Micron Optics, Inc.
sm125 Optical Sensing Interrogator
Product Manual and Technical Reference

Introduction

Features

- High-Accuracy, full-spectrum wavelength and power measurements
- Compact, rugged and portable
- Excellent thermal and long-term stability
- Ethernet remote control and data transfer, including wireless support for PDA
- Field-proven fast swept laser source
- Available internal NIST-traceable absolute wavelength reference ensure long-term accuracy and reliability
- Versatile on-board processor

Applications

- Long-term field measurement of multiple FBG, LPG, long-gauge interferometric and EFPI sensors
- Laboratory analysis of sensor behavior and shape using internal high-powered laser and high-dynamic range detection circuitry
- High volume applications where custom computational capabilities are required
- Obtain comprehensive feedback on sensor capabilities

Description

Micron Optics' sm125 is a compact interrogator specifically designed for measuring static to moderately dynamic phenomena, like strain, temperature, and pressure. The 1-10 Hz scan rates allow for simultaneous sampling of up to 160 sensors on a single fiber. The sm125 can be expanded to up to four optical channels (fibers) onboard and up to 16 using an optional channel expansion module.

The sm125 is based on the same proven Fiber Fabry-Perot Tunable Filter technology as other top-of-the-line sensor interrogator instruments from Micron Optics, but is designed to keep total system costs very low – especially in large volume applications where many sensor and interrogators are needed. Internal peak detection options and an Ethernet interface make data collection and analysis to any computer fast and easy. A LabVIEW™ remote utility example provides many display options for wavelength, temperature, pressure, displacement, etc.

Rugged applications are also served well by the sm125. It is designed and tested for long-term operation in extreme temperatures like those found at many measurement sites.

For sales and service information, contact please contact Micron Optics or your local representative.

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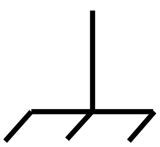
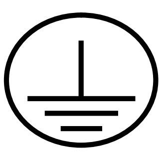
Note: Explanations and guidelines in this manual assume a fundamental working knowledge of fiber optic cables and connectors, as well as familiarity with the major computing environments and operating systems.

Please forward all comments or questions to sm125@micronoptics.com.

1. Safety, Compliance, and Warranty

1.1 Safety Symbols

The following symbols and messages may be marked on the unit. The purpose of safety symbols is to alert the user to possible dangers. The safety symbols and the explanations with them deserve your careful attention and understanding. The safety warnings do not by themselves eliminate any danger. The instructions or warnings they give are not substitutes for proper accident prevention measures.

Symbol	Description
	Laser Safety. Refer to user's manual for safety instructions for use and handling.
	Refer to user's manual for safety instructions for use and handling.
	Caution. Risk of electric shock.
	Frame or chassis terminal for electrical earth ground.
	Electrostatic discharge (ESD). Refer to user's manual for safety instructions in use and handling.
	Protective conductor terminal for electrical earth ground.
WARNING	This sign indicates a procedure with the potential to cause serious injury or loss of life to the user if not performed with strict adherence to all safety instructions. Ensure that all conditions are fully understood and met before proceeding.
CAUTION	This sign indicates a procedure with the potential to cause serious damage to or destruction of the unit if not performed with strict adherence to the all safety instructions. Ensure that all conditions are fully understood and met before proceeding.

1.2 Line Power

WARNING: If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. There are not internal user-serviceable parts.

The sm125 can operate from any DC power supply that supplies 5V +/- 5% and can supply 8 A of current.

WARNING: To avoid possibility of injury or death, do not operate any electrical device with visible damage to power supply, line cord, or outer enclosure.

CAUTION: Do not expose the unit directly to rain or other excessive moisture.

IMPORTANT NOTICE REGARDING POWER CONNECTORS: The sm125 is equipped with two (2) input power connectors. The front panel mounted connector is a three (3) terminal, removable terminal block that is intended for fixed wiring applications. Therefore, it is extremely important that the power be applied in the proper sequence:

1. With the power supply OFF…
2. Connect the power supply leads to the terminal block.
3. Plug the power connector block into the front panel of the sm125.
4. Tighten the two (2) retaining screws.
5. Apply power.

If the front panel power terminal block needs to be removed, the power supply MUST be turned OFF BEFORE it is disconnected or reconnected.

This is extremely important as these types of connectors are not intended to be used as switches.

If the unit is to be used in a portable application (or one where the power is cycled), use the rear panel mounted coaxial power connector which is designed to handle power application and disconnect under all load conditions.

Micron Optics recommends the use of a qualified surge protector to prevent damage from unexpected power transients.

1.3 Signal Outputs and Peripherals

-The only required peripheral for normal operation is an RJ-45 Ethernet Cable.

-Additional Ports:

VGA:	Can be used for limited diagnostic purposes, including display of IP parameters.
COM1, RS-232:	Available for other communications protocols on OEM basis.
COM2, RS-485:	Available for other communications protocols on OEM basis.
USB:	Used with optional USB-Ethernet converter for wireless Ethernet communication.
8 pin DIN:	Used for sm125 accessories, including optional sm041 Channel Expansion Module.

1.4 Laser Safety

Initial Laser Safety Information for Swept Laser Source

The specifications for these instruments are as follows:

		sm125
Laser Type		Fiber Laser
Laser Class		1
(According to IEC 60825-1, 21 CFR 1040.10)		
Output Power (CW)		
	min	>0.06mW
	max	<0.25mW
Beam Diameter		9mm
Numerical Aperture		0.1
Wavelength		1510nm – 1590nm

NOTE:  

The laser safety warning labels are fixed on the instrument.

You MUST return instruments with malfunctioning lasers to Micron Optics for repair and calibration.

WARNING: Use of controls or adjustment of performance or procedures other than those specified for the laser source may result in hazardous radiation exposure.

Refer servicing only to qualified and authorized personnel. There are no internal user-serviceable parts.

WARNING: Do not enable the laser (turn on instrument) when neither an optical connector nor FC/APC connector cover is connected the optical output connector. Refer to section 6 for location of optical outputs.

The laser is enabled when power is supplied to the instrument and the instrument is initialized. The red LED on the instrument from panel indicates power is present.

WARNING: Under no circumstances look into the end of an optical cable attached to the optical output when the device is operational.

WARNING: The laser radiation is not visible to the human eye, but it can seriously damage your eyesight.

CAUTION: Connecting damaged or dirty fibers to the unit can damage the optical connectors on the unit.

CAUTION: Never force-fit an optical connector. A ferrule may break off and damage the unit.

CAUTION: Do not attempt to connect an FC/PC or FC/UPC optical connector to the front panel mount FC/APC connectors of the sm125. Such mismatched connections can lead to malfunction or even damage of the module.

Follow standard guidelines for cleaning optical fibers.

1. Fold a lint-free wipe into a compress.
2. Moisten the compress with isopropyl alcohol.
3. Remove the connector's protective cover.
4. Press the connector endface firmly to the moistened section of the compress for a moment, then forcefully wipe the end with a twisting motion towards the edge of the compress, finishing in a clean, dry section of the compress. Repeat process, making sure to not reuse dirty sections of the compress.
5. Discard the used compress.

NOTE: In order to maintain optimal measurement performance of the sm125, the front panel optical connectors must be kept clean. Use of an In-Adapter Ferrule Cleaner is recommended periodically. Please contact Micron Optics or visit www.micronoptics.com to purchase or receive a recommendation for an appropriate ferrule cleaner.

1.5 Compliance Information

This product complies with Part 15 of the FCC Rules. Operation is subject to the following two considerations: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This product complies with Emissions Standard EN61326-1, Subpart B Rules and Regulations Class A limits, EN61000-3-2 and EN61000-3-3.

This product complies with Immunity Standard EN61326-1 (2000).

This product complies with Safety Standard EN61010-1.

This product complies with 21 CFR Subchapter J.

This product complies will all applicable European Normatives and is CE compliant.

1.6 Warranty and Calibration Information

Micron Optics offers excellent warranty protection for all components, modules and instruments sold. Details regarding the warranty are available in the Terms and Conditions of Sale distributed at the time of purchase.

The Micron Optics sm125 Optical Sensing Interrogator is designed with long-term field deployment in mind. Continual on-board calibration procedures using epoxy-free, Telcordia qualified optical referencing components and/or NIST Standard Reference Materials ensure that sensor wavelength measurements remain within specification over the life of the product.

2. Specifications

Specifications	sm125-700 (preliminary)	sm125-500	sm125-200
Optical			
Number of Optical Channels	4 (8 & 16 available)	4 (8 & 16 available)	1
Wavelength Range	1510-1590 nm	1510-1590 nm	1520-1570 nm
[a] Wavelength Accuracy	1 pm	1 pm	10 pm
[b] Wavelength Stability	1 pm	1 pm	5pm
[c] Wavelength Repeatability	0.5 pm at full speed, 0.2 pm with 10 averages		
[d] Dynamic Range	30dB	50 dB	40dB
Scan Frequency	10 Hz	1 Hz (2 and 5 Hz available)	
Typical Sensor Spacing	> 2 x Sensor Bandwidth		
Optical Connectors	FC/APC (E2000 available)		
Mechanical			
Dimensions	114 mm x 234 mm x 132 mm		
Weight	2 kg (4.5 lbs)		
Environmental			
Operating Temperature	0° to 50°C		
Operating Humidity	0 to 80%, non-condensing		
Storage Temperature	-20° to 70°C (preliminary)		
Storage Humidity	0 to 95%, non-condensing		
Electrical			
Input Voltage	+5 VDC (12 or 24 VDC convertors available)		
AC/DC Convertor	Included (100~240 VAC, 47~63 Hz)		
Power Consumption	18 W typ, 30 W Max		
[e] Local Data Storage	Available (external USB memory)		
Interfaces	Ethernet (TCP-IP) (USB, RS-232, RS-485, and wireless Ethernet available)		
Protocols	Custom MOI protocol via Ethernet (Modbus and others available)		
Data Management			
On-Board Firmware	Full-spectrum and peak-detection modes		
Remote Software	Spectral analysis, peak detection, data logger, peak tracking, and instrument control		
LabView Source Code	Allows for customization of remote software		
Options			
Wireless PDA Kit	Wireless Ethernet communication (802.11b), USB adaptor, PDA, and PDA Utilities		
PDA Utilities Software	Data display, data logger, and instrument control		
Channel Expansion	Please See Our 8 or 16 channel sm041 Multiplexers		
Battery Pack (for sm125)	12V rechargeable battery power supply		

050729v

Notes:

[a] Per NIST Technical Note 1297, 1994 Edition, Section D.1.1.1, definition of "accuracy of measurement"
1 pm accuracy in -700 model for 40nm scan range.

[b] Captures effects of long term use over full operating temperature range of the instrument.

[c] Per NIST Technical Note 1297, 1994 Edition, Section D.1.1.2, definition of "repeatability [of results of measurements]"

[d] Defined as laser launch power minus detection noise floor. Detection BW limits DR for scan rates >2 Hz.

[e] USB memory operating conditions may differ from sm125 specifications.

Table 2.1: Specifications

3. Connections

Figure 3. A front panel view of the sm125 Optical Sensing Interrogator

3.1 Electrical Connections

The sm125 module is powered with 5Vdc. The unit can be run from any 5V +/-5% DC power supply capable of providing 8.0 A current. The sm125 module is also available with an external AC adapter which accepts an input voltage ranging from 100-240 Vac within a frequency range of 47 to 63Hz.

The sm125 is equipped with two input power connectors. The primary power connector that works with the supplied AC adapter is a rear panel mounted coaxial power connector, designed to handle power application and disconnect under all load conditions.

The front panel mounted connector is a three (3) terminal, removable terminal block that is intended for fixed wiring applications. Therefore, it is extremely important that the power be applied in the proper sequence:

1. With the power supply OFF…
2. Connect the power supply leads to the terminal block.
3. Plug the power connector block into the front panel of the sm125.
4. Tighten the two (2) retaining screws.
5. Apply power.

IMPORTANT NOTICE REGARDING POWER CONNECTORS:

If the front panel power terminal block needs to be removed, the power supply MUST be turned OFF BEFORE it is disconnected or reconnected. This is extremely important as these types of connectors are not intended to be used as switches. Failure to follow these guidelines can result in damage to the sm125 unit.

3.2 Communication Ports

A LAN connection on the front of the sm125 facilitates an Ethernet TCPIP connection. USB, RS-232, and RS-485 are available as options or in OEM configurations.

Also available is an optional compact wireless B USB adapter to facilitate wireless Ethernet networking. Presently, the Netgear MA111 v1 (not v2) Wireless B and Linksys WUSB12 adapters are supported. Please contact Micron Optics for a list of additional compatible devices.

3.3 Optical Connections

The sm125 is available with 1 to 4 optical connections. These FC/APC connectors are located on the right side of the module front panel. Care should be taken to use only clean APC connectors. Dirty or mismatched connectors will cause degradation in performance and may damage unit. Front panel-mounted FC/APC connectors should be periodically cleaned to maintain optimal performance.

An optional sm041 Channel Expansion Module can be purchased separately to increase the available number of channels from 4 to 8 or 16.

3.4 LED Indicators

Three LED indicators can be found on the lower left side of the sm125 front panel. These indicators communicate the current status of the module to the user. Located on the far left, the red “Power” indicator will illuminate when electrical power is supplied to the unit. The center indicator in the cluster is a green LED labeled “Ready.” This LED will illuminate when the module has completed its bootup and initialization sequence. Illumination of this green LED is a signal to the user that remote communication can begin. When remote communication is active, the third and rightmost indicator in the cluster will activate. The amber “Client” LED is an indication that a client is actively connected to the module.

4. Specifications Definitions and Test Methodology

Wavelength Accuracy –

Defined as "accuracy of measurement", per NIST Technical Note 1297, 1994 Edition, Section D.1.1.1, the "closeness of the agreement between the result of a measurement and the value of the measurand."

Accuracy is here reported as the standard uncertainty of the distribution of measurements made over the course several minutes, relative to the NIST Standard Reference Material 2519, as described in NIST Special Publication 260-137. Of the HCN lines characterized by NIST, those used in the qualification of MOI spectral interrogators are the 21 lines certified by NIST (or a subset thereof) with an expanded uncertainty (coverage factor k=2) of +/-0.0006nm.

To be consistent with the sensing and telecom industries' expectation of low distribution and low systematic error of wavelength measurements, MOI enhances its definition of wavelength accuracy to a more stringent definition that includes a component of "systematic error", defined in NIST Technical Note 1297, Section D.1.1.6. Here, "systematic error" is defined as the "mean that would result from an infinite number of the same measurand carried out under repeatability conditions minus the value of the measurand." Here, again the measurand is NIST SRM 2519.

In total, the wavelength accuracy reported for MOI spectral interrogators is the absolute value of the "systematic error" plus the standard uncertainty of the "accuracy of measurement," or $|\mu| + \sigma$ of the series of wavelength measurements made on the atomic absorption NIST Standard Reference Material 2517. In order to eliminate stability effects of peak detection which might influence the accuracy measurement, averaging of the spectrum prior to peak detection is performed.

In addition to the measurements made relative to the atomic absorption references, measurements are made on Fabry-Perot artifacts which provide spectral features across the full measurement wavelength range of the Equipment Under Test (EUT). The Fabry-Perot artifacts are characterized using a method similar to that by which NIST determines absolute wavelengths for the gas absorption SRMs (see NIST Special Publication 260-137.) By the fundamentals of operation, the Fabry-Perot elements exhibit a high degree of linearity in the frequency domain, limited to ~1pm by chromatic dispersion. This behavior is used to ensure frequency measurement linearity, and thus relative wavelength accuracy, outside of the wavelength ranges that can be measured using the NIST SRMs.

Repeatability –

Defined as "Repeatability (of results of measurements)", per NIST Technical Note 1297, Section D.1.1.2, the "closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement," called "repeatability conditions."

"Repeatability conditions" include using the same measurement procedure, the same observer, the same measuring instrument used under the same conditions (constant temperature), the same location, and repetition over a short period of time.

In the interest of making such measurements most applicable to the users of MOI products, the test artifact selected for the repeatability test is representative of a typical sensor which might be used, of bandwidth ~0.1nm, high reflectivity. Repeated measurements are made on the artifact by the EUT over the course of minutes, and the standard uncertainty (1 σ distribution) of the resulting measurements is reported as the Repeatability.

In order to address multiple likely applications, the repeatability may be reported at multiple data rates or averaging conditions (e.g. @ 250 Hz with no averaging, or at 10Hz with 25 averages per data point.)

Stability –

In order to enhance the utility of the accuracy and repeatability specifications, a specification called stability has been added. The stability specification captures effects of operating temperature and longer term testing of the EUT, involving a minimum of one thermal cycle over the operating temperature of the device.

The measurement for stability involves capturing data on an artifact of sufficient stability with optical features that cover the full measurement wavelength range of the EUT, such as a Fabry-Perot etalon. The agreement between successive measurements is recorded over wavelength, time, and temperature. The resulting 1 σ distribution is calculated and reported as the stability of the EUT.

In the measurements and calculations used for computing the stability parameter, no data averaging is employed.

Resolution –

To be derived by user for specific applications based upon stability and repeatability specifications.

Reproducibility –

Defined as "reproducibility (of measurement results)", per NIST Technical Note 1297, Section D.1.1.3, the "closeness of agreement between the results of measurements of the same measurand carried out under changed conditions of measurement."

Here, the "changed conditions" include a different observer, measurement instrument, or time. In principle, this specification is intended to ensure that a given measurand could be measured by multiple MOI spectral interrogators using the same data analysis tools at different times and by different users, and achieve measurement results that are consistent within the reproducibility specification.

In order to quantify the reproducibility of measurements from a particular class of instruments, a complete wavelength accuracy analysis is made on each, and a mean "error of measurement" is calculated. This "error of measurement" is defined by NIST Technical Note 1297, Section D1.1.4, the error (of measurement)", and is measured relative to NIST SRM 2519. The reproducibility is then defined as the standard deviation of the set of "error" measurements across a sample of measured instruments.

5. TCP-IP Remote Control Interface

5.1 Configuration

Data transfer to and from the sm125 is through a 100Mbit/S Ethernet port on the front of the unit. The unit can be connected to an existing network through a hub or it can be connected directly to a host PC using a crossover Ethernet cable. Both of these arrangements require that the sm125 and the host be on the same logical network. The network administrator can assure this by providing an appropriate static IP address and Net mask for the sm125 and/or host PC. These values can be configured using the remote commands outlined in section 5.5 of this manual.
The sm125 supports bi-directional communication through a data socket (port #50000).

NOTE: The **default IP address and Net mask** for the sm125 are **10.0.0.122** and **255.255.255.0**, respectively.

Alternatively, data transfer to and from the sm125 unit can be facilitated by a USB – Wireless Ethernet adapter. The host PC's wireless Ethernet card should be configured to connected in "Ad-hoc" or "Computer-to-computer" mode, and not "Network Infrastructure" mode. Again, the sm125 and host must be on the same logical network. The network administrator can assure this by providing an appropriate static IP address and Netmask for the sm125 and/or host PC.
Wireless communication is also bi-directional and uses a data socket (port #50000).

NOTE: The **default Wireless LAN IP address and Net mask** for the sm125 are **192.168.1.122** and **255.255.255.0**, respectively.

5.2 Communication Protocol

Commands and queries to the sm125 are in the form of ASCII strings that begin with a # character and end with a linefeed (ASCII char 10 [0x0a in hex, '\n' in C, vbLf in Visual Basic]). All characters sent to the sm125 are internally buffered until a linefeed character is detected. Once the sm125 receives the linefeed, it then interprets all the buffered data that preceded the linefeed. In response to the received data, the sm125 will first return a 10-byte ASCII string. This 10-byte string is not a response to the submitted command or inquiry. Rather, the 10-byte string representing the number bytes contained in the response to the command. This is the number of bytes that the host is expected to read in addition to the first 10 bytes. The example below illustrates the point:

host: #IDN?<LF>
sm125: 0000000032
sm125: SM125, Rev. 0.00001, Micron Optics, Inc.

In this example, the host has issued the #IDN? command to the sm125. This command is used to retrieve the sm125 software version number. In response to this command, the sm125 first submits the 10-byte string “0000000032” indicating that the response to the #IDN? command is 32 bytes long. The sm125 then submits the 32-byte string “SM125, Rev. 0.00001, Micron Optics, Inc.” to the host. Thus, for every command written to the sm125 by the host, the host must make 2 reads. The first read is always 10 bytes long. The second read has a variable length dictated by the first. Note that this protocol is followed whether or not the data sent to the sm125 is a valid command. A LabVIEW implementation of the above example appears in Figure 5.2 below. A VisualBasic implementation appears thereafter.

