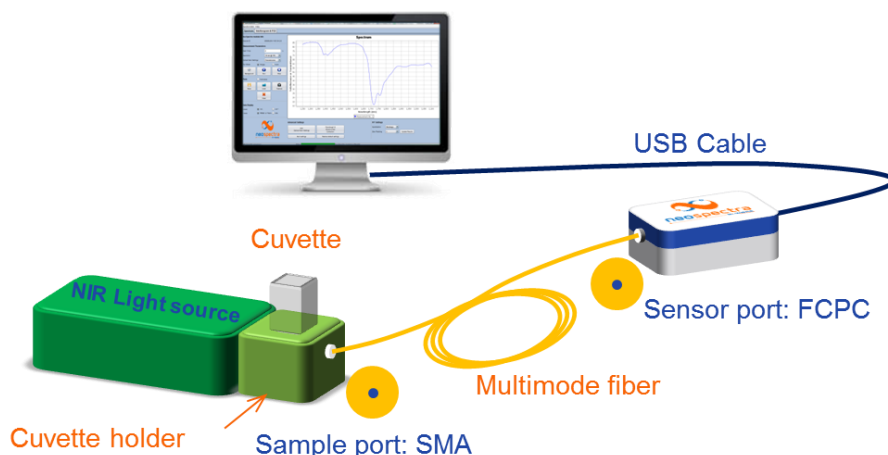
## Chapter 5 Recommended setups

*NeoSpectra SWS62221 evaluation modules are delivered with a standard evaluation kit. It is usually recommended to start evaluation with the components of the standard evaluation kit in order to replicate the performance measured in Si-Ware Systems' labs and to speed-up the learning curve. The kits can then be replaced by any other sampling and host environments that suits the unique requirements of the end-use application.*

*In this chapter, we describe the recommended setups for the evaluation of NeoSpectra for transmission and diffuse reflectance measurements*

### 1. Transmission measurements

The standard setup for transmission measurements should be built as shown in Figure 5.1.



**Figure 5.1: Diagram of evaluation setup for transmission measurement using the standard evaluation kit**

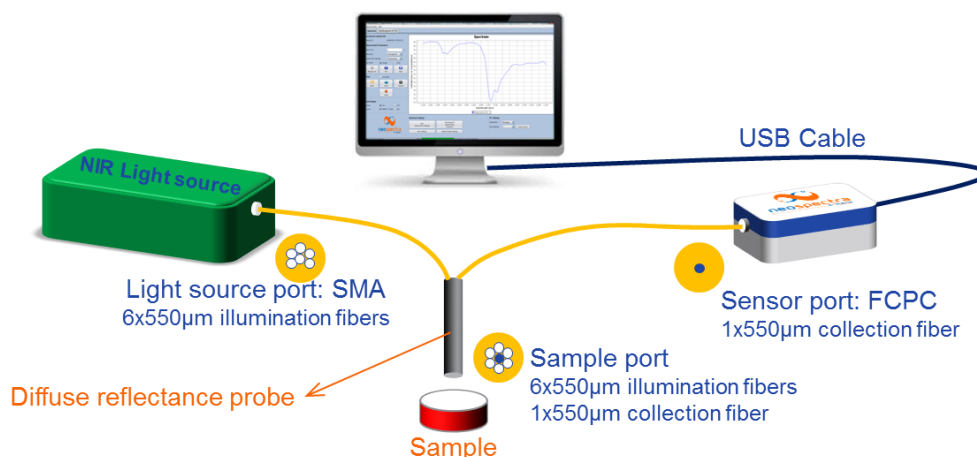
The recommended components are summarized in Table 5.1.

**Table 5.1: Components of evaluation setup for transmission measurements**

#	Component	Recommended Type	Specifications
1	Light source	Halogen or Tungsten-Halogen	Coupled light power, within wavelength range, to the module should be from 2,500 $\mu$ W to 3,500 $\mu$ W
2	Optical connection	Multimode optical fiber	Fiber 2: FCPC – SMA, Core diameter $\varnothing > 400 \mu$ m and NA = 0.22
3	Sample holder	Quartz cuvettes	Pathlengths 1 mm, 2mm, 5 mm, or 10 mm. Depending on the sample absorptivity within the spectral range.
4	Electrical connection	USB cable	USB2.0 to micro-USB
5	Host	PC	SpectroMOST installed

## 2. Diffuse reflection measurements

The standard setup for diffuse reflection measurements should be built as shown in Figure 5.2.



**Figure 5.2: Diagram of evaluation setup for diffuse reflection measurement using the standard evaluation kit**

The recommended components are summarized in Table 5.2.

**Table 5.2: Components of evaluation setup for diffuse reflection measurements**

#	Component	Recommended Type	Specifications
1	Light source	Halogen or Tungsten-Halogen	Coupled light power to the module should be >100 µW within its spectral range, The source should have a spot diameter of 1.5 mm to 2 mm at its SMA connector interface.
2	Optical interface	Reflection probe	<ul style="list-style-type: none"> <li>6 illumination fibers. Core diameter Ø= 550 µm or 600 µm</li> <li>Collection fiber. Core diameter Ø= 550 µm or 600 µm</li> <li>FCPC connector (fiber to NeoSpectra)**</li> </ul>
3	Sample reference	Spectralon/PTFE	Reflectivity 95%
4	Electrical connection	USB cable	USB2.0 to micro-USB
5	Host	PC	SpectroMOST installed

\*\* For reflection probes with SMA output port, it is required to have a hybrid fiber with core diameter Ø > 400 µm FCPC Connectorized at one end and SMA Connectorized at the other end. Besides an SMA/SMA feed-through adaptor is needed.

## Chapter 6 Evaluation Usage Guide

*SpectroMOST and the recommended evaluation setups are delivered as evaluation kits of NeoSpectra spectral sensors.*

*In this chapter, we give a quick usage guide on how to use the kits to perform the evaluation of NeoSpectra modules.*

### 1. Transmission measurements

The following is an example to demonstrate the steps that should be followed to measure transmission spectra using SpectroMOST:

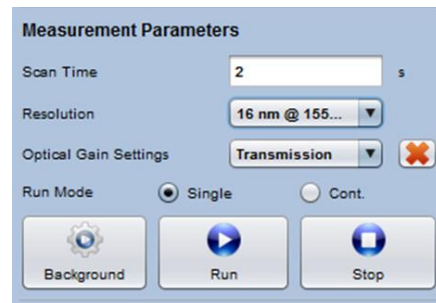
#### 1. Initialize:

- Open SpectroMOST.
- Connect the spectrometer module to the PC by the USB cable and wait for the module to initialize i.e. status bar's color becomes green.
- SpectroMOST automatically detects the module's Spectrometer ID in use and sets the appropriate interfacing parameters.

#### 2. Set measurement parameters:

(see Figure 6.1)

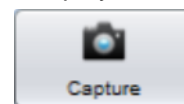
- Scan time: set the scan time that best fits your requirements.
- Resolution: select the resolution that best fits your requirements.
- Optical gain setting: select Transmission or another gain settings that you have created (see how to create new gain settings in section 3),
- Run mode: single



**Figure 6.1: Measurement parameters for transmission measurement**

#### 3. Make the measurement:

- To take a background measurement, make sure that there is no material placed in the light path and then click "**Background**" button, and then wait until the message "**Measurement completed successfully**" appears in the message bar.
- To measure spectrum, place the sample material under test in the light path and click "**Run**" button:
  - If operating in single mode: wait until the data is displayed.
  - If operating in continuous mode: SpectroMOST will operate consecutive measurements and will automatically update the plotted data. Click "**Capture**"



**Figure 6.2: Capture button**

(see Figure 6.2) to capture a certain measured spectra that is displayed on the screen or Click "**Stop**" to stop acquisition of new spectra.

#### 4. Post-measurement actions: (see Figure 6.3)

- Save plotted data (All visible plots will be saved)
- Load previously saved plots

- Plots are saved in file with an extension .spectrum. They can be easily viewed in a text reader converted to other readable formats.
- X-axis and Y-axis data units of displayed data can be changed as preferred.

