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# WA-7000 Multi-line Wavemeter®

# OPERATING MANUAL

Operating Manual (Rev. A)
08435-M-00

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burleigh

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## Assumptions

This Operating Manual provides information for individuals who use the Burleigh Instruments WA-7000 Multi-line Wavemeter.

This manual assumes familiarity with communication software and hardware interfaces with an IBM, or compatible, Personal Computer.

## Conventions

This Manual uses two style conventions to identify different types of information.

MODE This font represents a button on the Wavemeter front panel.

ZOOM This font represents an on-screen function.

# Section 1. Introduction and Setup

This section provides general information on the WA-7000 Multi-line Wavemeter and information on unpacking and setting up the Wavemeter.

## Overview

Burleigh's Wavemeters are instruments designed for simple, automatic and accurate wavelength measurement of continuous wave (CW) laser sources. The interference fringes produced by the input laser radiation in a scanning Michelson interferometer are sampled in the interferometer scan at equally spaced intervals calibrated by a built-in reference laser. A high-speed digital signal processor computes a Fourier Transform of the interferogram to obtain a spectrum of the input laser that is displayed on the Wavemeter screen.

Discrete wavelengths included in the input laser source appear as peaks in the spectrum. The wavelength of each peak is accurately determined based on the knowledge of the reference laser wavelength. The WA-7000 Multi-line Wavemeter uses a HeNe reference laser that provides an absolute wavelength accuracy better than ±1 part per million. Refer to Appendix A for complete specifications.

The WA-7000 Multi-line Wavemeter contains a rigid monolithic interferometer built inside a single block that makes it robust and reliable. Inside the instrument, both the reference laser and the input laser beams are coupled into the interferometer by fiber optic cables that ensure good optical alignment. An embedded computer generates the spectral display and derives the wavelength and power of each spectral peak. The front panel display, and other input and output functions are also controlled by the computer. The Wavemeter front panel has buttons to select different display screens, change parameters or display attributes, and manipulate the collection of data.

- Refer to **Section 2, Operation** for a step-by-step procedure on how to use the WA-7000.
- Refer to **Section 3, Front Panel Communications**, for detailed descriptions on the controls, display, and mode screens.
- Refer to **Section 5, Theory of Operation** & Calibration, for additional information on the Wavemeter's theory of operation.

The Wavemeter has a built-in bi-directional RS-232 interface and a GPIB interface for transmitting data and remotely controlling the Wavemeter. Data can be output to the floppy disk drive accessible through the front panel or output to the printer connected to the rear panel printer port. Refer to **Section 4, Remote Communications**, for information on these interfaces and the SCPI communication scheme.

The Monitor port on the back of the Wavemeter provides access to the interferometer fringe signals and timing signals that govern the wavelength measurement. Refer to **Appendix D, Rear Panel Controls**, for further information.

## Unpacking & Inspection

The Burleigh WA-7000 Multi-line Wavemeter 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 external shipping carton is not damaged, carefully remove and identify all of the components listed below. Contact Burleigh Instruments or your local representative if any of the components are missing. We recommend you save the shipping carton for future storage or transportation.

The Burleigh Wavemeter Systems include the following components:

