MODEL 428
MULTI-WAVELENGTH METER

3/6/2018

USER'S MANUAL

The information contained in this publication is subject to change without notice.

CONTENTS

1 INTRODUCTION 4
Welcome 4
Safety Notices 4
General Safety Considerations 5
Inspection 6

2 INITIAL INSTRUMENT SETUP 7
General 7
Power Supply Connections 7
Signal Output Connections 8

3 OPERATION 9
Start Up 9
Front Panel 9
Optical Signal Input 10
Front Panel Controls 11
Display Screens 11
Configuration Screens 17

4 OPTICAL SPECTRUM ANALYZER SOFTWARE 24
Software Installation 24
Spectrum Screen 26
Function Descriptions 27
Wavelength Screen 32
Menu Function Descriptions 32

5 REMOTE COMMUNICATIONS 42
Communications Setup 42
SCPI Communications Scheme 45
SCPI Command Detail 49

APPENDIX A – SPECIFICATIONS 67

APPENDIX B – WARRANTY & SERVICE 68
Warranty 68
Service 68

APPENDIX C – MONITOR PORT 69

APPENDIX D – TROUBLESHOOTING 70

APPENDIX E – SPECTRAL CALCULATION 72

Declaration of Conformity 73

1 INTRODUCTION

Welcome

Thank you for purchasing the 428 Multi-Wavelength Meter from Bristol Instruments. Two different versions of this system are available, the 428A and the 428B. The 428A measures the absolute wavelength of CW lasers to an accuracy of ± 0.2 parts per million (± 0.3 pm at 1550 nm). The 428B has an accuracy of ± 0.65 parts per million (± 1.0 pm at 1550 nm). The operational wavelength range of these systems is 1270 – 1650 nm (236 – 182 THz).

This *User's Manual* includes information about the 428A and 428B Multi-Wavelength Meters. It covers all the topics necessary to help you operate your system.

If you have any questions about the operation of your 428 system, please do not hesitate to call Bristol Instruments at (585) 924-2620. Or, you can contact us at service@bristol-inst.com.

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Safety Notices

Warning denotes a hazard. It calls attention to a procedure that, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

Caution denotes a hazard. It calls attention to a procedure that, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

General Safety Considerations

This product has been designed and tested in accordance with IEC 61010-1 and has been supplied in a safe condition. The instruction documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

This instrument is classified as an FDA Class I Laser Product (IEC Laser Class 1).

WARNING **If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in the specified mode without deviation from the written instructions. Use of this product in any manner other than described herein may cause permanent damage to eyesight and therefore is strictly prohibited.**

WARNING ***Never*** **inspect or clean a fiber-optic cable without first disconnecting the entire cable assembly from the optical source. Failure to take this precaution can permanently damage your eyesight.**

WARNING **No user serviceable parts are inside. Refer servicing to Bristol Instruments or its representatives only. To prevent electrical shock, do not remove covers.**

WARNING **To prevent electrical shock, disconnect this instrument from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **This is a Safety Class 1 product (provided with protective ground). The mains plug shall only be inserted in a socket outlet provided with a protective ground contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

CAUTION Always use the three-prong AC power cord supplied with this instrument. Failure to ensure adequate grounding by not using this cord may cause instrument damage.

CAUTION *Do not* connect AC power until you have verified the line voltage is properly grounded and within the specified range (90–260 VAC and 47–63 Hz). Damage to the instrument could result.

CAUTION This instrument has autoranging line voltage input. Be sure the supply voltage is within the specified range.

CAUTION Maximum safe input is 65 mW of optical power. Laser input power in excess of 65 mW can result in damage to the instrument.

CAUTION Use care in handling fiber-optic connectors. Always clean the fiber end prior to insertion into the instrument's fiber-optic connector for optimum performance. Failure to do so can result in damage to the instrument. To prolong instrument service life, it is advantageous to attach a new fiber-optic patchcord to the instrument and use its other end for the connect/disconnect procedure.

Inspection

The 428 Multi-Wavelength Meter is packed in a carton designed to give maximum protection during shipment. If the outside of the shipping carton is damaged, notify your shipping department immediately. Your shipping department may want to notify the carrier.

If the shipping carton is not damaged, carefully remove and identify all of the components listed below. Contact Bristol Instruments or your local representative if any of the components are missing. We recommend that you save the shipping carton for future storage or transportation.

The 428 system includes the following components:

- ✓ Multi-Wavelength Meter chassis
- ✓ Power cord (North America and Japan only)
- ✓ USB 2.0 cable
- ✓ Rack mount kit
- ✓ USB flash-drive with *NuView* software and *User's Manual*

2 INITIAL INSTRUMENT SETUP

General

1 Place the 428 Multi-Wavelength Meter on a firm horizontal surface.

2 Make sure that there is at least 2 inches (50 mm) of clearance on all sides of the instrument to allow for ventilation.

Power Supply Connections

WARNING **This is a Safety Class 1 product (provided with protective ground). The mains plug shall only be inserted in a socket outlet provided with a protective ground contact. Any interruption of the protective conductor inside or outside of the product is likely to make the product dangerous. Intentional interruption is prohibited.**

CAUTION Always use the three-prong AC power cord supplied with this instrument. Failure to ensure adequate grounding by not using this cord may cause instrument damage.

CAUTION *Do not* connect AC power until you have verified the line voltage is properly grounded and within the specified range (90–260 VAC and 47–63 Hz). Damage to the instrument could result.

CAUTION This instrument has autoranging line voltage input. Be sure the supply voltage is within the specified range.

1 Verify that the line power meets the requirements shown below.

- 95 to 260 VAC
- 47 to 63 Hz
- Protective Ground

2 Connect the line-power cord to the power input connector on the instrument's back panel (Figure 2.1).

3 Connect the other end of the line-power cord to the power receptacle.

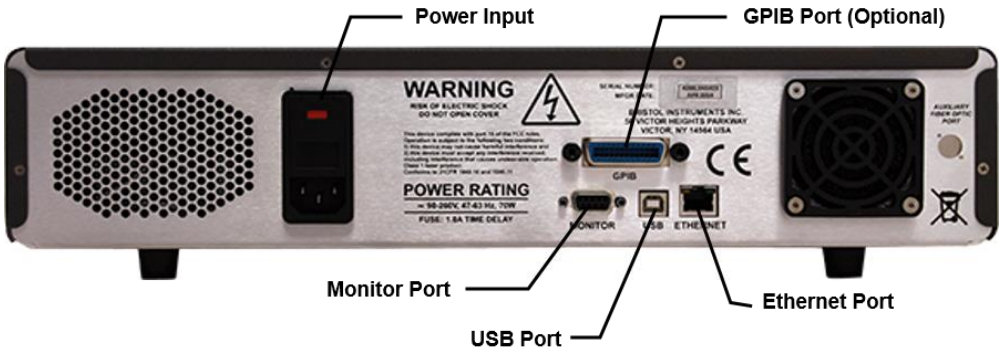


Figure 2.1: Back Panel

Signal Output Connections

The 428 Multi-Wavelength Meter has the following connections for signal output and communications. These connections are located on the instrument's back panel (Figure 2.1).

- **USB Port** – Interface to a PC for instrument control and data reporting.
- **Ethernet Port** – Interface to a PC or network for instrument control and data reporting.
- **GPIB (Optional)** – Interface to a PC for instrument control and data reporting.
- **DB-9 Monitor Port** – Used to monitor the interference fringe pattern and instrument timing signals with an oscilloscope. A full description is provided in Appendix C.

Rack Mount Kit Installation

The 428 Multi-Wavelength Meter can be mounted in a standard 19" instrument rack by attaching the rack mount brackets. These brackets are attached to the front bezel of the system using the 8-32 x 5/8" flat head socket screws included in the rack mount kit. For proper fit, the feet under the chassis may be removed.

CAUTION Do not reinsert the screws once the feet are removed. Damage to the internal components of the instrument may result.

CAUTION When the system is mounted in an enclosed instrument rack, be careful not to block the fan on the back panel. Adequate ventilation must be provided inside the instrument rack to prevent overheating.

---

3 OPERATION

Start Up

Turn on the power switch located on the instrument's front panel. The instrument's self-test takes approximately 20 seconds, at which point the model 428B is ready for operation. The model 428A displays the message "Reference Laser Stabilizing" until the laser is stabilized. Typical laser warm-up time is about 15 minutes, or less if the instrument has been used within the past several hours.

Front Panel

The front panel of the model 428 is shown in Figure 3.1. The display reports wavelength, power, and OSNR in various formats. It also displays configuration information that defines how data is collected and reported. The buttons control how data is collected and reported.

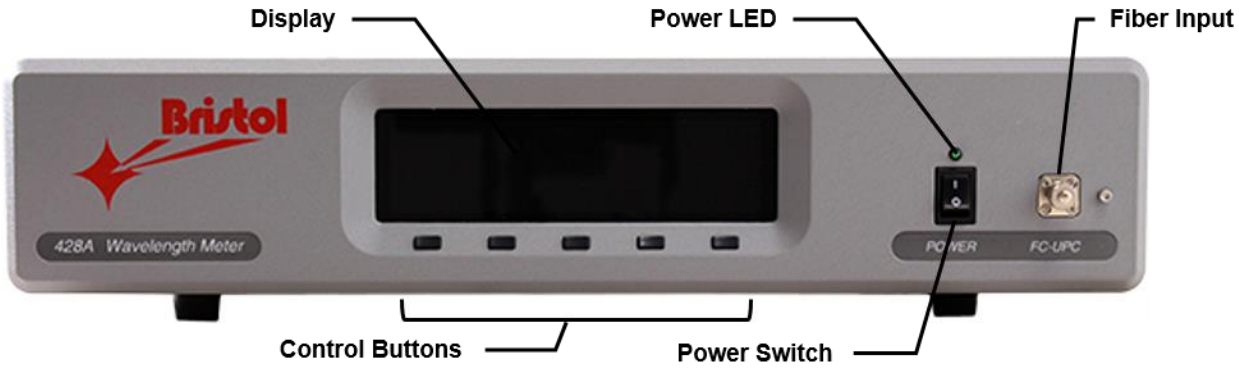


Figure 3.1: Front Panel

Power Switch
Turns the system on and off.

Power LED
Shows the power status. When lit (green), the unit is on.

Fiber Input
The optical signal under test enters the system through an FC/UPC or FC/APC fiber-optic connector.

Display
Reports the measurement data in several formats and shows various configuration parameters.

Control Buttons
Select and change parameters that affect how data is collected and reported.

Optical Signal Input

WARNING **_Never_ inspect or clean a fiber-optic cable without first disconnecting the entire cable assembly from the optical source. Failure to take this precaution can permanently damage your eyesight.**

CAUTION Use care in handling fiber-optic connectors. Always clean the fiber end prior to insertion into the instrument's fiber-optic connector for optimum performance. Failure to do so can result in damage to the instrument. To prolong instrument service life, it is advantageous to attach a new fiber-optic patchcord to the instrument and use its other end for the connect/disconnect procedure.

CAUTION Maximum safe input is 65 mW of optical power. Laser input power in excess of 65 mW can result in damage to the instrument.

The optical signal under test enters the 428 system through an FC/UPC or FC/APC fiber-optic connector on the front panel of the instrument (Figure 3.1).

1 Ensure that all fiber-optic connectors are clean and dry.

2 Connect your fiber-optic patchcord to the pre-aligned FC/UPC or FC/APC fiber-optic connector on the instrument's front panel. Make certain that the alignment key on the fiber-optic patchcord's connector (Figure 3.2) is properly seated in the slot of the input connector.

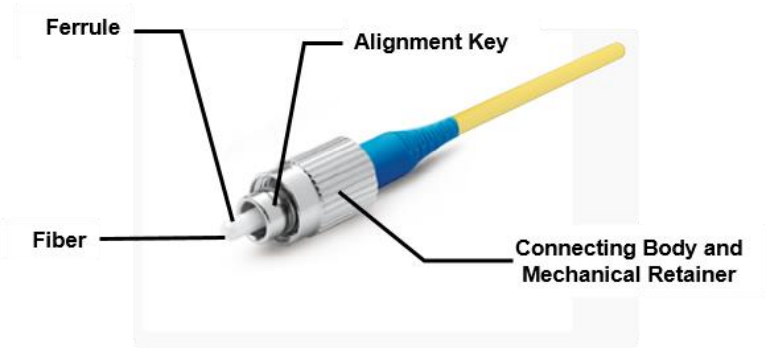


Figure 3.2: Basic Components of an FC/PC Fiber-Optic Connector

3 Tighten the mechanical retainer with a light to medium finger-tightness. Exceeding this torque may result in a poor connection or may damage the connector.

Front Panel Controls

Five control buttons on the front panel select and change parameters that affect how data is collected and reported (Figure 3.1). These control buttons switch between the different Display and Configuration Screens, and change the value or status of parameters on each screen. The names and functions of the Control Buttons are listed below (from left to right).

Mode

This button is used to cycle between the different Display and Configuration Screens: Main, List, and Config. Within Config mode, there are six separate Configuration Screens that can be accessed using the Change button.

Up (↓) and Down (↑) Arrows

These buttons are primarily used to scroll through a list of wavelength values on the List Mode Display Screens. Pressing the Arrow buttons will also cycle through the values or status options for the highlighted parameter if other options are available.

Change

This button is used to cycle through a highlighted parameter's values or status options.

Select

This button cycles between the user-changeable parameters on the currently displayed screen.

Display Screens

Two Display screens are used to report measurement data. Pressing the Mode button cycles between the Main Mode Display Screen, the List Mode Display Screen, and the Config Mode Display Screen.

Main Mode Display Screen

Displays both wavelength and power, in the chosen units, of either the highest-power laser channel (Peak), a single chosen laser channel (Chan), or the weighted average of all wavelengths and powers (FPAv).

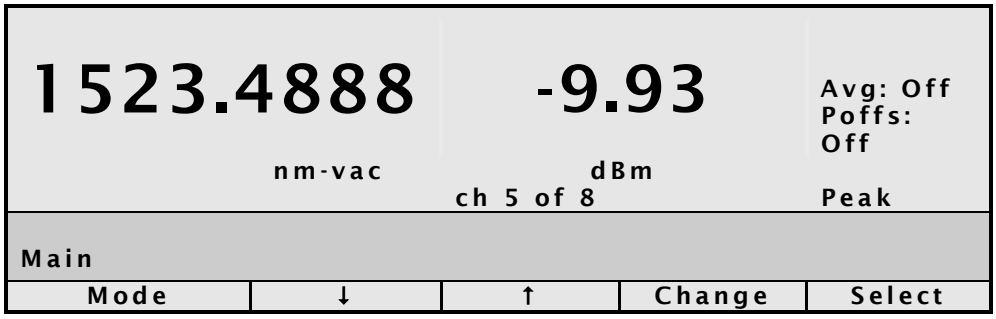


Figure 3.3: Main Mode Display Screen

- **Wavelength –** Displays the measured wavelength (nm), wavenumber (cm^{-1}), or frequency (THz) of the optical signal under test.

- **Wavelength Units and Medium –** Identifies the units chosen for the measurement of wavelength (nm), wavenumber (cm^{-1}), or frequency (THz). Also identifies the medium to which the measurement is referenced. The options are vacuum (-vac) or standard air (Std Air) at 20°C, 760 mm Hg, and 0% relative humidity. The Wavelength Units and Medium can be changed from Config Screen 1.

- **Power –** Displays the measured optical power in the user selected units.

- **Power Units –** Identifies the units chosen for the measurement of power. The options are mW or µW (scaled automatically) or dBm. This parameter can be changed from Config Screen 1.

- **Peak/Chan/FPAv –** Identifies the channel or measurement method displayed. Use the Select button to highlight the displayed measurement method, and the Change or Arrow buttons to cycle through the three options.

  – **Peak –** Displays the wavelength of the highest power channel. The channel number is given below the wavelength units.

  – **Chan –** Displays the wavelength of a user-selected channel. The channel number is indicated below the wavelength units, and can be changed using the Arrow keys.

  – **FPAv –** Displays the power-weighted average wavelength of all peaks measured. This is useful when the center wavelength of a group of input lines is desired, such as that of a typical Fabry-Perot laser.