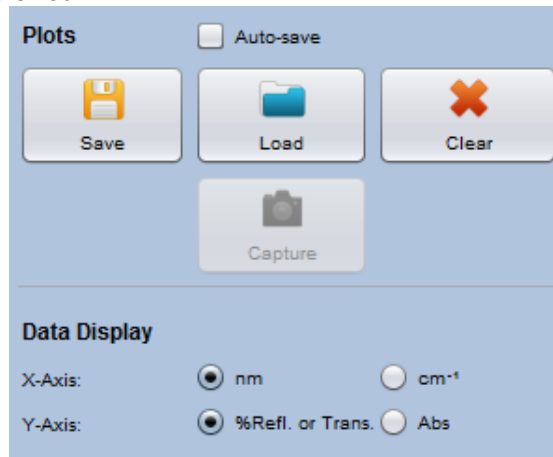


Figure 6.3: Save & Load plots and Adjusting axis' units on SpectroMOST

## 2. Diffuse reflection measurements

The following is an example to demonstrate the steps that should be followed to measure diffuse reflection spectra using SpectroMOST:

### 1. Initialize:

- Open SpectroMOST.
- Connect the spectrometer module to the PC by the USB cable and wait for the module to initialize i.e. status bar's color should turn from yellow to green.
- SpectroMOST automatically detects the module's Spectrometer ID in use and sets the appropriate interfacing parameters.

### 2. Optimize the optical power coupling:

- Go to the Interferogram tab in SpectroMOST software.
- Adjust the parameters: (see Figure 6.4)
  - Scan time: 100 ms (Short scan time is selected for high repetition rates of measurements. No intent to have high SNR in this step)
  - Resolution: select the resolution that best fits your requirements.
  - Optical gain settings: select Reflection or another gain settings that you have created (see how to create new gain settings in section 3).
  - Run Mode: continuous
- Place the probe inside the holder.

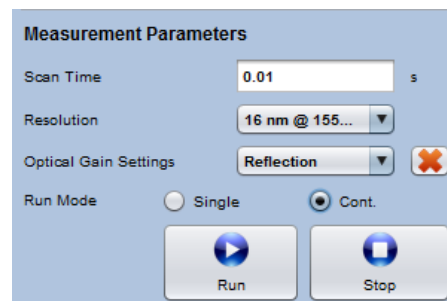
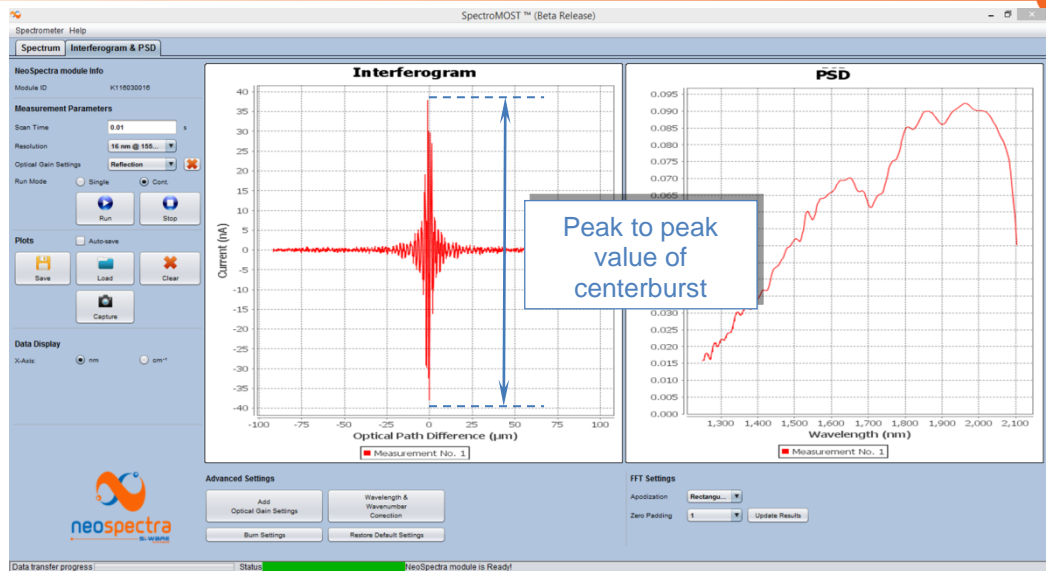


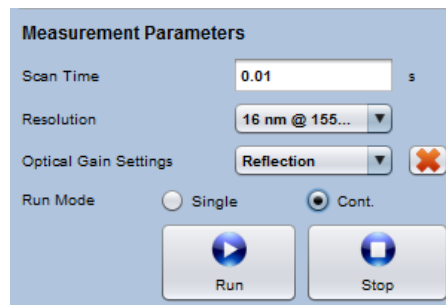
Figure 6.4: Measurement parameters for optimization of optical power coupling in reflectance measurements





**Figure 6.5: Monitoring interferogram's peak to peak on SpectroMOST to optimize the power coupling**

- Place Spectralon® at the front face of the probe
  - Click **“Run”**
  - Monitor the interferogram & PSD plots:
    - The plots will keep being refreshed. Keep monitoring the peak to peak value of the interferogram's center burst (see Figure 6.5) while slightly adjusting the distance between the probe and spectralon inside the holder.
    - Stop adjusting the distance at the point where the value of the peak to peak centerburst in the interferogram and/or the PSD value are maximum, and lock it with the screw. This is the optimum optical distance which should be few millimeters.
    - Optional: Capture the plots and save them for future reference.
  - Click **“Stop”**.
- 3. Set measurement parameters:** (see Figure 6.6)



**Figure 6.6: Measurement parameters for reflection measurement**

- 4. Make the measurement:**
- To take a background measurement, make sure that there is no material placed in the light path and then click the background button. Wait until the message **“Measurement completed successfully”** appears in the message bar.

- To measure spectrum, place the sample material under test at the front face of the probe and click the “Run” button:
    - If operating in single mode: wait until the data is displayed.
    - If operating in continuous mode: SpectroMOST will operate consecutive measurements and will automatically update the plotted data. Click “Capture” (see Figure 6.2) to capture a certain measured spectra that is displayed on the screen or Click “Stop” to stop the acquisition of new spectra.
5. **Post-measurement actions:** (see Figure 6.3)
- Save plotted data (All visible plots will be saved)
  - Load previously saved plots
  - Plots are saved in file with an extension .spectrum. They can be easily viewed in a text reader converted to other readable formats.
  - X-axis and Y-axis data units of displayed data can be changed as preferred.

## 3. Advanced settings

### 3.1. Managing gain settings

If the default gain settings are not adequate to the source, the user may need to add a new gain setting (see explanation in Chapter 3 - Section 2.1).

The following steps can be taken to manage the optical gain settings.

#### 3.1.1. Create new optical gain settings

To create new optical gain settings, proceed in the following steps:

1. Click on “Add Optical Gain Settings” button to open the wizard. (see Figure 6.7)

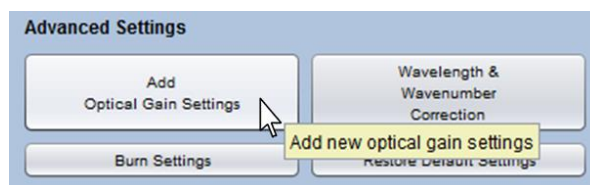


Figure 6.7: Opening wizard for the creation of new optical gain settings

2. In the wizard, type the name of the optical gain you would like to add in the “Setup Name” field (see Figure 6.8).
3. Click on “Proceed>>” button.
4. A window will pop up asking you to connect the light source to the module. Connect the light source and press “OK.”
5. To save the settings press on the “Proceed>>” button.
6. A notification message will pop-up informing the user that the settings have been saved successfully.
7. Press the “OK” button. The setting should now be saved on the host.
8. The new optical gain setting should now appear in the “Optical Gain Settings” drop down list (see Figure 6.9).