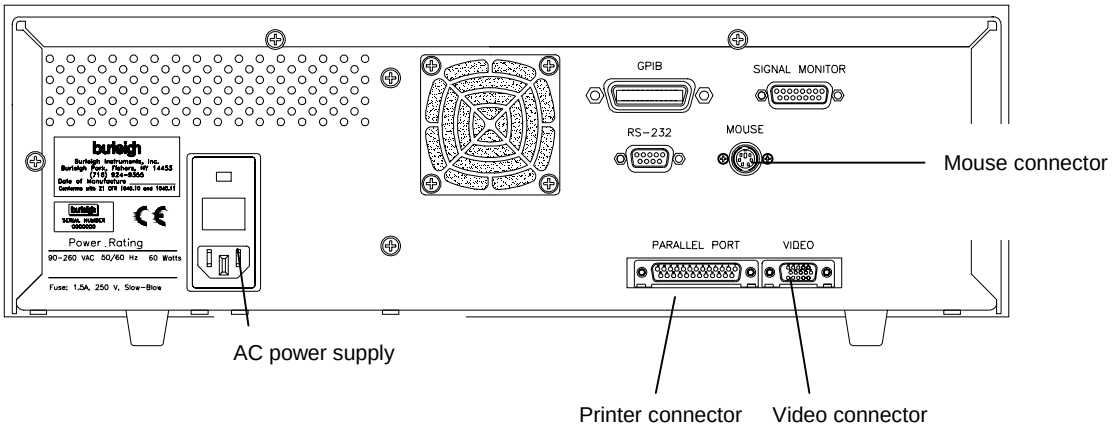
- Wavemeter
- Power cord
- Operating Manual

## Setup

Setting up the Wavemeter is a very simple operation as described in the procedure below.

The operating system is Microsoft Windows. A color VGA screen is built into the front panel, but a computer monitor can also be attached to the rear panel connector for a larger display. A 3.5" floppy drive accessible from the front panel is used for transferring data or loading alternate custom programs.

The standard fiber optic input connector is FC/UPC, but other fiber optic connectors are available.




1. Place your Wavemeter on a firm horizontal surface.
2. Attach the AC line cord. The Wavemeter uses a universal power supply that works with any line voltage 90-260 VAC, 50/60 Hz.
3. If you want to use a mouse to operate the Wavemeter (this is optional), connect the mouse cable to the MOUSE connector on the rear panel.
4. To connect a printer to the WA-7000 so you can print various data and display screens, connect a standard parallel port cable to the PARALLEL PORT connector on the rear panel. (Refer to section Appendix E, Installing a Printer Driver for more information.)
5. If you want to use a standard video monitor to provide a larger display, connect the monitor cable to the VIDEO connector on the rear panel.
6. Turn on the Power Switch on the front panel of the Wavemeter. The system's self-test takes approximately 30 seconds.

7. Ensure all fiber optic connectors are clean and dry (see below). Then connect your fiber optic cable to the fiber optic connector on the Wavemeter front panel. Make sure the fiber end does not rub against any surface and do not overtighten.

**CAUTION: Use care in handling fiber optic connectors. Always clean the fiber end prior to insertion into the connector for optimum performance and to avoid power measurement errors.**

## Fiber End Cleaning

To make good optical measurements, it is extremely important to clean the fiber optic connector before each connection. Dirt on the connector can degrade the reliability of the measurement and cause permanent damage to the connector resulting in an expensive repair.

Modern fiber optic connectors rely on a glass-to-glass contact to reduce Fresnel reflections at the connector interface. A dirty or damaged connector on the cable can damage the input connector on the WA-7000 front panel. Always use a good quality cable connector. If there is any question of the surface quality on the tip of the cable connector, inspect it under a microscope for scratches or debris.

Instructions: To clean the end of the connector on the fiber optic cable, first gently wipe the tip with a lint-free swab or lens paper dipped in isopropyl alcohol. Then dry it by wiping gently with a clean dry lint-free lens paper. As soon as the connector is dry, insert it in the WA-7000 panel or cover it for later use.

- Never use a metal or other hard object for cleaning that would scrape the connector.
- Do not apply index matching gel or oils.
- Always keep connectors covered for protection when not in use.

## Fan Filter Cleaning

The fan on the rear panel of the WA-7000 provides important ventilation to components inside the chassis. A filter covers the fan opening to keep out dust. This filter should be cleaned periodically, especially if it becomes noticeably dirty.

To clean the dust filter,

1. Pry off the plastic grill covering the filter with a small screwdriver.
2. Use a small brush, plus soap and water if necessary to clean the filter.
3. When the filter is dry, reposition it and snap the grill back in place.