- **Average (AVG) –** The instrument displays the results from each measurement, or the result from an averaged number of measurements (2, 4, 8, 16, 32, 64, or 128) chosen in Config Screen 1. The instrument will display a measurement after the chosen number of interferograms is collected, averaged, and analyzed. For averages between 2 and 32, the display will then be updated with each successive measurement. For averages of 64 or 128, the display will be updated after each block of interferograms has been averaged.

  Use the Select button to highlight the Average value, and the Change or Arrow buttons to cycle through the averaging states. Off indicates that the average function is disabled, while a numeric value indicates that an average is being calculated.

- **Power Offset (Poffs) –** The instrument can adjust the power measurement to account for an external attenuator by using a Power Offset value equal to the external attenuation. This is useful if the optical input power would otherwise exceed the maximum measurable input of 10 mW (10 dBm). The Power Offset value (1-20 dB) is chosen in the Config Screen 1.

  Use the Select button to highlight the Power Offset value, and the Change or Arrow buttons to adjust the Power Offset state. Off indicates that the Power Offset is disabled, while a numeric value indicates that the Power Display is adjusted by the specified Power Offset.

List Mode Display Screen – Main

Displays wavelength, power, and optical signal-to-noise-ratio (OSNR) for up to 5 channels simultaneously. This data can be sorted by wavelength (Wav) or power (Pow).

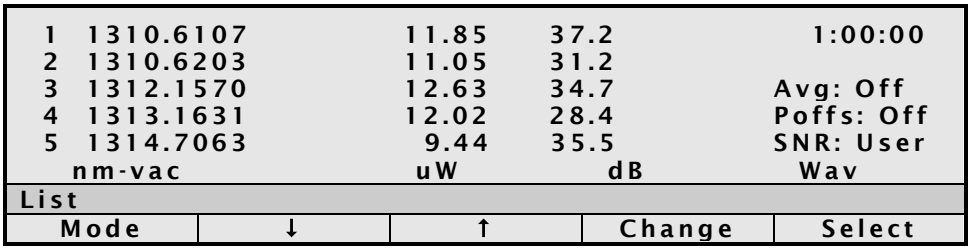


Figure 3.4: List Mode Display Screen – Main

- **Wavelength List –** Displays the current wavelength, wavenumber, or frequency value for up to 5 channels. If the optical signal has more than 5 channels, the Arrow buttons can be used to scroll to any of the up to 1000 computed wavelengths. The scrolling may be done either by line (Smooth) or by page (Page). The scrolling method is selectable in Config Screen 1.

- **Wavelength Units and Medium –** Identifies the units chosen for the measurement of wavelength (nm), wavenumber (cm^{-1}), or frequency (THz). Also identifies the medium to which the measurement is referenced. The options are vacuum (-vac) or standard air (Std Air) at 20°C, 760 mm Hg, and 0% relative humidity. The Wavelength Units and Medium can be changed from Config Screen 1.

- **Power Values List –** Displays the measured optical power, in the user selected units, directly to the right of its corresponding wavelength or frequency value.

- **Power Units –** Identifies the units chosen for the measurement of power. The options are mW or µW (scaled automatically) or dBm. This parameter can be changed from Config Screen 1.

- **Signal-to-Noise Ratio (SNR) –** The OSNR for each channel, expressed in dB, is displayed directly to the right of its corresponding power value. The OSNR is calculated as the ratio of the power in the optical channel relative to either a user selected noise location (User) or relative to the interpolated noise at the channel location (Auto).The noise at the channel location is interpolated by calculating the average of the noise measured 100 GHz to the left and to the right of the peak location. If another channel is less than 200 GHz from the peak, then the noise is calculated midway between the two channels.

- **Measurement Timer –** Displays the time in hours, minutes, and seconds that the instrument has been tracking channel values. The timer is reset when the instrument is restarted, or can be manually restarted with the Reset option on List Mode Display Screen – Drift.

- **Average (AVG) –** The instrument displays the results from each measurement, or the result from an averaged number of measurements (2, 4, 8, 16, 32, 64, or 128) chosen in Config Screen 1. The instrument will display a measurement after the chosen number of interferograms is collected, averaged, and analyzed. For averages between 2 and 32, the display will then be updated with each successive measurement. For averages of 64 or 128, the display will be updated after each block of interferograms has been averaged.

  Use the Select button to highlight the Average value, and the Change or Arrow buttons to cycle through the averaging states. Off indicates that the average function is disabled, while a numeric value indicates that an average is being calculated.

- **Power Offset (Poffs) –** The instrument can adjust the power measurement to account for an external attenuator by using a Power Offset value equal to the external attenuation. This is useful if the optical input power would otherwise exceed the maximum allowed input of 10 mW (10 dBm). The Power Offset value (1-20 dB) is chosen in Config Screen 1.

  Use the Select button to highlight the Power Offset value, and the Change or Arrow buttons to adjust the Power Offset state. Off indicates that the Power Offset is disabled, while a numeric value indicates that the Power Display is adjusted by the specified Power Offset.

- **Signal-to-Noise Ratio (SNR) –** This indicates how OSNR values are calculated. Use the Select button to highlight the SNR value, and the Change or Arrow buttons to adjust the SNR state. OSNR is calculated relative to the interpolated noise at the channel location (Auto), or at a user selected noise location (User). The noise location and noise bandwidth are chosen in Config Screen 3.

- **Sorting Type –** Displays the current sorting type for the list data. Use the Select button to highlight the Sorting Type value, and the Change button to cycle through the options (Wav or Pow).

List Mode Display Screen – Drift

Displays each channel's tracked measurement behavior in a variety of ways. The different options for display are the difference between each channel's maximum and minimum wavelength/power values (Max-Min), each channel's maximum wavelength/power values (Max), each channel's minimum wavelength/power values (Min), and the difference between each channel's current wavelength/power values and the wavelength/power values at the start of the measurement period (Diff). Use the Select button to highlight the Drift value, and use the Change button to cycle through the display options.

- **Max-Min –** Displays the difference between the maximum and minimum values that each channel has recorded. The first column displays the difference in wavelength, and the second column displays the difference in power. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

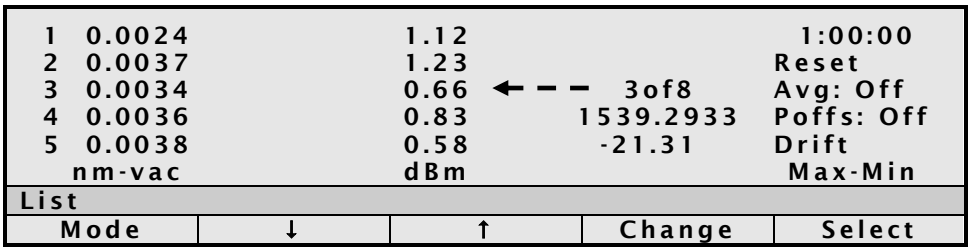


Figure 3.5: Drift – Max-Min

- **Max –** Displays the maximum value that each channel has recorded. The first column displays the maximum wavelength values, and the second column displays the maximum power values. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

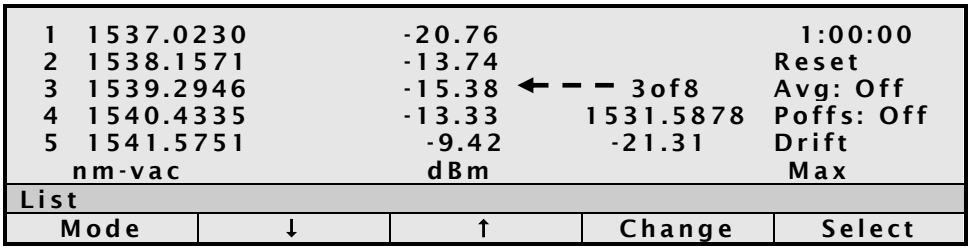


Figure 3.6: Drift – Max

- **Min –** Displays the minimum measurement value that each channel has recorded. The first column displays the minimum wavelength values, and the second column displays the minimum power values. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

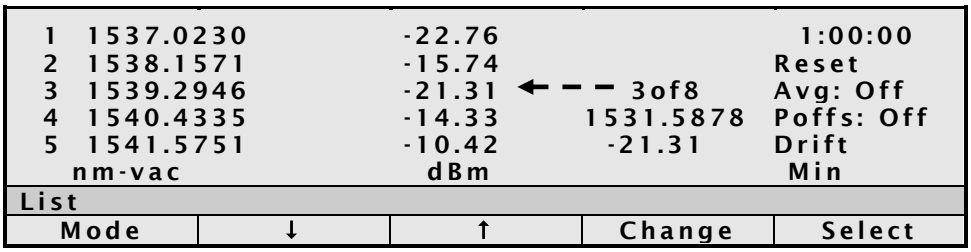


Figure 3.7: Drift – Min

- **Diff –** Displays the difference between the start measurement and currently displayed measurement values for each channel. The first column displays the difference in wavelength, and the second column displays the difference in power. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

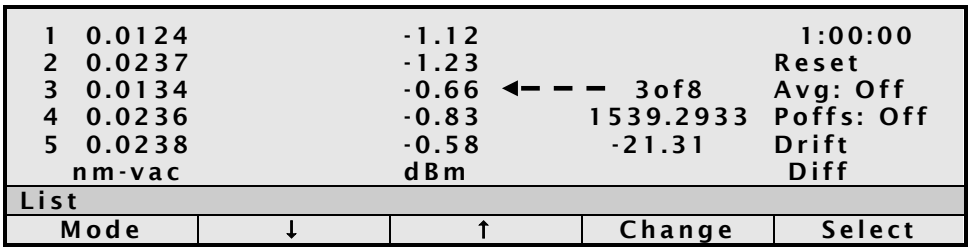


Figure 3.8: Drift – Diff

- **Measurement Timer –** Displays the time in hours, minutes, and seconds that the instrument has been tracking channel values. The timer is reset when the instrument is restarted, or can be manually restarted with the Reset option.

- **Reset –** Restarts the tracking of channel values. Use the Select button to highlight Reset, and use the Change button to reset the timer.

List Mode Display Screen – Delta

Displays the difference between each channel's measured wavelength and a chosen reference channel (Ref) or the wavelength of the nearest 100 GHz ITU grid line (ITU). Use the Select button to highlight the Delta value, and use the Change button to cycle through the Delta states.

- **REF –** Displays the difference in wavelength between each channel and the reference channel (chosen in Config Screen 2). The first column displays the difference in wavelength values, and the second column displays the current power values. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

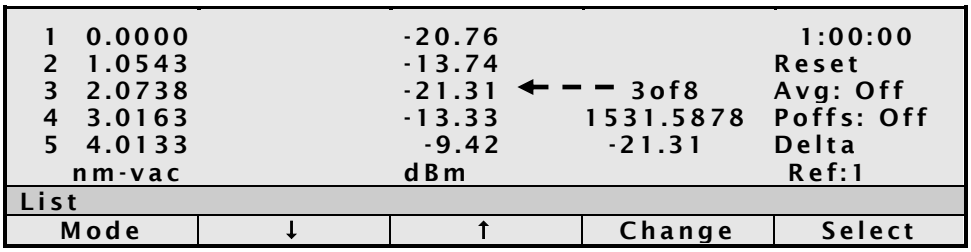


Figure 3.9: Delta – REF

- **ITU –** Displays the difference in wavelength between each channel and the nearest 100 GHz-spaced ITU gridlines covering 1528.77 nm to 1563.86 nm. The first column displays the difference in wavelength values, and the second column displays the current power values. The third column displays the channel number, current wavelength, and current power of a chosen channel. Use the Arrow buttons to select a channel, which is indicated by the tip of the dashed arrow.

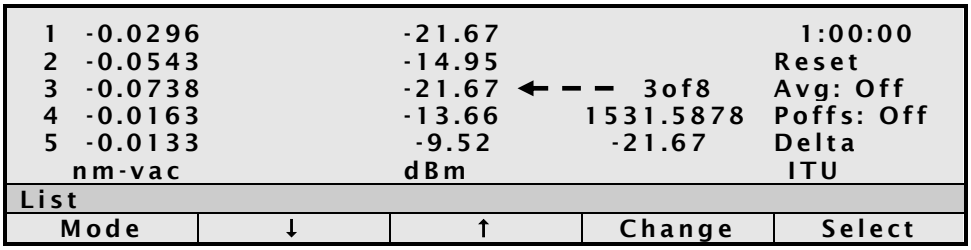


Figure 3.10: Delta – ITU

Configuration Screens

Six Configuration Screens are used to change and report instrument setup details. These screens are shown in Figures 3.11 to 3.16. To access the Configuration Screens, press the Mode button until the Config indicator appears in the illuminated status bar, then use the Change button to select the desired Config Screen.

Configuration Screen 1

Displays and allows changes to parameters that affect how the instrument makes and displays the wavelength, frequency, and power measurements.

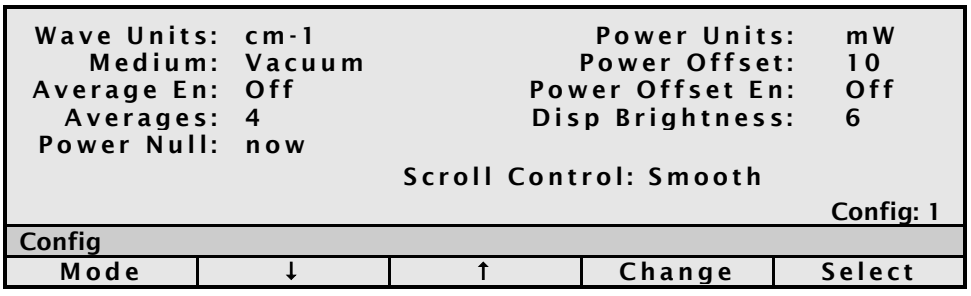


Figure 3.11: Configuration Screen 1

- **Wave Units –** Identifies the units chosen for the measurement of wavelength (nm), wavenumber (cm^{-1}), or frequency (THz). Use the Select button to highlight the Wave Units value, and use the Change or Arrow buttons to set the desired units.

- **Medium –** Identifies the medium in which the measurement occurs as vacuum (-vac) or standard air (Std Air) at 20°C, 760 mm Hg, and 0% relative humidity. Use the Select button to highlight the Medium value, and use the Change or Arrow buttons to set the desired medium.

- **Average En –** Identifies the status of the Average function. Use the Select button to highlight the Average En value, and use the Change or Arrow buttons to turn averaging on or off.

- **Averages –** Determines the number of measurements used for averaging wavelength and power when the Averaging function is enabled. The choices are 2, 4, 8, 16, 32, 64, or 128 measurements. Use the Select button to highlight the Average value, and use the Change or Arrow buttons to set the desired number.

- **Power Null –** Resets the null value used for the power calculation. Use the Select button to highlight the Power Null value, and use the Change or Arrow buttons to activate the Power Null. When activated, the instrument will display the message "Done."

  NOTE: For best results, use this feature when the fiber connector's protective cap is attached, ensuring that stray light does not affect the baseline power measurement.

- **Power Units –** Identifies the units chosen for the display of the power measurement. The choices are mW or µW (scaled automatically), or dBm. Use the Select button to highlight the Power Units value, and use the Change or Arrow buttons to set the desired units.

- **Power Offset –** Determines the Power Offset value when the Power Offset function is enabled. The Power Offset options are 1-20 dB. Use the Select button to highlight the Power Offset value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat to set the second digit.

- **Power Offset En –** Identifies the status of the Power Offset function. Use the Select button to highlight the Power Offset En value, and use the Change or Arrow buttons to turn the Power Offset on or off.

- **Disp Brightness –** Determines the brightness of the display on a scale of 1 to 7, with 7 being the brightest. Use the Select button to highlight the Disp Brightness value, and use the Change or Arrow buttons to increase or decrease the brightness setting.

- **Scroll Control –** Selects the method of scrolling through optical channels while in the List Mode display screen. The options are scrolling one line per Arrow button press (Smooth) or scrolling one page of 5 lines per Arrow button press (Page). Use the Select button to highlight the Scroll Control value, and use the Change or Arrow buttons to set the Scroll Control method.

Configuration Screen 2

Displays and allows changes to parameters specifying the conditions for valid channel recognition.