**Important note**

If you connect the module-in-use to another host, the newly created gain settings will not be transported unless you burn these settings on the module. (see how to burn settings on the module in section 3.3)

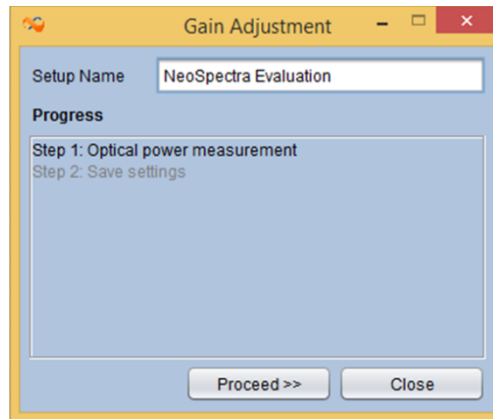


Figure 6.8: Wizard for the creation of new optical gain settings

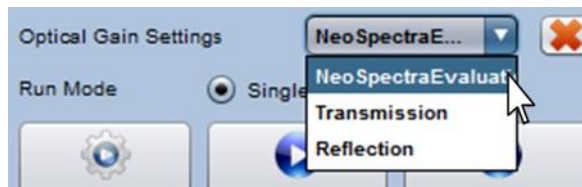


Figure 6.9: New optical gain settings created

**3.1.2. Deleting an optical gain setting:**

In order to delete an optical gain setting that you have previously created, proceed in the following steps:

1. Select the optical gain setting you would like to delete from the “**Optical Gain Settings**” drop down list
2. Click on the delete button next to the drop down list (see Figure 6.10).
3. A confirmation message will pop-up, click on the “**Yes**” button to proceed.

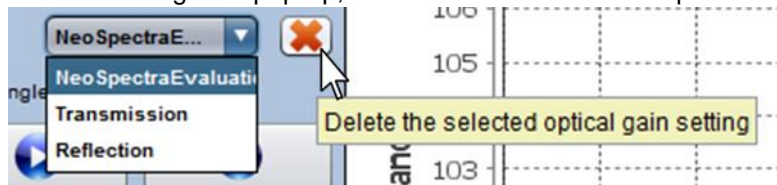


Figure 6.10: Deleting a created optical gain setting

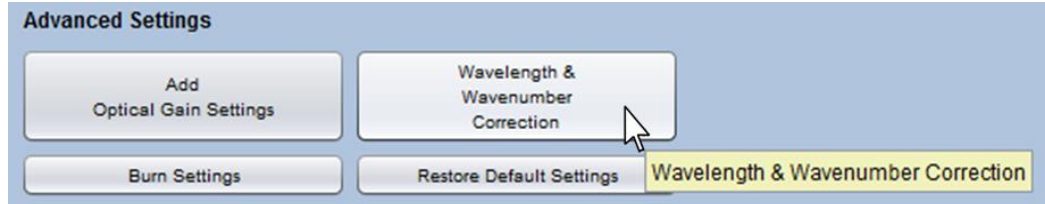
**3.2. Applying wavelength correction**

In rare cases in which you find some wavelength or wavenumber errors, you may want to perform wavelength/ wavenumber correction. SpectoMOST features two techniques that enable making this correction (see explanation about the types of wavelength correction in Chapter 3 - Section2.4)

### 3.2.1. Applying Self-correction:

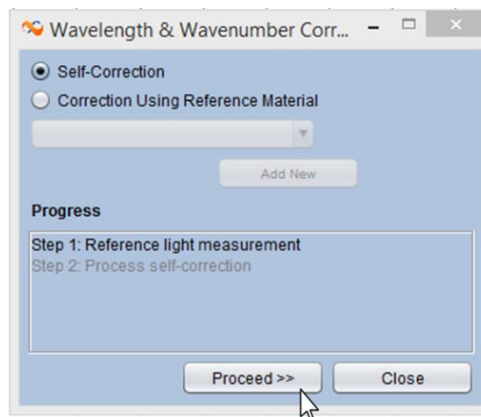
In order to apply wavelength correction using the self-correction technique, proceed in the following steps:

1. Click on the “**Wavelength & Wavenumber Correction**” button to open the wizard (see Figure 6.11).



**Figure 6.11: Opening wizard for wavelength and wavenumber correction**

2. Select the “**Self-Correction**” radio button and click on the “**Proceed>>**” button (see Figure 6.12).
3. A window will pop up asking you to connect the light source to the module. Connect a broadband NIR light source (as specified in Table 5.1) and click “**OK.**”
4. Wait until the auto-correction is done, a window will pop up by the end of the operation.
5. Click “**OK**”, then “**Close**” the wizard.



**Figure 6.12: Performing wavelength and wavenumber calibration using self-correction technique**

#### Important note

**If you connect the module-in-use to another host, the wavelength correction will not be transported unless you burn the new settings on the module (see how to burn settings on the module in section 3.3).**

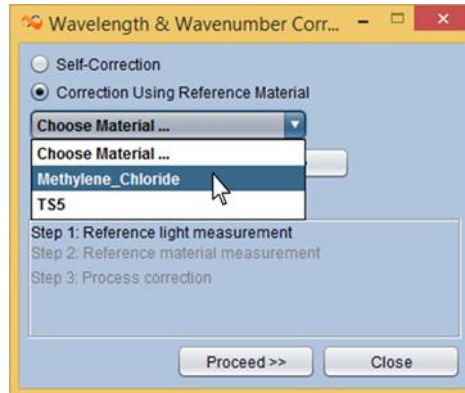
### 3.2.2. Applying Correction Using Reference Material

Methylene Chloride and TS5 can be used as reference materials for wavelength correction [3]. NIR spectra for these materials are pre-stored on SpectroMOST. If you would like to apply the wavelength correction using any of these materials, you can follow the steps below directly. Otherwise, you’ll first have to create data for new reference material.

#### A. Wavelength correction using reference material that already exists:

1. Click on the “**Wavelength & Wavenumber Correction**” button to open the

- wizard (see Figure 6.11).
2. Select the “**Correction Using Reference Material**” radio button.
  3. Select the material name from the drop down list (see Figure 6.13).
  4. Click on the “**Proceed>>**” button.
  5. A window will pop up asking you to connect the light source to the module. Connect the light source with no sample in the light path and click “**OK.**”



**Figure 6.13: Selecting reference material for wavelength correction**

6. Wait until the measurement is processed. The step should be highlighted in green after the measurement is done.
7. Now it's time to take a measurement with the reference material. To initiate this step, click on the “**Proceed>>**” button
8. A window will pop up asking you to insert the sample. Connect the light source with a sample in the light path and click “**OK.**”
9. Wait until the measurement is done, a window will pop up by the end of the operation.
10. Click on the “**OK**” button, then “**Close**” the wizard

**Important note**

**If you connect the module-in-use to another host, the wavelength correction will not be transported unless you burn the new settings on the module. (see how to burn settings on the module in section 3.3)**

**B. Creation of data for new reference material:**

1. Click on the “**Wavelength & Wavenumber Correction**” button to open the wizard. (see Figure 6.11)
2. Select the “**Correction Using Reference Material**” radio button.
3. Click on the “**Add New**” button. (see Figure 6.14)
4. A new window will pop-up (see Figure 6.15):
  - In the text box insert the name of the material and two distinctive wavelength points in nanometer units using the following format:
    - *Standard\_Calibrator\_Name* {<1<sup>st</sup> value in nm> , <2<sup>nd</sup> value in nm>}. (For example: NewMaterial{1367.5,1417.5}).
  - The chosen wavelength values are the ones that the software will use to operate the wavelength correction.
5. Click “**OK**”
6. If your entry is correct, a new window will pop-up stating the creation of the new reference has been completed. The newly created reference material should now appear in the dropdown menu. (see Figure 6.16)