# Section 2. Operation

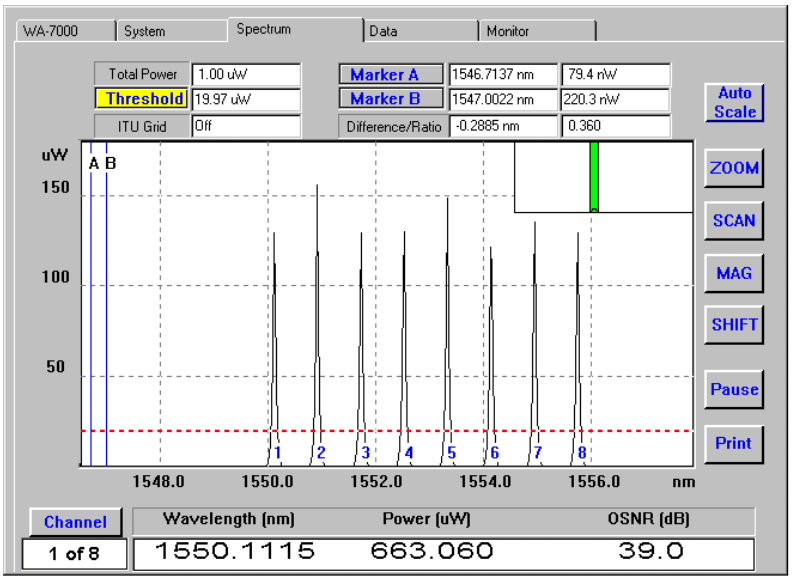
## Using the WA-7000

The WA-7000 Multi-line Wavemeter uses Fast Fourier Transform (FFT) analysis of a signal from a scanning Michelson interferometer to obtain the spectrum of multi-wavelength laser sources within a fiber, such as found in WDM telecommunication systems. The Wavemeter is capable of displaying a spectrum of up to 200 channels with a resolution of approximately 50 pm and optical signal-to-noise ratio (OSNR) greater than 30 dB for a single line spectrum. The wavelength and power of each spectral line can be reported as a table of values or plotted graphically in real time. The measurement rate of the instrument is 0.5 Hz (one measurement every two seconds).

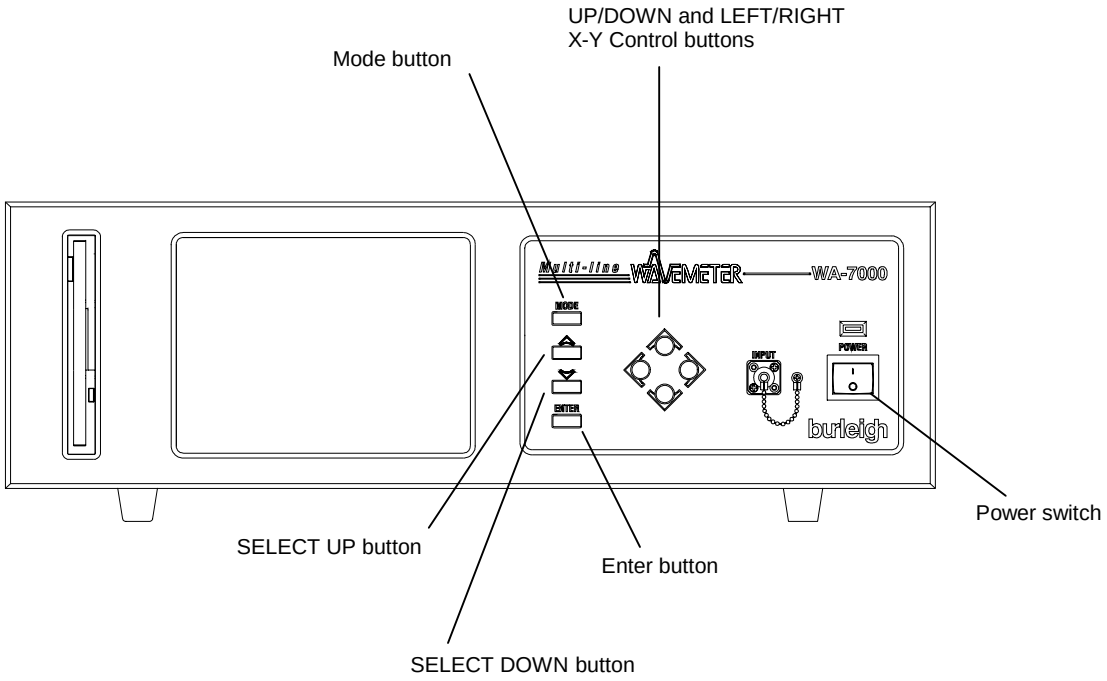
Follow the procedure below to operate the WA-7000. Detailed descriptions of functions on each screen are provided in **Section 3, Front Panel Communications**.