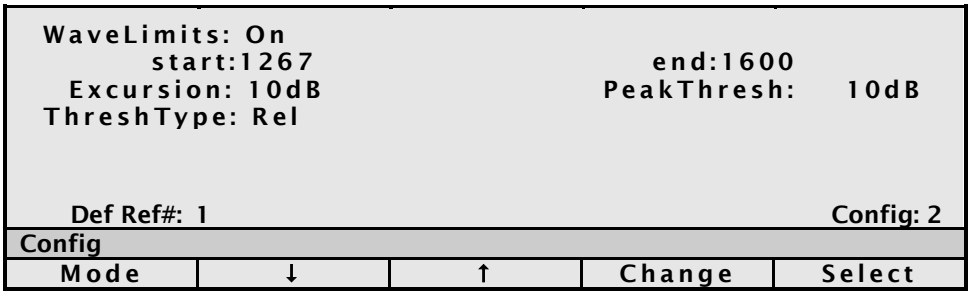


Figure 3.12: Configuration Screen 2

- **WaveLimits –** This parameter limits the wavelength range from which the instrument will find and display channels. When the WaveLimits are on, the instrument will display only the channels found between the Start and End wavelengths. When off, the instrument will display all channels that it finds.

- **Start –** Identifies the lower end of the wavelength range (nm only) of the WaveLimits parameter. Use the Select button to highlight the Start value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all four digits are set.

- **End –** Identifies the upper end of the wavelength range (nm only) of the WaveLimits parameter. Use the Select button to highlight the End value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all four digits are set.

- **Excursion –** One of two user-specified criteria for a spectral feature to be recognized as a valid channel by the instrument. Excursion defines the minimum distance between the peak and the measurement noise floor on either side of the peak. This parameter's options are 1-30 dB, with a default value of 10 dB. If a different Excursion value is desired, use the Select button to highlight the Excursion value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat to set the second digit.

- **PeakThresh –** One of two user-specified criteria for a spectral feature to be recognized as a valid channel by the instrument. PeakThresh defines the minimum height that a spectral feature must reach to be designated as a channel. This parameter's values are 0-40, in units of dB or dBm, with a default value of 10 dB. If a different threshold value is desired, use the Select button to highlight the PeakThresh value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat to set the second digit.

- **ThreshType –** Determines whether the peak threshold is relative to the most intense peak in the optical signal (Rel) or an absolute value from the noise floor (Abs). Use the Select button to highlight the ThreshType value, and use the Change or Arrow buttons to set the ThreshType method.

- **Def Ref # –** Identifies the reference channel for the Delta calculation. The options for the Def Ref # are channels 1-999. Use the Select button to highlight the Def Ref # value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat to set the second digit.

Configuration Screen 3

Displays and allows changes to the parameters that specify how the Optical Signal-to-Noise Ratio (OSNR) is computed.

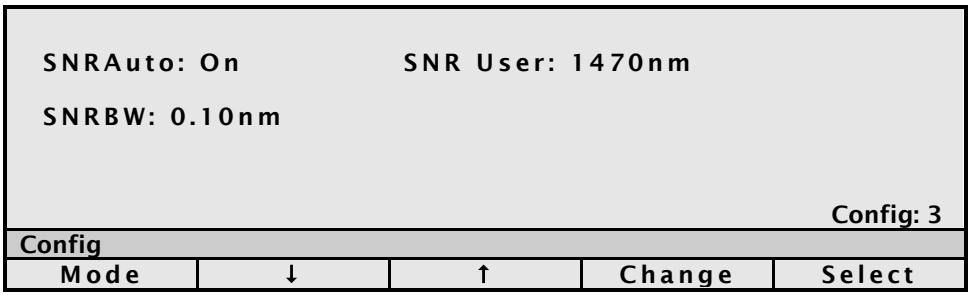


Figure 3.13: Configuration Screen 3

- **SNRAuto –** The OSNR is calculated as the ratio of the power in the optical channel, either relative to the interpolated noise at the channel location (On), or relative to a user selected noise location (Off). The noise at the channel location is interpolated by calculating the average of the noise floor, measured 100 GHz to the left and to the right of the peak location. If another channel is less than 200 GHz from the peak of interest, then the noise is calculated at the midpoint between the two channels.

  Use the Select button to highlight the SNRAuto value, and use the Change or Arrow buttons to change the SNRAuto status on or off.

- **SNRUser –** Identifies the wavelength, in nanometers, where the noise is measured for use in the OSNR calculation if SNRAuto is off. Use the Select button to highlight the SNRUser value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all four digits are set.

- **SNRBW –** Identifies the noise bandwidth used in the ONSR calculation if SNRAuto is off. When SNRAuto is on, the noise bandwidth is 0.10 nm. Use the Select button to highlight the SNRBW value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all four digits are set.

Configuration Screen 4

Allows the measurement parameters and instrument settings to be saved and recalled. Changes to some settings, such as the Ethernet IP Address, will not take effect until the instrument is rebooted.

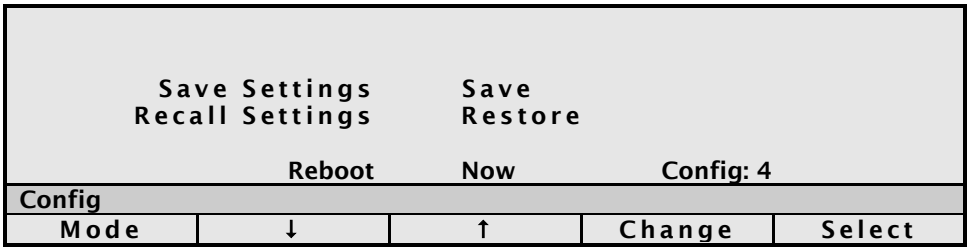


Figure 3.14: Configuration Screen 4

- **Save Settings –** Saves all current parameter values and settings. These values will be recalled on power up. Use the Select button to highlight the Save Settings value, and use the Change or Arrow buttons to activate Save. The instrument will then display a "Confirm?" message. Press the Change or Arrow buttons to confirm, resulting in a "Saved" message.

  NOTE: Changes to the GPIB or IP addresses are only activated after the settings are saved.

- **Recall Settings –** Changes all parameter values and settings to the most recently saved parameter values and settings. Use the Select button to highlight the Recall Settings value, and use the Change or Arrow buttons to activate Recall. The instrument will then display a "Confirm?" message. Press the Change or Arrow buttons to confirm, resulting in a "Recalled" message.

- **Reboot –** Reboots the software so the manually-entered Ethernet address will be recognized by the instrument. Use the Select button to highlight the Recall value, and use the Change or Arrow buttons to activate Reboot. The instrument will then display a "Reboot?" message. Press the Change or Arrow buttons to confirm, resulting in a "Rebooting…" message.

Configuration Screen 5

Displays and allows changes to information and parameters that are pertinent to the setup of the instrument for remote communications. For further information, see the Remote Communications section (Chapter 5).

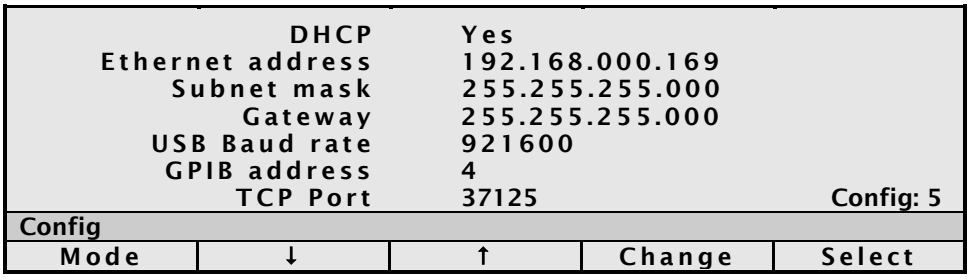


Figure 3.15: Configuration Screen 5

- **DHCP –** Identifies the status of the Dynamic Host Configuration Protocol (DHCP) used for remote communications via Ethernet. When DHCP is enabled (Yes), it automatically assigns an open IP Address to the instrument. When DHCP is disabled (No), the network administrator must manually assign the instrument an open IP Address. Use the Select button to highlight the DHCP value, and use the Change or Arrow buttons to change the DHCP status.

- **Ethernet Address, Subnet Mask, and Gateway –** Identifies the IP Address used for remote communications via Ethernet. Questions about the appropriate settings for these parameters should be directed to the network administrator. For more information, see the Remote Communications section (Chapter 5). Use the Select button to highlight the value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all twelve digits are set.
- **USB Baud Rate –** Determines the transfer rate of the signal for the USB interface (Baud Rate). The choices are 9600, 19200, 38400, 56000, 57600, 115200, 138240, 230400, 460800, and 921600.

  NOTE: For the vast majority of user applications, the default rate of 921600 is the correct Baud Rate and should not be changed. If the USB Baud Rate must be changed, use the Select button to highlight the USB Baud Rate value and use the Change or Arrow buttons to change the USB Baud Rate.

- **GPIB Address –**This parameter will only be visible if the GPIB option is installed. Available GPIB Address values are 0 through 30. Use the Select button to highlight the GPIB Address display, and use the Change or Arrow buttons to change the GPIB Address value. Changes to the GPIB address are only activated after saving the settings as described under Configuration Screen 4.

- **TCP Port –** This is the port reserved for communication with a PC running *NuView Display Software*. Changing the TCP Port number is not recommended, and will disable the instrument from connecting to the *NuView Display Software*.

Configuration Screen 6

Displays various details about the instrument. With the exception of the IP Address, these parameters are fixed, and may not be edited.

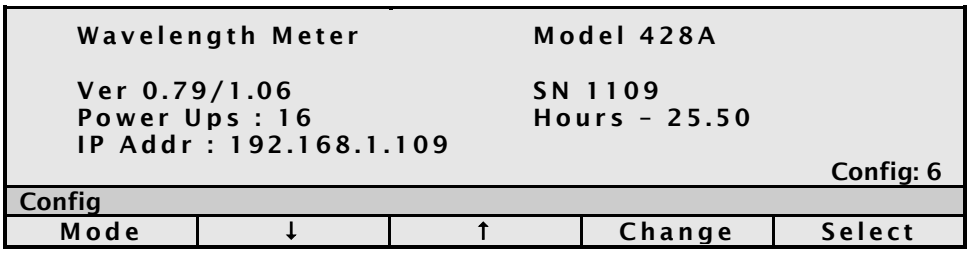


Figure 3.16: Configuration Screen 6

- **Model –** Displays the type and model number of the instrument.
- **Ver –** Displays the instrument's current embedded software and firmware versions.
- **Power Ups –** Displays the number of times the instrument has been powered on.
- **IP Address –** Displays the IP Address currently used for remote communications via the Ethernet interface. This parameter can be changed from the Configuration Screen 5.
- **SN –** Displays the serial number of the instrument.
- **Hours –** Displays the total number of hours that the system has been powered on.

4 OPTICAL SPECTRUM ANALYZER SOFTWARE

Software Installation

The *NuView* display software, provided on the *Application Software* flash drive displays the collected data from the 428 Multi-Wavelength Meter. The following computer hardware is required to run the software.

- A PC running Microsoft Windows 7, 8 or 10
- At least 1 GB of available RAM
- USB 2.0 (or later), Ethernet port for instrument connection, or a wired or wireless network connection (to connect to the instrument over the network)
- Monitor
- Mouse or other pointing device

1 Insert the *Application Software* flash drive into a USB port on your PC. Double click on the *NuView* software installer to begin.

2 Once the software is installed, a shortcut to the *NuView* software will automatically be placed on the Start Menu (or Application Menu) of the PC. Click on this icon to open the application.

3 Navigate to the "Help" menu and select "Model 428 User's Manual" to download a PDF file of the 428 system's *User's Manual* (this file) from Bristol Instruments' website. This *User's Manual* will describe installation and operation of the 428 system. A copy of this manual is also included on the *Application Software* flash drive.

4 Start the *NuView* display software by clicking on its icon. The *NuView* display software will display the Bristol Instruments logo before any instrument is connected (Figure 4.1).

Figure 4.1: Start-Up Screen

5 Open the Instrument Menu and select Connect.

6 Select "Model 428" from the drop-down list.

7 To connect via an Ethernet network, manually enter the IP address for the instrument using the keyboard and click "Connect." To connect using USB, manually enter the COM port for the instrument and click "Connect." If the COM port is unknown, click "Scan for Instruments" to locate the instruments that are connected to the PC. Double click on the desired instrument from the list to populate the COM port field and click "Connect."

The status text at the bottom-left corner of the screen should change to "Connected." If an error message is displayed, check that the instrument is running and connected to the PC.

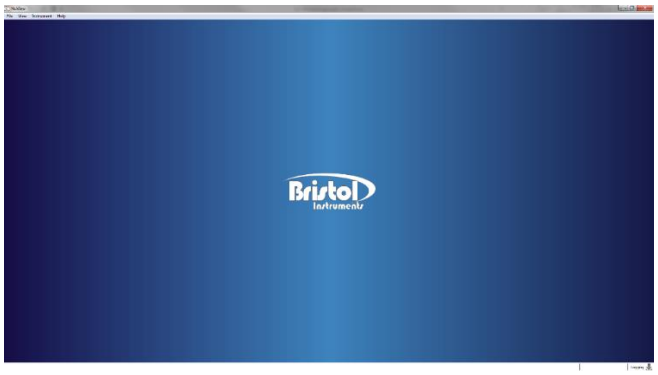


Figure 4.1: Start-Up Screen

Spectrum Screen

The Spectrum Screen of the *NuView* display software displays the measured spectrum of the optical input signal and quantitative data collected from the 428 system. Its display features are described in this section.

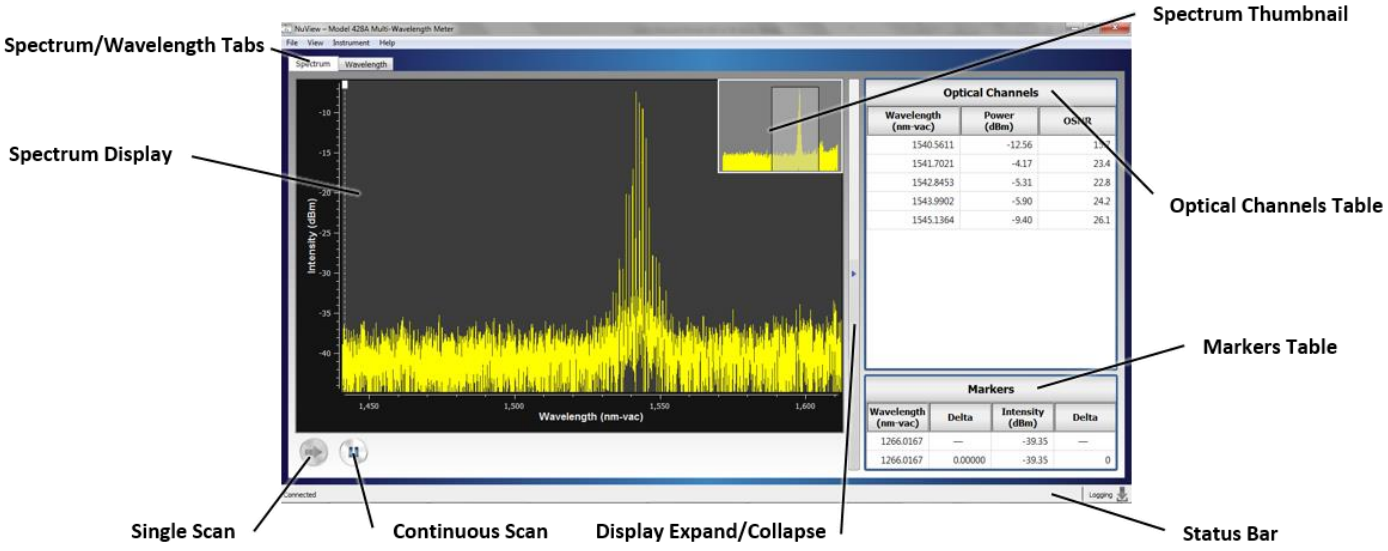


Figure 4.2: Components of the Spectrum Screen

Spectrum/Wavelength Tabs

Allows the user to toggle between the Spectrum Screen and a Wavelength Screen that displays the wavelength and power of the highest intensity channel, a user selected channel, or the averaged power density of all channels measured.

Spectrum Display

Displays the measured spectrum of the optical input signal. The spectrum can be displayed in units of nm, µm, GHz, THz or cm^{-1}. Intensity can be displayed in units of dB or mW.

Single Scan

Starts a single measurement, displays the spectrum, and reports quantitative data in the Markers Table. Once the application is connected to the instrument, the Optical Channels Table will update continuously until the connection is terminated.