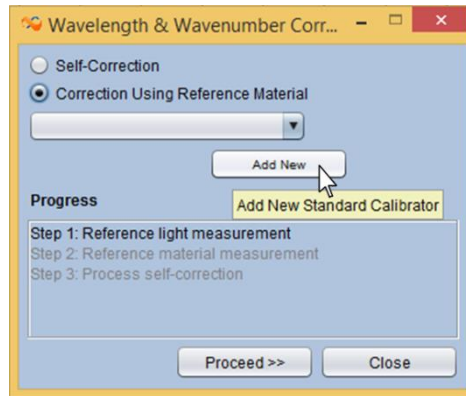


Figure 6.14: Creating of data for a new reference material

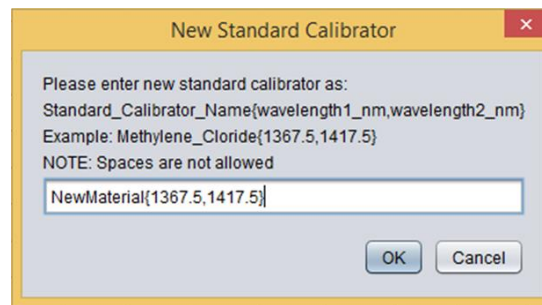


Figure 6.15: Inserting data for a new reference material

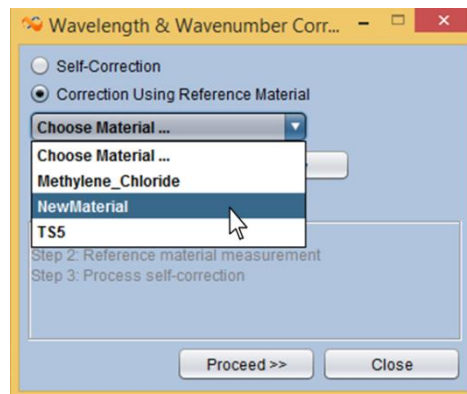


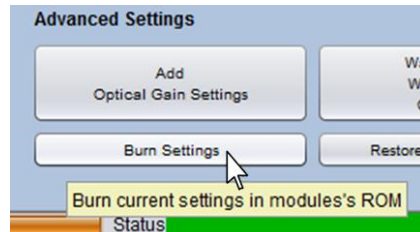
Figure 6.16: New reference material for wavelength correction created in SpectroMOST

### 3.3. Burning settings into NeoSpectra modules

As mentioned earlier, the gain settings and the wavelength correction won't be transported with the NeoSpectra module to other host systems unless the new settings are burnt into the module.

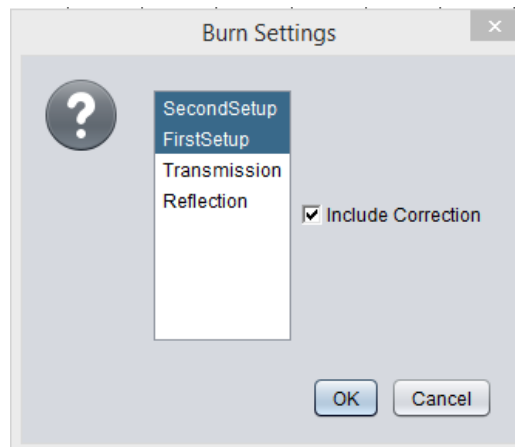
To burn the optical gain setting and/or the wavelength correction to the module, proceed in the following steps:

1. Click on the **"Burn Settings"** button. (see Figure 6.17)



**Figure 6.17: Opening wizard to burn settings on NeoSpectra module**

2. In the wizard, select from the list of the optical gain settings that you would like to burn to the module. To select multiple settings, hold the "CTRL" button while clicking on the settings names.
3. Check the "include correction" checkbox, if needed.
4. Click on the **"OK"** button (see Figure 6.18).



**Figure 6.18: Selecting the settings to be burnt on the NeoSpectra module**

At any time, you can restore the module to factory settings by clicking on **"Restore Default Settings"**. You can choose which settings to restore from the dropdown menu of the wizard.

### 3.4. FFT Settings

FFT Settings consist of two parameters that are used by the software to convert the interferogram data into a spectrum: the Apodization function and number of Zero Padding points (see explanation in Chapter 3 - Section2).

The selection of the apodization and zero padding options can be performed before or after the measurement by selecting these options from the drop down menus:

- Select the Apodization option from the "Apodization" drop down list.
- Select the Zero Padding option from "Zero Padding" drop down list
- Click the **"Update Results"** button

- A new spectrum with the new FFT settings will be drawn in the display area

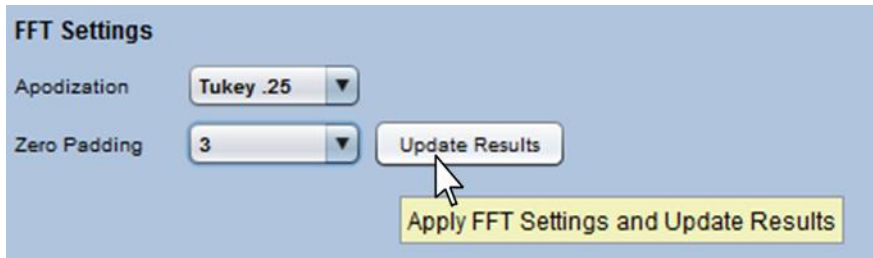


Figure 6.19: Adjusting FFT settings



## Chapter 7 Recommended Tests

*Different parameters specify the performance of spectral sensors, and some of them are dependent on external factors e.g. the SNR depends on the optical power level coupled into the spectral sensor.*

*In this chapter, certain tests that allow the characterization of the performance of NeoSpectra modules are explained. These tests are the ones that were used to define the specifications of NeoSpectra modules.*

### 1. Spectral range

#### 1.1. Definition

The spectral range, is the total useful wavenumber ( $\nu$ ) or wavelength ( $\lambda$ ) range for the module [4]. The upper and lower wavelength limits ( $\lambda_U$  and  $\lambda_L$  respectively) are determined by the wavelength points where the Power Spectral Density (PSD) (also known as single beam spectra) reaches one tenth of maximum measured energy over the range [5]. (see illustration in Figure 7.1)

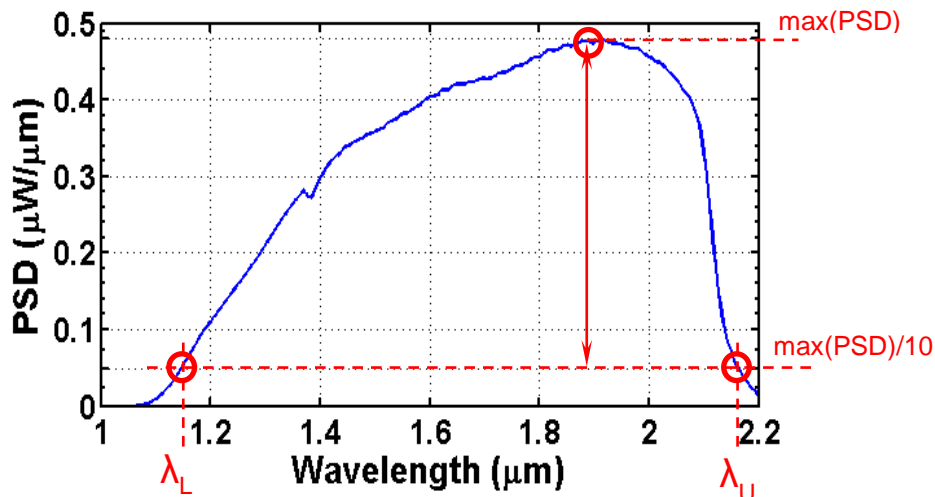


Figure 7.1: Determination of the upper and lower limits of the spectral range

#### 1.2. Characterization method

The PSD is obtained by applying a Fourier Transform on the light source's measured interferogram with no sample in the light path. It can be directly obtained from the "Interferogram & PSD" tab in SpectroMOST (see Chapter 4 - Section2). The data are reported by using external processing for the calculation of the upper and lower wavelength limits for 100 consecutive measurements, and plotting the calculated values in a plot similar to the one shown in Figure 7.2 [5]. Variation in the wavelength limits in the plot can be interpreted as unstable performance of the system.