5.2.1 Basic LabVIEW Implementation of sm125 TCP-IP Protocol

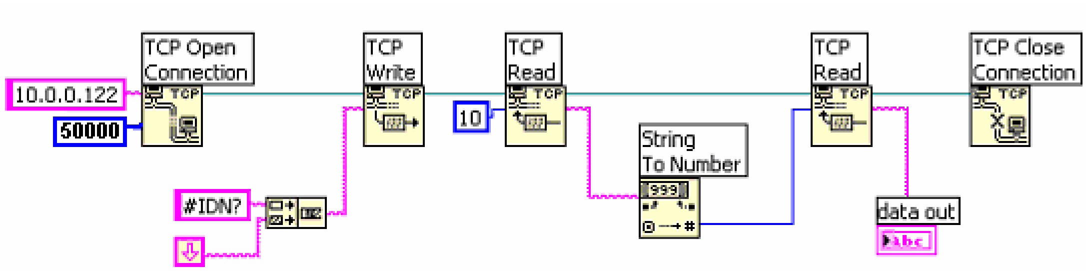


Figure 5.2: A LabVIEW implementation of the example.

5.2.2 Basic VisualBasic Implementation of sm125 TCP-IP Protocol

- A Winsock control allows user to communicate with sm125 via Transmission Control Protocol (TCP)
- To establish the Winsock control in Visual Basic, select Microsoft Winsock Control 6.0 from the Component dialog box of the Project Menu.
- Set Protocol property of the Winsock as sckTCPProtocol. Set the RemoteHost and RemotePort properties of the Winsock as sm125's IP address and 50000, respectively. –Give a name to the Winsock control (e.g. tcpClient).
- Establish connection with sm125 with the command,

```
Call tcpClient.Connect
```

Once the connection is established (check connection status with tcpClient.State) send command to sm125 to request data size.

```
Call tcpClient.SendData("#IDN?" & vbLf)
```

- Wait until 10 bytes are received and get data size as string.

```
While tcpClient.BytesReceived < 10
        DoEvents
Wend
Call tcpClient.GetData(strSize, vbString, 10)
```

- Convert data size format from string into integer.

```
intSize = Cint(strSize)
```

- Then, read data for data size.

5.3 Data Retrieval

Sensor wavelength data can be retrieved from the sm125 using the #GET_DATA command. The response of a #GET_DATA command starts with a Main Header, which gives information about current version of the protocol, number of DUTs contained in the response and a sequence counter for the data. After the Main Header comes the data for all of the DUTs. The number of DUT channel entries on the table is a function of how many DUT channels are enabled. This data structure can carry from 1 – 4 channels for an sm125 and expands to as many as 16 channels for an sm125 with an sm041 Channel Expansion Module. The actual wavelength data for each DUT is preceded with a Sub Header, which gives the size of the Sub Header, the starting wavelength point of the data, the wavelength difference between each data point, number of data points and the DUT number.
A description of the response is available in **Table 5.4.1**.

5.4 Data Interpretation

The data returned by the #GET _DATA command is a binary string that encodes a mixed set of data.

First comes a 20-byte long Main Header, which contains five 4-byte fields. Each field represents a 32-bit unsigned integer with Least-Significant-Byte (LSB) first.

After the Main Header comes the wavelength data for every configured DUT. Every array of actual wavelength data for each channel is preceded by a 20-byte long Sub Header. The Sub Header consists of five 4-bytes fields. Each field represents a 32-bit unsigned integer with the LSB first. The “Min Wavelength” field and the “Wavelength Increment” field are both multiplied by a factor of 10,000 before they are transmitted from the unit. To convert the values back to floating point wavelength numbers, in nm, one must divide the corresponding 32-bit values by 10,000.

Each wavelength data point value is represented by a 16-bit signed integer, with the LSB first. The values are multiplied by a factor of 100 before they are transmitted from the unit. To convert the values back to floating point numbers the two decimals precision, one must divide each 16-bit integer with 100.

The response structure is at most 128108 (20+4*20+4*2*16001) bytes long for a four channel unit.

The byte offsets along with a brief description of each quantity are summarized in the following table. This table shows an example of the structure if the Number of DUTs (byte offset 8 in the main header) was equal to four. As such four channel clusters (comprised of SubHeader, Min Wavelength, Wavelength Increment, nPoints, DUT number, and Data) are present. If the Number of DUTs were a number other than four, then the number of data clusters would scale accordingly.

Entry	**Byte Offset**	**Atomic Size (bytes)**	**Total Size (bytes)**	**Description**
Size of Main Header	0	4 (U32)	4	The size of the Main Header. In this version it is set to 20.
Protocol Version	4	4 (U32)	4	Current version of the definition of this response structure.
Number of DUTs	8	4 (U32)	4	Number of DUTs this response contains
Reserved	12	4 (U32)	4	Reserved for future use.
Counter	16	4 (U32)	4	A sequential counter for the data set that the instrument has processed internally.
Size of Sub Header 1	20	4 (U32)	4	The size of the Sub Header
Min Wavelength	24	4 (U32)	4	Wavelength of the first data point, multiplied by 10000. Default value is either 15100000 (1510.0 nm) or 15200000 (1520.0 nm).
Wavelength Increment	28	4 (U32)	4	Wavelength distance between each data point, multiplied by 10000. Default value is 50 (5 pm).
Number of Data Points (nPoints)	32	4 (U32)	4	Number of data points for this DUT. Default value is either 10001 or 16001.
DUT number	36	4 (U32)	4	The number of the DUT that this data belongs to (1 – 16).
Data	40	2 (U16)	2*nPoints	The actual data for each wavelength sampled. Every data point value is multiplied by 100.
Size of Sub Header 2	40 + 2*nPoints	4 (U32)	4	The size of the Sub Header
Min Wavelength	44 + 2*nPoints	4 (U32)	4	Wavelength of the first data point, multiplied by 10000. Default value is either 15100000 (1510.0 nm) or 15200000 (1520.0 nm).
Wavelength Increment	48 + 2*nPoints	4 (U32)	4	Wavelength distance between each data point, multiplied by 10000. Default value is 50 (5 pm).
Number of Data Points (nPoints)	52 + 2*nPoints	4 (U32)	4	Number of data points for this DUT. Default value is either 10001 or 16001.
DUT number	56 + 2*nPoints	4 (U32)	4	The number of the DUT that this data belongs to (1 – 16).
Data	60 + 2*nPoints	2 (U16)	2*nPoints	The actual data for each wavelength sampled. Every data point value is multiplied by 100.
Size of Sub Header 3	80 + 4*nPoints	4 (U32)	4	The size of the Sub Header
Min Wavelength	84 + 4*nPoints	4 (U32)	4	Wavelength of the first data point, multiplied by 10000. Default value is either 15100000 (1510.0 nm) or 15200000 (1520.0 nm).
Wavelength Increment	88 + 4*nPoints	4 (U32)	4	Wavelength distance between each data point, multiplied by 10000. Default value is 50 (5 pm).
Number of Data Points (nPoints)	92 + 4*nPoints	4 (U32)	4	Number of data points for this DUT. Default value is either 10001 or 16001.
DUT number	96 + 4*nPoints	4 (U32)	4	The number of the DUT that this data belongs to (1 – 16).

Data	100 + 4*nPoints	2 (U16)	2*nPoints	The actual data for each wavelength sampled. Every data point value is multiplied by 100.
Size of Sub Header 4	100 + 6*nPoints	4 (U32)	4	The size of the Sub Header
Min Wavelength	104 + 6*nPoints	4 (U32)	4	Wavelength of the first data point, multiplied by 10000. Default value is either 15100000 (1510.0 nm) or 15200000 (1520.0 nm).
Wavelength Increment	108 + 6*nPoints	4 (U32)	4	Wavelength distance between each data point, multiplied by 10000. Default value is 50 (5 pm).
Number of Data Points (nPoints)	112 + 6*nPoints	4 (U32)	4	Number of data points for this DUT. Default value is either 10001 or 16001.
DUT number	116 + 6*nPoints	4 (U32)	4	The number of the DUT that this data belongs to (1 – 16).
Data	120 + 6*nPoints	2 (U16)	2*nPoints	The actual data for each wavelength sampled. Every data point value is multiplied by 100.

Table 5.4.1: Description of #GET_DATA response structure

NOTE: Use of an optional sm041 Channel Expansion Module will facilitate as many as 16 optical channels. The #GET_DATA data structure will expand for all available channels that have been activated. Additional channels enabled by the sm041 module can be activated using the #SET_DUT(X)_STATE command outline in the next section.

5.5 Other User Commands

Other available user commands are listed below. The use of these commands follows the same communication and data retrieval protocols outlined in sections 5.2 and 5.3, respectively. All sm125 commands are followed by a response from the unit, indicating either the successful completion of a command or a syntax error.

#IDN?

This command returns a string containing the instrument name and revision.

Implementation: Query unit for identification.

<u>Syntax</u>:

#IDN?

<u>Response:</u>

Micron Optics sm125 Optical Sensing Interrogator, Rev 1.0

#GET_SYSTEM_IMAGE_ID

This command returns a string containing the revision identification of the firmware currently installed in the instrument.

Implementation: Query unit for software revision identification.

<u>Syntax</u>:

#GET_SYSTEM_IMAGE_ID

<u>Response:</u>

#SYSTEM_IMAGE_ID Image: Sm125, Rev 0.6, Created: Mon Sep 20 15:41:41 2004

#GET_PRODUCT_SN

This command returns a string containing the serial number of the connected instrument.

Implementation: Query unit for product serial number.

Syntax:
#GET_PRODUCT_SN

Response:
#PRODUCT_SN SIA3XX

#SET_IP_ADDRESS

This command changes the IP address of the instrument

NOTE: The **default IP address** for the sm125 version 0.9 or higher is **10.0.0.122**.

Implementation: Set unit IP address

Syntax:
#SET_IP_ADDRESS 10.0.0.122

Response:
#IP_ADDRESS 10.0.0.122

#SET_IP_NETMASK

This command changes the IP Netmask of the instrument

NOTE: The **default IP Netmask** for the sm125 version 0.9 or higher is **255.255.255.0**.

Implementation: **Set unit IP Netmask**

Syntax:

#SET_IP_NETMASK 255.255.255.0

Response:

#IP_NETMASK 255.255.255.0

#GET_IP_ADDRESS

This command gets the currently configured IP address of the instrument

Implementation: **Get unit IP address**

Syntax:

#GET_IP_ADDRESS

Response:

#IP_ADDRESS 10.0.0.122

#GET_IP_NETMASK

This command gets the currently configured IP Netmask of the instrument

Implementation: **Get unit IP Netmask**

Syntax:

#GET_IP_NETMASK

Response:

#IP_NETMASK 255.255.255.0

#SET_WLAN_IP_ADDRESS

This command changes the Wireless LAN IP address of the instrument

NOTE: The **default WALN IP address** for the sm125 version 0.9 or higher is **192.168.1.122**.

Implementation: **Set unit WLAN IP address**

Syntax:

#SET_ WLAN _IP_ADDRESS 192.168.1.122

Response:

 # WLAN _IP_ADDRESS 192.168.1.122

#SET_WLAN_IP_NETMASK

This command changes the Wireless LAN IP Netmask of the instrument

NOTE: The **default WLAN IP Netmask** for the sm125 version 0.9 or higher is **255.255.255.0**.

Implementation: **Set unit WLAN IP Netmask**

Syntax:

#SET_WLAN_IP_NETMASK 255.255.255.0

Response:

#WLAN_IP_NETMASK 255.255.255.0

#GET_WLAN_IP_ADDRESS

This command gets the currently configured Wireless LAN IP address of the instrument

Implementation: **Get unit WLAN IP address**

Syntax:

#GET_WLAN_IP_ADDRESS

Response:

#WLAN_IP_ADDRESS 192.168.1.122

#GET_WLAN_IP_NETMASK

This command gets the currently configured Wireless LAN IP Netmask of the instrument

Implementation: **Get unit WLAN IP Netmask**

Syntax:

#GET_WLAN_IP_NETMASK

Response:

#WLAN_IP_NETMASK 255.255.255.0

#GET_DUT1_STATE

This commands queries the sm125 for the acquisition state for the particular device under test (DUT) channel specified by the command name. As shown in this example, the sm125 module would respond with the acquisition state for Channel 1. In order to query the acquisition state for Channel 4, the command would simply be modified to reflect the changed channel to **#GET_DUT4_STATE.**

The acquisition state signifies if a particular channel's data acquisition is active (parameter = 1) or inactive (parameter = 0).

Implementation: **Query the acquisition state for a single channel.**

Syntax:

#GET_DUT1_STATE

Response:

#DUT1_STATE 1

#SET_DUT1_STATE

This command sets the acquisition state for the particular channel specified by the command name. As shown in this example, the sm125 module would set the acquisition state for Channel 1. In order to set the acquisition state for Channel 4, the command would simply be modified to reflect the changed channel to **#SET_DUT4_STATE.**

Setting the acquisition state for a channel to 1 will cause the sm125 module to collect data for that channel and include a corresponding entry in the data transfer command responses. Inclusion of the parameter 1 will cause the specified channel to become active; parameter 0 will cause the specified channel to become inactive.

This command is used to trigger the use of an optional sm041 channel expansion unit, if connected to the sm125 module. If a channel above Channel 4 is activated, the sm125 will initiate switch drive commands to the attached sm041 module and port the data accordingly through the data transfer command responses. See included 16 channel data acquisition example program for details.

Implementation: **Set the acquisition state for a single channel.**

Syntax:

#SET_DUT1_STATE 1

Response:

#DUT1_STATE 1

5.6 LabVIEW TCP-IP Utility Examples

5.6.1 Four Channel Complete Interface

Included with the sm125 unit is a full four channel example program that uses the TCP-IP communication protocol. The example is written in National Instruments LabVIEW, and is available as an open-source LabVIEW library and as a stand-alone executable. The sm125 software installation disk contains a version for the LabVIEW 7.1 Full Development System..

The included sm125 remote utility and LabVIEW examples are compatible with Windows 98, NT, 2000, and XP. An 800MHz Pentium III or better is recommended to run the utilities.

This LabVIEW example, shown in Figures 5.6.1-5.6.X, uses the command set and protocol as described in sections 5.2 – 5.4 of this document. The data can be retrieved, parsed and plotted at the full acquisition speed of the sm125 module.

NOTE: Any changes to software content following the release of this manual will be captured and explained under the "Show Help" section of the software itself.

5.6.1.1 Initialization and Connection

Figure 5.6.1.1 shows a screen shot of the LabVIEW utility immediately after initialization. A pop-up window polls the user for the IP address of the sm125.

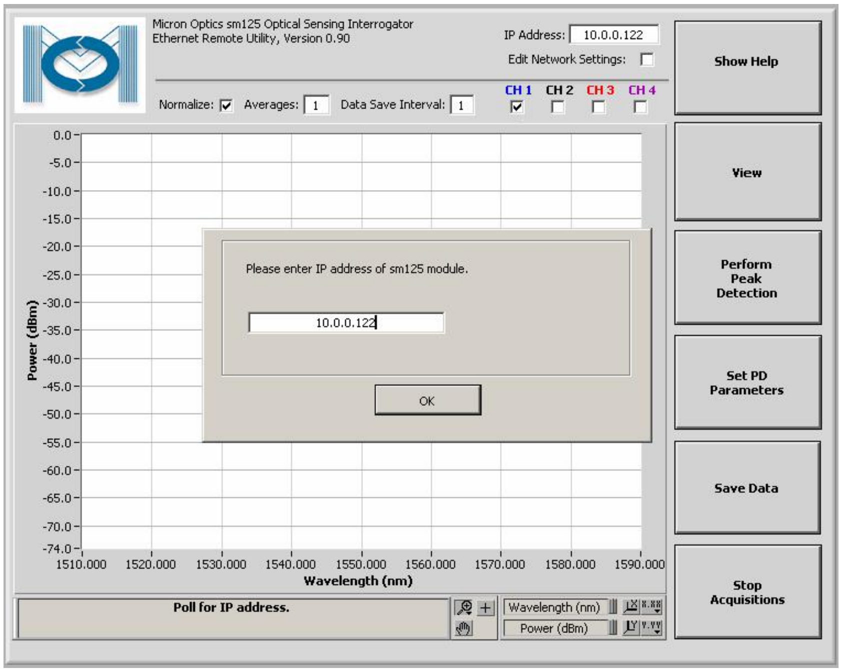


Figure 5.6.1.1: Screen Shot from included LabVIEW Ethernet remote utility

Once the sm125 remote utility is connected and running, it can be used to set the IP address and Netmask settings of the sm125 unit. Beneath the IP Address control on the remote utility is a boolean checkbox control labeled "Edit Network Settings." Selecting this box will initiate a sequence to change those settings. The user will be asked to choose between wired and wireless settings, then polled to enter the desired IP address and Netmask, with the current values offered as the default. When the values have been entered, the settings are automatically saved to the sm125 and will take effect upon sm125 reboot.

5.6.1.2 Spectrum Graph Mode

Figure 5.6.1.2 shows a screen shot of the LabVIEW remote utility in Spectrum Graph Mode with Channel 1 active. The array of boolean checkboxes above the graph on the right allows the user to activate and deactivate each of the available sensor or device under test (DUT) channels, up to four. The color of the boolean control labels correspond to the display colors for each of the channels on the graph. Figure 5.6.1.3. shows how these colors allow the user to visually discriminate between data from the multiple DUT channels.

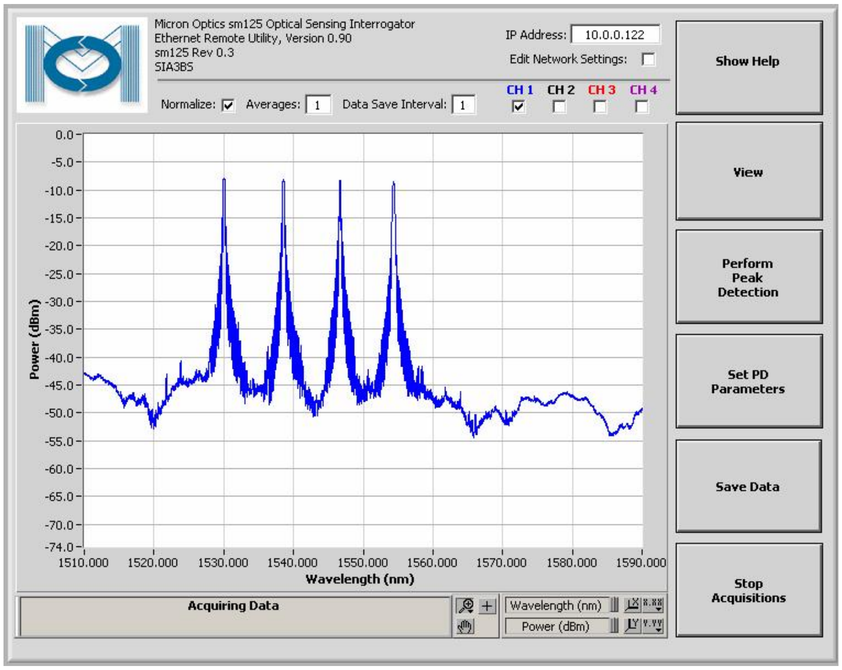


Figure 5.6.1.2: Screen shot of LabVIEW remote utility with Channel 1 Active.

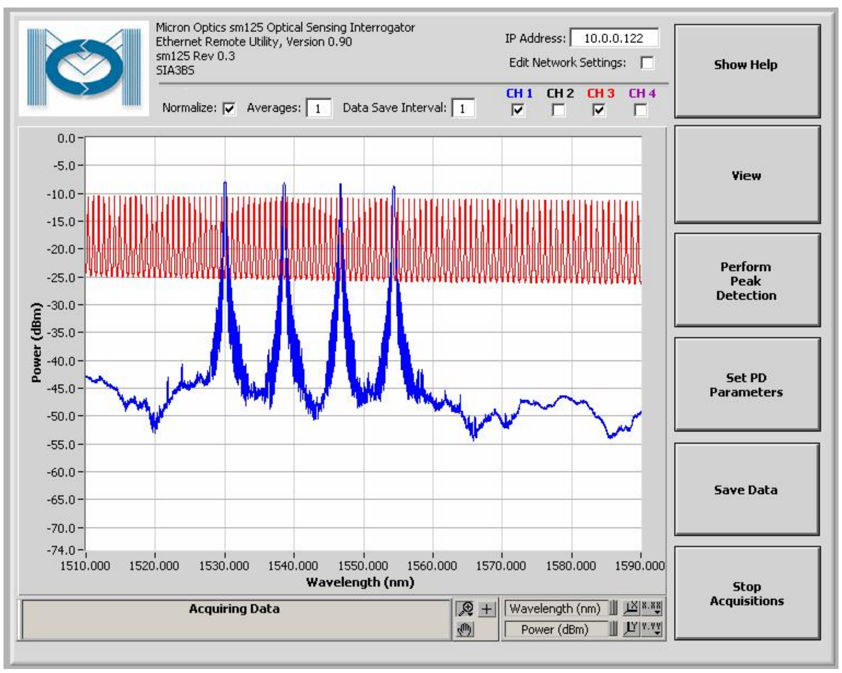


Figure 5.6.1.3. LabVIEW remote utility with multiple channels active.