Continuous Scan

Starts or stops continuous spectral measurements, and continuously updates the quantitative data in the Markers Table. Once the application is connected to the instrument, the Optical Channels Table will update continuously until the connection is terminated.

Spectral Thumbnail

Shows a small representation of the entire measured spectrum, and highlights the portion that is currently displayed in the Spectrum Display.

Optical Channels Table

Displays the wavelength, power and optical signal-to-noise ratio for each optical channel reported by the 428 system. Once the application is connected to the instrument, the Optical Channels Table will update continuously until the connection is terminated

Markers Table

Reports the position, position delta, intensity, and intensity Delta for two user positionable Markers.

Display Expand/Collapse

The Spectrum Display can be expanded or collapsed using the Display Expand/Collapse button. When expanded, the Spectrum Display hides the Optical Channels and Markers Tables.

Status Bar

Shows the status of the Logging function (on/off).

Function Descriptions

Single Scan

Selecting the Single Scan button (left) initiates a single spectral measurement. During the measurement, the Single Scan button changes its appearance to its greyed-out inactive state (right). After the measurement, the Spectrum Display and Markers Table are updated. The Optical Channels Table continuously updates when the *NuView* display software is connected to the 428 system.

Continuous Scan

Selecting the Continuous Scan button (left) initiates the continuous measurement of spectral data. After the Continuous Scan button is selected, it changes its appearance to the Pause button (right). The Spectrum Display and Markers Table are updated continuously until the Pause button is selected. Selecting the Pause button stops data collection and the Spectrum Display and Markers Table display the last measured data. The Optical Channels Table continuously updates when the *NuView* display software is connected to the 428 system.

Spectrum Thumbnail

A small representation of the entire measured spectrum. When the Spectrum Display shows only a portion of the measured spectrum (see Display Zoom function), the thumbnail highlights the displayed spectrum with a box. A portion of the spectrum can be highlighted by left-clicking and dragging in the thumbnail across the spectral feature of interest.

If the thumbnail hides a spectral feature of interest in the Spectrum Display, it can be disabled by un-selecting Show Spectrum Thumbnail in the View menu.

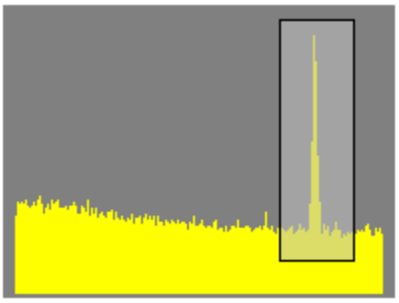


Figure 4.3: Spectrum Thumbnail

Display Zoom

The displayed spectrum can be magnified to focus on a portion of the measured spectrum. Before zooming, left-click on the spectrum to ensure that the Spectrum Display is active.

- **Horizontal Zooming –** Scrolling the mouse wheel upwards will zoom in horizontally on the spectrum at the mouse cursor location. Scrolling the mouse wheel downwards will zoom out horizontally on the spectrum at the mouse cursor location.

Vertical Zooming – Holding the shift key on user's keyboard while scrolling the mouse wheel upwards will zoom in vertically on the spectrum at the mouse cursor location. Holding down the shift key while scrolling the mouse wheel downwards will zoom out vertically on the spectrum at the mouse cursor location. Vertical zooming cannot be used when the Autoscale y Axis function on the View Menu is enabled.

Right-clicking the mouse brings up the Zoom menu, which includes three Zoom options.

- **Fit y Axis to Spectrum –** Scales the Intensity axis to fit the entire spectrum on the Spectrum Display window.
- **Zoom Out Full –** Returns the display to the full operating range.
- **Zoom Out –** Undoes the most recent zoom operation. This function can be used repeatedly until the full range of the spectrum is visible.

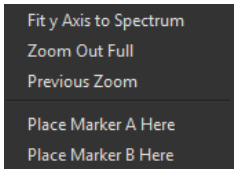


Figure 4.4: Zoom and Marker Menu

Display Panning

When the Spectrum Display is zoomed, left-clicking and dragging in the Spectral Graph will pan the Spectrum Display horizontally. Holding down the Shift key while left-clicking and dragging will pan the Spectrum Display vertically. Panning is disabled when the user is manually placing cursors.

Optical Channels Table

This table displays each channel identified by the 428 system's peak-finding algorithm, and arranges them in ascending order of their spectral positions. Once the application is connected to the instrument, the Optical Channels Table and Wavelength Display (described in the next section) will update continuously until the connection is terminated.

The Optical Channels Table displays the spectral position (Wavelength, Frequency, or Wavenumber), the associated power (Power), and the optical signal-to-noise ratio (OSNR) of each wavelength channel.

Optical Channels

Wavelength (nm-vac)	Power (dBm)	OSNR
1536.9648	-16.30	15.0
1538.1028	-12.56	19.0
1539.2417	-13.39	18.3
1540.3812	-11.47	20.2
1541.5229	-7.82	23.8
1542.6654	-7.45	24.4
1543.8109	-8.45	23.4
1544.9571	-8.38	23.6

Figure 4.5: Optical Channels Table

Markers Table

Two Markers are available that can be positioned at any point in the Spectrum Display for quantitative analysis. A Marker identifies the relative intensity of the measured spectrum at a specific spectral position. They are displayed as small rectangles at the top of the Spectrum Display with vertical tracing lines extending to the spectral axis.

Markers are placed by right-clicking at the desired location, and selecting "Place Marker A Here" or "Place Marker B Here" in the Zoom and Marker Menu (Figure 5.10). A Marker can be repositioned by left-clicking anywhere on the Marker and dragging it to the desired location, or by right-clicking and re-placing the Marker. Markers are hidden by right-clicking and selecting "Hide Markers" from the Zoom and Marker Menu (Figure 5.10).

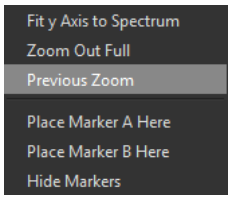


Figure 4.6: Zoom and Marker Menu

The Markers Table displays the spectral position (Position), difference between the two Markers' spectral positions (Delta), intensity (Intensity), and difference between the two Markers' intensity values (Delta). The Marker Table displays dashes if there are no Markers placed on the Spectrum Display.

Markers

	Wavelength (nm-vac)	Delta (nm-vac)	Intensity (dBm)	Delta (dBm)
A	1437.6807	—	-43.40	—
B	1596.9032	159.2225	-41.32	2.080

Figure 4.7: Markers Table

Display Expand/Collapse

The Spectrum Display can be expanded or collapsed by using the Expand/Collapse button to the right of the Spectrum Display.

Expanding the Spectrum Display allows for a larger viewing area of the measured spectrum. When expanded, the larger viewing area hides the Optical Channels and Markers Tables. (Figure 4.8).

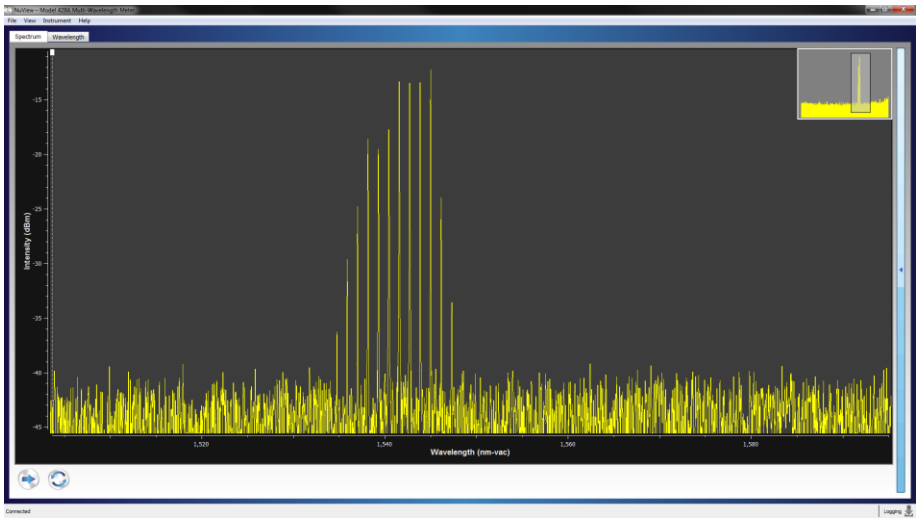


Figure 4.8: Spectrum Display Expanded

Collapsing the Spectrum Display reduces the viewing area of the measured spectrum and makes the Optical Channels and Markers Tables visible (Figure 4.9).

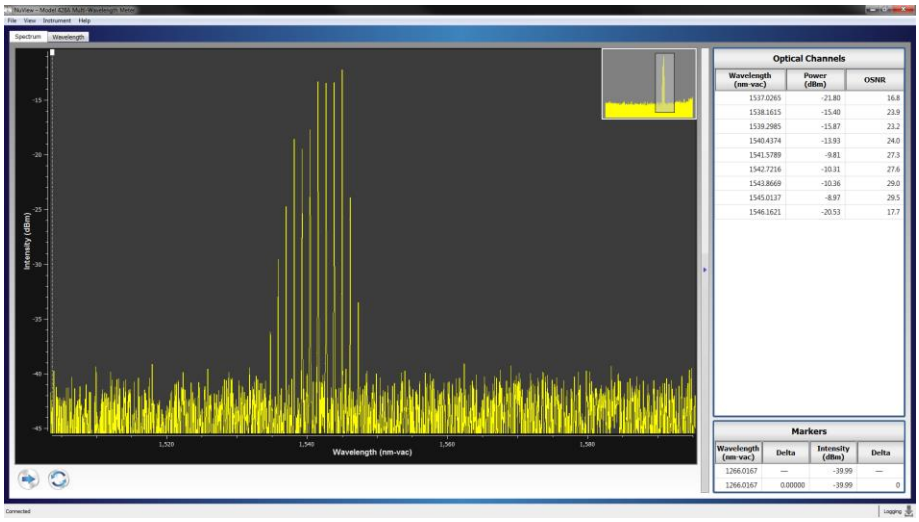


Figure 4.9: Spectrum Display Collapsed

Status Bar

The Status bar is located at the bottom of the Spectrum Screen. It provides information about the current state of the instrument as described below.

- **Logging Status –** The downloading icon is gray when logging is inactive, and green when logging is active.

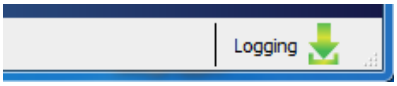


Figure 4.10: Status Bar

Wavelength Screen

The Wavelength Screen of the *NuView* display software displays both wavelength and power from the Main Mode Display Screen on the 428 instrument front panel. The *NuView* display software wavelength and power units are set from the View menu, and independent from the wavelength and power units on the 428 instrument's front panel.

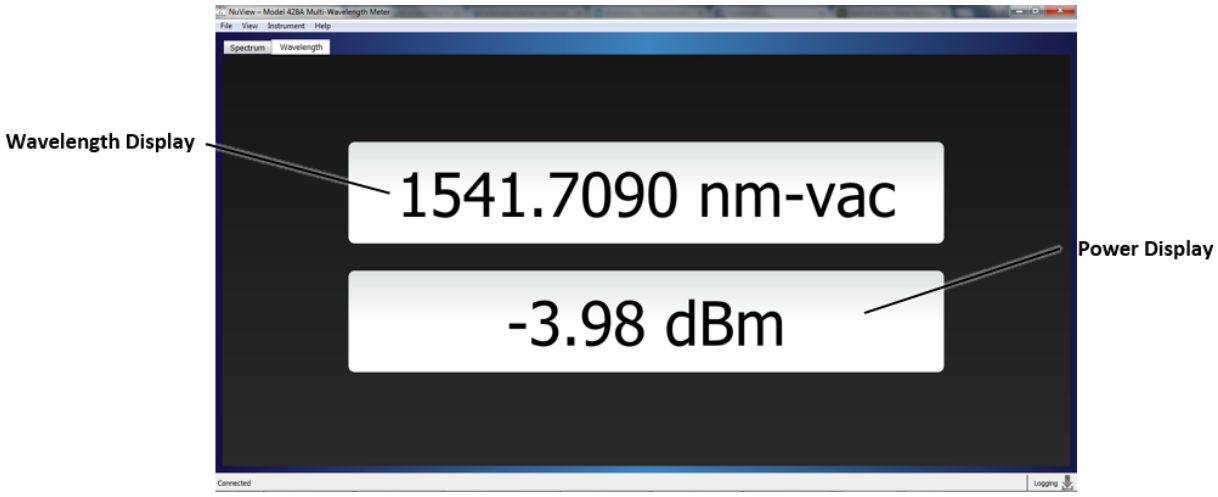


Figure 4.11: Wavelength Screen

Wavelength Display

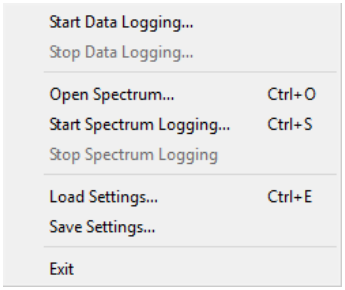
Displays the absolute wavelength, wavenumber, or frequency of the optical channel indicated on the Main Mode Display Screen. The Wavelength Display shows the highest-power laser channel, a single chosen laser channel, or the power-weighted average of all peak wavelengths.

Power Display

Displays the absolute power of the optical channel indicated on the Main Mode Display Screen. This is either the highest power laser channel, a single chosen laser channel, or the average of all the peak powers.

Menu Function Descriptions

File Menu



- **Start Data Logging –** The wavelength, Cursors and Marker measurements can be logged in a Comma-Separated Value (*.csv) file format for use in other graphing programs. If "Stop after..measurements" or "Stop after…hours, minutes, seconds" are selected, logging will stop automatically after the specified number of measurements or amount of time, respectively. If "Stop manually" is selected then logging must be stopped manually by clicking the Stop Data Logging menu item. The default file name is "NuView log 1.csv." If you use this filename, the number at the end will increment each time you begin a new log.

  The columns of the CSV file are defined by the available measurement parameters listed below. The first column of the log file is a timestamp for each measurement, followed by the selected parameters. Click the check box next to a parameter to include that column in the CSV file.

  – **Instrument Status –** A hexadecimal number corresponding to the instrument status at each measurement. The status numbers are defined in Appendix D.

  – **Max Peak Wavelength –** The absolute wavelength, wavenumber, or frequency of the most intense spectral feature.

  – **Max Peak Intensity –** The power of the most intense spectral feature.

  – **Channel Wavelength –** The absolute wavelength, wavenumber, or frequency of each peak identified as a channel.

  – **Channel Power –** The full width at half maximum intensity of each peak identified with a Cursor.

  – **Channel OSNR–** The integrated intensity of each peak identified with a Cursor.

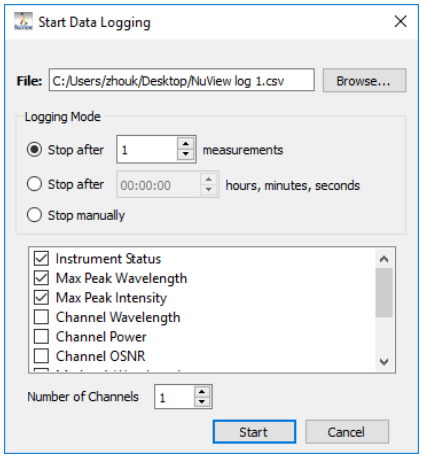
  – **Marker A Wavelength –** The spectral position of Marker A.

  – **Marker A Intensity –** The relative intensity of the spectrum at Marker A's spectral position.

  – **Marker B Wavelength –** The spectral position of Marker B.

  – **Marker B Intensity –** The relative intensity of the spectrum at Marker B's spectral position.

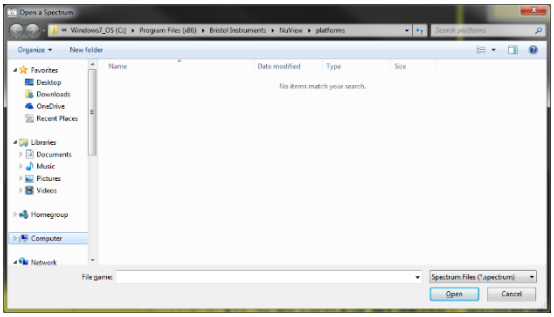
    The number of Channel columns included in the log file is specified below the measurement parameters. If the number of Channels in the Optical Channel Table is less than the Number of Channels specified, the remaining columns in the log file are filled with zeroes. The Number of Channels can be adjusted incrementally using the up/down arrows or by highlighting the current number and entering a new number with the keyboard.