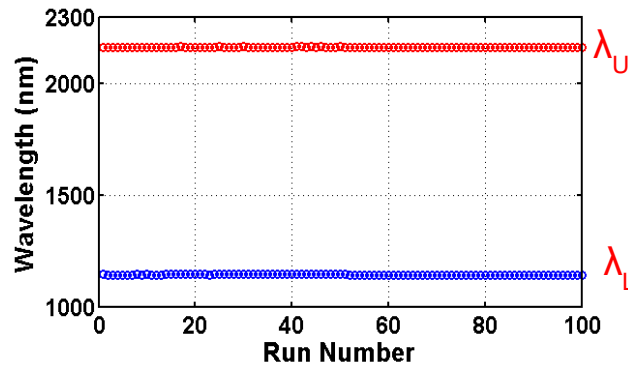


Figure 7.2: Plotting upper and lower wavelengths for the characterization of the spectral range

## 2. Signal-to-Noise Ratio (SNR)

### 2.1. Definition

Noise is defined as the variation in the signal response for repeated measurements. The Signal to Noise Ratio (SNR) measures the module's ability to reproduce a spectrum under the same conditions (e.g. temperature) and the same instrumental configurations (e.g. resolution, and integration time) over a certain period of time [1].

### 2.2. Characterization method

The SNR can be visually evaluated by measuring the 100% line. The 100% line is obtained by dividing two single-beam spectra ( $S_1(\nu)$  &  $S_2(\nu)$  with no sample in the beam path) acquired under identical conditions of resolution and measurement time and taken immediately one right after the other.

$$T_{100\%line}(\nu) = \frac{S_2(\nu)}{S_1(\nu)} \times 100$$

Ideally, the 100% line should be a flat line across the wavelength range. Practically, due to system non-idealities and noise, the 100% line looks like the plots shown in Figure 7.3.

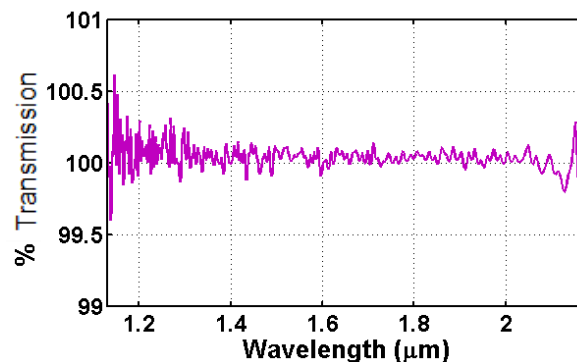


Figure 7.3: Example of 100% line

At a certain wavelength  $\lambda_o$ , the **SNR** is calculated from Root Mean Square Noise ( $N_{rms}$ ), which is the standard deviation of the baseline value in 100 consecutive 100% lines. The relationship between **SNR** and  $N_{rms}$  is given by

$$SNR = \frac{100}{N_{rms}}$$

To visualize the variation of the SNR across the spectral range, the SNR is calculated at each wavenumber as described above. The values of the SNR are then plotted against the wavelength / wavenumber.

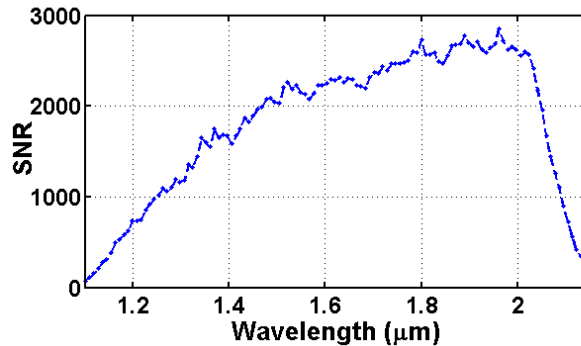


Figure 7.4: Example of the variation of the SNR across the spectral range

### 2.3. Effect of scan time on SNR

The noise consists of random and repetitive components. The repetitive components cannot be eliminated from the signal. However, the contribution of the random components can be reduced by averaging a bigger number of scans ( $N_{scan}$ ) i.e. increasing the integration time ( $t_{scan}$ ). The value of the measured SNR of a certain instrument is proportional to the square root of the number of averaged scans i.e. the square root of the integration time:  $SNR \propto \sqrt{N_{scan}} \propto \sqrt{t_{scan}}$  [1].

You can test this behavior by adjusting the scan time from the software, and calculate the SNR at certain wavelengths using the method explained in section 2.2. Plotting SNR versus the square root of the scan time should result in a linear function (see Figure 7.5).

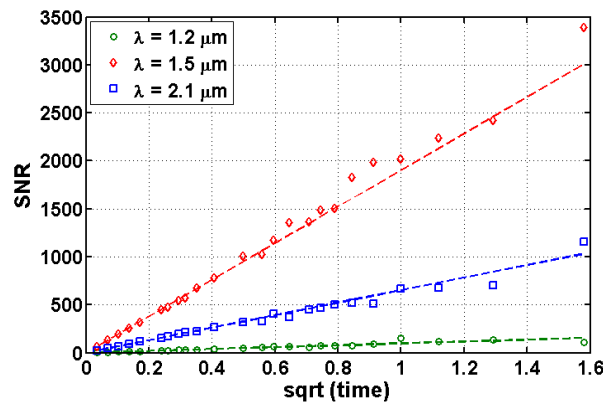


Figure 7.5: Example plot that shows the effect of increasing the scan time on the SNR

### 3. Resolution

#### 3.1. Definition

Resolution is the minimum spacing between two consecutive wavelength / wavenumber points that can be fully resolved by the module. Similar to any FT-IR instrument, the resolution of SWS62221 is limited by the maximum Optical Path Difference (OPD) between the interfering beams in the Michelson interferometer i.e. the maximum travel range of the moving mirror.

The resolution in wavenumber ( $\Delta\nu$ ) is constant across the spectral range. The relationship between resolution in wavelength ( $\Delta\lambda$ ) at certain wavelength  $\lambda$  (in nm), and  $\Delta\nu$  (in  $\text{cm}^{-1}$ ) is governed by  $\Delta\lambda = 10^7 \Delta\nu \lambda^2$  plotted in Figure 7.6

In NeoSpectra, the resolution can be adjusted by selecting one of the following pre-set values:

- $\Delta\lambda = 8 \text{ nm}$  at  $\lambda=1,550 \text{ nm} \rightarrow \Delta\nu = 33.3 \text{ cm}^{-1}$
- $\Delta\lambda = 16 \text{ nm}$  at  $\lambda=1,550 \text{ nm} \rightarrow \Delta\nu = 66.6 \text{ cm}^{-1}$

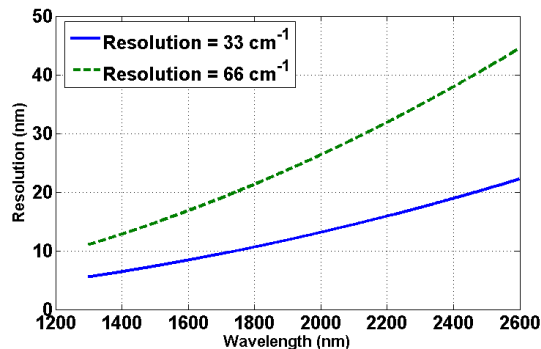
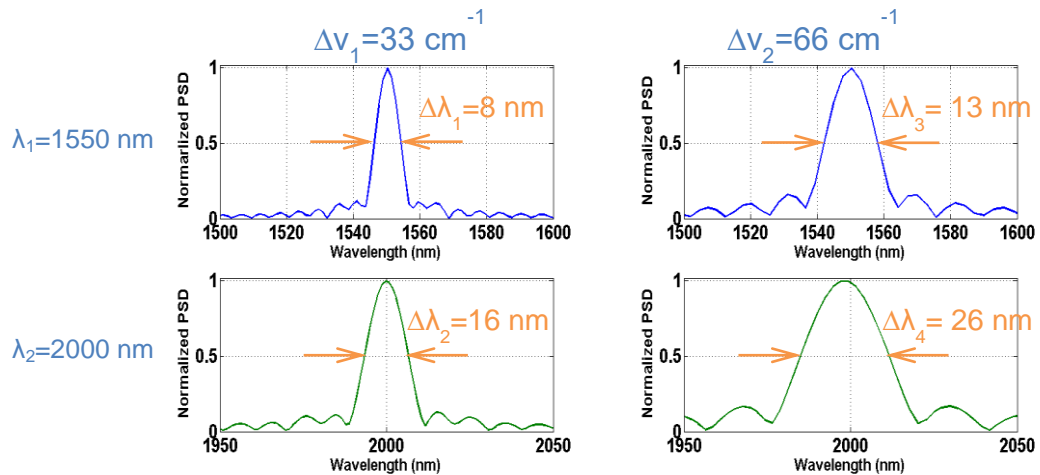