Figure 5.6.1.3 shows the sm125 measuring a mixed collection of FBG and Fabry-Perot Sensors. The FBG sensors can be seen on Channel 1 represented by the blue trace, and selected by the blue-labeled boolean control “CH 1.” The FP sensor can be seen on Channel 3, represented by the red trace and selected by the red-labeled boolean control “CH 3.”

Other front panel controls visible on the LabVIEW remote utility are:

-Normalize.

This boolean checkbox control will toggle the power normalization feature. This feature normalizes the DUT traces to an internal monitor of the optical output power as a function of wavelength. This tool is intended to assist in flattening out the resultant optical spectrum of optical sensors such that peak detection is simplified.

-Peak Avgs.

This control will allow the user to set a number of peak detected values to be used in a boxcar average. Data will continue to be reported at the acquisition speed of the unit, but the peak detected values will reflect the average value over the number of averages set. This tool can be used to minimize the effects of system and peak detection noise to increase measurement repeatability on signals that are relatively stable for peak detection, but may change value relatively rapidly.

-Spectrum Avgs.

This control will allow the user to set a number of optical spectrum traces to be used in a boxcar average. Data will continue to be reported at the acquisition speed of the unit, but the spectrum will reflect the average optical signal over the number of averages set. This tool can be used to minimize the effects of system noise to increase measurement repeatability on signals that may be difficult to peak detect.

-Data Stream Interval.

As will be explained in a later section of this manual, data can be saved in multiple formats. For "Streaming Data", peak wavelength data will be continuously streamed to disk at a rate determined by the acquisition rate divided by the Data Stream Interval. For example, at an acquisition rate of 1 Hz and a Data Stream Interval of 10, data will be saved to disk at 1/10 Hz, or every 10s.

-Show Help

This control activates the on-screen help feature, which will be covered in more detail in a later section of this manual.

-**Perform Peak Detection**

This control activates the remote utility's peak detection algorithm, which is used to distill full spectral data into useful center wavelength values for sensor signals. The behavior of the peak detection algorithm will be set by the PD parameters, explained in the next paragraph.

-Set PD Parameters

The next two Remote Utility functional buttons are used to perform peak detection on the acquired full spectral data sets. Figure 5.6.1.4 shows a view of the Remote Utility with the Perform Peak Detection and Set PD parameters buttons activated. The "Perform Peak Detection" button activates the peak detection algorithms, which will operate based on the PD Parameters as defined by the functions described in the next section. When "Perform Peak Detection" is set to on, the spectral data plots will change from solid lines to dashed lines, and the peak detected values will be indicated by a solid round dot of identical color to the spectrum plot.

The "Set Peak Detect Parameters" button will open a window allowing the user to customize peak detection parameters for each of the available channels, up to four. When this feature is active, the graph display will be reduced in size to accommodate display of both the graph and the parameters control, as seen in Figure 5.6.6.

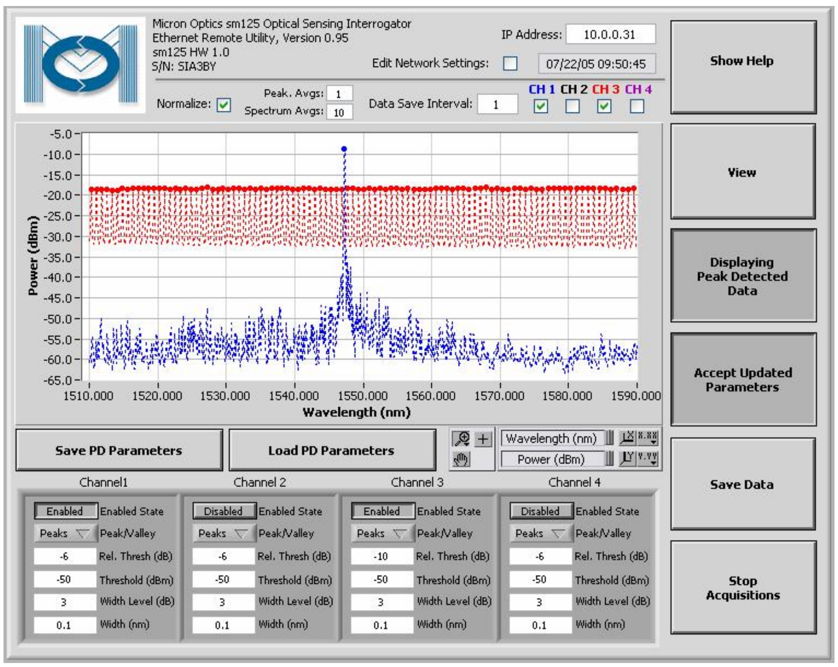


Figure 5.6.1.4 sm125 Remote Utility with Set PD parameters selected

The "Perform Peak Detection" feature can be used in conjunction with the "Set Peak Detect Parameters" function to implement known or experimentally derive appropriate parameters. The parameters that can be set for each of the channels are as follows:

Enabled State:

This boolean control either enables or disables peak detection for the particular channel.

Peaks/Valleys:

This control dictates whether the PD algorithm will identify Peaks or Valleys found in the full spectral profile for the particular channel.

Rel. Thresh (dB):

This control sets the relative threshold for the peak detection algorithm in units of dB. The relative threshold will set the effective threshold for the peak detection algorithm at the prescribed level below the point of highest power for peak detection, or above the point of lowest power for valley detection. For example, if a relative threshold of 3dB is set for a channel with highest optical power at -15 dBm, the effective threshold will be set at -18dBm, provided that the **Threshold** value is set below -18dBm.

For example, assume that a single FBG is to be monitored on a particular channel, like the FBG seen in Figure 5.6.1.4 on Channel 1. It can be seen that the peak power value of the FBG is -8dBm or so. Use of the **Rel. Thresh** parameter with a value of 3dB will set the effective threshold for the peak detection at -11dB, which is well above the noise floor of this instrument. Should the level of the FBG change, the relative nature of the peak detection will allow the unit to continue to find the FBG center location. For example, if the round trip path loss for the FBG should increase by 10 dB, the peak power value of the FBG would be -18 dB, and Rel. Thresh would still be 3dB, and so the new effective threshold would be -21 dBm.

Threshold (dBm):

This control sets the absolute minimum threshold that can be used by the peak detection algorithm. Use of this parameter prevents the relative threshold from setting the effective threshold below a known noise floor limit. If the value of threshold set by the **Rel. Thresh** parameter is lower than the **Threshold** value for peak detection (or higher, for valley detection), then the value set by **Threshold** will be used.

Continuing the example from above, should the path loss of the FBG were to increase substantially, say by 40 – 50 dB, it is possible that the reflected signal could be dominated by noise, either in form of system back reflection or instrument noise floor. In that event, it would not be optimal for the peak detection algorithm to continue to set the effective threshold 3dB below the point of highest power: doing so could result in peak detection of noise, not signal. To prevent this from happening, the **Threshold** parameter is used. The value set by **Threshold** defines the lowest effective threshold that will be used by the peak detection algorithm, despite a value which might be set lower by the relative threshold.

Width Level (dB):

This parameter sets the relative level for each peak at which the width will be compared to the width requirement, seen in the next parameter description. Typically, this value might be set to 3dB, indicating that the sensor's 3dB bandwidth will be evaluated against the width requirement in determining its peak value. This parameter can be modified in order to isolate desired signals in the presence of unwanted side lobes. It can also be modified to track signals of smaller than normal contrast in a highly back reflective environment.

Width (nm):

This parameter is used to set the width requirement for the peak detection, in conjunction with the **Width Level** parameter described above. For a given pair of parameters, only spectral features with a bandwidth evaluated at a level of **Width Level** down from the peak of value greater than **Width** will be considered to be a peak.

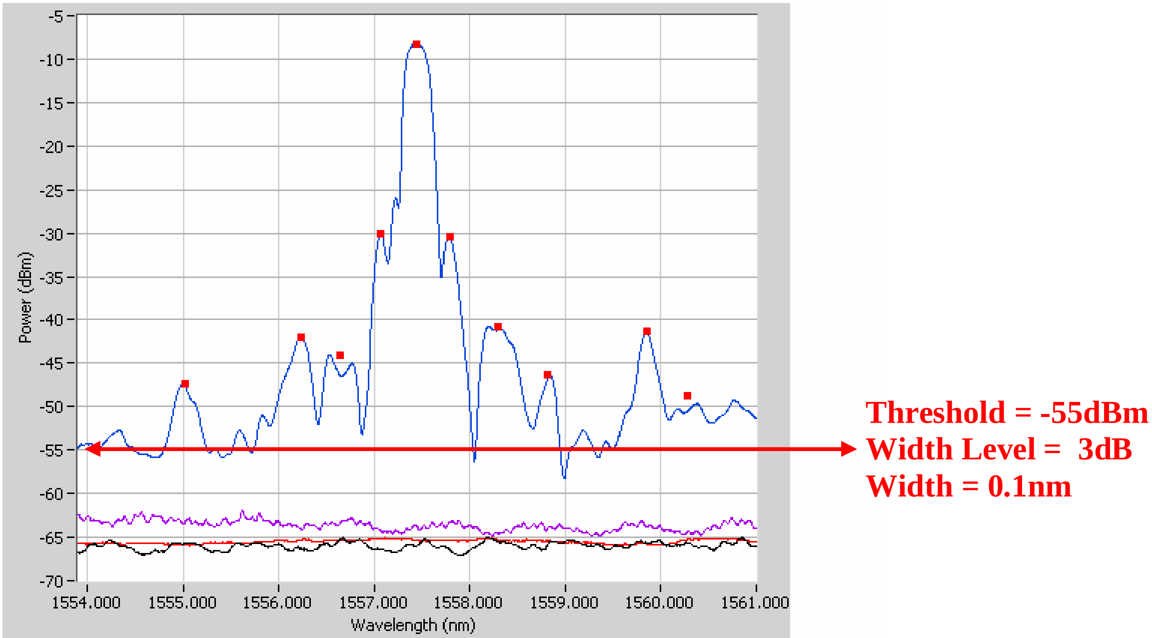
For example, assume **Width Level** and **Width** values of 3 dB and 0.1 nm, respectively. A sensor feature will only be captured a peak if the width of the signal at 3dB below the peak exceeds 0.1 nm. These parameter values will detect signals with 3dB bandwidths of 0.200 nm, for example, but will ignore any sidelobes adjacent to the signal that might have 3dB bandwidths of 0.07nm.

Note on Optimization of Peak Detection Parameters:

The basic sm125 peak detection application functions in a relatively intuitive manner, using a unique threshold level (derived from both Rel. Thresh and Threshold parameters) and peak width (derived from both Width Level and Width parameters) for each channel. The algorithm will identify the central wavelength value and peak amplitude of any spectral peak feature that exceeds the specified threshold value in a symmetric manner with a spectral width greater than the specified peak width.

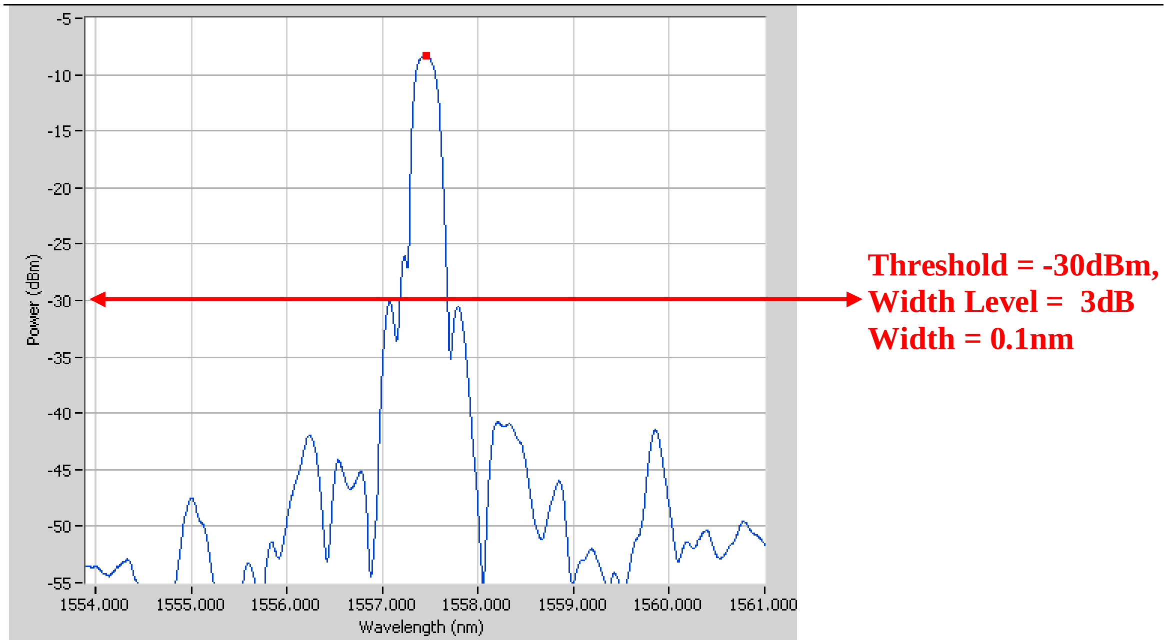
The width and threshold parameters can be optimized to selectively detect peaks of desired width and amplitude, while ignoring other spurious peak features. This section will show how the controls can be used to derive desired results.

Four peak detection cases will be shown here, Cases A – D. Each case shows the same spectral feature with different peak detection parameters. The example feature is the reflection spectrum of an FBG component, and has several strong side modes or spurious peaks. Each of the four cases will show how the judicious selection of peak detection parameters can lead to desirable results.



Case A: Threshold set to –55 dBm, Width Level set to 3dB, Width set to 0.1 nm.

The first case, Case A, shows the FBG spectrum peak detected with the threshold set to –55dBm, the width level set to 3dB, and the 3dB width set to 0.1 nm. The principal reflectance peak is at ~-8dBm and the width is on the order of 0.25 nm. These particular parameters allow for the detection of many higher side modes of lower amplitude and narrower spectral width. While these results may serve well in certain applications, many applications would require the isolation of only the principal mode and would require some parameter refinement.

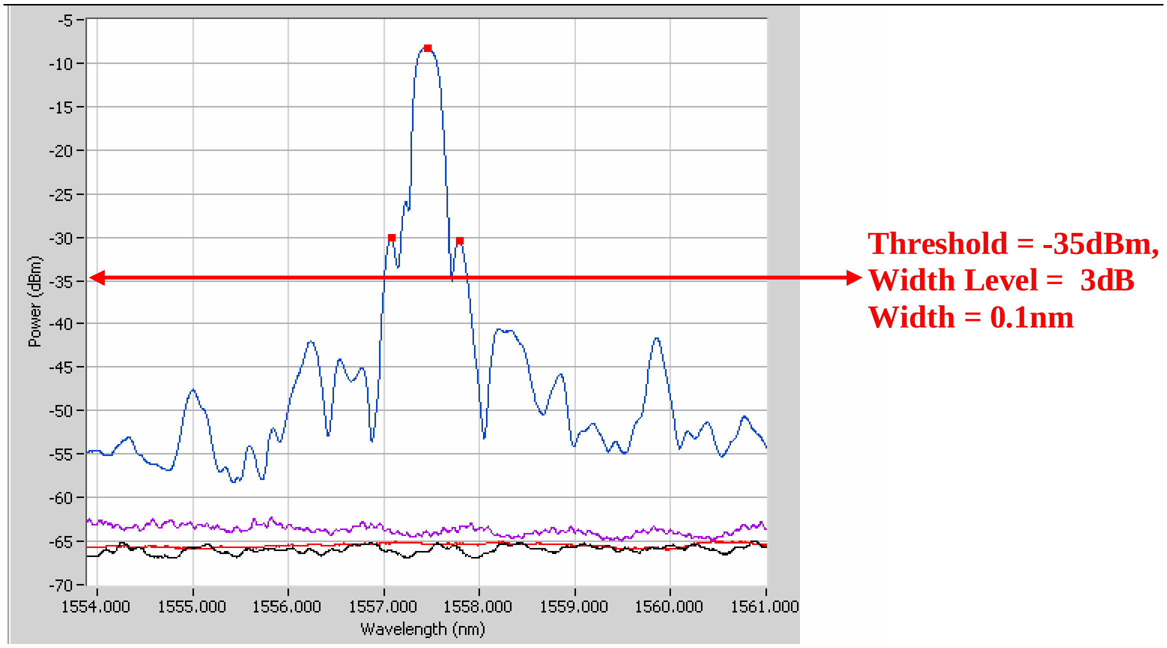


Case B: Threshold set to –30 dBm, Width Level set to 3dB, Width set to 0.1 nm.

Case B shows a simple modification to the PD parameters to isolate the principal mode. By simply increasing the threshold level, using the Rel. Thresh and/or Threshold parameters, above all of the side modes, the resulting peak detected values are restricted to only the fundamental mode. In this case, only amplitude discrimination is used.

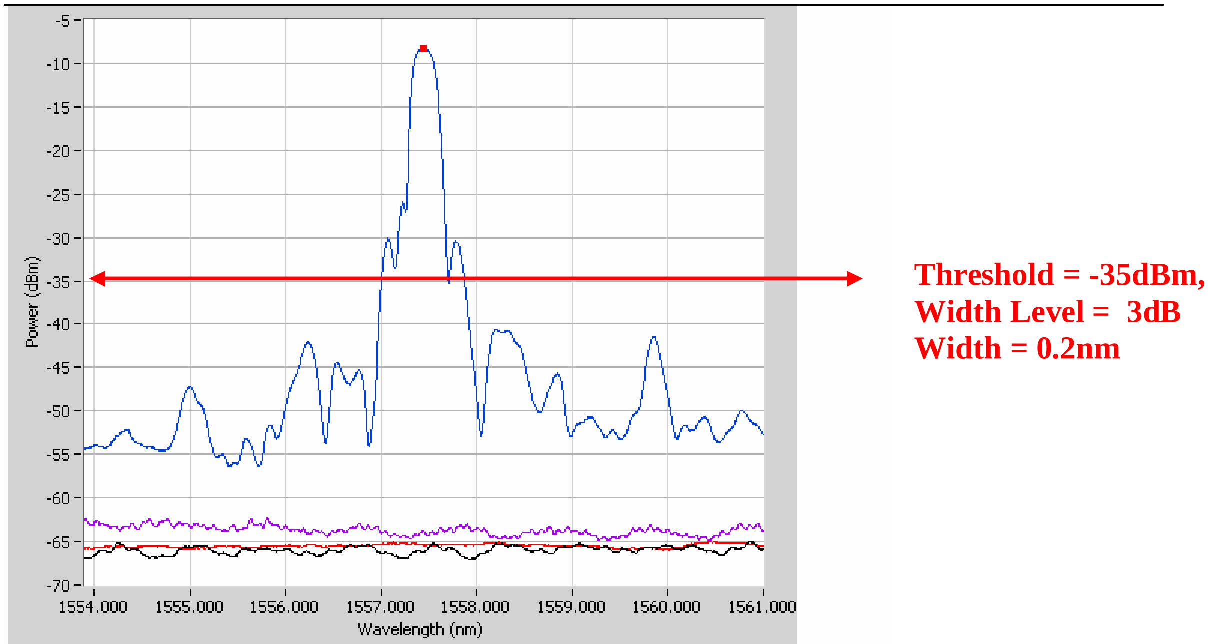
This technique can be employed under simple circumstances, where either few sensors are present or all sensors are at a similar signal level. Imagine, though, that a second sensor was present and needed detection. Imagine also that the second sensor was of similar bandwidth properties, but was offset from the first sensor in both wavelength and amplitude. If the peak amplitude of the second sensor was at –31dB, below the threshold value set a –30 dB, the sensor would not be detected. In this case, a more thoughtful means of discriminating sensor peaks and spurious side modes must be employed.