Click on Start Data Logging, then change the log file name and location or use the default name and location. Select the radio button for the logging type. When "By Measurements" is selected, the number of measurements can be adjusted incrementally using the up/down arrows or by highlighting the current numeric value and entering a new numeric value with the keyboard. When "By Duration" is selected, the time can be adjusted incrementally using the up/down arrows or by highlighting the current time duration and entering a new time duration with the keyboard. Click Start to begin the logging of wavelength data.

- **Stop Data Logging –** Stops the current logging operation. Note that if you started logging using the "By Measurements" or "By Duration" options, logging will stop automatically and you do not need to click on Stop Data Logging unless you wish to abort early. In any case, the logging data will be written to the specified file when data logging is stopped.

- **Open Spectrum –** Opens a previously saved measurement of spectral data from a Bristol proprietary format file. Click on Open Spectrum, browse to find the desired spectrum, select it, and click on Open to display the saved spectrum. Opening a saved spectrum will end connection, if any, from the *NuView* display software to the 428 system.



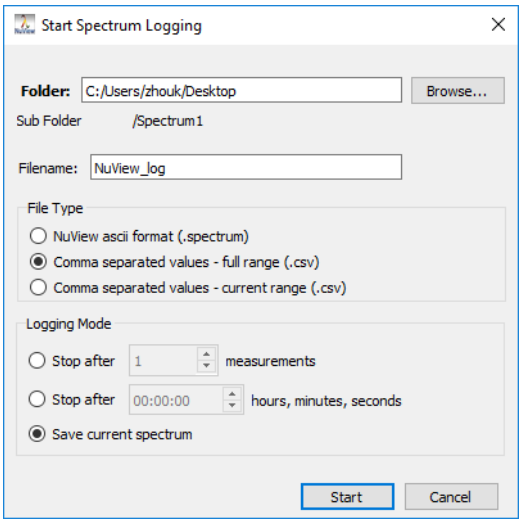
- **Start Spectrum Logging –** Saves a single spectrum or multiple spectra to a Bristol proprietary format (*.spectrum) or Comma-Separated Value (*.csv) format file or files. Each CSV file contains one spectrum, and each line of the CSV file contains a wavelength in nanometers, a comma, and an intensity value. The CSV file type can be saved as the entire spectrum (full range) or the current Spectrum Display view (current range). Files saved in the Bristol proprietary format can only be read by the *NuView* software, and the *NuView* display software cannot read files in the CSV format.

When logging multiple spectra, the *NuView* display software will separate the saved spectra into subfolders. Each subfolder follows a numbered naming convention (Spectrum1, Spectrum2, etc) and contains a maximum of 10 proprietary or CSV formatted spectrum files. The spectrum files within the subfolders are labeled with a user selected prefix followed by the numbers 0 through 9 (NuView_log_0, NuView_log_1, etc).

The Logging Mode radio button allows the user to choose a specific number of spectra to save, a time duration for logging spectra, or saving the currently displayed spectrum.

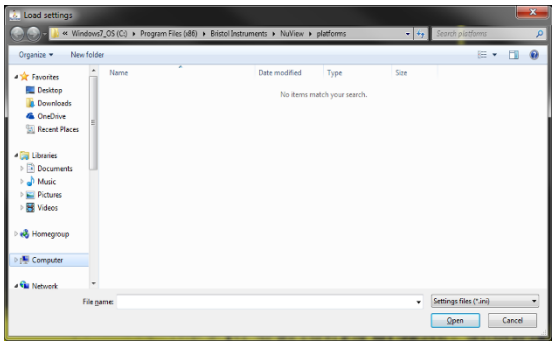
Click on Start Spectral Logging, enter the folder location, select the desired file type and logging mode using the radio buttons, and click Save.

Note: Continuous Scan must be selected to log one or more spectrum files.



- **Stop Spectral Logging –** Ends the current logging of spectral data. Any incomplete spectrum files are discarded, while all previously saved spectrum files are kept in the specified location.

- **Load Settings –** Opens a previously saved Settings file from a text-based initialization (*.ini) format file. These files can be used to quickly configure the *NuView* display software for different users or experimental setups. Click on Load Settings, browse to find the desired settings file, select it, and click on Open to load the Settings file.



- **Save Settings –** Saves the current *NuView* software settings to a text-based initialization (*ini) format file. The Settings file saves the following parameters.

  – **Spectral Units –** The units for the x-axis of the Spectral Graph in nanometers, microns, gigahertz, terahertz or wavenumbers.

  – **Spectral Range –** The start and end values for the x-axis of the Spectral Graph.

  – **Intensity Units –** The units for the y-axis of the Spectral Graph in mW or dBm.

  – **Intensity Range –** The start and end values for the y-axis of the Spectral Graph.

  – **Logging Type –** The type of measurement logging, specified as number of measurements, measurement time, or continuous measurement.

  – **Logged Measurement Settings –** The checklist of measurement parameters (Instrument Status, Max Peak Wavelength, etc).

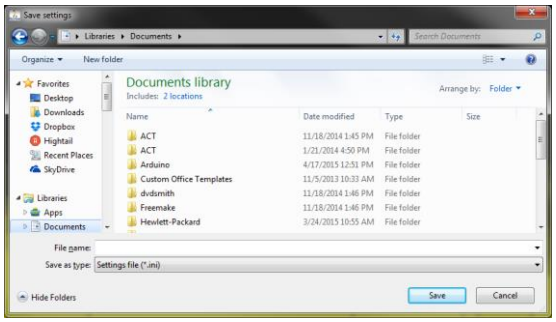
  – **Save Location –** The log file location.

  – **Number of Channels –** The number of channels columns specified in Start Data Logging Dialog.

  – **Autoscale Status –** Whether Autoscale y Axis is enabled or disabled.

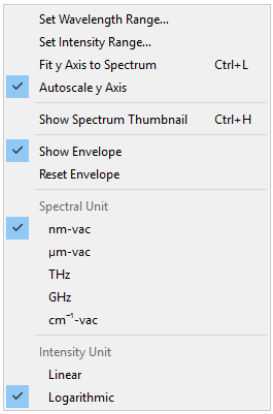
  – **Spectrum Thumbnail Status –** Whether the Spectrum Thumbnail is enabled or disabled.

  Click on Save Settings, enter the file name and folder location and click Save.



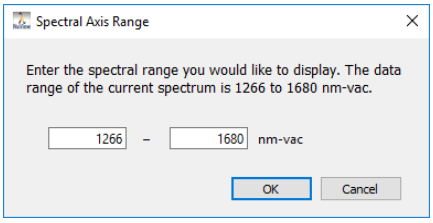
- **Exit –** Exits out of the *NuView* display software.

View Menu



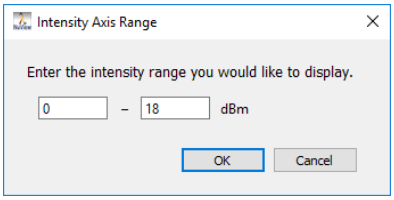
- **Set Wavelength Range –** Lets the user zoom in on a specific portion of the x-axis. The Wavelength Range entered must be within the current operating range of the instrument, or an error message will be displayed.

  Click on Set Wavelength Range and enter the desired start and end wavelength, frequency, or wavenumber values with the keyboard. Click OK to return to the Spectrum Display showing the specified range. The Spectrum Display can be further zoomed in or out using the Display Zoom function.



- **Set Intensity Range –** Lets the user zoom in on a specific portion of the y-axis. The Intensity Range entered must be within the current operating range of the instrument, or an error message will be displayed.

  Click on Set Intensity Range and enter the desired start and end dB or linear values with the keyboard. Click OK to return to the Spectrum Display showing the specified intensity range. The Spectrum Display can be further zoomed in or out using the Display Zoom function.



- **Fit y Axis to Spectrum –** Adjusts the Intensity axis a single time to provide the most complete view of the current spectrum on the Spectrum Display. Fit y Axis to Spectrum zooms the view in or out as necessary to maximize the current spectrum presence in the display area.

- **Autoscale y Axis –** Automatically and continuously expands the Intensity axis of the Spectrum Display as necessary to fit the updating spectral features into the display area. Vertical zooming cannot be used when Autoscale y Axis is enabled.

  Unlike Fit y Axis to Spectrum, Autoscale y Axis zooms the view out only, and only when the current peak intensities are larger than the current Spectrum Display. This is to avoid flickering from the display quickly zooming in and out from rapid increases/decreases in spectral intensity from the laser under test.

- **Show Spectrum Thumbnail –** Adds/Removes the Spectrum Thumbnail from the Spectrum Display.

- **Envelope –** The Envelope function displays the highest intensity recorded for each point on the spectrum, indicating how the spectral features are changing with time. The Envelope is represented by a blue trace over the yellow trace of the current spectrum.

  – **Show Envelope –** Envelope can be turned on by clicking Show Envelope. Envelope is turned off by clicking Show Envelope a second time.

  – **Reset Envelope –** Restarts the values shown by the Envelope trace.

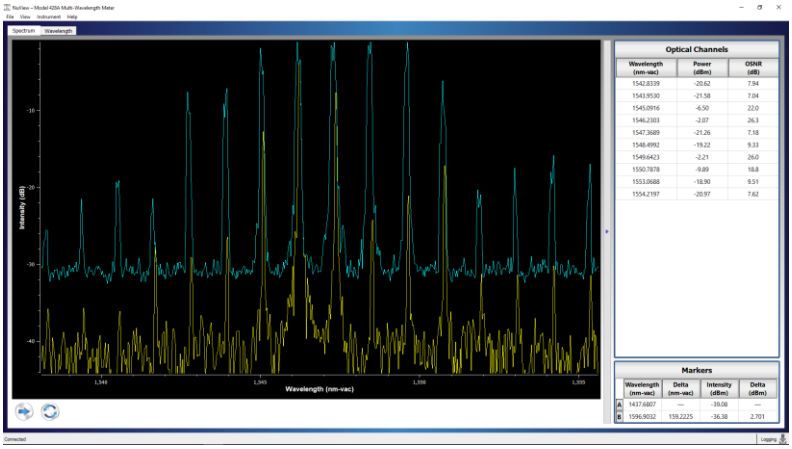


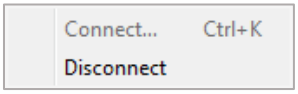
Figure 4.12: Envelope Trace

- **Spectral Unit –** Allows the user to select the spectral units for the Spectrum Display and Wavelength Screen.
  - **nm-vac –** Sets spectral units to nanometers (vacuum values).
  - **µm-vac –** Sets spectral units to micrometers (vacuum values).
  - **GHz –** Sets spectral units to gigahertz.
  - **THz –** Sets spectral units to terahertz.
  - **cm^{-1}-vac –** Sets spectral units to wavenumbers (vacuum values).

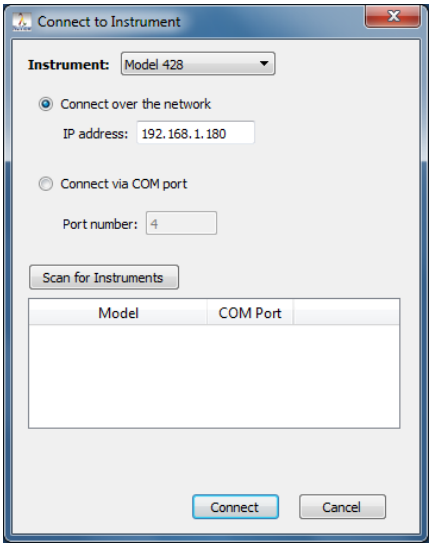
  NOTE: In other scientific publications, the units of nanometers, micrometers, and wavenumbers may refer to the values in an air, standard air, or vacuum environment. The 428 Wavelength Meter provides spectral measurements as values in a vacuum environment, and units that are dependent on environment are given a "-vac" suffix to emphasize this fact.

- **Intensity Unit –** Allows the user to select the options for the Intensity axis of the Spectrum Display.
  - **mW –** Displays power in a linear scale.
  - **dBm –** Displays power in a log scale.

Instrument Menu

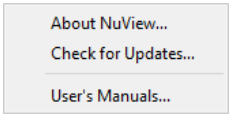


- **Connect –** The 428 system can be connected to a PC by either USB 2.0 interface or Ethernet interface. Click on Connect and choose between "Connect via COM port" or "Connect over the network." If "Connect via COM port" is chosen, click on Scan to search for all 428 systems connected to the PC. Double click on the desired instrument to populate the COM port, or manually enter the COM port using the keyboard. Click on Connect to link to the instrument.

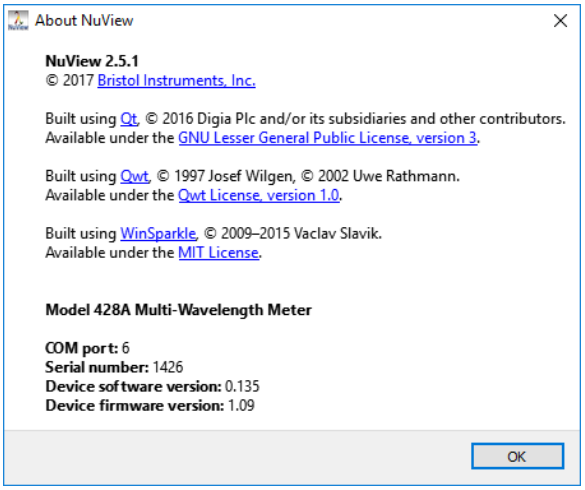


- **Disconnect –** Used to disconnect the 428 system from the PC.

Help Menu

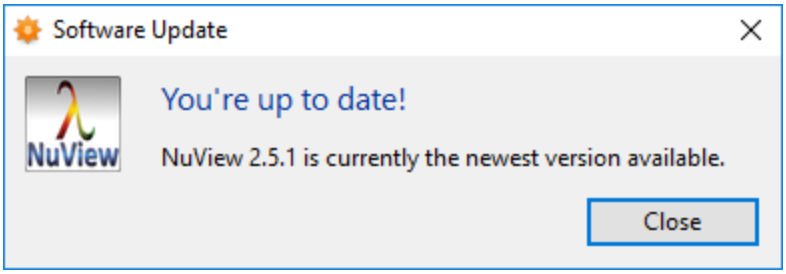


- **About -** Displays the *NuView* software version, the embedded software versions, and information about the 428 system.

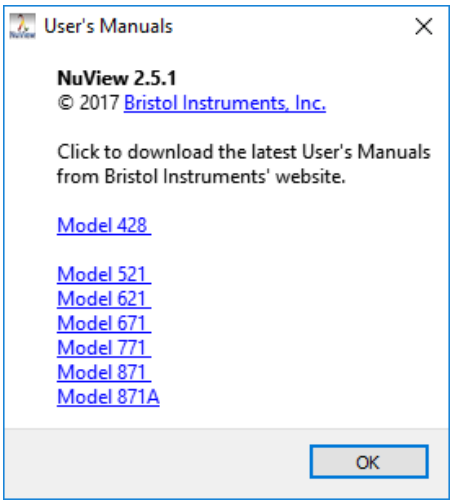


- **Check for Updates –** Contacts the *NuView* display software server to check for software updates. The *NuView* display software will prompt the user to check for software updates when the *NuView* software is opened the second time, and the user is given the option to have the *NuView* display software automatically check for updates weekly.

  If an update is available, the user is directed to download an installer for the latest *NuView* display software. Save the installer to the desired location on the PC, close all currently open instances of the *NuView* display software, and run the installer. There is no action required if the *NuView* display software is up to date.



- **User's Manuals –** Opens a dialog box with a list of all available User's Manuals. Clicking an instrument hyperlink starts downloading the latest version of the User's Manual from Bristol Instruments' website.



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5 REMOTE COMMUNICATIONS

The 428 system can transfer measurement data to a PC or be controlled remotely by a PC using the USB or Ethernet interfaces. A GPIB interface is also available as a factory installed option. Connections for the USB, Ethernet, and GPIB interfaces are located on the back panel of the instrument. The Standard Commands for Programmable Instruments (SCPI) communications scheme is used to communicate with the 428 system.

Communications Setup

USB Interface

The 428 system's driver software converts the USB port to a virtual COM port. Any software that can communicate with a COM port can communicate with the 428 system's USB interface, if the PC's COM port matches the baud rate of the 428 system, which has default value of 921600. In addition, the PC's communication software must also be set for 8 bits, no parity, 1 stop bit, and no handshaking.