Figure 7.6: Variation of resolution in wavelength across the spectral range

#### 3.2. Characterization method

Resolution ( $\Delta\nu$  in wavenumber, and  $\Delta\lambda$  in wavelength) may be evaluated in several ways. The *nominal* resolution (in  $\text{cm}^{-1}$ ) is given by the reciprocal of the maximum optical path difference (OPD, in cm). Resolution may also be evaluated by calculating the full width at half maximum (FWHM) of the instrument line shape function obtained taking both the maximum OPD and apodization function into account (see Figure 7.7). The resolution is characterized by measuring the absorption spectrum of a reference sample with several very sharp absorption bands (such as methylene chloride) or a narrow band-pass optical filter [5].

The FWHM of the bands in these spectra when measured at high resolution should be significantly narrower than the resolution to be measured.



**Figure 7.7: Wavelength resolution of  $\Delta v=33 \text{ cm}^{-1}$  and  $\Delta v=66 \text{ cm}^{-1}$  measured at  $\lambda=1550 \text{ nm}$  and  $\lambda=2000 \text{ nm}$**

## 4. Wavelength errors

### 4.1. Definitions

There are two different types of wavelength errors that can be qualified separately:

- **Wavelength Accuracy:** this factor quantifies the discrepancy between the actual measured value of a certain wavelength and the true standard value. It is defined as the difference between the measured wavelength of a wavelength standard, and the nominal wavelength reported for that wavelength standard under the same conditions of resolution and apodization function.
- **Wavelength Repeatability:** this factor quantifies the module's ability to reproduce absorptions at the same wavelength for the same sample. It is quantified by calculating the standard deviation of wavelength error for different measured spectra for the same standard sample.

### 4.2. Characterization method

There are several materials with unique spectra that enable their use for the characterization of wavelength errors (see examples in Table 7.1).

**Table 7.1: Example of materials used for characterization of wavelength errors and their corresponding absorption peaks**

Materials	Pathlength (mm)	Absorption peaks used for characterization of wavelength errors (nm) <sup>††</sup>
Methylene Chloride	1	1155, 1417, 1690, 2245
TS5	10	1446.6, 1652.3, 1693.1, 1948, 2060.1, 2111, 2248.2, 2353.3, 2373.4, 2385.4, 2537.5

The wavelength errors are calculated by taking several consecutive spectra measurements of reference materials and calculating the errors according to the definitions described in section 4.1.

<sup>††</sup> See details of measurement conditions in [3]

## 4.3. Photometric linearity

### 4.3.1. Definition

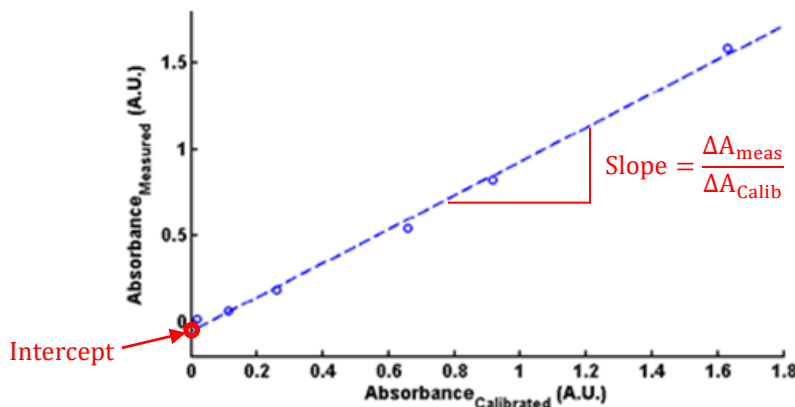
Photometric linearity is an important parameter that gives an indication about the conformation of the spectrometer's spectral response to Beer-Lambert's law at different concentration levels and/or thicknesses of the sample.

### 4.3.2. Characterization method

Below, we describe two possible methods for the characterization of the photometric linearity of a NeoSpectra module.

#### Characterization by changing sample concentration:

Characterization can be done by plotting the measured absorbance levels ( $A_{meas}$ ) against the calibrated values of the standard materials with known absorbance values ( $A_{calib}$ ) at certain wavelengths for different concentration levels. The values of the slope and the intercept of the regression line of this plot are used as indicators of the performance of the spectrometer (see Figure 7.8). Ideally, the regression line of this plot should be a line with a slope 1 and intercept 0.



**Figure 7.8: Plot for the characterization of the photometric linearity by changing the concentration levels of the sample**

The samples to be used for the characterization, the number of datapoints, the concentration levels, the wavelengths at which the measurements are to be performed, and the acceptable values of slope and intercept usually depend on the requirements of the target application. For instance, the pharmacopoeia guidelines, stipulate that a minimum set of four standards with reflectances varying between 10% and 90% should be acquired at wavelengths 1200 nm, 1600 nm, and 2000 nm. Standards having lower reflectances (eg 2%, 5%) should be added to the set if the instrument is being employed for the measurement of low reflectance (less than 10% reflectance). The value of the slope should be in the range of  $1.0 \pm 0.05$ , and the value of the intercept should be in the range of  $0.0 \pm 0.05$  [6].

#### Characterization by changing sample thickness:

A simpler but less accurate method is to plot the measured absorbance levels ( $A_{meas}$ ) at a certain wavelength against the thickness of sheets of a polymer (e.g. acrylic (see Figure 7.9)) that is used as a sample. The values of the intercept and the norm of residuals of the regression line are used as indicators of the performance of the spectrometer (see Figure 7.10).

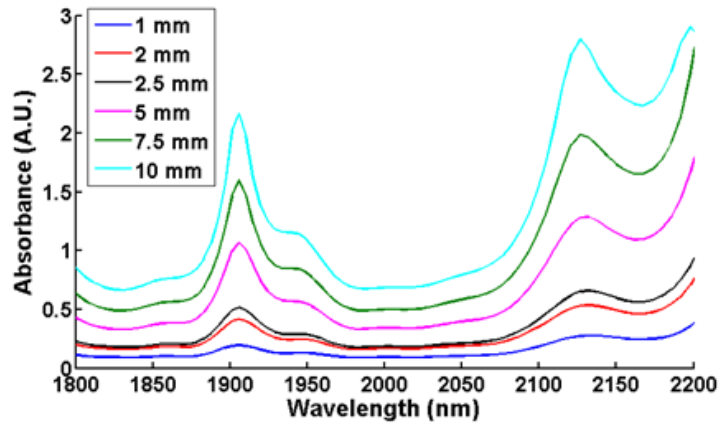


Figure 7.9: NIR spectral response of acrylic sheets at different thicknesses

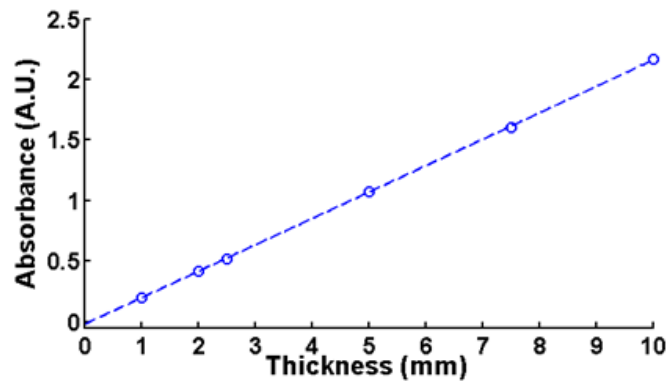


Figure 7.10: Typical plot for variation of absorbance values at different thicknesses of an acrylic sample