In the attempt to detect this second sensor, the threshold value would need to be reduced to a level at least 3 dB below the peak value of –32 dB. Case C shows the threshold set to –35 dB, which would be sufficient to detect the second sensor peak at –31 dB. By simply reducing the threshold, though, some of the sidemodes from the original sensor are again detected. In order to maintain detection of the second sensor peak at –31 dB and prevent detection of the sidelobes at a similar power level, a second method for discrimination must be used.



Case C: Threshold set to –35 dBm, Width Level set to 3dB, Width set to 0.1 nm.

Note that the spectral width of the principal peak of the FBG and its side modes are significantly different. By selecting a higher value of the peak detection width, the algorithm can isolate only the peaks which are larger than the width. The figure for Case D shows the results of increasing the PD width from 0.1 nm to 0.2 nm. In this way, the PD algorithm can accommodate sensors at various levels through bandwidth discrimination.



Case D: Threshold set to –35 dBm, Width Level set to 3dB, Width set to 0.2 nm.

Save PD Parameters:

Once peak detection parameters are set, they can be stored to a file location of the user's choice. The peak detection algorithm is saved as a flattened string data file that can be saved as a simple text file.

Load PD Parameters:

Once peak detection parameters have been saved, they can be loaded from the file. The LV utility will un-flatten the string file and restore the parameters.

When desired PD parameters have been selected, toggling the "Accept Update Parameters" will return the utility to its ordinary functions.

In addition to Spectral Graph View, two other modes of data visualization are available in the four channel LabVIEW example. These other modes can be accessed by pressing the "View" button, which can be found on the right side of the GUI, second button from the top. Clicking the "View" button repeatedly causes the GUI to toggle among the three available views. The next two sections explain these views.

5.6.3 Peak Table Mode

In Peak Table mode, the resultant values from the peak detection algorithm will be displayed on the table. The first column will contain a single value reflecting the counter, or relative timestamp, of the data set collected by the sm125. The next four columns will contain wavelengths that represent the peak values as derived by the PD algorithms for each of the present channels, up to four. Figure 5.6.3 shows a view of the sm125 Remote Utility in Peak Table display mode.

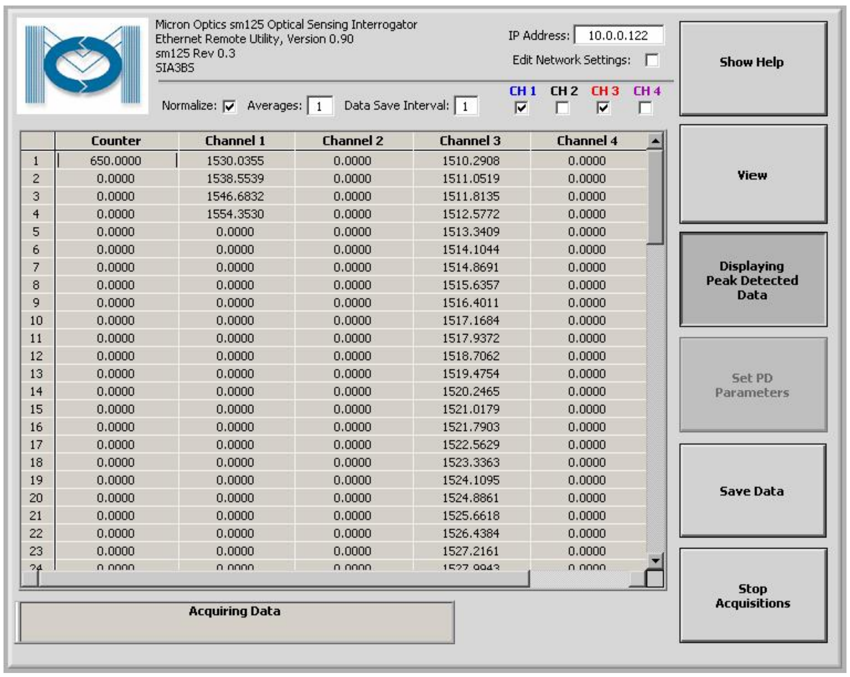


Figure 5.6.3. sm125 Remote Utility in Peak Table display mode.

5.6.4 Peak Tracking Mode

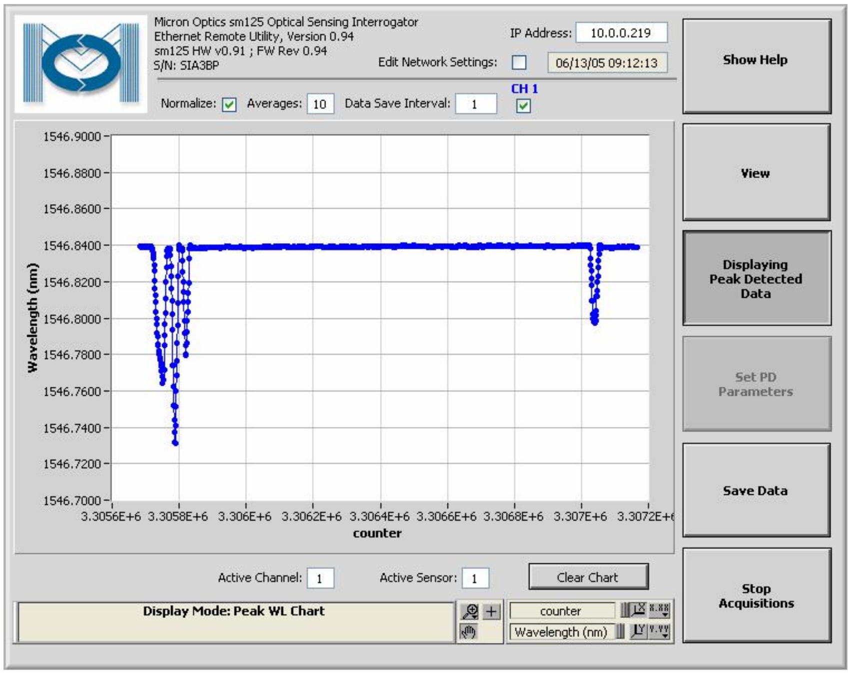


Figure 5.6.4 sm125 Remote Utility in Peak Tracking Mode.

Peak tracking mode displays a single FBG value in a strip chart versus timestamp. This view is a convenient way to visually track changes in a sensor value. Controls for this mode include "Active Channel" and "Active Sensor", which together select among the available channels and sensors to get the appropriate sensor value for display. Figure 5.6.4 shows an image of the sm125 remote utility in Peak Tracking mode.

5.6.5 Data Save Utilities

The sm125 LabVIEW remote utility also provides a mechanism to save the spectral data collected by the unit to a file. Note on figure 5.6.4 a control button located on the right side labeled "Save Data." By clicking on that button, the user will initiate a save data sequence. Immediately following the activation of the button, the user will be prompted to choose what type of data to save, either Full Spectrum or Peak Data. Figure 5.6.5 shows a screen shot of the utility at this phase of the Save Data sequence.

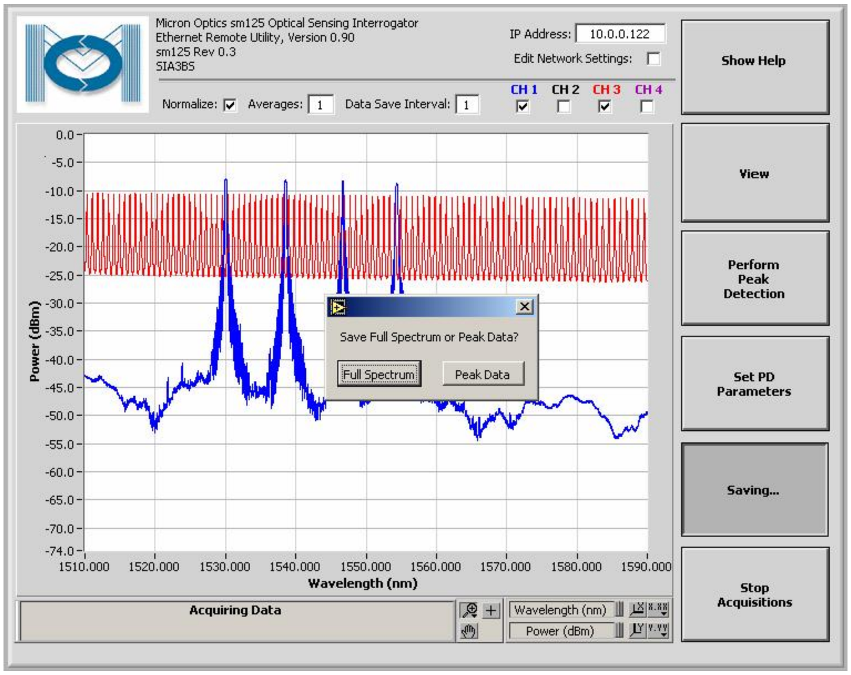


Figure 5.6.5. Remote Utility screen shot during Data Save sequence.

Should the user choose "Full Spectrum", he will be prompted for a filename and path to which the data should be saved. Data is stored in following format: Each entry consists of five columns, delimited by tabs. Each column contains a number of elements equal to the number of spectral samples collected by the sm125, commonly 3201, 5001, 10001 or 16001. The first column represents the X-axis or Wavelength scale. Each of the next four columns represent the corresponding optical power array for each of the present channels 1-4, in that order. Any channels either not present or without data will be represented by a column of zeros. An example of the format for the saved data is seen Table 5.6.5.1 below. These might be representative of the first few lines of a system with Channels 1 and 3 active:

1520.000	-32.400	0.000	-2.980	0.000
1520.005	-32.390	0.000	-3.370	0.000
1520.010	-32.450	0.000	-3.650	0.000
1520.015	-32.410	0.000	-3.930	0.000
1520.020	-32.380	0.000	-4.170	0.000
1520.025	-32.360	0.000	-4.360	0.000
1520.030	-32.340	0.000	-4.570	0.000
1520.035	-32.350	0.000	-4.810	0.000
1520.040	-32.370	0.000	-5.140	0.000
1520.045	-32.460	0.000	-5.430	0.000
1520.050	-32.510	0.000	-5.550	0.000
1520.055	-32.420	0.000	-5.690	0.000
1520.060	-32.450	0.000	-5.950	0.000
1520.065	-32.370	0.000	-6.190	0.000

Table 5.6.5.1. Example of Full Spectrum data file format

Should the user choose "Peak Data", he will be prompted to choose between "Single Save" and "Streaming Data." Single save will save the peak detected data one time to disk, after a selection of filename and path are selected by the user. If streaming data is selected, the PD data will be saved to the selected file at a rate determined by the acquisition rate divided by the Data Stream Interval (see earlier explanation of the Data Stream Interval control for details).

The user will then be prompted whether or not to “Reference timebase locally for these measurements.” The timebase included in the datasets reflects the total number of acquisitions of the sm125 unit since its last bootup. For a 1Hz unit, the timebase can then be interpreted as the number of seconds that the unit has been on. For a 10 Hz unit, the counts reflect 1/10th second acquisitions. The “reference timebase locally for these measurements” will cause the saved dataset to start the timebase over again at zero.

The peak data will be stored according to the following format:

Each entry consists of a single row, delimited by tabs. The first entry of the row is the timestamp for the data set. The next four entries are the number of sensors for the four channels, in order. Following the number of sensor are all of the read sensor wavelengths and amplitudes, with each channels wavelength and power reading grouped together. In the example shown in Table 5.6.5.2 below, there is one sensor on channel 1, two sensors on channel 3 and zero sensors on channels 2 and 4.

TIMEBASE	CH1	CH2	CH3	CH4	DATA					
10421.000	1	0	2	0	1547.2300	-8.9100	1534.3432	1544.1429	-8.5200	-8.8100
10422.000	1	0	2	0	1547.2300	-8.9100	1534.3432	1544.1429	-8.5200	-8.8100
10423.000	1	0	2	0	1547.2297	-8.9100	1534.3435	1544.1422	-8.5700	-8.8500
10424.000	1	0	2	0	1547.2297	-8.9100	1534.3435	1544.1422	-8.5700	-8.8500
10425.000	1	0	2	0	1547.2300	-8.8300	1534.3444	1544.1407	-8.5700	-8.7700
10426.000	1	0	2	0	1547.2308	-8.9200	1534.3442	1544.1423	-8.5600	-8.9000
10427.000	1	0	2	0	1547.2308	-8.9200	1534.3442	1544.1423	-8.5600	-8.9000
10428.000	1	0	2	0	1547.2302	-8.9100	1534.3444	1544.1430	-8.5600	-8.8400
10429.000	1	0	2	0	1547.2300	-8.8600	1534.3432	1544.1415	-8.5500	-8.8100
10432.000	1	0	2	0	1547.2296	-8.8600	1534.3435	1544.1423	-8.5700	-8.7700
10433.000	1	0	2	0	1547.2303	-8.9600	1534.3429	1544.1414	-8.5300	-8.8000
10436.000	1	0	2	0	1547.2299	-8.8600	1534.3444	1544.1435	-8.5700	-8.8200
10439.000	1	0	2	0	1547.2293	-8.9200	1534.3428	1544.1400	-8.5700	-8.8400

Table 5.6.5.2 Example of Peak Data file format

5.6.6 On-screen Help Menu

Note the button on the upper right side of the remote utility labeled “Show Help.” By clicking on this control, the user will activate a help screen, which will guide the user through the operation of the LabVIEW remote utility example. Any changes to the remote utility example following the release of this manual will be captured and sufficiently explained using this on-screen Help feature. Figure 5.6.6 shows the sm125 remote utility with the help screen active. To hide the help screen, simply click on the upper right button again, now labeled “Click Here to Hide Help Screen.”

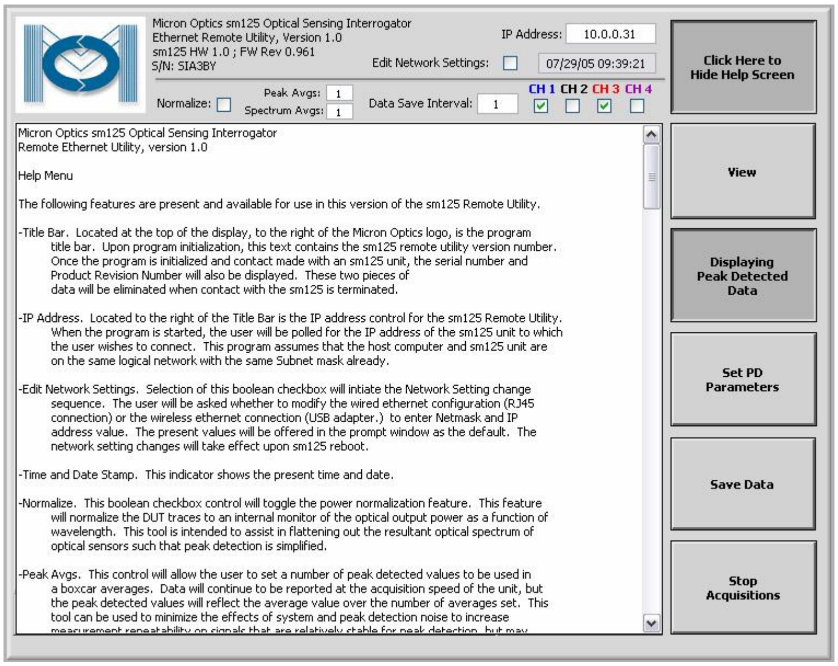


Figure 5.6.6. sm125 Remote Utility with the Help Screen active.

The LabVIEW remote utility is provided both as a full LabVIEW library and as an executable. The full library is open source code, allowing for simple application-specific customizations. The executable is a stand alone application, which does not require that the user have a full development copy of LabVIEW.

5.6.7 16 Channel Acquisition Example (with sm041)

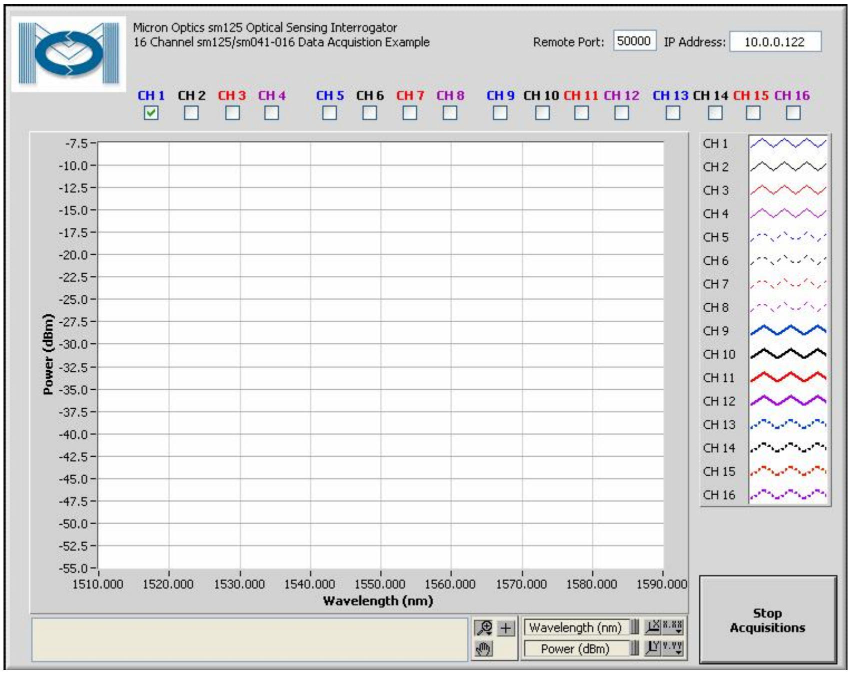


Figure 5.6.7. sm125 16 Channel Acquisition Example

Also included in the sm125 CD-ROM materials is a 16 Channel Acquisition Example. This example program utilizes the commands required to operate the sm125 module with the optional sm041 Channel Expansion Module. Each of the boolean controls seen fon the top of the interface enables/disables its corresponding acquisition channel on the sm125/sm041 combination. Additional details regarding the physical connections between the two devices can be found in the sm041 Product Manual.

6. Mechanical Drawings and Rack Mounting Considerations

6.1 Mechanical Drawings

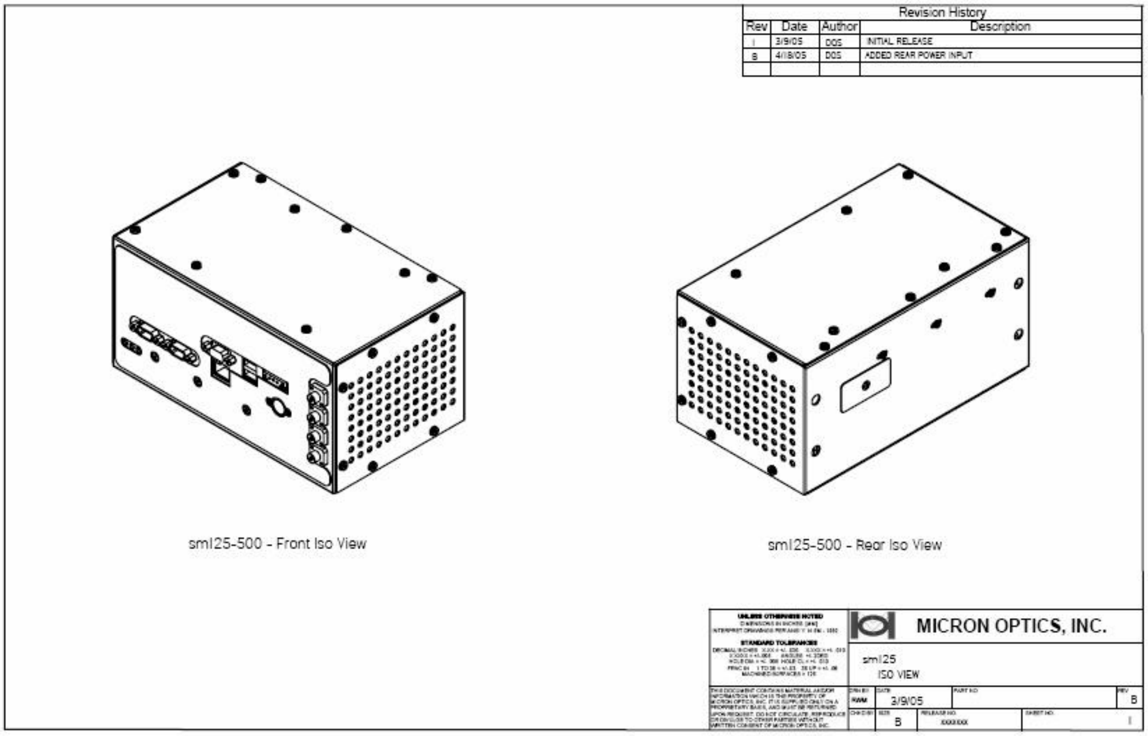


Figure 6.1.1: Mechanical drawings of the sm125 platform.