NOTE: For the vast majority of user applications, the default rate of 921600 is the correct Baud Rate for the 428 system and should not be changed. If the USB Baud Rate must be changed, use the Select button to highlight the USB Baud Rate value on Config Screen 4 and use the Change or Arrow buttons to change the USB Baud Rate.

- **Installation of the Virtual COM Port Driver Software**

  1 Insert the *Application Software* CD into your CD-ROM drive. If Autorun is enabled on your system, installation will start automatically. Otherwise, double click on the installer to begin.

  2 Once the software is installed, a shortcut to the *NuView Display Software* will automatically be placed on the Start Menu (or Application Menu) of the PC.

  3 Make sure the supplied USB cable is connected to the USB connector on the back panel of the 428 system and to a USB port on the PC.

  4 Turn the 428 system on. The message "Found New Hardware" should appear on the PC display, followed by an automatic identification and installation of the virtual COM port driver.

  5 The 428 system is now ready for communication via the USB interface.

Ethernet Interface

The 428 Multi-Wavelength Meter is a Telnet server, using the default Telnet port 23. This is not to be confused with the config parameter "TCP port", which is used by the *NuView Display Software*.

- **Cabling -** The Ethernet port of the model 428 can be connected to the network hub or switch using a straight-through CAT-5 Ethernet cable since regular ports (non-uplink) on all hubs and switches are already crossed-over by default. A crossover cable is required if, and only if, Auto-MDIX is not supported.

- **IP Address Set-Up -** The IP address for the 428 system is assigned manually or automatically using the Dynamic Host Configuration Protocol (DHCP) on Config Screen 5.

  When DHCP is enabled (Yes), then the 428 system sends a broadcast query over the network requesting necessary information from a DHCP server. Upon receipt of a valid request, the server will assign to the 428 system an IP address, a lease (length of time for which the allocation is valid), and other IP configuration parameters, such as the subnet mask. The query is initiated immediately after booting, and must be completed before the 428 system can be accessed via IP-based communication with other hosts.

  If a DHCP server is not present on the network, or if a fixed IP address is preferred, then DHCP can be turned off (No) and the IP address can be assigned manually. Use the Select button to highlight the DHCP value, and use the Change or Arrow buttons to change the DHCP status. It is important to assign an IP address that is not already in use.

  The Subnet Mask is also entered from Config Screen 5. The Subnet Mask should match that being used by the PC, and the IP Address should fall in the same subnet. Contact the network administrator to determine the correct setting. Use the Select button to highlight the value's left most digit, use the Change or Arrow buttons to set the desired number, and use the Select button to highlight the next digit to the right. Repeat until all twelve digits are set.

  NOTE: If the IP Address is changed, the setting must be saved using the Save Settings command, and then the 428 system must be power cycled or rebooted using the Reboot command on Config Screen 4.

Connecting Using Telnet

A Telnet session example from a networked PC running Windows 8, 7, Vista or XP is given below.

1 Click on Start/Programs/Accessories/Command Prompt, or type "cmd" into the Search bar.

2 To start a Telnet session, type "Telnet" at the command prompt followed by the 428 system's IP address displayed on Configuration Screen 4.

```
C:\>Telnet 192.168.1.109

MityDSP Telnet Server
Copyright 2005, Critical Link LLC

Ctrl-D – Exit
Ctrl-E _ Toggle Echo

Bristol Instruments
*IDN?
Bristol Wavemeter, 428A, 1109, 0.79
:MEAS:POW?
-15.44
```

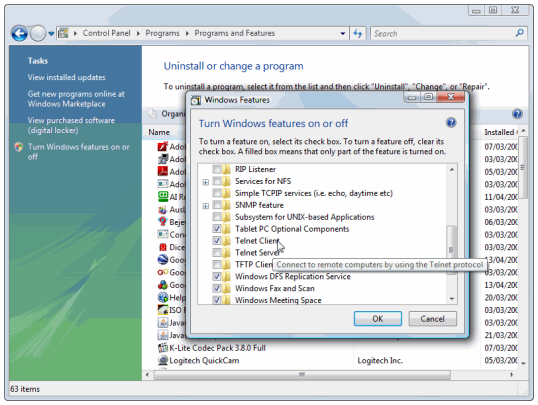
Telnet must be explicitly installed on a PC running Windows Vista, using the following instructions.

1 Go to the Start Menu, then click Control Panel.

2 Select Programs and Features.

3 Click "Turn Windows features on or off," found in the left column.

4 Check the box next to Telnet Client, and click OK.



SCPI Communications Scheme

This section describes the communication scheme of the 428 Multi-Wavelength Meter. It follows the Standard Commands for Programmable Instruments (SCPI) Syntax and Style Guidelines. The following table provides a summary of commands by subsystem.

Note: "[…]" brackets indicate an optional argument, and "{… | … | …}" brackets indicate a choice from a set of arguments.

Group & Command	Description
Common Commands	These commands are defined by IEEE 488.2 and control the functions that are common to all IEEE 488.2 instruments.
*CLS	Clears all event registers and the error queue.
*ESE?	Queries the bits in the standard event status enable register.
*ESE <integer>	Sets the bits in the standard event status enable register.
*ESR?	Queries the value of the standard event status register.
*IDN?	Queries instrument model number, serial number and firmware version.
*OPC?	Queries the operation complete bit of the standard-event status register.
*RCL	Restores instrument settings.
*RST	Resets instrument to default settings.
*SAV	Saves instrument settings.
*STB?	Queries the value of the status byte.
Measurement Instructions	These commands obtain measurements from the instrument.
:MEASure {:ARRay | :SCALar} {:POWer | :ENVironment | :FREQuency | :WAVelength | :WNUMber }?	Queries power or wavelength that will be measured during the next scan cycle. MEAS is interpreted to mean, "Initiate a new reading and return the value when the reading is complete". When used with a :SCALar command, only one value is returned. When used with an :ARRay command, a comma delimited array of values, preceded by the number of values, is returned.
:READ {:ARRay | :SCALar} {:POWer | :ENVironment | :FREQuency | :WAVelength | :WNUMber}?	Queries power or wavelength that is currently being measured, and returns when the measurement is complete. When used with a :SCALar command, only one value is returned. When used with an :ARRay command, a comma delimited array of values, preceded by the number of values, is returned.

:FETCh {:ARRay | :SCALar} {:POWer | :ENVironment | :FREQuency | :WAVelength | :WNUMber}?	Queries power, or wavelength that was measured during the last measurement cycle and returns immediately. When used with a :SCALar command, only one value is returned. When used with an :ARRay command, a comma delimited array of values, preceded by the number of values, is returned.
CALCulate Subsystem	These commands obtain calculated values from the instrument, or set calculation parameters in the instrument. In general, calculated values are values derived from actual measurements.
:CALCulate:DATA? {POWer | FREQuency | WAVelength | WNUMber }	Queries the data resulting from delta and drift measurements.
:CALCulate:DRIFt[:STATe]?	Queries if DRIFt is to be calculated.
:CALCulate:DRIFt[:STATe] { ON | OFF }	Selects DRIFt as the quantity to be calculated.
:CALCulate:DRIFt:METHod?	Queries the method used for DRIFt calculation (either Max-Min, Max, Min, or Diff).
:CALCulate:DRIFt:METHod {STARt | MAXMin |MAX | MIN}	Selects the method used for DRIFt calculation (either Max-Min, Max, Min, or Diff).
:CALCulate:DELTa[:STATe]?	Queries if DELTa is to be calculated.
:CALCulate:DELTa[:STATe] { ON | OFF }	Selects DELTa as the quantity to be calculated.
:CALCulate:DELTa:METHod?	Queries the method used for DELTa calculation (either REF or ITU).
:CALCulate:DELTa:METHod {REF | ITU}	Selects the method used for DELTa calculation (either REF or ITU).
:CALCulate:DELTa:REF?	Queries the method used as the reference for the delta calculations.
:CALCulate:DELTa:REFerence {ITU | channel number}	Selects the signal to be used as the reference for the delta calculations.
:CALCulate:RESet	Resets the CALCulate subsystem. This command resets the Elapsed Time counter, sets the Min & Max values to the Current value, and sets the Start value to the Current value.
:CALCulate:TIMe[:ELAPsed]?	Returns the time since last power on or reset.
CALC2 Subsystem	These commands set and query the spectral data, the peak thresholding, and the secondary calculations e.g. drift, max-min, etc.
:CALCulate2:DATA?	Queries the frequency spectrum of the input signal.
:CALCulate2:PEXCursion?	Queries the peak excursion threshold.
:CALCulate2:PEXCursion	Sets the peak excursion threshold.
:CALCulate2:PTHReshold?	Queries the peak threshold.
:CALCulate2:PTHReshold	Sets the peak threshold.
CALCulate2:THREShold?	Queries the peak threshold type.
:CALCulate2:THREShold {REL | ABS}	Sets the peak threshold type, either relative or absolute
CALCulate2:WCOE?	Queries the wavelength calibration coefficient.
:CALCulate2:WLIMit[STATe]?	Queries the wavelength limits state (ON or OFF).

CALCulate2:WLIMit[:STATe]?	Queries the wavelength limits state.
:CALCulate2:WLIMit[:STATe] {ON | OFF}	Turns wavelength limits on or off.
:CALCulate2:WLIMit:{ :STARt | STOP }?	Queries wavelength limit STARt or STOP wavelength.
:CALCulate2:WLIMit:STARt {1267…1686}	Sets the starting wavelength for the wavelength limit range.
:CALCulate2:WLIMit:STOP {1267…1686}	Sets the stopping wavelength for the wavelength limit range.
:CALCulate2:FPAV?	Queries the state of the Fabry-Perot Averaging mode (ON or OFF)
:CALCulate2:FPAV	Sets the instrument in the FPAV mode. FETCh, READ, and MEAS queries return the power-weighted average wavelength or total power.
:CALCulate2:AVERage[:STATe]?	Queries the spectral averaging state.
:CALCulate2:AVERage[:STATe] {ON | OFF}	Turns spectral averaging on or off.
:CALCulate2:AVERage:COUNt?	Queries the number of spectra to be averaged.
:CALCulate2:AVERage:COUNt	Sets the number of spectra to be averaged.
:CALCulate2:AVG:CLEar	Resets and restarts the spectral averaging, if spectral averaging is turned on.
:CALCulate2:SNR:AUTO?	Queries the state of the OSNR location and bandwidth automatic calculation.
:CALCulate2:SNR:AUTO{ON | OFF}	Turns the automatic calculation of OSNR location and bandwidth on or off.
:CALCulate2:SNR:WAVelength?	Queries the user wavelength used for SNR calculations.
:CALCulate2:SNR:WAVelength	Sets the user wavelength location used for SNR calculations, if SNR:AUTO is OFF.
:CALCulate2:SNR:BANDwidth?	Queries the user bandwidth used for SNR calculations.
:CALCulate2:SNR:BANDwidth	Sets the user bandwidth used for SNR calculations, if SNR:AUTO is OFF.
DISPlay Subsystem	These commands change the state of the instrument's front panel.
:DISPlay:DIALog?	Queries the current display screen on the front of the instrument.
:DISPlay:DIALog {MAIN | LISt }	Selects the current display screen on the front of the instrument.
:DISPlay:UNITs:POWer?	Queries the power units used for display.
:DISPlay:UNITs:POWer {DBM | MW}	Selects the power units used for display.
:DISPlay:UNITs:WAVelength?	Queries the wavelength units used for display.
:DISPlay:UNITs:WAVelength {NM | THZ | WNUMber }	Selects the wavelength units used for display.
SENSe Subsystem	These commands are used to control factors that affect the way in which the measurements are taken.
:SENSe:AVERage?	Queries the wavelength and power averaging state. (See also CALC2:AVER).

:SENSe:AVERage {OFF | 2 | 4 | 8 | 16 | 32 | 64 | 128}	Sets the wavelength and power averaging state to either a numerical value (power of 2) or OFF.
:SENSe:MEDium?	Queries the type of medium for the wavelength calculation.
:SENSe:MEDium {AIR | VACuum}	Selects the type of medium for the wavelength calculation. Does not affect wavelength reported in THz units.
:SENSe:POWeroffset?	Queries the power offset for the power measurements. The units are in dB.
:SENSe:POWeroffset {OFF | 1 | ... | 20}	Selects the offset for the power measurements in units of dB. Used to offset the effect of an external power attenuator.
:SENSe:NULL	Resets the null value used for the power calculation. This is to be used only when the fiber connector protective cap is on to ensure that light does not enter the system.

STATus Subsystem	These commands are used to retrieve SCPI or instrument status.
:STATus:QUEStionable:CONDition?	This command queries the SCPI Questionable Status register, which contains bits that indicate that one or more measurement types are of questionable accuracy.
:STATus:QUEStionable:ENABle?	This command queries the Questionable Enable register.
:STATus:QUEStionable:ENABle <integer>	Used to set and clear bits in the SCPI Questionable Enable register.
SYSTem Subsystem	
:SYSTem:ERRor?	Reads error strings from the Error Queue. If the Error Queue has any entries, the Error Queue bit is set in the Status Byte.
:SYSTem:HELP:HEADers?	This query returns a list of all commands/queries supported by the instrument.
UNIT Subsystem	This command affects the power units used by the SCPI interface.
:UNIT:POWer?	Queries power units (dBm or milliwatts).
:UNIT:POWer {DBM | MW}	Selects power units to be dBm or milliwatts. This command does not affect the front panel display in any way.

SCPI Command Detail

This section provides detailed information for all SCPI programming commands of the 428 Multi-Wavelength Meter. The commands are organized by subsystem.

Common Commands

***CLS**

Description	The *CLS (clear status) command clears the event status register and the error queue.

***ESE?**

Description	Queries the bits in the event status enable register.
Query Response	Returns an integer which is the sum of all the bit values for those bits that are set. See Event Status Register Enable table below.

***ESE <integer > mask from 0 to 255**

Description	The *ESE (event status enable) command sets the bits in the event status enable register and enables the corresponding events in the event status register. For each bit that is set (equal to 1), the corresponding bit is enabled in the event status register (ESR). <integer> is an integer value which is the sum of all of the bit values for those bits that are set.

Event Status Enable Register

BIT	BIT VALUE	ENABLES
7	128	Power On (PON)
6	64	Not Used
5	32	Command Error (CME)
4	16	Execution Error (EXE)
3	8	Device Dependent Error (DDE)
2	4	Query Error (QYE)
1	2	Not Used
0	1	Operation Complete (OPC)

***ESR?**

Description	The *ESR (event status register) query returns a value which encodes the bits in the event status register. If any bits are set in the ESR, then the ESR summary bit will be set in the STB.
Query Response	Returns an integer which is the sum of all the bit values for those bits that are set. See Event Status Register table below.

Event Status Register

BIT	BIT VALUE	CONDITION
7	128	Power On (PON)
6	64	Not Used
5	32	Command Error (CME)
4	16	Execution Error (EXE)
3	8	Device Dependent Error (DDE)
2	4	Query Error (QYE)
1	2	Not Used
0	1	Operation Complete (OPC)

***IDN?**

Description	The *IDN (identification number) query returns a string value which contains the instrument type, serial number, and firmware version. The third value is the instrument serial number. The last value is the software version and will reflect the actual version number.
Query Response	BRISTOL WAVELENGTH METER, 428A, 1109, 0.79

***OPC?**

Description	The *OPC (operation complete) query returns a one (1) when all pending device operations are complete.
Query Response	{0 | 1}

***RCL**

Description	The *RCL (recall) command restores instrument settings. It is the same as using the Recall Settings function through the display.

***RST**

Description	The *RST (reset) command returns the instrument's settings to a known state.