# Part III - Developing with NeoSpectra



## Chapter 8 The Software Development Kit (SDK)

*The Software Development Kit (SDK) is a set of APIs that enables communicating data and commands with NeoSpectra spectral sensors. These APIs can be used to develop the end-use application software. The spectra analysis algorithms can be integrated within the code of the application software using external sets of codes.*

*In this chapter, we describe a quick overview on what to expect in the SDK. A complete listing of the APIs and error codes are provided in the SDK description document. Please contact Si-Ware Systems if you do not have this document or to confirm that you have the latest version.*

### 1. Description of the package

The SDK package consists of the following folders:

- **bin:** Output folder for the user application.
- **bin\_debian\_arm\_x86:** contains spectrometer libraries, jar and configuration files to be used for Debian 32bit platform on ARM architecture.
- **bin\_ubuntu\_x86:** contains spectrometer libraries, jar and configuration files to be used for Ubuntu 32bit platform.
- **bin\_ubuntu\_x64:** contains spectrometer libraries, jar and configuration files to be used for Ubuntu 64bit platform.
- **bin\_win\_x86:** contains spectrometer libraries, jar and configuration files to be used for Windows 32bit platform.
- **bin\_win\_x64:** contains spectrometer libraries, jar and configuration files to be used for Windows 64bit platform.
- **spectromost:** contains the source code of SpectroMOST. This code is can be used as a reference to the developers when they are developing their unique software.

### 2. Software architecture

SpectroMOST SDK has two main components:

- **Application Software:** this component should be replaced by the end-use application software. "spectromost.jar" and other third party modules are delivered for reference
- **Spectrometer Driver:** the interface between the application software and the drivers of NeoSpectra module. This includes the components from which the APIs and the commands to the hardware are called.

The architecture of the SDK is structured as shown in Figure 8.1.

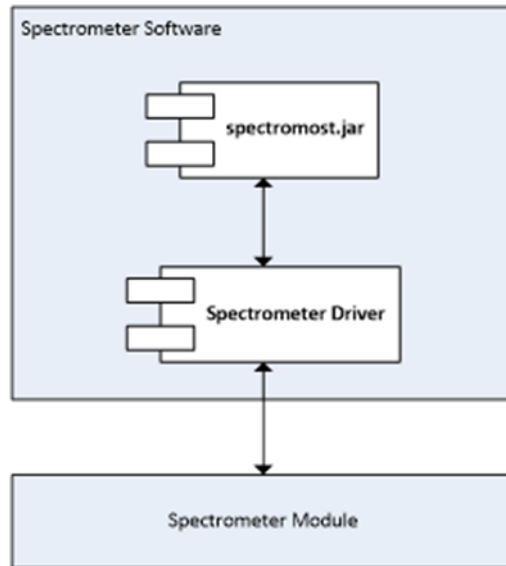


Figure 8.1: SDK Components

### 3. Quick description of the APIs:

The APIs (explained in details in the SDK description documents) are the commands that enable the application of the following functions with the NeoSpectra module:

- Identify the state of the system
- Perform initialization
- Perform measurements (background, spectrum, interferogram, PSD) with specific parameters (resolution, scan time, gain settings)
- Manage advanced settings (optical gain settings, wavelength correction)

A typical operation of the system is as follows (see flowchart in Figure 8.2):

1. Perform initialization
2. Wait in idle state for a run command.
3. When receiving a run command:
  - a. Switch the device on
  - b. Use the correct calibration folder to use in run procedure
  - c. Wait for run to be finished
  - d. Request output data
  - e. Switch the device off
4. Return to idle state waiting for new run command

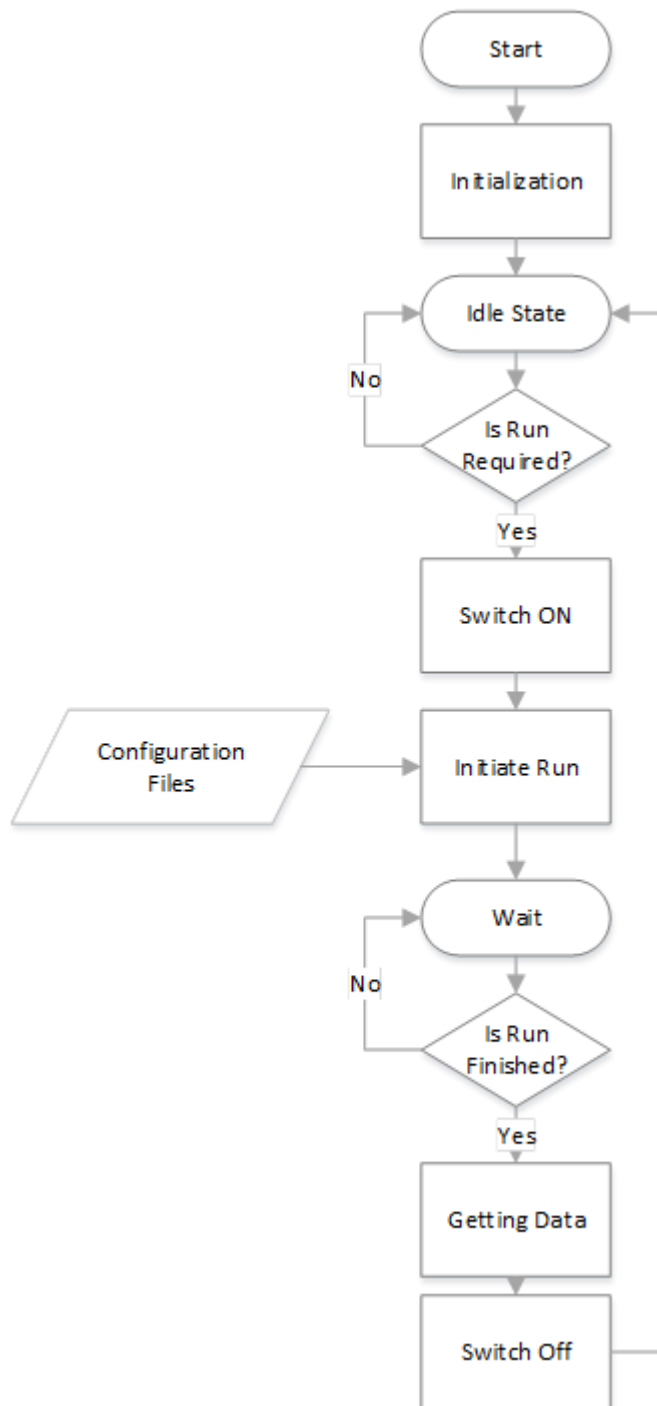


Figure 8.2: Operation flowchart

## Chapter 9 Usage guide for development of end-use application

*NeoSpectra SWS62221 can be built into a wide variety of environments. Certain conditions need to be accounted for when developing the end-use system in order to ease the development process and allow the module to run smoothly.*

*In this chapter, we briefly list the recommendations and/or requirements for building the components around the NeoSpectra module i.e. the sampling setup and the host. Furthermore, we provide a quick usage guide on how to build the application software on the host.*

### 1. The hardware

#### 1.1. Optical input

The light coupled into the NeoSpectra module should maintain the conditions listed in Table 9.1:

**Table 9.1: Requirements for the sampling setup**

Parameter	Value
Spot size	≥ 400μm (smaller spot sizes implies lower optical power coupled into the system)
NA	> 0.1 (smaller NA implies lower optical power coupled into the system)
Optical power	70μW – 4 mW across the spectral range 1,200 – 2,500 nm