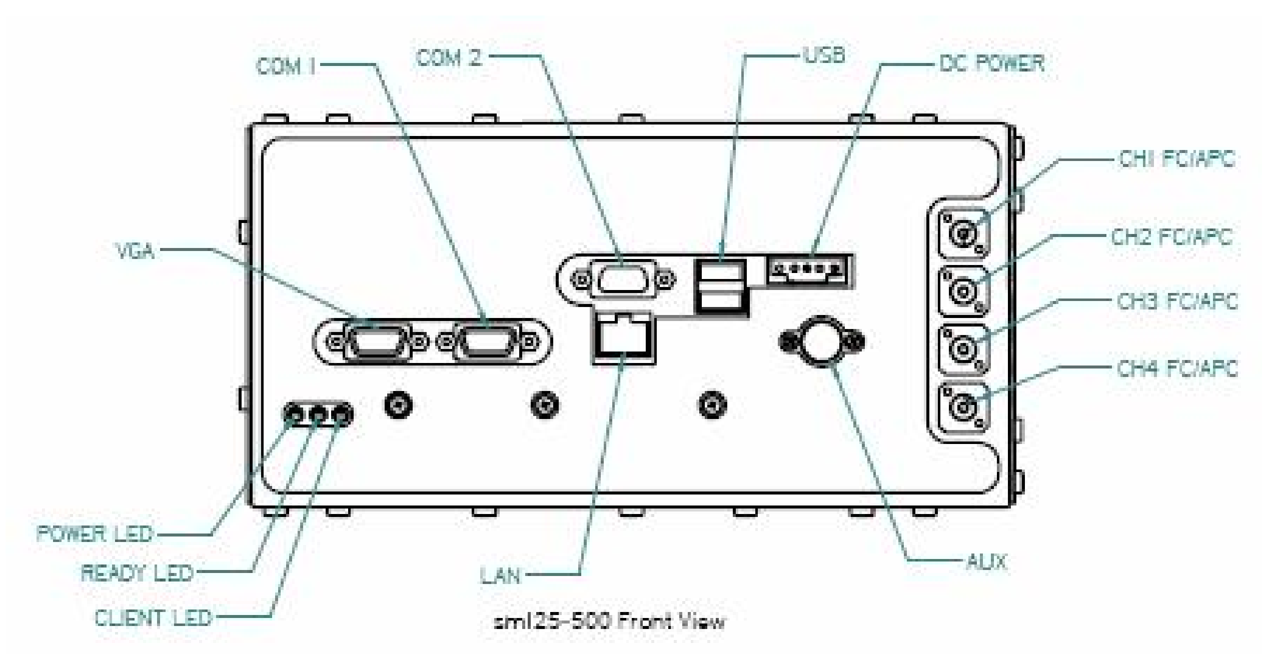


Figure 6.1.2: Front view diagram of the sm125 unit.

Figure 6.1.2 is a diagram of the front side of the sm125 module and shows the following features (see also Section 3):

POWER LED: This red indicator confirms that power has been supplied to the module.

READY LED: This green indicator confirms that the initialization sequence of the unit has completed and remote communications are possible.

CLIENT LED: This amber indicator is illuminated when there is an open remote connection to the module.

VGA: This port can be used to attach an external monitor for diagnostic purposes.

COM1: Available for option RS-232 communication port.

COM2: Available for option RS-485 communication port.

USB: Used for optional wireless Ethernet converter or optional local data storage to memory media.

DC POWER: The front panel mounted connector is a three (3) terminal, removable terminal block that is intended for fixed wiring applications. Therefore, it is extremely important that the power be applied in the proper sequence:

1. With the power supply OFF…
2. Connect the power supply leads to the terminal block.
3. Plug the power connector block into the front panel of the sm125.
4. Tighten the two (2) retaining screws.
5. Apply power.

LAN: This RJ-45 connector is used for the Ethernet communication port.

AUX: This port is an 8 pin DIN connector used to connect the sm125 to accessories, including the available sm041 Channel Expansion Module.

CH1 (-CH4) FC/APC: As many as four optical connectors can be found on the front panel of the sm125 module. Use only FC/APC jumpers to connect to the front panel FC/APC connectors.

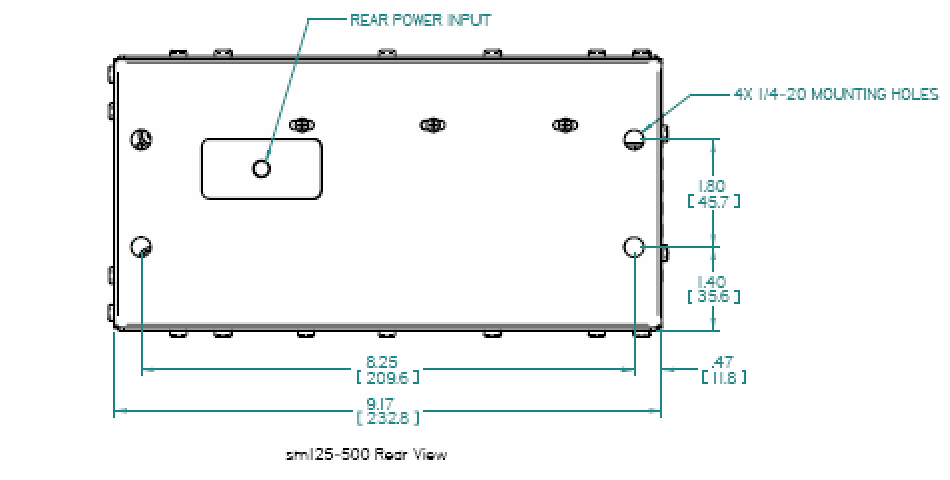


Figure 6.1.3 Rear view diagram of the sm125 unit.

Figure 6.1.3 is a diagram of the rear view of the sm125 module and shows the following:

REAR POWER INPUT: This rear panel mounted coaxial power connector is designed to handle power application and disconnect under all load conditions. Use this connector for all applications in which a fixed power connector is not required.

MOUNTING HOLES. These threaded holes on the rear of the sm125 allow for direct mounting of the module.

Figure 6.1.4 shows a side view of the sm125 module.

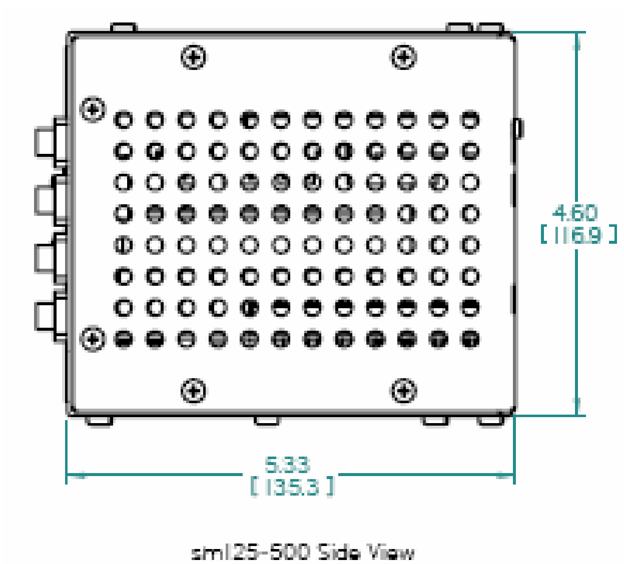


Figure 6.1.4 Side view diagram of the sm125 unit.

6.2 Mounting Options

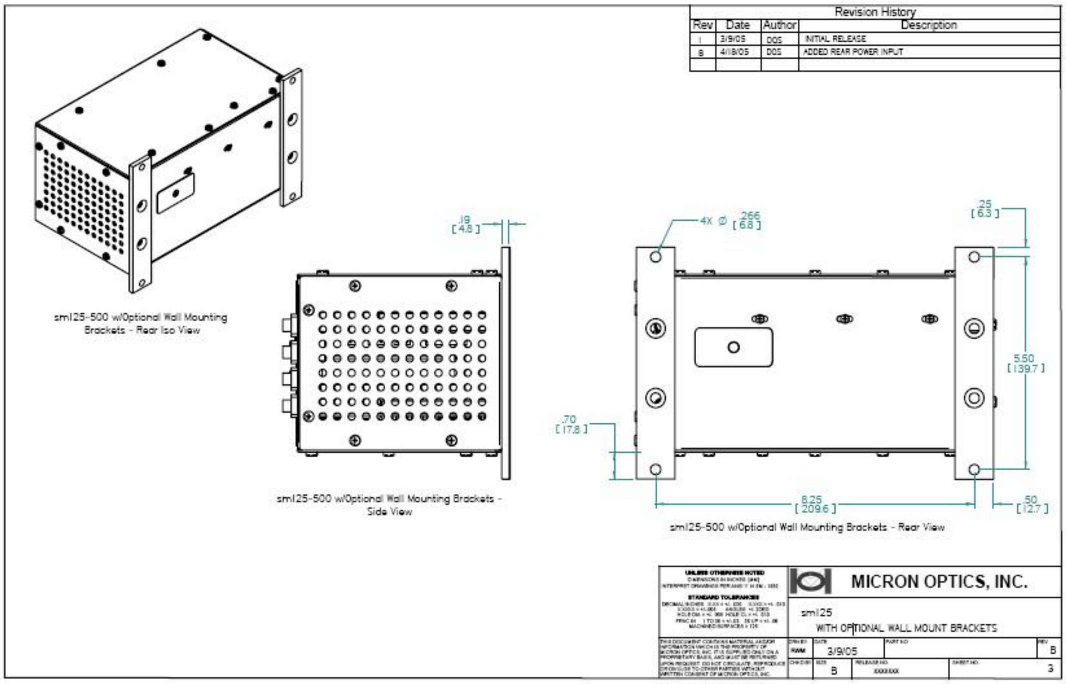


Figure 6.2.1 Mounting Option 1: Flat Mounting Bracket

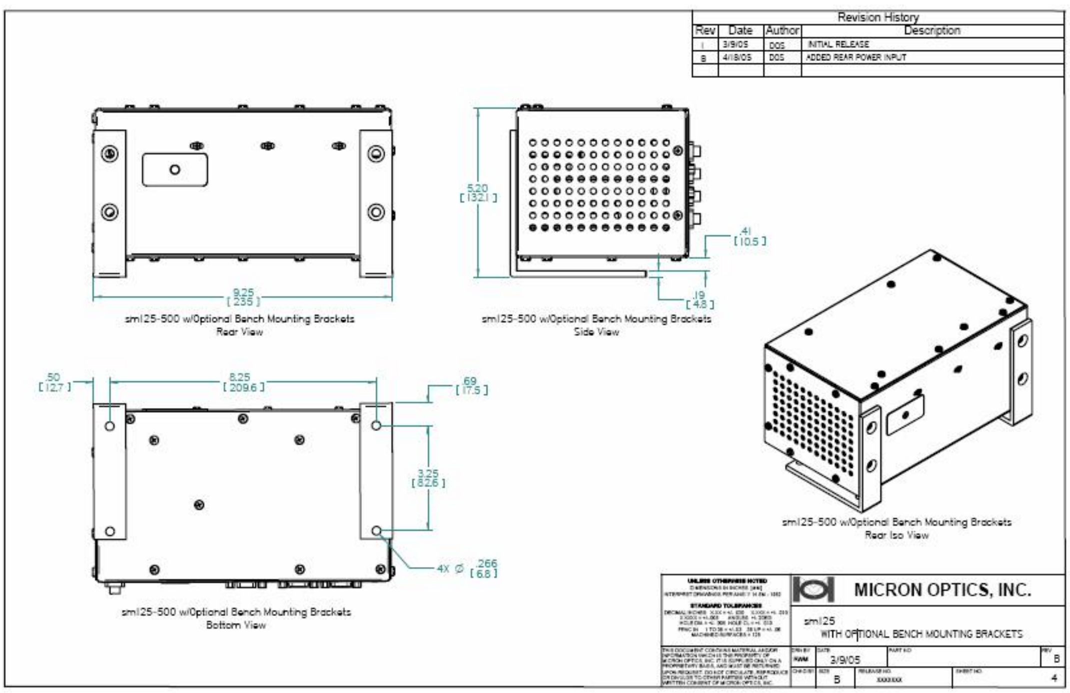


Figure 6.2.2. Mounting Option 2: Angle Mounting Bracket

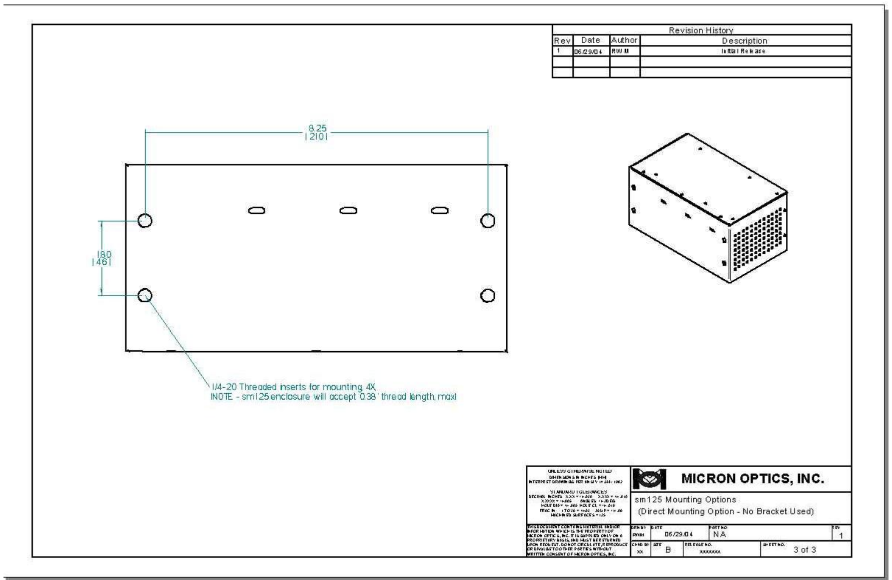


Figure 6.2.3. Mounting Option 3: Direct Mounting

7. Other Considerations

- A warm up period following complete initialization should be observed for maximum wavelength accuracy and stability. For 1Hz sm125 models, maximum stability will be achieved after five minutes. For 10 Hz models, data will continue to stabilize for up to 30 minutes.

Appendix A – Configuring TCP-IP Settings for sm125 Communication

Section 1. Selecting settings to connect to the sm125.

If you are not familiar with the various classes of IP addresses, seek help from your network administrator. He or she will assist in choosing a compatible IP address and Netmask for both sm125 and host computer.

As was mentioned in Section 5.1 of this manual, data transfer to and from the sm125 is facilitated through the Ethernet port of the sm125. The unit can be connected to an existing network through a hub or it can be connected directly to a host PC using a crossover Ethernet cable. Either arrangement requires that the sm125 and the host be on the same logical network. In other words, the host PC and the sm125 must be set for the same Netmask and different, but compatible IP addresses. Using the default IP address and Netmask for the sm125 of **10.0.0.122** and **255.255.255.0**, respectively, the following settings can be used to connect to the sm125:

Case 1: Correct Settings

	Host PC	**sm125**
Netmask	255.255.255.0	255.255.255.0
IP Address	10.0.0.121	10.0.0.122

Reason they work: The sm125 and host PC share the same Netmask. The sm125 and host PC have different IP addresses of the same IP class.

Case 2: Incorrect Settings

	Host PC	**sm125**
Netmask	255.255.255.0	255.255.255.0
IP Address	10.0.0.122	10.0.0.122

Reason: The sm125 and host PC have the same IP address. The sm125 needs a unique address on the network. If any other PC connected to the network is assigned to the same IP address, communication will fail.

Case 3: Incorrect Settings

	Host PC	**sm125**
Netmask	255.255.255.0	255.255.255.0
IP Address	192.168.1.1	10.0.0.122

Reason: The sm125 and host PC are not on the same subnet, as dictated by the IP address. See your network administrator to select compatible values.

Case 4: Incorrect Settings

	Host PC	**sm125**
Netmask	255.0.0.0	255.255.255.0
IP Address	10.0.0.121	10.0.0.122

Reason: The sm125 and host PC do not have identical Netmask settings.

Instructions for setting the Netmask and IP address for the host PC are captured in the next section of this Appendix, Configuring TCP-IP Settings for sm125 Communication.

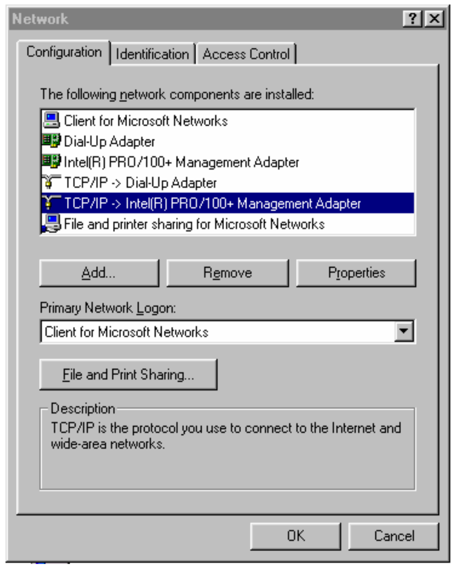
The provided remote LabVIEW utility can be used to change the Netmask and IP address settings of the sm125, once connected. See details for changing network settings with the LabVIEW remote utility in Section 5.6 of this manual.

These same guidelines should be followed whether using the wired or wireless Ethernet options.

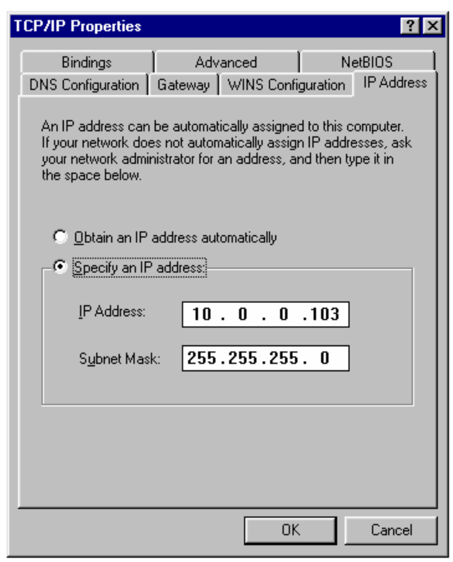
Should there be any uncertainty regarding the settings of an sm125 unit, there are a set of System Utilities included in the sm125 CD-ROM that will help identify or reset the settings. Please refer to Appendix B of this manual to view instructions for use of the System Utilities. Alternatively, connection of a VGA monitor to the sm125 VGA output will display sm125 network settings.

Section 2. Setting the Net mask and IP address on the host PC.

1. Windows 98: On a Windows 98 machine, locate the “Network Neighborhood” icon on the desktop. Right-click and choose “Properties.” The following window will open.

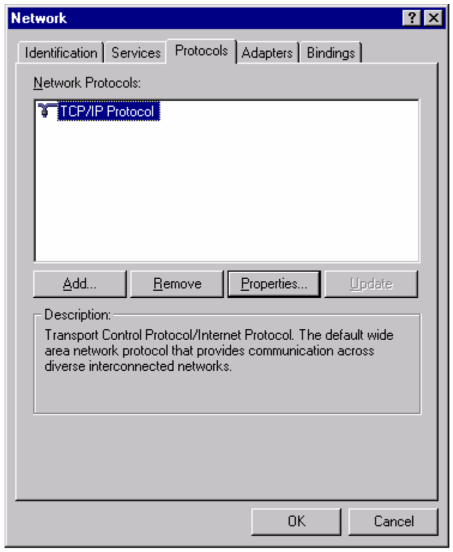


Highlight the appropriate TCP/IP adapter and click “Properties”. The following window will then open.