Commands Affected by *RST

COMMAND	SETTING AFTER AN *RST COMMAND
:CALCulate:DELTa[:STATe]	OFF
:CALCulate:DELTa:METHod	ITU
:CALCulate:DELTa:REF	1
:CALCulate:DRIFt[:STATe]	OFF
:CALCulate:DRIFt:METHod	STARt
:CALCulate:STARt[:STATe]	OFF
:CALCulate2:AVERage[:STATe}	OFF
:CALCulate2:AVERage:COUNt	2
:CALCulate2:FPAV	OFF
:CALCulate2:PEXCursion	10 dB
:CALCulate2:PTHReshold	10 dB
:CALCulate2:SNR:AUTO	ON
:CALCulate2:SNR:WAVelength	1470
:CALCulate2:SNR:BANDwidth	0.10
:CALCulate2:THREShold	REL
:CALCulate2:WLIMit[:STATe]	OFF
:CALCulate2:WLIMit:STARt	1267
:CALCulate2:WLIMit:STOP	1686
:DISPlay:DIALog	MAIN
:DISPlay:UNITs:POWer	DBM
:DISPlay:UNITs:WAVelength	THz
:SENSe:AVERage	OFF
:SENSe:MEDium	VAC
:SENSe:POWeroffset	OFF
:UNIT:POWer	DBM

***SAV**

Description	The *SAV command saves instrument settings. It is the same as using the Save Settings function through the display.

***STB?**

Description	The *STB (status byte) query returns the current value of the instrument's status byte.
Query Response	Returns an integer that is the sum of all the bit values for those bits that are set. See the instrument Status Byte table.

Instrument Status Byte

BIT	BIT VALUE	CONDITION
5	32	A bit is set in the questionable register (see STATus subsystem)
3	8	The errors in the error queue (see SYSTem subsystem)
2	4	A bit is set in the event status register

Measurement Instructions

The measurement instructions are used to return a reading to the computer. The three basic measurement instructions are MEASure, READ, and FETCh. Functions for these instructions are POWer, ENVironment, FREQuency, WAVelength, and WNUMber.

The :FETCh command will return a reading based on the last complete scan of the instrument's interferometer. Using :FETCh, it is possible to collect new measurements at the instrument's specified measurement rate. However, if :FETCh queries are made faster than the instrument's measurement rate, it is possible to get the same reading twice. Old readings are indicated by a bit in the questionable status register.

The :MEASure command will return a reading based on the next scan cycle of the instrument's interferometer. The :READ command will return a reading based on the current scan of the instrument's interferometer. The :MEASure and :READ commands guarantee that each reading returned is a new one. However, because :MEASure waits until after the end of the current measurement cycle before returning a reading, measurement rates can be as slow as half the instrument's scan rate. To get multiple measurement types from a single scan (i.e., WAVelength, POWer, etc.), use :READ followed by one or more :FETCh queries.

The :MEASure command can be considered a macro that executes multiple SCPI commands and is equivalent to:

```
:ABORt
:INITiate
:FETCh[ : <function> ]?
```

{:MEASure|:READ|:FETCh}{:ARRay|:SCALar}{:POWer|:ENVironment|:FREQuency|:WAVelength|:WNUMber|:OSNR}?

Description	Queries a reading of the given type from the measurement subsystem.
Query Response	See below.
Examples	See below.

Measurement Instruction Functions

:POWer?

Description	Returns a power reading in either Watts or dBm as specified by the :UNIT:POWer function.
Query Response	For a SCALar query, one numeric value is returned. For an ARRay query, an integer value indicating the number of entries, followed by comma separated numerical values in fixed point notation. (e.g., 2, -12.67, -15.49)
Examples	:READ:ARR:POW? :FETC:SCAL:POW?

:ENVironment?

Description	Returns the instrument's internal temperature in degrees Celsius (ºC) and pressure in millimeters of mercury (mm Hg). The response is independent of the choice of SCALar or ARRay.
Query Response	Two numerical values with units separated by a comma (e.g., 28.5 C, 740 MMHG).
Examples	:MEAS:ARR:ENV? :FETC:ARR:ENV?

:FREQuency?

Description	Returns an input laser reading in units of THz.
Query Response	A single numerical value (e.g., 193.67357) for SCALar. An integer value indicating the number of entries, followed by an array of comma separated numerical values (e.g. 2, 193.67357, 193.77482) for ARRay.
Examples	:FETC:ARR:FREQ? :MEAS:ARR:FREQ?

:WAVelength?

Description	Returns an input laser wavelength value in units of nm.
Query Response	A single numerical value (e.g., 1531.5877) for SCALar. An integer value indicating the number of entries, followed by an array of comma separated numerical values (e.g. 2, 1531.5877, 1532.7832) for ARRay.
Examples	:FETC:SCAL:WAV? :READ:ARR:WAV?

:WNUMber?

Description	Returns an input laser reading in units of cm^{-1}.
Query Response	A single numerical value (e.g., 6643.2891) for SCALar. An integer value indicating the number of entries, followed by an array of comma separated numerical values (e.g. 2, 6643.2891, 6654.1123) for ARRay.
Examples	:FETC:SCAL:WNUM? :MEAS:ARR:WNUM?

:OSNR?

Description	Returns the optical signal to noise ratio (OSNR) of each channel in dB.
Query Response	A single numerical value (e.g., 35.4) for SCALar. An integer value indicating the number of entries, followed by an array of comma separated numerical values (e.g. 4, 15.3, 36.2, 19.6, 14.3) for ARRay.
Examples	:FETC:SCAL:OSNR? :MEAS:ARR:OSNR?

CALCulate Subsystem

The CALCulate subsystem { XE "Commands:CALCulate" } is used to read and control the instrument's calculated values. The instrument continuously updates minimum and maximum readings as well as deriving differences such as maximum minus minimum and current minus start.

To retrieve CALCulate subsystem data, first choose a calculate data type and then perform a calculate query. For example, to read the delta power, issue the following commands:

:CALC:DELT:STAT ON	Set up to read a delta value.
:CALC:DELT:METH REF	Delta values are relative to the reference channel.
:CALC:DATA? POW	Read the delta power.

CALCulate Subsystem Functions

:DATA? { POWer | FREQuency | WAVelength | WNUMber }

Description	Returns a calculated value of a pre-selected data type in the specified units. In order for this function to return a result, you must first set up the CALCulate subsystem using the :DRIFt, :DELTa, or :RESet commands.
Query Response	A numerical value in fixed point notation.
Examples	:CALC:DATA? POW :CALC:DATA? WAV

:DRIFt[:STATe]?

Description	Queries the state of the :DRIFt function.
Query Response	OFF or ON
Examples	:CALC:DRIF:STAT? :CALC:DRIF?

:DRIFt[:STATe] { ON | OFF }

Description	Sets the state of the :DRIFt function to either ON or OFF.
*RST value	OFF
Examples	:CALC:DRIF OFF :CALC:DRIF:STAT ON

:DRIFt:METHod?

Description	Queries the state of the :DRIFt:METHod function.
Query Response	{ STARt | MAXMin | MAX | MIN }
Examples	:CALC:DELT:METH?

:DRIFt:METHod { STARt | MAXMin | MAX | MIN }

Description	Sets the state of the :METHod function to either STARt (to get current – starting values), MAXMin (to get maximum – minimum channel values), MAX (to get maximum values), or MIN (to get minimum values).
*RST value	STARt
Examples	:CALC:DRIF:METH STAR :CALC:DRIF:METH MAX

:DELTa[:STATe]?

Description	Queries the state of the :DELTa function.
Query Response	OFF or ON
Examples	:CALC:DELT:STAT? :CALC:DELT?

:DELTa[:STATe] { ON | OFF }

Description	Sets the state of the :DELTa function to either ON or OFF.
*RST value	OFF
Examples	:CALC:DELT OFF :CALC:DELT:STAT ON

:DELTa:METHod?

Description	Queries the state of the :DELTa:METHod function.
Query Response	{ ITU | REF}
Examples	:CALC:DELT:METH?

:DELTa:METHod { ITU | REF }

Description	Sets the state of the :METHod function to either ITU (to get current – ITU grid values) or REF (to get current – ref channel values).
*RST value	ITU
Examples	:CALC:DELT:METH REF :CALC:DELT:METH ITU

:DELTa:REF?

Description	Queries the reference channel.
Query Response	A single numerical value.
Examples	:CALC:DELT:REF?

:DELTa:REF <integer>

Description	Sets the reference channel to <integer>.
*RST value	1
Examples	:CALC:DELT:REF34

:RESet

Description	Resets the minimum, maximum, and start values to the current reading. Resets the deltas and drifts to zero, and sets the elapsed time to 00:00:00. This affects the CALCulate subsystem as well as the instrument's front panel display. It is the same as using the Reset function via the front panel display.
Examples	:CALC:RES

:TIMe[:ELAPsed]?

Description	Queries the elapsed time since the instrument was turned on or was reset using the CALC:RES command. *RST only affects instrument settings.
Query Response	A time in HH:MM:SS format.
Examples	:CALC:TIM? :CALC:TIM:ELAP?

CALCulate2 Subsystem Functions

:DATA?

Description	Queries the frequency spectrum of the input signal.
Query Response	An array of comma separated numerical values in scientific notation.
Examples	:CALC2:DATA? (**Note**: to accurately recreate the frequency axis see Appendix E)

:PEXCursion?

Description	Queries the peak excursion value.
Query Response	A single numerical value in dB units
Examples	:CALC2:PEXC?

:PEXCursion

Description	Sets the amount that a peak must rise and fall above the local noise floor to be identified as a channel. The parameter that is passed is the desired excursion in dB units.
*RST value	10 dB
Examples	:CALC2:PEXC 15

:PTHReshold?

Description	Queries the value of the channel threshold.
Query Response	A single value in dB (REL) or dBm (ABS) units, dependent on the :CALC2:THREShold setting
Examples	:CALC2:PTHR?

:PTHReshold

Description	Sets the value of the channel threshold, based on either the tallest peak in the spectrum (REL) or as an absolute value (ABS).
*RST value	10 dB (REL)
Examples	:CALC2:PTHR 10

:THREShold?

Description	Queries the threshold type
Query Response	{REL | ABS}
Examples	:CALC2:THRES?

:THREShold {REL | ABS}

Description	Sets the threshold type to either relative (REL) or absolute (ABS).
*RST value	REL
Examples	:CALC2:THRES ABS

:WCOE?

Description	Queries the factory set wavelength calibration coefficient. Used to properly scale the x axis of the spectrum. See Appendix E.
Query Response	
Examples	:CALC2:WCOE?

:WLIMit [:STATe]?

Description	Queries the wavelength limit state.
Query Response	{ON | OFF}
Examples	:CALC2:WLIM:STAT?

:WLIMit [:STATe] {ON | OFF}

Description	Turns the wavelength limiting to ON or OFF. If ON, the channel identification and wavelength calculations are limited to
*RST value	OFF
Examples	:CALC2:WLIM:STAT ON

:WLIM{:STARt | :STOP}?

Description	Queries the wavelength start or stop wavelength.
Query Response	A single numerical value in nanometer units.
Examples	:CALC2:WLIM:STAR? :CALC2:WLIM:STOP?

:WLIM {:STARt | :STOP}

Description	Sets the threshold type to either relative (REL) or absolute (ABS).
*RST value	1267 nm and 1686 nm
Examples	:CALC2:WLIM:STAR 1490 :CALC2:WLIM:STOP 1580

:FPAV?

Description	Queries the Fabry-Perot calculation method state.
Query Response	{ON | OFF}
Examples	:CALC2:FPAV?

:FPAV{ON | OFF}

Description	Sets the Fabry-Perot calculation method to ON or OFF. If ON, the wavelength is calculated as the weighted average of all spectral peaks and the power is the total power of all spectral peaks. This function is useful for characterizing the central wavelength and total power of multi-mode FP lasers.
*RST value	OFF
Examples	:CALC2:FPAV ON

:AVERage[:STATe]?

Description	Queries the state of the spectral averaging.
Query Response	{ON | OFF}
Examples	:CALC2:AVER{:STATe}?

:AVERage[:STATe] {:ON | :OFF}

Description	Turns spectral averaging ON or OFF. Determines the number of scans used to calculate wavelength and power when the average function is enabled. The choices are 2, 4, 8, 16, 32, 64, or 128. When average is on, the interferograms from the selected number of averages are collected and averaged before any measurements are computed and displayed.
*RST value	OFF
Examples	:CALC2:AVER ON :CALC2:AVER:STAT ON

:AVERage:COUNt?

Description	Queries the number of scans used to calculate the wavelength and power when the average function is enabled.
Query Response	{2 | 4 | 8 | 16 | 32 | 64 | 128}
Examples	:CALC2:AVER:COUN?

:AVERage:COUNt {2 | 4 .. | 128}

Description	Determines the number of scans used to calculate wavelength and power when the average function is enabled. The choices are 2, 4, 8, 16, 32, 64, or 128. When average is on, the interferograms from the selected number of scans are collected and averaged before any measurements are computed and displayed.
*RST value	2
Examples	:CALC2:AVER:COUN 32

:AVERage:CLEar

Description	Resets and restarts the spectral averaging, if spectral averaging is turned ON.
Examples	:CALC2:AVER:CLE

:SNR:AUTO?

Description	Queries the automatic calculation of the OSNR location and bandwidth state.
Query Response	{ON | OFF}
Examples	:CALC2:SNR:AUTO?

:SNR:AUTO {ON | OFF}

Description	Turns the automatic calculation of OSNR location and bandwidth ON or OFF. If ON, the OSNR is calculated as the ratio of the power in the optical channel relative to the interpolated noise at the channel location. The noise at the channel location is interpolated by calculating the average of the noise measured 100 GHz to the left and to the right of the channel location. If another channel is less than 200 GHz away, then the noise is calculated midway between the two channels. The bandwidth for the noise is fixed at 0.1 nm if AUTO is ON. If AUTO is OFF, then the user selected noise location (:SNR:WAV) is used to measure the noise and the bandwidth is the user selected bandwidth (:SNR:BAND).
*RST value	ON
Examples	:CALC2:SNR:AUTO OFF

:SNR:WAVelength?

Description	Queries the user selected location for noise calculation when :SNR:AUTO is OFF.
Query Response	{1267…1686}
Examples	:CALC2:SNR:WAV?

:SNR:WAVelength <integer>

Description	Sets the user selected location for noise calculation when :SNR:AUTO is OFF.
*RST value	1470
Examples	:CALC2:SNR:WAV 1430

:SNR:BANDwidth?

Description	Queries the user bandwidth in nanometers used for SNR calculations.
Query Response	{0.02 … 2.00}
Examples	:CALC2:SNR:BAND?

:SNR:BANDwidth <fixed point number>

Description	Sets the bandwidth in nanometers used for SNR calculations when :SNR:AUTO is OFF.
*RST value	0.10
Examples	:CALC2:SNR:BAND 1.20

DISPlay Subsystem

The DISPlay subsystem { XE "Commands:DISPlay" } is used to manipulate the instrument's front panel through the USB or Ethernet interfaces. These commands do not affect the readings from the SCPI interface.

DISPlay Subsystem Functions

:DIALog?

Description	Queries the display dialog currently shown by the 428.
Query Response	{ MAIN | LIST | POWer }
Examples	:DISP:DIAL?

:DIALog { MAIN | LISt }

Description	Selects the instrument's front panel display.
*RST value	MAIN
Examples	:DISP:DIAL MAIN :DISP:DIAL LIS

:UNITs:POWer?

Description	Queries the units being used for power values on the front panel display.
Query Response	{ DBM | MW }
Examples	:DISP:UNIT:POW?

:UNITs:POWer { DBM | MW }

Description	Sets the units being used for power values on the front panel display. It is the same as changing the power units via the front panel display.
*RST value	DBM
Examples	:DISP:UNIT:POW MW :DISP:UNIT:POW DBM

:UNITs:WAVelength?

Description	Queries the units being used for wavelength values on the front panel display.
Query Response	{ NM | THZ | WNUMBER }
Examples	:DISP:UNIT:WAV?

:UNITs:WAVelength { NM | THZ | WNUMber }

Description	Sets the units being used for wavelength values on the front panel display. It is the same as changing the wavelength units via the front panel display.
*RST value	THZ
Examples	:DISP:UNIT:WAV WNUM :DISP:UNIT:WAV NM

SENSe Subsystem

The SENSe subsystem { XE "Commands:SENSe" } allows changes in parameters that affect how the instrument makes measurements.

SENSe Subsystem Functions

:AVERage?

Description	Queries the wavelength and power averaging state.
Query Response	{OFF | 2 | 4 | 8 | 16 | 32 | 64 | 128}
*RST value	OFF
Examples	:SENS:AVER?

:MEDium?

Description	Queries the medium used for wavelength calculations.
Query Response	{ AIR | VAC }
Examples	:SENS:MED?

:MEDium {AIR | VACuum}

Description	Sets the medium used for wavelength calculations. It is the same as using the Medium function via the front panel display.
*RST value	VAC
Examples	:SENS:MED AIR :SENS:MED VAC

:POWeroffset?