#### 1.2. Host

For the integration of NeoSpectra SWS62221 with single board computers. It is recommended to use Debian 32 ARM architecture. The operation of NeoSpectra has been tested and validated on the following platforms:

- Raspberry Pi 2
- BeagleBone

### 2. The software (SDK)

#### 2.1. Installation

SpectroMOST should be installed before proceeding with the SDK installation steps. After downloading the SDK package the following steps should be performed in Eclipse IDE:

1. Open a new project: Click **File**→**New**→**Java Project**
2. Uncheck **“Use default location”**
3. In the **“Location”** field, browse to the location of the SDK package (e.g. D:\SDK v4.0)
4. Press the **“Next”** button
5. Under the source tab, the SDK package hierarchy should be displayed. Select the folder corresponding to your operating system. Right click and select **“Use as source folder”**
6. Make sure that only 2 folders are marked as source folders (Spectromost/src and the folder corresponding to your operating system)
7. Make sure that the **“Default output folder”** field contains the path to the bin

- folder (e.g. D:\SDK v4.0\bin)
8. **Click on the libraries tab, remove any paths that don't belong to your operating system**
  9. Click "**Finish**"
  10. From the menu select "**Run→Run Configurations**"
  11. Write click on "**Java Application**" and click "**New**"
  12. Under the "**Main**" tab, in the "**Main class**" field, click on "**Search**".
  13. In the "**Select Main Type**" window, type "**UserInterface**" and select it from the list. Click "**OK**"
  14. Click on the "**Arguments**" tab. In the "**VM arguments**" field, type the following commands:
    - For Windows platforms:
      - -Djava.library.path="`<path to the SDK libraries corresponding to your platform>`" -  
Dswing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
      - For example: -Djava.library.path="D:/SDK v4.1/bin\_winx64" -  
Dswing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
    - For Linux based platforms:
      - -Djava.library.path="`<path to the SDK libraries corresponding to your platform>`" -  
Dswing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel -jamvm
  15. Click "Run"

## 2.2. How to use

### On Windows/Linux Platform:

The code that generates the SpectroMOST software code should be available upon installation and can be used as a sample code. You can either edit the sample code or build a new application.

### On Beaglebone or Raspberry Pi boards:

You can perform the installation steps on a Windows/Linux based PC, build your JAVA application on PC (SpectroMOST code can be used as an example), copy the SDK with your output JAR files to the board, and then run it from the board.

## **Part IV - Miscellaneous**

## Chapter 10 Disclaimers

*Certain conditions may cause malfunction or damage of NeoSpectra spectral sensor modules. Please read this chapter carefully before handling NeoSpectra modules.*

### 1. Precautions & Limitations

#### 1.1. Usage precautions

1. Do not apply excessive vibration or shock to the device. Although vibration rejection mode is supported, excessive vibrations or shock may damage the current version of SWS62221.
2. Do not inject input power to the module more than (4 mW) or lower than (2 mW) within the spectral range (1,200 – 2,600 nm). This may cause improper operation of the instrument and does not guarantee the specification in transmission mode. For reflection mode, do not apply input power lower than (70  $\mu$ W).

#### 1.2. Storage

1. Do not store in humid, dusty, or unclean places. This may cause malfunction for the whole instrument.
2. Module should be stored in environments complying to the conditions stated in this section.

#### 1.3. Handling

1. Do not use organic solvents in cleaning (acetone, alcohol....etc). Wipe with dry and clean tissue.
2. When attempting to connect the fiber, do not apply excessive force to the optical connector. Excessive force may damage the connector and will affect measurement results.
3. Make sure that the FC-PC connector of the external fiber is well cleaned before connecting it to the NeoSpectra module. An uncleaned connector may damage the optical interface.

#### 1.4. Software installation

1. If older versions of SpectroMOST (v1.0 to v3.4) were previously installed, it is highly recommended to install this version on a different PC to avoid spectrometer driver conflicts.

### 2. Known issues

1. A single instance of SpectroMOST can't operate multiple modules. When connecting multiple modules to the same host, each module has to be connected to a different instance of SpectroMOST. To switch between the different modules, the user will have to switch between the different instances. If a module is disconnected from the host and then reconnected, it may not connect to the same instance of the software they were connected to before the disconnection.
2. The optical gain settings of the background and the sample measurement have to be the same. In Spectrum tab, SpectroMOST doesn't support having an optical gain setting that is different from the background. The gain setting should be set to the measurement with the higher coupled power level, which is usually the background, in the case of measuring samples that attenuate

optical power, where the coupled power level in sample measurement is three times less than background, SNR of sample measurement is degraded. To solve this issue, manual calculation of the spectrum in Interferogram & PSD tab can be done by adjusting two gain settings, one for background and another for sample. You can then collect spectrum data by calculating the ratio of sample measurement and background measurement. In this case, SNR of sample measurement is optimized, however some baseline shift may exist due to gains mismatch. Such baseline shifts can be calibrated at the start of measurement and then subtracted from absorbance spectra afterwards.

3. The wavelength/wavenumber vector delivered from different modules of the same type is not the same. This can be manually adjusted by changing some parameters in the modules' configuration files. In future versions of the software, users will be able to make this adjustment from the GUI and/or the SDK.



## Chapter 11 Troubleshooting

Whenever you encounter an issue during the evaluation of NeoSpectra spectral sensors and/or the integration of the module in your unique environment, you may need to refer back to the product manual.

In this chapter, we summarize the most common issues that you may encounter, describe the root cause, and propose actions to take in order to resolve the issue. If none of the proposed actions help you to solve your problem or if you are encountering an issue that is not listed in this chapter, please contact [neospectra.support@si-ware.com](mailto:neospectra.support@si-ware.com).

### 1. System performance

#	Symptom	Possible Cause	How to act
1	Noise is at a high level	Insufficient optical power is coupled into the system	Make sure that the optical power is within the recommended range and make sure that all of the components of the sampling setup are well positioned and intact.
		Optical gain settings are not well-optimized	Make sure that you are using the correct optical gain settings and create new optical gain settings with your setup if you haven't already done so.
		System is stabilizing	Make sure you have waited sufficient time for your light source to stabilize and more than 15 minutes for the NeoSpectra module to stabilize.
2	The wavelength accuracy is worse than usual	The module is operating at an inadequate temperature	Make sure that the ambient temperature does not exceed 40°C.
		Aging effect if operating in harsh environments	Perform wavelength calibration routines.
3	The baseline of the spectrum is shifted above or below 100%	Optical gain settings are not well optimized	Make sure that you are using the correct optical gain settings and create new optical gain settings with your setup if you haven't already done so.
		Measurements are taken during the warm up time of the light source	Make sure that measurements are taken after the stabilization of the light source. You may need to refer to the datasheet of the light source to know the typical warm up time. If the measurements are to be taken during the warm up time, frequent background measurements are required.
		Background and/or sample measurement have been taken during the warm	Make sure that measurements are taken 15 – 20 minutes after connecting the module to the host. If the measurements are to be taken during the warm up time, frequent

		up time of the module.	background measurements are required.
4	Wavelength drifts, or baseline tilts are observed in the measured spectra	Background and/or sample measurement have been taken during the warm up time of the module.	Make sure that measurements are taken 15 – 20 minutes after connecting the module to the host. If the measurements are to be taken during the warm up time, frequent background measurements are required.

## 2. SpectroMOST

#	Symptom	Possible Cause	How to act
1	The software does not detect the NeoSpectra module although it is connected	Problem with the USB cable	Change the USB cable
		Driver is not properly installed	Check in the device manager that the USB driver is properly installed. You may need to manually remove the driver from the device manager and reinstall SpectroMOST.

## 3. SDK

#	Symptom	Possible Cause	How to act
1	Linking errors while building the application	Pointing to the wrong libraries folder	Check in your eclipse configuration that you are pointing to the correct libraries corresponding to your operating system.

## References

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