1. Turn on the WA-7000 power switch on the front panel of the machine.

   The Spectrum screen appears on the WA-7000 display. This screen allows you to view the optical spectrum of the input signal.




Note: If you wish to change your settings, press the **MODE** button four times to move to the System tab. For more information on the System tab, refer to **Setting Up the System** at the end of this section.




Use the **MODE** button on the left side of the Wavemeter's front panel to sequentially select the tabs for the WA-7000, System, Spectrum, Data, and Monitor screens.

Use the **SELECT UP/SELECT DOWN** buttons to scroll up or down through the available functions on each screen. The selected function will be highlighted in yellow.

Use the **UP/DOWN** AND **LEFT/RIGHT** X-Y Control buttons to adjust the highlighted function. Refer to **Section 3, Front Panel Communications** for more information.

Note: If you are using a mouse, the operation of the MODE and SELECT UP/SELECT DOWN buttons can be performed by clicking on screen tabs or buttons.

2. To adjust the vertical scale, select the **Auto Scale** function and press the **ENTER** button. This automatically rescales the display vertically for easy viewing and sets an appropriate threshold.

   Spectral peaks above the threshold indicate a separate channel. In general, you want to set the threshold to a place ABOVE any peaks or noise that you wish to ignore.

3. To adjust the threshold, select the **Threshold** function and use the **UP/DOWN** X-Y Control buttons to adjust the threshold line to a level of your choice.

4. To adjust the horizontal scale and narrow in on an area of interest, use the **ZOOM** and **SCAN** functions with the **LEFT/RIGHT** X-Y Control buttons.

   In the upper right corner of the display there is a Thumbnail image of the full wavelength range with a green band that indicates the region that you are viewing.

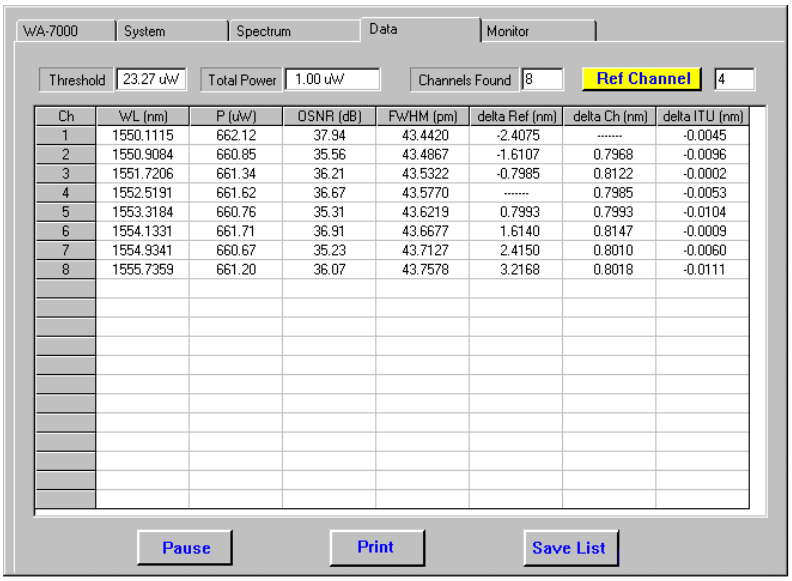
5. To change the vertical scale and magnify an area of interest, use the **MAG** and **SHIFT** functions with the **UP/DOWN** X-Y Control buttons.