Description	Queries the power offset being added to power values. It is the same as using the Poffs function via the front panel display. The power offset is in units of dB.
Query Response	{ OFF | 1 | 2 | 3 | ... | 19 | 20 }
Examples	:SENS:POW?

:NULL

Description	Resets the null value used for the power calculation. This is to be used only when the fiber connector protective cap is on to ensure that light does not enter the system.
*RST value	0.00
Examples	:SENS:NULL

STATus Subsystem

The STATus subsystem { XE "Commands:STATus" } is used to retrieve status information from the instrument and to mask or screen what status can be retrieved.

Status registers give information about the instrument and the latest measurement. Status enable registers allow some status information to be ignored. Status information disabled though the status enable registers will not show up in the status registers.

STATus Subsystem Functions

:QUEStionable:CONDition?

Description	Queries the SCPI Questionable Status Register which contains bits that indicate that one or more measurement types are of questionable accuracy. The bits in the register are described in the table below.
Query Response	An integer which is the sum of the bit values for all bits in the register that are set.
Examples	:STAT:QUES:COND?

Questionable Status Register

BIT	BIT VALUE	DESCRIPTION
0	1	The wavelength has already been read for the current scan.
1	2	(not used)
2	4	(not used)
3	8	The power value is outside the valid range of the instrument.
4	16	The temperature value is outside the valid range of the instrument.
5	32	The wavelength value is outside the valid range of the instrument.
6	64	(not used)
7	128	(not used)
8	256	(not used)
9	512	The pressure value is outside the valid range of the instrument.
10	1024	Indicates that the reference laser has not stabilized.

:QUEStionable:ENABle?

Description	Queries the SCPI Questionable Enable Register.
Query Response	An integer which is the sum of the bit values for all bits in the register that are set.
Examples	:STAT:QUES:ENAB?

:QUEStionable:ENABle <integer>

Description	Used to set and clear bits in the SCPI Questionable Enable Register. This register contains bits that are used to mask one or more conditions indicated in the Questionable Status Register. Clearing a bit (setting it to zero) causes that condition to be masked so that, even if the condition is true, its associated bit will not get set in the Questionable Status Register. The Questionable Enable Register has the same format as the Questionable Status Register. See table above.
Examples	:STAT:QUES:ENAB 1024 (enables "reference laser not stable" bit) :STAT:QUES:ENAB 2047 (enables all bits)

SYSTem Subsystem

The SYSTem subsystem { XE "Commands:SYSTem" } supplies information and status about the SCPI command parser.

SYSTem Subsystem Functions

:ERRor?

Description	Reads error strings from the SCPI Error Queue. If the Error Queue has any entries, the Error Queue bit is set in the Status Byte. The instrument has a 30 entry, first-in, first-out queue. Repeatedly sending the query :SYST:ERR? returns the error numbers and descriptions in the order in which they occurred until the queue is empty. Any further queries return 0, "No error" until another error occurs. A table of possible errors is shown below.
Query Response	<integer>, <string> (e.g., –104, "Data type error")
Examples	:SYST:ERR?

SCPI Errors

ERROR NUMBER	DESCRIPTION
0	No error
-101	Invalid character
-102	Syntax error
-103	Invalid separator
-104	Data type error
-220	Parameter error
-221	Settings conflict
-222	Data out of range
-230	Data corrupt or stale

:HELP:HEADers?

Description	Reads a list of all commands and queries supported by the instrument. Each line of the response is terminated by a linefeed. The first line indicates the number of bytes of help data that follow. The remaining lines are strings of help data. All lines of data must be read before continuing normal operations.
Query Response	#<integer> <string> <string> <string> ... <string>
Examples	:SYST:HELP:HEAD?

UNIT Subsystem

For the instrument, there is a single query and command in the UNIT subsystem { XE "Commands:UNIT: }. This is used to query and change the units that the SCPI interface uses for reporting power.

UNIT Subsystem Functions

:UNIT:POWer?

Description	Queries the state of the power units that will be used when the SCPI interface returns power values.
Query Response	{ DBM | MW }
Examples	:UNIT:POW?

:UNIT:POWer {DBM | MW}

Description	Sets the state of the power units that will be used when the SCPI interface returns power values. This setting does not affect the display.
*RST value	DBM
Examples	:UNIT:POW DBM :UNIT:POW MW

APPENDIX A – SPECIFICATIONS

		428A	428B
OPTICAL SIGNAL		CW and modulated	
WAVELENGTH			
	Range	1270 – 1650 nm (182 – 236 THz)	
	Absolute Accuracy [1, 2, 3]	± 0.2 parts per million (± 0.3 pm at 1550 nm) (± 0.3 pm at 1310 nm)	± 0.65 parts per million (± 1.0 pm at 1550 nm) (± 0.9 pm at 1310 nm)
	Differential Accuracy [4]	± 0.15 parts per million	± 0.5 parts per million
	Minimum Resolvable Separation [3, 4]	10 GHz (equal power lines input)	
	Calibration	Continuous - built-in stabilized single-frequency HeNe laser	Continuous - built-in standard HeNe laser
	Display Resolution	0.0001 nm	
	Units [5]	nm, cm^{-1},THz	
POWER			
	Calibration Accuracy	± 0.5 dB (± 30 nm from 1310 and 1550 nm)	
	Flatness [4]	± 0.2 dB (1270 – 1600 nm), 30 nm from any wavelength	
	Linearity [4]	± 0.3 dB (1270 – 1600 nm), lines above -30 dBm	
	Polarization Dependence	± 0.5 dB (1270 – 1600 nm)	
	Display Resolution	0.01 dB	
	Units	dBm, mW, µW	
SIGNAL-TO-NOISE RATIO [4, 6]		> 40 dB (100 averages), ≥ 100 GHz channel spacing > 35 dB (100 averages), ≥ 50 GHz channel spacing	
OPTICAL INPUT SIGNAL			
	Sensitivity **Single line input** **Multiple lines input** [4]	-40 dBm (1270 – 1600 nm), -30 dBm (1600 – 1650 nm) 30 dB below total input power, but not less than single line input sensitivity	
	Maximum Power **Displayed level** **Safe level**	+ 10 dBm, sum of all lines input + 18 dBm, sum of all lines input	
	Return Loss	35 dB (UPC connector), 50 dB (APC connector)	
	Maximum Number of Lines [7]	1,000	
MEASUREMENT RATE (TIME)		4 Hz (0.25 s)	
MEASUREMENT MODES			
	Data Mode	Single channel, list by wavelength table, list by power table	
	Delta Mode	Delta wavelength from ITU grid, delta wavelengths and powers from reference channel	
	Drift Mode	Maximum, minimum, drift (max-min) of wavelengths and powers over time Current, start, drift (current-start) of wavelengths and powers over time	
INPUTS/OUTPUTS			
	Optical Input	9/125 µm single-mode fiber (FC/UPC or FC/APC)	
	Instrument Interface	Library of commands (SCPI) via USB 2.0, Ethernet, and optional GPIB	
ENVIRONMENTAL [4]			
	Warm-Up Time	< 15 minutes	None
	Temperature/Pressure/Humidity	+15°C to +30°C (-10°C to +70°C storage) | 500 - 900 mm Hg | ≤ 90% R.H. at + 40°C (no condensation)	
DIMENSIONS AND WEIGHT			
	Dimensions (H x W x D) | Weight	3.5" x 17.0" x 15.0" (89 mm x 432 mm x 381 mm) | 17 lbs (7.65 kg)	
POWER REQUIREMENTS		90 - 264 VAC, 47 - 63 Hz, 80 VA max	

(1) Defined as measurement uncertainty, or maximum wavelength error, using a coverage factor of 3 providing a confidence level of ≥ 99.7%.
(2) Traceable to an NIST standard (SRM 2517a).
(3) For multi-wavelength measurement, >15 GHz channel separation is required to achieve specified wavelength accuracy.
(4) Characteristic performance, but not warranted.
(5) Data in units of nm and cm^{-1} are given as vacuum value.
(6) For lines above -25 dBm, 0.1 nm noise bandwidth.
(7) OSNR is reduced as the number of lines is increased.

Bristol Instruments reserves the right to change the detail specifications as may be required to permit improvements in the design of its products. Specifications are subject to change without notice.

APPENDIX B – WARRANTY & SERVICE

Warranty

The 428 Multi-Wavelength Meter is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Bristol Instruments will repair, or at its option, replace parts that prove to be defective when the instrument is returned prepaid to Bristol Instruments. Before returning an instrument, always call Bristol Instruments for return authorization. The warranty will not apply if the instrument has been damaged by accident, misuse, or as a result of modification by persons other than Bristol Instruments personnel.

It is important to call Bristol Instruments or your local sales representative in advance of returning the unit for a Return Authorization Number (RA#). This will ensure the prompt handling of the repair, as well as provide important tracking information.

The liability of Bristol Instruments, (except as to title) arising out of supplying said product, or its use, whether under the foregoing warranty, a claim of negligence, or otherwise, shall not in any case exceed the cost of correcting defects in the products as herein provided. Upon expiration of the warranty period specified herein, all liability shall terminate. The foregoing shall constitute the sole remedy of the buyer. In no event shall the seller be liable for consequential or special damages.

Service

There are no user serviceable parts inside the 428 Multi-Wavelength Meter. All service and repair work for the instrument is to be done at Bristol Instruments.

If you have any questions about the operation of your 428 system or need to have your 428 system serviced, please call Bristol Instruments at (585) 924-2620. Or, you can contact us at service@bristol-inst.com.

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APPENDIX C – MONITOR PORT

The Monitor Port on the rear panel of the 428 Multi-Wavelength Meter provides a combination of analog and digital signals for observing the interference fringe signals and measurement timing signals using an oscilloscope. The Monitor Port uses a 9-pin, female, D-sub style connector shown in Figure D-1 and with a pinout described in the table below.

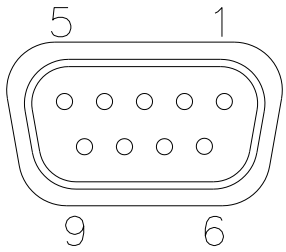

Figure D-1: Monitor Port

Pin Number	Signal Name	Signal Type	Description
1	REFERENCE	Analog	Reference laser sinusoidal interference fringe signal.
2	INPUT	Analog	Input laser sinusoidal interference fringe signal.
3			N/C
4			N/C
5	GROUND	-	Circuit ground.
6			N/C
7	TRIGGER	TTL	Scanning Window Trigger is a digital pulse with a duration that defines the maximum measurement interval for the interferometer scan. It goes active (H=active) during the allowed measurement interval.
8	ZOP	TTL	Zero Optical Path (ZOP) is a digital signal that indicates the location (timing) of equal path length in the arms of the interferometer. For scans of one direction, a positive edge indicates ZOP. For scans of the other direction, a negative edge indicates ZOP.
9	WINDOW	TTL	Scanning Window digital output is derived from the amplitude of the input laser fringe signal. When the p-p amplitude of this signal exceeds 1 volt, within the Trigger interval and before or spanning the ZOP transition, the Window is active (H=active). Depending on the character of the input laser fringes, there may be several Windows during a Trigger, but the first Window period to terminate after the ZOP transition is the only "Valid Window" used for the measurement.

APPENDIX D – TROUBLESHOOTING

The 428 Multi-Wavelength Meter continually checks the quality of the signal it is analyzing and alerts the user to unusual conditions that might affect the precision of the wavelength measurement.

Main Display Error Messages

The following table provides a list of error messages displayed on the instrument's Front Panel and what they mean. If an error message is displayed, please call Bristol Instruments for additional information and/or instructions.

Error Message	Description
Wavelength Range Error	The wavelength (or frequency) measurement is outside of the specified range of the instrument.
Reference Laser Error	This indicates that the internal HeNe reference laser is not operating properly.
System Temperature Error	This indicates that the instrument temperature is outside of the allowed range of 0 to 50°C, or that there is a problem with the temperature sensor. Measurement will continue using the temperature at the end of the allowed range closest to the temperature sensor's reading.
Pressure Range Error	This indicates that the ambient pressure is outside of the allowed range of 500 to 900 mm Hg, or that there is a problem with the pressure sensor. Measurement will continue using the pressure at the end of the allowed range closest to the pressure sensor's reading.
Input Power Too High	The instrument has detected an input power level that is beyond the 30 mW allowed safe limit. Measurement will be suspended when this message is displayed.
Input Power Too Low	The instrument has detected an input power level below the minimum input required. Measurement will continue but not be within specified accuracy and/or repeatability limits.

NuView Error Messages

The following table provides a list of error messages displayed by the *NuView Display Software* and what they mean. If an error message is displayed, please call Bristol Instruments for additional information and/or instructions.

Error Message	Description
Power Out of Bounds	The instrument has detected a power measurement that is outside of the specified range of the instrument.
Laser Not Stable	This indicates that the internal HeNe reference laser of the model A has not stabilized yet.
Temperature Out of Bounds	This indicates that the instrument temperature is outside of the allowed range of 0°C to 50°C for the temperature sensor, or that there is a problem with the sensor. Measurement will continue using the temperature at the end of the allowed range closest to the temperature sensor's reading.
Pressure Out of Bounds	This indicates that the ambient pressure is outside of the allowed range of 500 to 900 mm Hg, or that there is a problem with the pressure sensor. Measurement will continue using the pressure at the end of the allowed range closest to the pressure sensor's reading.
Wavelength Out of Bounds	The instrument has detected a wavelength that is outside the operating range of the instrument.
Reference Fringes Low	The instrument has detected that there are insufficient reference fringes to perform an accurate measurement. This may be due to either a failing reference laser, or misalignment in the interferometer.

APPENDIX E – SPECTRAL CALCULATION

The spectrum of the input signal can be recovered by using the query ":CALC2:DATA?" The response will be the spectral intensity in scientific notation for each of the 16384 spectral frequency bins.

The uncorrected wavelength in nanometers for any spectral point m can then be calculated using the formula:

$$\lambda u[nm] = \frac{2 * \lambda Ref}{1 - \frac{m}{65536}}$$

For a model 428A, λ_{Ref} is equal to 632.9909nm; for a model 428B, λ_{Ref} is equal to 632.9914nm.

To accurately compute the wavelength, the dispersion of air and internal calibration factors must be taken into account.

The dispersion of air can be approximated by:

$$Dispersion(\lambda u, T, P) = 3.1686 - 0.00371 * \lambda u + 9.3127 * 10^{-7} * \lambda u^2 + 0.01229 * T - 4.9238 * 10^{-5} * T^2 - 0.00408 * P$$

Where the wavelength is in units of nanometers, the temperature, T, is in units of degrees Celsius (C) and the pressure, P, is in units of millimeters of mercury (mmHg).

The temperature and pressure can be queried using ":FETCH:SCAL:ENV?".

The dispersion corrected vacuum wavelengths can then be computed as:

$$\lambda[nm] = \lambda u[nm] * \left[[WCOE + Dispersion(\lambda u, T, P)] * 10^{-6} + 1\right]$$

The internal wavelength calibration coefficient can be queried using "READ:CALC2:WCOE?".

To calculate the x-axis values in frequency, invert the wavelength values and multiply them by the speed of light, 299792458m/s.

EC and FCC
Declaration of Conformity

Manufacturer's Name:	Bristol Instruments, Inc.
Manufacturer's Address:	50 Victor Heights Parkway Victor, NY 14564 USA

declares this product:

Product Name:	Wavelength Meters
Model Number(s):	428A, 428B

conforms to the following directives:

73/23/EEC
89/336/EMC

as a result of having been tested satisfactorily to the following standards:

Safety: EN-61010-1: IEC 1010-1

EMC: EN61326: 1997+A1: 1998+A2: 2001 **Class A**

EN61000-4-2: 1995	**±4KV Air & Contact**
EN61000-4-3: 2006	**3V/m 80MHz-2.7GHz**
EN61000-4-4: 1995	**±1KV**
EN61000-4-5: 1995	**±1KV(L-G) ±0.5KV(L-L)**
EN61000-4-6: 1996	**3V 0.15-80MHz**
EN61000-4-11: 1994	**1 Cycle 100%**
EN61000-3-2: 2000	
EN61000-3-3: 2002	

FCC: FCC per CFR 47 Part 15; Class A – Unintentional Radiators

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Date of Issue: November 19, 2009

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