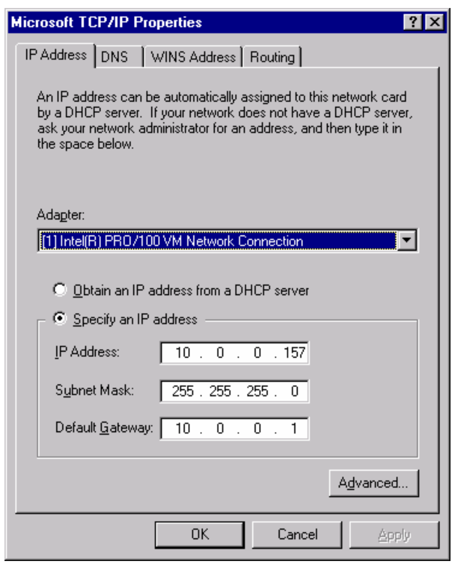


Choose “Specify an IP address” and you will have access to change the subnet mask and IP address. Click “OK” to save settings.

2. Windows NT: On a Windows NT machine, locate the “Network Neighborhood” icon on the desktop. Right-click and choose “Properties.” The following window will open.

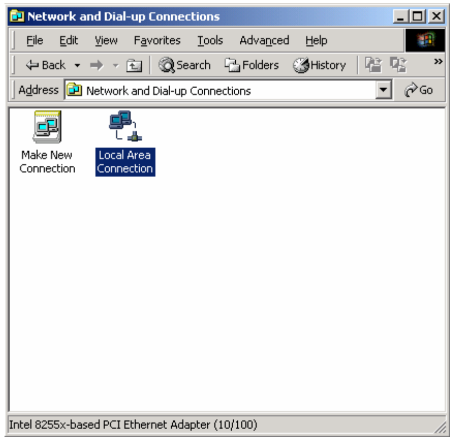


Click on the tab labeled "Protocols" and highlight the "TCP/IP Protocol". Click on "Properties" and the following window will open.

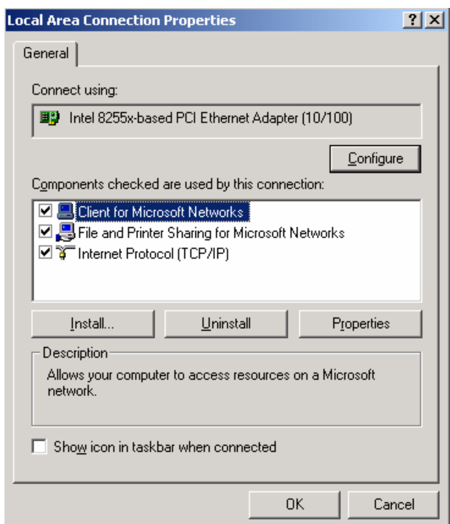


Choose "Specify an IP address" and you will have access to change the subnet mask and IP address. No entry for "Default Gateway" is required. Click "OK" to save settings.

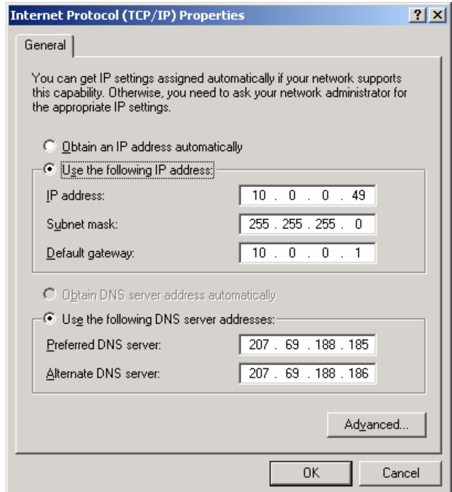
3. Windows 2000: On a Windows 2000 machine, click on the Start Bar and select "Settings", then "Control Panel". Double-click on "Network and Dial-up Connections" and the following window will open.



Right click on "Local Area Connection" and choose "Properties". The following window will then open.

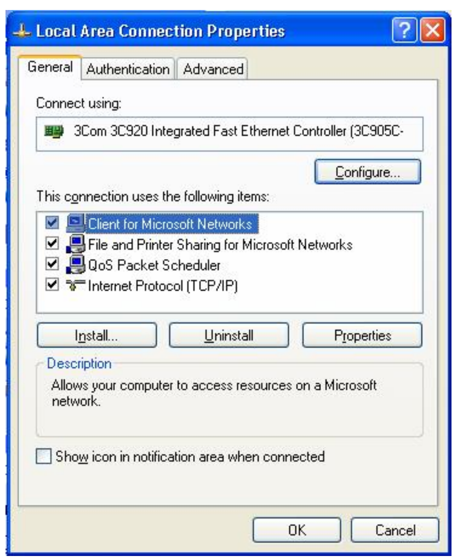


Highlight "Internet Protocol TCP/IP)" and click "Properties". The following window will then open.



Select “Use the following IP address” and you will have access to change the IP address and subnet mask. No entries for “Default Gateway”, “Preferred DNS server” or “Alternate DNS server” are required. Click “OK” to save the settings.

4. Windows XP: On a Windows XP machine, click and the Start Bar and select “Control Panel.” Click on the icon entitled “Network Connections” to open. When open, highlight the “Local Area Network” selection, right click, and choose “Properties”. The following window will open.



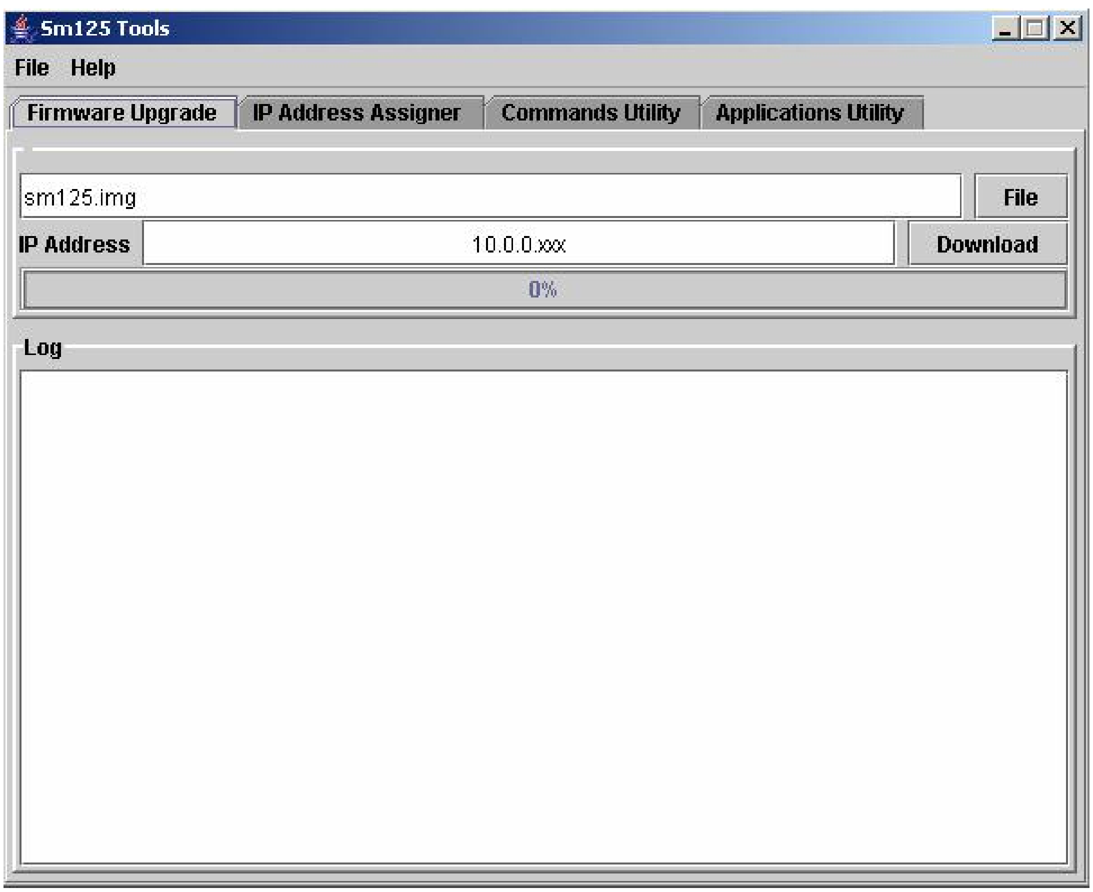
Highlight the “TCP/IP” entry and click “Properties”. You will then have access to change the IP address and subnet mask. Click “OK” to save settings.

Appendix B – sm125 System Tools

Included on the sm125 CD-ROM is a system configuration tools utility that can be used to perform several system level tasks related to the sm125. First, the utility can be used to identify and/or modify the network configuration settings for an sm125 unit. The sm125 Tools utility also provides a conduit for firmware upgrades for the sm125, as well as a means to installation additional application software for the sm125, as it becomes available. Presently, an internal Peak Detection application is available for use with the sm125. This section will explain the tools needed to install/manage the required firmware and applications software.

To find and install the system tools, browse the sm125 installation CD. On the root of the CD-ROM, you will find a folder called "sm125 System Tools". This folder contains two items: a file called "sm125Tools.jar" and a subfolder called "SunJRE". To install the Java Runtime engine required to run the system tools, open the "SunJRE" folder. Contained therein is an installation executable for the Runtime engine, called "j2re-1_4_2_05-windows-i586-p.exe". Click on this file and follow the instructions to complete installation.

Once the runtime engine is installed, click on the "sm125Tools.jar" file to run the system tools utility. The utility should appear as follows.



The sm125 Tools utility can be used in one of three ways: to download new firmware to the sm125, to identify the network settings and communicate basic commands to the sm125, and to install additional applications software to the sm125. The following sections will outline how to perform each of the above mentioned tasks.

To prepare for firmware upgrade or application loading, certain materials will be needed. The following steps outline how to obtain the necessary materials for completing these tasks.

1) If needed, download the most recent CD-ROM materials from our ftp site. At the time of printing, the most recent is RevD and can be found at ftp://ftp.micronoptics.com/outgoing/sm125/sm125_CD_RevD.zip. If the version has been incremented, follow a similar search path to find the most recent CD-ROM materials, indicated by the highest letter version suffix in the filename. Once this file is downloaded, extract all of its contents and burn to CD.

2) Download the most recent firmware from the ftp site. At the time of printing, the most recent is v1.0 and can be found at ftp://ftp.micronoptics.com/outgoing/sm125/Upgrades/sm125_1.0.img. If the version has been incremented, follow a similar search path to find the most recent firmware, indicated by the highest number version suffix in the filename.

3) Download the most recent internal peak detection application file from the ftp site. At the time of printing, the most recent is v1.0 and can be found at ftp://ftp.micronoptics.com/outgoing/sm125/Upgrades/Applications/sm125 Default Peak Detection Application/sm125PeaksApp_1.0.zip. (Each FTP directory includes a readme file which explains the contents of the present folder.)
If the version has been incremented, follow a similar search path to find the most recent application, indicated by the highest number version suffix in the filename.

4) Follow the instructions contained in Appendix B to complete the installation.

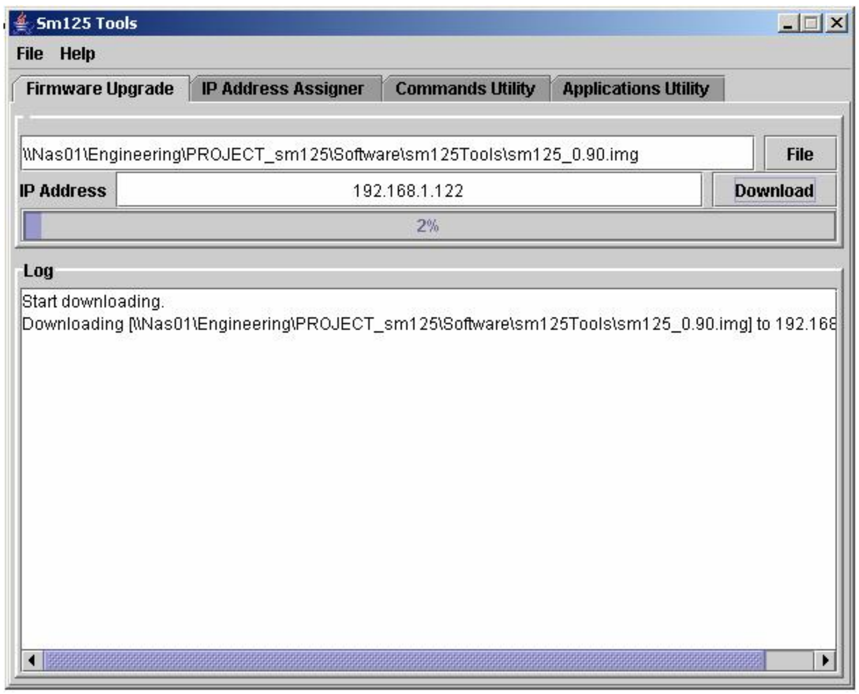
5) Information regarding the use of the internal peak detection application can be found in Appendix D of the sm125 manual.

6) A LabVIEW example using the internal peak detection application can be found in the CD-ROM RevD, under the folder labeled “data”.

I. Firmware Upgrade

The firmware upgrade portion of the utility is used to download new versions of firmware to the sm125 utility. This new firmware file might be emailed to the user as needed or be made available for download on the MOI ftp site, as listed above.
The sm125 firmware file will be found at that location and have the file extension ".img". Download the file from the ftp site to a local drive, and use the sm125 Tools utility to load to the sm125.

In order to load the firmware to the sm125, simply type in the IP address of the target sm125 device and browse the location of the downloaded ".img" file. Once the "Download" button is pressed, the log window will acknowledge the file transfer in process, and a progress bar will begin to track the transfer, as seen in the figure below.



When the log window indicates that the download is complete and the sm125 Client light goes off, cycle the power of the sm125 unit to complete the upgrade.

II. TCP/IP Parameter Management

Like any TCP/IP device, it is important that any changes to the default network settings of the sm125 be noted and recorded in a safe place. Should a user lose track of the network configuration settings for a particular sm125 unit, the sm125 Tools utility can be used to identify the correct settings. In order to use the utility in this capacity, follow the following steps.

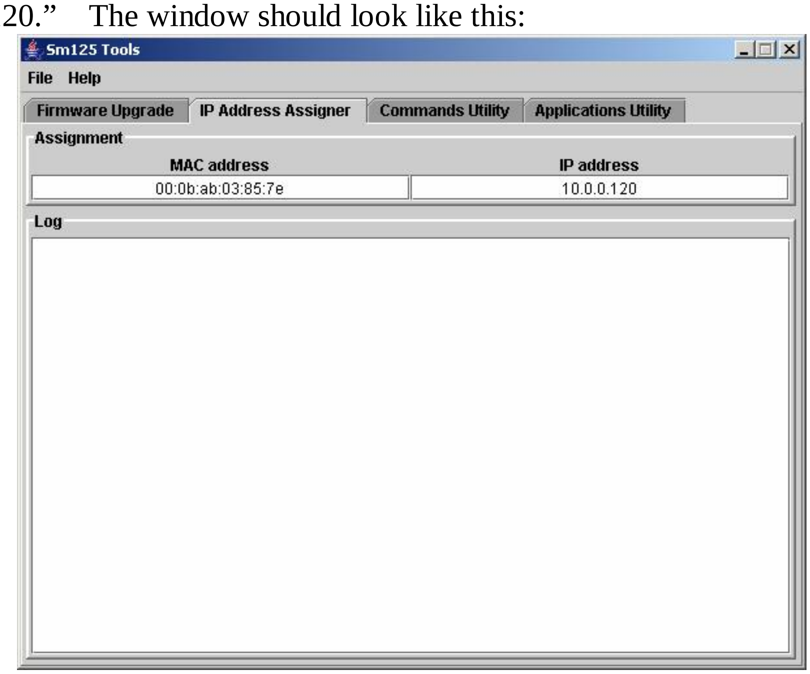
1. (Recommended) Remove the host PC and the sm125 from any LAN.

2. Click on "sm125Tools.jar" to start the system tools utility.

3. Click on the "IP Address Assigner" tab on the utility.

4. Locate the MAC address sticker on the bottom of the sm125 unit. Type the MAC address from the sticker into the "MAC address" window on the sm125 Tools utility. Be sure to separate each pair of characters with a colon and type all letters in lowercase. Warning: the MAC address label on the sm125 in printed in capital letters, but the sm125 Tools utility requires that the address be entered in lowercase (i.e. 000BAB 03857E becomes 00:0b:ab:03:85:7e).

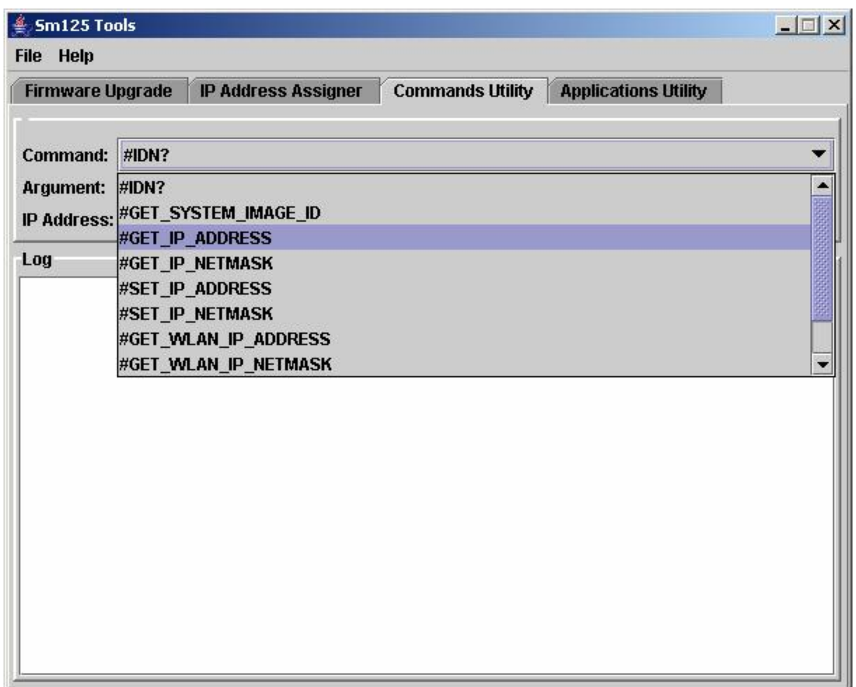
5. Enter a temporary IP address into the "IP address" window on the utility. The temporary IP address must be selected with care so that no other machine on the network will be affected. With the host PC disconnected from a LAN, the choice of temporary IP address becomes less critical. An example of a temporary IP address that would work is
"10.0.0.120." The window should look like this:



6. With the utility window still open, connect the sm125 to the host PC with the provided crossover cable and reboot the sm125 unit. When the unit completes booting, the MAC address with be identified in the "Log" section of the utility, and the temporary IP address will be sent to the unit. Through this temporary IP address, the user will be able to communicate with the sm125.

7. With the temporary connection in place, the user can then use the third tab of the sm125 Tools utility to identify or reassign the network settings for that sm125. Under the "Command Utility" tab, enter the temporary IP address that was used in the previous steps. This temporary IP address will not be stored on the sm125 unit and is only valid until power is cycled on the sm125.

8. With this utility, the user can choose from a list of commands, including those to identify the IP address and Netmask of the sm125, or those to set new values for the IP address and Netmask.

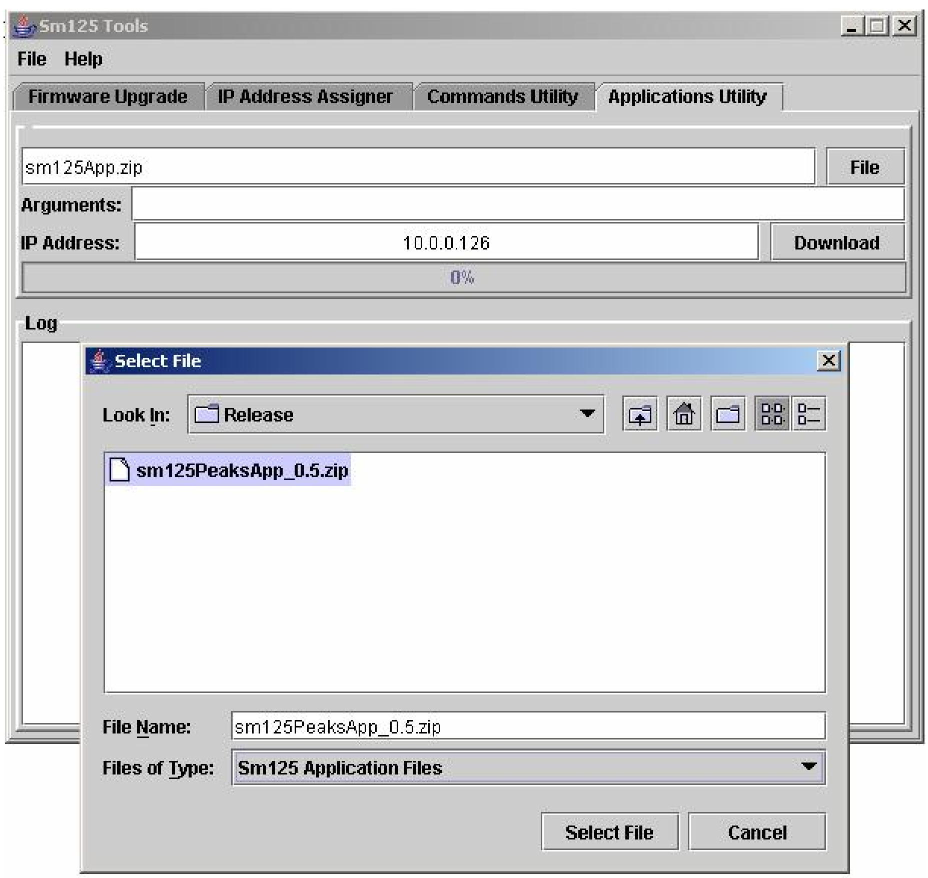


NOTE: If the user simply wishes to learn the IP address assigned to a particular module, use of an external VGA monitor provides an easy means of doing so. Connect an external monitor to the VGA port on the front of the sm125. After the module has gone through its complete boot sequence, it will display the IP address and Netmask for the module on the screen. This method can also be used to verify the installation of an optional USB to Ethernet converter.

III. Application Software Installation

The last class of uses for the sm125 Tools application is installation of additional application software. The sm125 has been designed to accommodate additional features, such as peak detection, parameter conversion, data storage, and other items on a custom or OEM basis. Each of these functions can be made available to run on an application completely independent of the sm125 firmware itself. As such, as separate installation procedure for the separate application software is followed.

Installation of application software is similar to the process used for firmware upgrade. Again, the sm125 Tools utility is used, this time selecting the "Applications Utility" tab on the top of the sm125 Tools window. Again, the user specifies a target sm125 module and browses to the appropriate applications file location. The example in the figure below shows version 0.5 of the default internal Peak Detection application ready to download to an sm125 at address 10.0.0.126. Once the file and target have been selected, the "Download" button will initiate file transfer to the sm125.



When the log window indicates that the download is complete and the sm125 Client light goes off, cycle the power of the sm125 unit to complete the upgrade.

Instructions for use will be included with each piece of specific application software and made available by CD-ROM or file download at our ftp site.

Appendix C – Troubleshooting

Problem	Resolution
Unit will not power on.	Make sure that power is supplied correctly to the unit. The coaxial power connector attaches to the rear of the unit, within the label reading “POWER”. When power is supplied, the red “Power” LED indicator on the lower left side of the front panel will become lit. The unit does not have a Power On button. Simply providing 5 volts to the rear mounted power connector (or the front panel industrial connector, following the proper order of steps) will cause the unit to initialize. If the unit experiences a spike in supply voltage, the power supply may need to cool down. Remove the line cord, wait one minute, replace the line cord, and try again to power on. Micron Optics recommends the use of a qualified surge protector for all of its instruments.
Unit periodically reboots by itself.	Are you using the industrial type 3 terminal block on the front of the unit to supply power? If so, are you following the recommendations of the manual for application of power? This connector is not intended to be used as a switch. If power if “hot-plugged” to this port, there may be damage to the connector which can cause power-related erratic behavior of the unit.
The sm125 module will not communicate.	Can you ping the module?
How do I “ping” the unit?	From the Windows Start bar, select “Run”. In the window that opens, type “ping” then a space, and then the IP address of the sm125 that you wish to communicate with. For example, if the IP address of the sm125 is 10.0.0.122, you would type “ping 10.0.0.122”. A DOS window will launch. The unit will reply if everything is correctly connected and configured. If there is a connection problem, the unit will time out or be deemed otherwise inaccessible.

The sm125 will not respond to the "ping" command.	Is the subnet mask set the same as or compatible with the host PC? See Appendix A for details. Are you pinging the correct IP address? If connecting directly from a PC, are you using an Ethernet crossover cable? If connecting through an existing network, are you using a standard Ethernet cable? If you are not familiar with the various classes of IP addresses, seek help from your network administrator. He or she will assist in choosing a compatible IP address for both sm125 and host computer.
How can I tell whether or not my Ethernet cable is of the standard or crossover variety?	The crossover cable should be labeled on its packaging as such. If the original packaging is not available, examine the wire colors at both RJ45 connectors. If the order of connector colors is identical at both ends, the cable is not a crossover. If two of the connector colors are opposite on one end relative to the other, the cable is a crossover cable.
I can "ping" the unit, but cannot run the LabVIEW example code.	When pinging, make sure that you are pinging the IP address for the sm125 itself and not the host computer. To open the source code, LabVIEW 7.1 is required. If LabVIEW 7.1 is not available, try the executable. To use the standard LabVIEW example, the full or professional version of LabVIEW 7.1 is needed. If only the Base package is available, contact MOI for a version reduced for the Base package at sm125@micronoptics.com. How many clients are connected to the sm125? The sm125 presently supports up to five simultaneous client connections. Installation of the internal peak detection application uses one of the five available connections. If you already have the maximum number of clients connected to the device, additional connections will not be possible.

When I run the sm125 executable, an error message appears that says a dll is missing.	Was the executable installed to the host PC using the installation program, or was it just run from the CD-ROM? Before the sm125 executable can run on a PC, the LabVIEW Runtime Engine must be installed. Place the sm125 installation disk in the CD-ROM drive, allow the installation window to open (or click on MOI_Install.exe, if the auto-insert notification is turned off of your CD-ROM drive) and click the "Install the Software" button on the MOI setup window. The installer will guide you through the rest of the process. Is the operating system of the host PC Windows 98, 2000, NT or XP? Earlier versions of Windows are not compatible with the installer used for the sm125. Please select a host PC with one of the above operating systems. There is an included dll for peak detection in the sm125 software. Make sure that the dll has been copied along with the LabVIEW programs to the target location on your computer.
I cannot remember the IP settings for the sm125 module.	Refer to Appendix B of this manual. The IP settings can either be extracted using the included sm125Tools Java program, or simply through the use of an external monitor.
LabVIEW example code communicates, but does not transfer data at the full rate.	How many clients do you have connected to the sm125? The sm125 will support up to 5 clients, but is optimized for maximum data transfer to a single client. If high speed data transfer is desired, restrict use to a single client and service additional clients with another server. Try to free as much of the host computer's resources as possible. Close other applications that may be running. Wireless Ethernet can at times limit the data transfer rate. If the rate of transfer is less than expected or acceptable, try using a wired Ethernet connection.
Extra peaks or no peaks are detected by the sm125.	Peak detection parameters may not be set correctly for present sensors. Peak detection parameters should be optimized for sensor bandwidth, peak shape, and sidelobe suppression. Make sure that there are no high back-reflection terminations or connections in the optical path. Such unwanted reflections could in extreme cases be misinterpreted as sensor wavelengths.
How can get more channels?	The sm125 can be configured for 1,2 or 4 channel operation. Additional channels, up to 16, can be enabled by the addition of an available sm041 Channel Expansion Module.

Can the sm125 acquire faster than 1 Hz?	The sm125 platform has been expanded in capability to support 2, 5, and 10 Hz acquisition rates. Please contact Micron Optics to inquire.
I'm already using an si425. Is it possible to use my existing software for sm125 measurements as well?	While the sm125 is significantly different in the way that sensor information is acquired and processed, Micron Optics has created a software interface for the sm125 that mimics that of the si425. Using this interface, the choice of instrument can potentially be transparent to user code. Please see Appendix D, Section IV for details.
Can the sm125 be used for transmission measurements on optical components?	Yes. Each channel on the sm125 functions as both transmitter (laser output) and receiver (optical detector.) Thus, in order to take transmission only measurement, it is necessary to prevent reflected signal from entering the transmission only channel. Two configurations can be used to accomplish this. Configuration 1. Use two channels and an isolator to get simultaneous transmission and reflection measurements. Connect the optical components in this order: Channel 1 -> DUT -> Isolator (pointing towards…) -> Channel 2. This will allow light from Channel 1 to reflect back to Channel 1 for a reflection measurement and propagate forwards through the isolator to Channel 2 for a transmission measurement. All light from Channel 2 will be stopped at the isolator, rendering Channel 2 temporarily as a receiver channel only. Configuration 2. Use a single channel and a circulator. Connect the common leg of the circulator to a channel on the sm125. Connect the other two legs to the DUT component. The circulator will cause light to be coupled into the component, travel in only one direction, and return to the sm125, thus enabling a transmission only measurement.
I have a sensor with an unusual shape. What can I do to modify the peak detection?	The provided peak detection algorithm is a dll support file specifically tailored for FBG and Etalon type sensors. Even so, the control afforded by the parameters allow for a wide variety of signals to be peak detected. Should modification of the parameters of the provided algorithm not produce the desired results, modifications to the provided LabVIEW source code can be made.

	The sm125 is a full spectrum instrument. As such, the complete optical profile for each sensor is acquired with every scan. Micron Optics provides open source LabVIEW drivers for the instrumentation so that modifications can be easily made by customers familiar with the LabVIEW environment. For those not interested in using LabVIEW, all functions can be implemented in practically any available language using the provided command set.
When I use the Channel Expansion Module, I see unstable wavelength reading on some channels.	Make sure that the state of each present channel is set correctly using the #SET_DUTX_STATE command structure. To decouple software issues from hardware concerns, try to run the provided 16 Channel Data Acquisition LabVIEW example.
Wireless communication to the sm125 is not working properly.	Make sure that your wireless adapter is on the approved list of compatible devices for the sm125. See section 3 of this manual or contact Micron Optics to be sure. Make sure that your firmware version on the sm125 is 0.85 or greater. You can access the firmware version using the **#GET_SYSTEM_IMAGE_ID** command. Successful installation of a USB Ethernet converter can be verified with an external monitor. With about ten seconds after insertion of the device, the sm125 will output a message to the monitor port indicating the IP address and Netmask of the WLAN interface. Verify that the wireless Ethernet adapter on your PC is functional. Remember that connection to the sm125 is a Peer-to-Peer connection, and not Network Infrastructure Mode. The same requirements for compatible IP address and Netmask as are in place for wired Ethernet connectivity apply to sm125 wireless connections.
The above suggestions have not solved the problem.	Please forward all questions and comments to sm125@micronoptics.com. Should technical assistance be needed, please utilize the GET_RAW_DATA utility on your sm125 distribution disk to generate a system summary file and email it MOI at the address listed above.

Appendix D – Default Internal Peak Detection Application

I. Introduction

Internal capabilities for performing peak detection of optical signals have been added to the sm125. This document will discuss how to load these capabilities to the sm125 module and how to use them once they are installed.

II. Installing the Peak Detection Application

Installation of the Peak Detection application can be facilitated by following the instructions found in Appendix B of this manual, "sm125 System Tools."

The default values for the four peak detection parameters may be set by the user in the Application Utility in the sm125Tools.jar utility during applications installation. The four parameters are:

Threshold

'-t -30.0' ‘-t’ sets the minimum threshold level in dB for the peak detection algorithm; default is -30.0 dB. Peaks below this threshold will be excluded. The negative sign indicates that the threshold distance will be measured down from 0 dB.

Width

'-w 0.15' ‘-w’ sets the minimum peak width in nanometers for acceptable peaks; default is 0.15 nm. Peaks narrower than this width will be excluded.

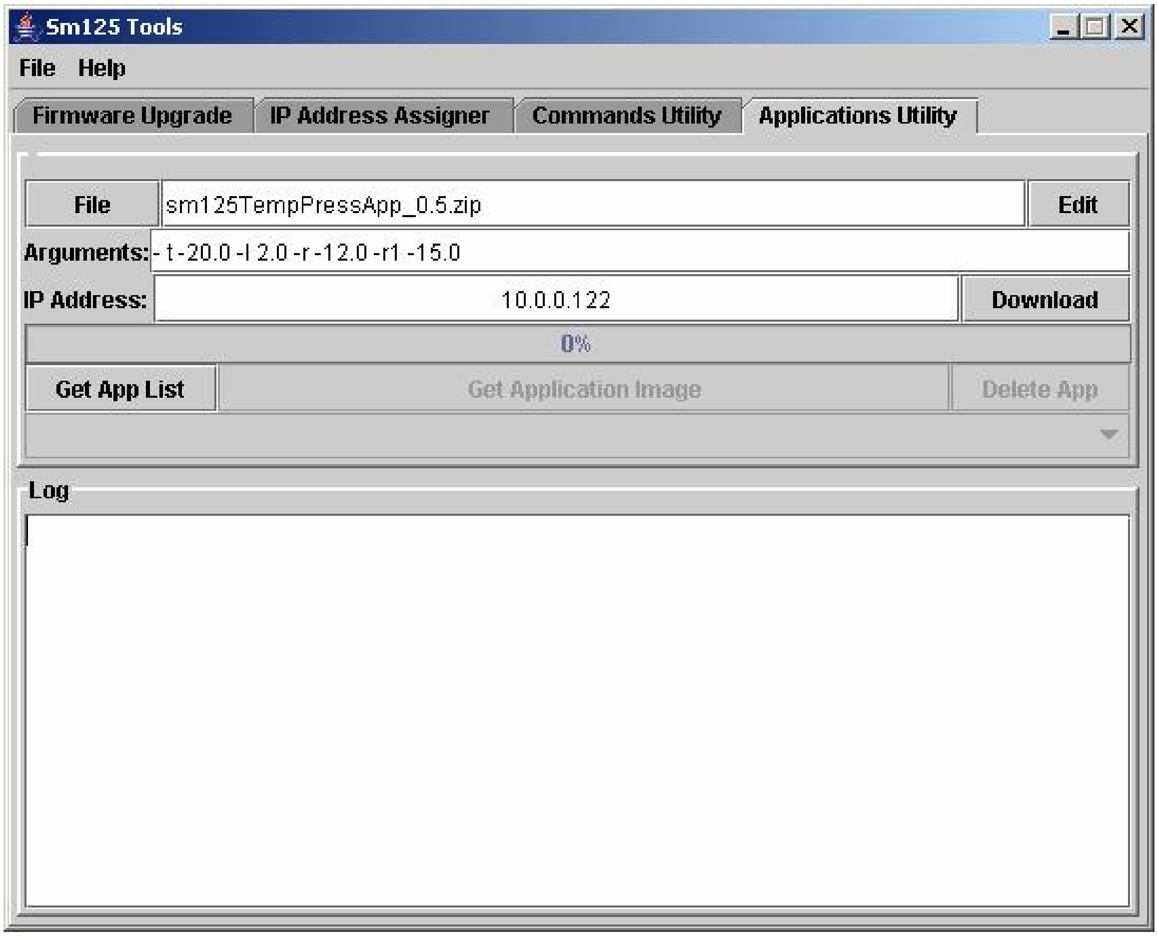
Width Level

'-l 3.0' ‘-l’ sets the level from the top of the peak in dB where the width is measured to compare with the ‘-w’ parameter; default is 3.0 dB. Note that ‘level’ is expressed as a positive number.

Relative Threshold

'-r -15.0' ‘-r’ sets the relative threshold in dB for the maximum acceptable distance from the tallest peak; default is -15.0 dB. Peaks that are more than 15.0 dB down from the tallest peak will be excluded. The negative sign indicates that the threshold distance will be measured down from the tallest peak.

Each of these arguments, as shown above, set the parameters simultaneously for all channels. However, now it is possible to set each parameter by channel. For example, '-t2 -20.0' sets the threshold level for channel 2 to -20.0 dB. (See section 5.6.1.2 for peak detection examples.)



In the figure above, the sm125Tools Application Utility is prepared for downloading the peak detection application zip file to the sm125. The filename, **sm125PeaksApp_0.5.zip** (or similar), is entered with its proper directory path in the "File" window. Also, pressing the "File" button will allow the user to browse to the proper file.

Arguments listed in the "Arguments" window are included to modify the defaults described earlier in this section. Entries are separated by spaces. In this example, the threshold for all channels is set to -20.0 dB; the level for all channels is set to 2.0 dB; and the relative threshold for all channels is set to -12.0 dB. The final argument in the list changes the relative threshold for channel 1 to -15.0 dB. Note that the '-w' parameter is not listed. This will leave its default value of 0.15 in place for width.

III. Peak Detection Application Commands and Parameters

The peak detection functionality of the sm125 module can be accessed and controlled remotely through a series of commands and parameters. This section will explain what those controls and parameters are.

#SET_PEAK_THRESHOLD_CH1

This command sets the threshold level in dBm for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose level would be set by the command is Channel 1. In order to set the threshold level for Channel 4, the command would simply be modified to reflect the changed channel to **#SET_PEAK_THRESHOLD_CH4.**

Implementation: **Set Peak Detection threshold level for a single channel.**

Syntax:

#SET_PEAK_THRESHOLD_CH1 –50.00

Response:

#PEAK_THRESHOLD_CH1 –50.00

#GET_PEAK_THRESHOLD_CH1

This command gets the threshold level in dBm for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose level would be retrieved by the command is Channel 1. In order to get the threshold level for Channel 4, the command would simply be modified to reflect the changed channel to **#GET_PEAK_THRESHOLD_CH4.**

Implementation: **Retrieve Peak Detection threshold level for a single channel.**

Syntax:

#GET_PEAK_THRESHOLD_CH1

Response:

#PEAK_THRESHOLD_CH1 –50.00

#SET_REL_PEAK_THRESHOLD_CH1

This command sets the relative threshold level in dBm for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose level would be set by the command is Channel 1. In order to set the relative threshold level for Channel 4, the command would simply be modified to reflect the changed channel to **#SET_REL_PEAK_THRESHOLD_CH4.**

Implementation: **Set Relative Peak Detection relative threshold level for a single channel.**

Syntax:

#SET_REL_PEAK_THRESHOLD_CH1 –6.00

Response:

#REL_PEAK_THRESHOLD_CH1 –6.00

#GET_REL_PEAK_THRESHOLD_CH1

This command gets the relative threshold level in dBm for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose level would be retrieved by the command is Channel 1. In order to get the relative threshold level for Channel 4, the command would simply be modified to reflect the changed channel to **#GET_REL_PEAK_THRESHOLD_CH4.**

Implementation: **Retrieve Relative Peak Detection threshold level for a single channel.**

Syntax:

#GET_REL_PEAK_THRESHOLD_CH1

Response:

#REL_PEAK_THRESHOLD_CH1 –6.00

#SET_PEAK_WIDTH_CH1

This command sets the peak width in nanometers for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose width would be set by the command is Channel 1. In order to set the peak width for Channel 4, the command would simply be modified to reflect the changed channel to **#SET_PEAK_WIDTH_CH4.**

Implementation: **Set Peak Detection peak width for a single channel.**

Syntax:

#SET_PEAK_WIDTH_CH1 0.25

Response:

#PEAK_WIDTH_CH1 0.25

#GET_PEAK_WIDTH_CH1

This command gets the peak width in nanometers for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose width would be retrieved by the command is Channel 1. In order to get the peak width for Channel 4, the command would simply be modified to reflect the changed channel to **#GET_PEAK_WIDTH_CH4.**

Implementation: **Get Peak Detection peak width for a single channel.**

Syntax:

#GET_PEAK_WIDTH_CH1

Response:

#PEAK_WIDTH_CH1 0.25

#SET_PEAK_WIDTH_LEVEL_CH1

This command sets the peak width level in dB for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose width level would be set by the command is Channel 1. In order to set the peak width level for Channel 4, the command would simply be modified to reflect the changed channel to **#SET_PEAK_WIDTH_LEVEL_CH4.**

Implementation: **Set Peak Detection peak width level for a single channel.**

Syntax:

#SET_PEAK_WIDTH-LEVEL_CH1 3.0

Response:

#PEAK_WIDTH_LEVEL_CH1 3.0

#GET_PEAK_WIDTH_LEVEL_CH1

This command gets the peak width level in dB for the peak detection algorithm for the particular channel specified by the command name. As shown in this example, the channel whose width level would be retrieved by the command is Channel 1. In order to get the peak width level for Channel 4, the command would simply be modified to reflect the changed channel to **#GET_PEAK_WIDTH_LEVEL_CH4.**

Implementation: **Get Peak Detection peak width level for a single channel.**

Syntax:

#GET_PEAK_WIDTH_LEVEL_CH1

Response:

#PEAK_WIDTH_LEVEL_CH1 3.0

#GET_PEAKS_AND_LEVELS

The data returned by #GET _PEAKS_AND_LEVELS is a binary string that encodes a mixed set of data. The first 4 bytes (LSB first, MSB last) form a 32-bit unsigned integer that represents the seconds portion of the timestamp. The second 4 bytes (bytes 4-7) is also a 32-bit unsigned integer that represents the micro-seconds portion of the timestamp. Thus:

seconds = byte 0 + byte 1*(2^8) + byte 2*(2^16) + byte 3*(2^24)
microseconds = byte 4 + byte 5*(2^8) + byte 6*(2^16) + byte 7*(2^24)

timestamp = seconds + microseconds/1000000.0

The data set serial number is also a 32-bit unsigned number with a byte offset of 8 (bytes 8-11). The serial_number = byte 8 + byte 9*(2^8) + byte 10*(2^16) + byte 11*(2^24)

The number of sensors detected on each of the channels is represented by an unsigned 16-bit integer with the following byte offsets:

channel 1: byte offset 12
channel 2: byte offset 14
channel 3: byte offset 16
channel 4: byte offset 18

For sm125 models with less than 4 channels, the structure remains the same and empty channels will return data as zero values.

The wavelength data for channel 1 is represented with signed 32-bit numbers with a byte offset of 32. Subsequent byte offsets scale by the number of signals detected.

Amplitude data is represented with signed 16-bit numbers. The byte offset is a function of the number of detected signals on each channel. The details of the data structure are presented in Table 1 below.

Entry	Byte Offset	Atomic Size (bytes)	Total Size (bytes)	Description
Timestamp (sec.)	0	4 (U32)	4	Seconds portion of the timestamp. The timestamp, which is the absolute time in microseconds elapsed since 00:00:00 of January 1, 1970, must be reconstructed by combining the seconds and the microseconds portions as described below.
Timestamp (μsec.)	4	4 (U32)	4	Microseconds portion of the timestamp. See the note above on the seconds portion. The microseconds portion must be combined with the seconds portion to reconstruct the full timestamp as follows: ***timestamp = sec portion*** ***+ (μsec portion)/1000000*** The computed timestamp is a double-precision float.
Serial Number	8	4 (U32)	4	Serial number of the data set. Data points are sequentially numbered. In situations where the possibility of data loss or corruption exists during transfers, the serial number can be used to re-order and/or determine when data loss has occurred.
#Sensors 1 (NS1)	12	2 (U16)	2	The number of sensors detected on the first, second, third and fourth channels respectively.
#Sensors 2 (NS2)	14	2 (U16)	2	
#Sensors 3 (NS3)	16	2 (U16)	2	
#Sensors 4 (NS4)	18	2 (U16)	2	
Thermal Stability Flag	20	2(U16)	2	Thermal Stability Flag. This value is non-zero when the system is in warm-up stage.
MUX State	22			Communicates switch position when channel expansion module used. Values 0, 1 for 8 channels; 0,1,2,3 for 16 channel system.
Reserved	24	1	8	---
Ch1 data	32	4 (S32)	2*NS1	
Ch2 data	32+4*(NS1)	4 (S32)	2*NS2	
Ch3 data	30+ 4*(NS1+ NS2)	4 (S32)	2*NS3	
Ch4 data	32+4*(NS1 +NS2+NS3)	4 (S32)	2*NS4	
Ch1 levels	32+4*(NS1+NS2+NS3+NS4)	2 (S16)	NS1	
Ch2 levels	32+4*(NS1+NS2+NS3+NS4) + 2*(NS1)	2 (S16)	NS2	
Ch3 levels	32+4*(NS1+NS2+NS3+NS4) + 2*(NS1+NS2)	2 (S16)	NS3	
Ch4 levels	32+4*(NS1+NS2+NS3+NS4) + 2*(NS1+NS2 +NS3)	2 (S16)	NS4	

Table 1: description of #GET_PEAKS_AND_LEVELS structure

IV. Internal Peak Detection LabVIEW Example

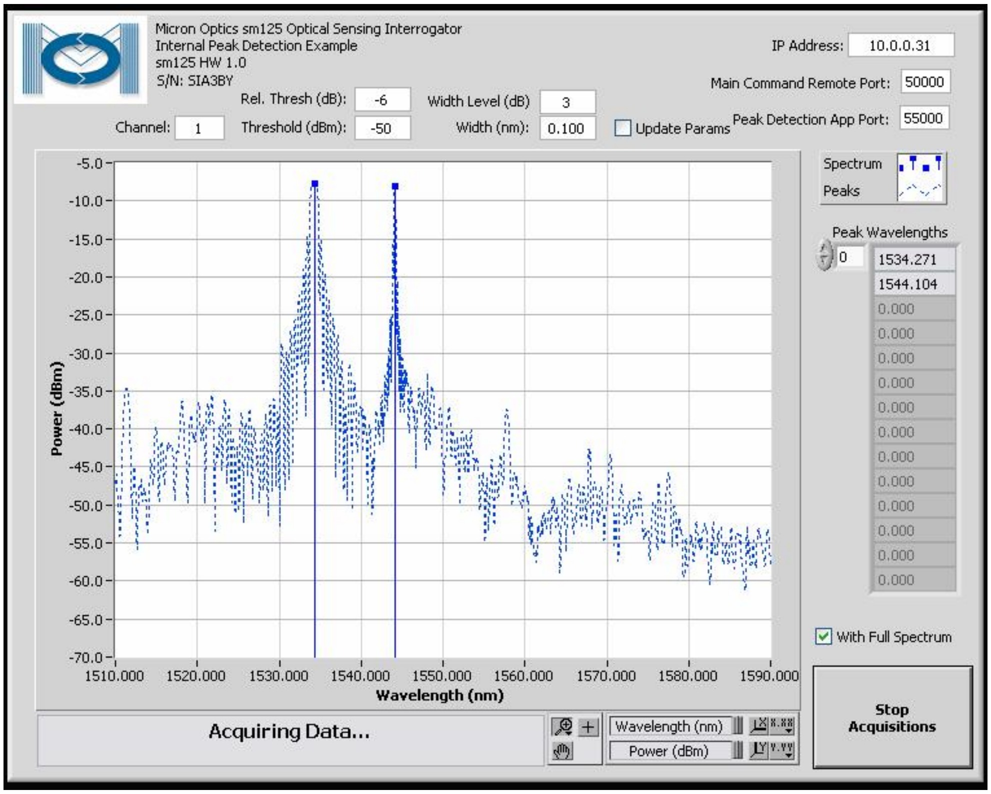


Figure 1. sm125 Internal Peak Detection LabVIEW Example

Figure 1 shows a screen shot of the included Internal Peak Detection Example. This example uses the peak detection command set outlined in this Appendix to perform peak detection on the collected spectrum inside the sm125 module itself. The purpose for this example is to demonstrate the internal peak detection functionality and to allow the user to familiarize himself with the features of the peak detection algorithm.

Controls available in this example include: Channel selection, Threshold and Relative Threshold controls, Width Level and Width controls, as well as IP address and port selectors. The example can either display peaks only, or simultaneous spectrum and peak data, for purpose of illustration.

IV. si425 Transparency

There has been customer interest in having transparency between the si425 and sm125 from the software perspective. While emulation of the si425 capabilities was not the original intention of the sm125 module, it is recognized that there are situations where absolute compatibility would be beneficial, particularly for applications with an existing software base.

To this end, the following additional command has been added to the sm125 Peak Detection Application. Once installed to the sm125, this application will allow the sm125 to respond to software queries in an identical for to the command for the si425 of the same name.

This command reduces the atomic size of the Wavelength Data to only 16 bytes, thus reducing the possible resolution of the native sm125 measurements. In some circumstances, though, this is found to be preferable to a difference in the format from the si425 format.

#READ_DATA_AND_LEVELS

#READ_DATA_AND_LEVELS return strings that scale in size with the number of sensors present. As such, the offsets for each channels data are a function of the number of sensors on each channel. The byte offsets for each channel dataset are described in Table 2.

Wavelength data is formatted as a 16 bit number representing an offset from a central value. The central value is a wavelength value in units of nanometers, found at byte offset 26. The scaling factor, found at byte offset 28, has units of counts/nm. To reconstruct the wavelength value, divide by the scaling factor (28) and add the offset

(26). For example, if the scaling factor = 1000, and the offset value = 1545.000, then a data value of 478 would be converted to wavelength in the following manner:

$$478/100 + 1545.000 = 1545.478$$

Use of the optional 8 or 16 channel expansion module requires that data be multiplexed within the above structures according to optical switch position. The optical switch position data (MUX state) can be found in the data structures at byte position 24. The multiplexed wavelength information is coded into the data structure in the following way.

A Multiplexed Channel is located at (MUX state * 4) + Physical Channel, where the MUX state can be 0, 1, 2, or 3 and the Physical Channel is 1, 2, 3, or 4, as seen on the front of the si425 instrument.

For example, data for the Multiplexed Channel 13 would be found in the entry for Physical Channel 1 when the MUX state is 3, or: *(3 * 4) + 1 = 13.*

The byte offsets along with a brief description of each quantity are summarized in the tables following.

Entry	**Byte Offset**	**Atomic Size (bytes)**	**Total Size (bytes)**	**Description**
Timestamp (sec.)	0	4 (U32)	4	Seconds portion of the timestamp. The timestamp, which is the absolute time in microseconds elapsed since 00:00:00 of January 1, 1970, must be reconstructed by combining the seconds and the microseconds portions as described below.
Timestamp (μsec.)	4	4 (U32)	4	Microseconds portion of the timestamp. See the note above on the seconds portion. The microseconds portion must be combined with the seconds portion to reconstruct the full timestamp as follows: ***timestamp = sec portion*** ***+ (μsec portion)/1000000*** The computed timestamp is a double-precision float.
Serial Number	8	4 (U32)	4	Serial number of the data set. Data points are sequentially numbered. In situations where the possibility of data loss or corruption exists during transfers, the serial number can be used to re-order and/or determine when data loss has occurred.
Buffers	12	2 (U16)	2	Available buffer space. When the available buffer space drops to zero, data loss will result. Monitor this quantity to assure that no data loss occurs. A steadily decreasing buffers value indicates that the data transfer across the Ethernet link is not keeping up with the rate of data generation inside the si425. As of version 1.0, the available buffer is represented as a percentage.
#Sensors 1 (NS1)	14	2 (U16)	2	The number of sensors detected on the first, second, third and fourth channels respectively.
#Sensors 2 (NS2)	16	2 (U16)	2	
#Sensors 3 (NS3)	18	2 (U16)	2	
#Sensors 4 (NS4)	20	2 (U16)	2	
Thermal Stability Flag	22	2(U16)	2	Thermal Stability Flag. This value is non-zero when the system is in warm-up stage.
MUX state	24	2(U16)	2	Communicates switch position when channel expansion module used. Values: 0,1 for 8 channels; 0,1,2,3 for 16 channel system.
Wavelength Offset	26	2(U16)	2	Offset value for conversion from count to wavelength.
WL Granularity	28	2(U16)	2	Granularity multiplier for count-WL conv.
Reserved	30	1	10	---
Ch1 data	32	2 (S16)	NS1	
Ch2 data	32+2*(NS1)	2 (S16)	NS2	
Ch3 data	32+ 2*(NS1+NS2)	2 (S16)	NS3	
Ch4 data	32+2*(NS1 +NS2+NS3)	2 (S16)	NS4	

Ch1 levels	32+2*(NS1+NS2+NS3+NS4)	2 (S16)	NS1	
Ch2 levels	32+2*(2*NS1+NS2+NS3+NS4)	2 (S16)	NS2	
Ch3 levels	32+2*(2*NS1+2*NS2+NS3+NS4)	2 (S16)	NS3	
Ch4 levels	32+2*(2*NS1+2*NS2+2*NS3+NS4)	2 (S16)	NS4	

Table 2: Description of #READ_DATA_AND_LEVELS structure

It is expected that the command #READ_DATA_AND_LEVELS will be used by software which was written to interface to the si425 instrument. As such, that software would not have the capability of using the **#SET_PEAK_THRESHOLD** and **#SET_PEAK_WIDTH** commands. In lieu of programmatically setting these parameters, the user can simply utilize the default parameters (-20 dB and 0.15 nm, respectively) or can choose to redefine the default parameters during the installation of the Peak Detection application to the sm125 module.

The parameters can be changed using the sm125Tools utility, as seen in Figure 3. Before the application zip file is downloaded to the sm125 module, the desired parameters can be entered on the “Arguments” line following the protocol outlined in the following example.

EXAMPLE:

To install the sm125 Peak Detection Application to the sm125 module, changing:

- Port #: from the default value of 50000 to 1852
- Peak Detection Threshold: from the default value of –50 dBm to –35 dBm
- Peak Detection Relative Threshold: from the default value of -15 dB to -6 dB
- Peak Detection Width Level: from the default value of 3dB to 2 dB.
- Peak Detection Width: from the default value of 0.15 nm to 0.20 nm

add those parameters to the "Arguments" line, designating each value with the following space-delimited characters:

- Port: "-p"
- Threshold: "-t"
- Width: "-w"

resulting in an "sm125Tools" window that is populated that that seen in Figure 2.

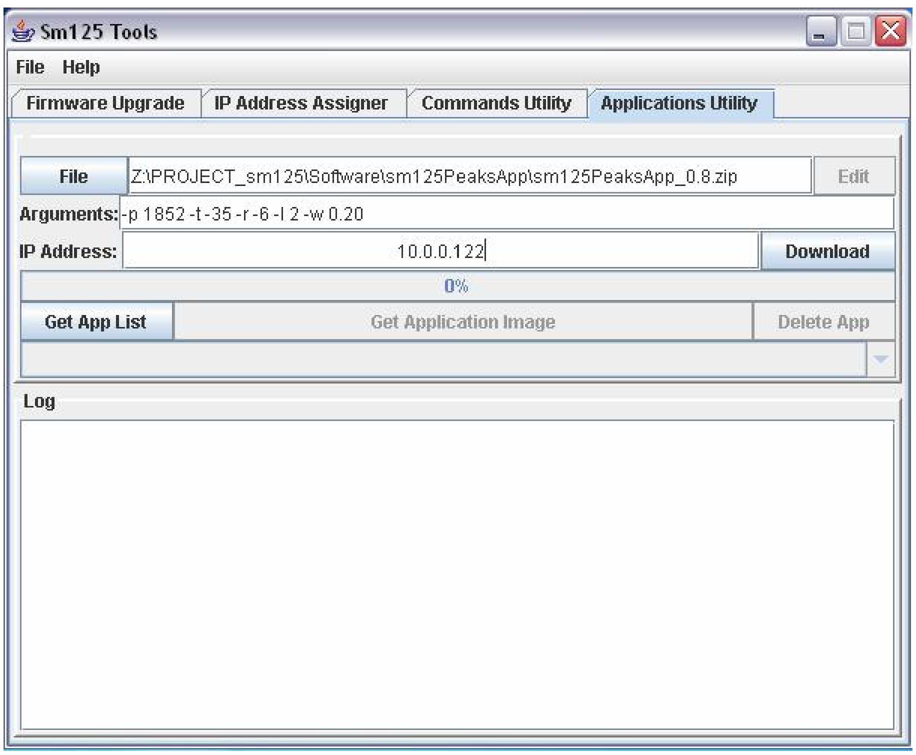


Figure 2. View of sm125Tools Utility with parameters loaded into "Arguments" control line.

Using this method, the Peak Detection Application can be re-installed at any time with new parameters, such that default values can be updated.

International Certification for Fiber Optic Sensing

Use of Key Intellectual Property Associated With Fiber Optic Sensing Applications

Micron Optics, Inc. (MOI) and United Technologies Corporation (UTC) have reached agreement regarding UTC's complete Optical Sensing Systems portfolio including both US and worldwide patents. This means that every Micron Optics sensing instrument ever produced is certified for use with fiber Bragg grating sensors. Additionally, those who purchase sensors or full systems from MOI are certified for the use of those sensors and systems in their sensing applications.

This is a powerful advantage for all Micron Optics customers because the UTC patent portfolio contains the fundamental techniques necessary for effective use of fiber Bragg grating and other optical sensors.

Three types of certification are available from Micron Optics:

Type 1: Certification covers the sensor interrogation instrument only. Micron Optics ships a certificate with every MOI unit delivered and specifically identifies, by serial number, the instrument covered by the certificate.

Type 2: Certification covers the optical sensors only. Micron Optics ships a certificate with all optical sensors delivered and specifically identifies, by serial number and/or description, the sensors, sensor transducers, sensor arrays, sensor modules etc. covered by the certificate. Certified sensors are tested and qualified for use with Micron Optics Interrogators.

Type 3: Certification covers the Optical Sensing System in total as denoted on the certificate. Systems are typically comprised of one or more sensor interrogation instruments and one or more optical sensors. Certified systems have been tested and qualified for interrogator-sensor interoperability.

MICRON OPTICS

INTERNATIONAL CERTIFICATION
FOR FIBER OPTIC SENSING

This document certifies that the owner of this Product is covered under an International Licensing Agreement for Patents related to Fiber Optic Sensing to the extent set forth by the Certification Type listed below. This ensures that the bearer is authorized to use the Product in the area of Optical Sensing under USA and International Patents held by Micron Optics, Inc. (MOI) and United Technologies Corporation (UTC).

Issued To:	Company Name
Certification Type:	Type 1
Effective Date:	January 21, 2004

Product Type	Manufacturer	Description	Model	Serial #
Instrument	Micron Optics	Sensing Interrogator	Si425-500	SIA2RU
Sensor	NA	NA	NA	NA

MICRON OPTICS PATENTS
6,504,616 B1; 6,449,047; 6,362,904; 6,327,036; 6,263,002; 6,137,812; 6,115,122; 6,044,189; 5,892,582; 5,838,437; 5,563,973; 5,509,093; 5,425,039; 5,422,970; 5,375,181; 5,289,552; 5,212,746; 5,212,745; 2,040,972; 2,034,318; EP 979,101,342; EP 979,109,469.

UNITED TECHNOLOGIES PATENTS
4,761,073; 5,513,913; 5,564,832; 5,401,956; 5,493,390; 4,950,883; 4,996,419; 4,761,073; 4,806,012; 5,007,705; 5,042,898; 5,394,488; 5,399,854; 5,426,297; 5,469,520; 5,493,113; 5,511,083; 5,546,481; 5,594,747; 5,657,406; 5,604,836; 5,666,372; 5,691,999; 5,770155; 08/346,059; 5,317,576; 5,305,335; 5,401,956; 5,493,390; 5,511,083; 5,513,913; Internat'l 0192659; 1885629; 0681681; 3462212; 0803049; 0312902; 2141102; NI-073067; 1262407; 0438757; 3002268; 0192659; 1885629; 0507882; 3182420; 0507877; 3187417; 0753130; 95192033.2; 215950; 0783718; 0795118; 95196508.5, 0316846, 0812484; 0758493; 0813759; 6952658730; 0866991; 96198439.2; 10-402674; 0435217; 3219415; NI-58189; 0783780; 0862729; 96198436.8; 10-402673; 0795117; 95196458.5; 3410101; 322430; 0435217; 2634694; 3219415; 0435217; 2634694; 3219415; 0803049; 0312902; 2141102; 3219415; 1262407; 0812484; 0681681; 0681681

EXPLANATION OF LEGAL COVERAGE
Type 1: Certification covers the Interrogation Unit only denoted on the Certificate.
Type 2: Certification covers the Optical Sensors only denoted on the Certificate.
Certified Sensors have been tested and qualified for use with Micron Optics Interrogators.
Type 3: Certification covers the Optical Sensing System denoted on the Certificate comprised of the Interrogation Unit and Optical Sensors.
Certified Systems have been tested and qualified for Interrogator-Sensor interoperability.

This CERTIFICATION remains in effect for the life of the Product(s) listed above.

Micron Optics decided to proceed and implement this perpetual Worldwide UTC-MOI Agreement to add a significant benefit to Micron Optics' customers. The terms and conditions of this Worldwide Agreement have been structured to clearly and forcefully protect our customers from potential exposure to litigation due to infringement of worldwide intellectual property. We are committed to enable our customers to focus their efforts and energy on creating useful and exciting applications in Optical Sensing.