   The Shift function is most useful when working with the logarithmic (dBm) scale.

6. To freeze the display at a particular point, select the **Pause** function and press the **ENTER** button.

   The Pause function label switches to **Go** for resuming display updating.

7. Use the **Channel** function to view the computed values for up to 200 channels, one channel at a time. Keep pressing the **UP/DOWN** X-Y Control buttons until the channel you want appears in the text box at the bottom of the screen.
8. Use the **Marker A** or **Marker B** functions with the **LEFT/RIGHT** X-Y Control buttons to move the markers to a desired location on the display. A red dot appears at the intersection point of the spectrum. If you set both markers, the wavelength difference and power ratio are displayed in the **Difference/Ratio** box at the top of the screen.
9. The **Total Power** box displays the total input power from the source.
10. The **ITU Grid** box indicates the status of the ITU Grid setting on the System screen. It is either Off, 50 GHz, 100GHz, or Hidden (if the wavelength range displayed is too wide).
11. To move to the **Data** tab, press the **MODE** button. The Data screen displays measurements for all channels detected above the threshold in a tabular form.



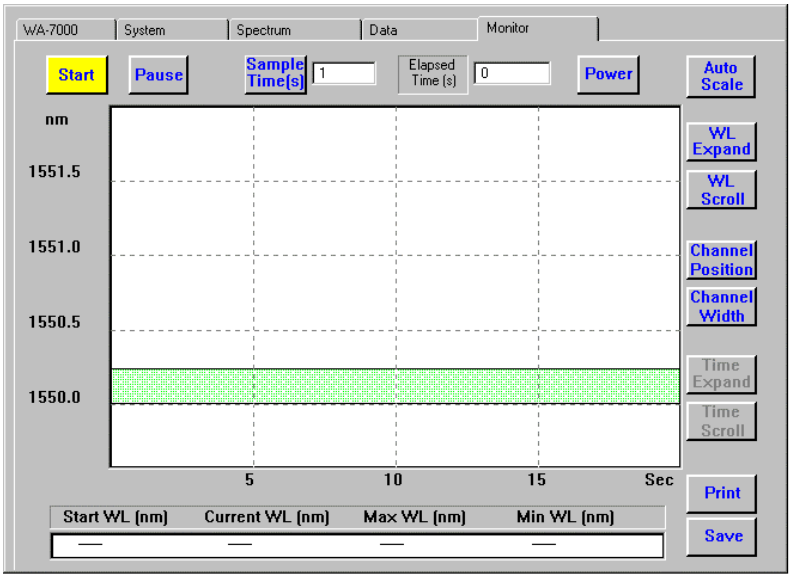

| Ch | WL (nm) | P (uW) | OSNR (dB) | FWHM (pm) | delta Ref (nm) | delta Ch (nm) | delta ITU (nm) |
|---|---|---|---|---|---|---|---|
| 1 | 1550.1115 | 662.12 | 37.94 | 43.4420 | -2.4075 | ------- | -0.0045 |
| 2 | 1550.9084 | 660.85 | 35.56 | 43.4867 | -1.6107 | 0.7968 | -0.0096 |
| 3 | 1551.7206 | 661.34 | 36.21 | 43.5322 | -0.7985 | 0.8122 | -0.0002 |
| 4 | 1552.5191 | 661.62 | 36.67 | 43.5770 | ------- | 0.7985 | -0.0053 |
| 5 | 1553.3184 | 660.76 | 35.31 | 43.6219 | 0.7993 | 0.7993 | -0.0104 |
| 6 | 1554.1331 | 661.71 | 36.91 | 43.6677 | 1.6140 | 0.8147 | -0.0009 |
| 7 | 1554.9341 | 660.67 | 35.23 | 43.7127 | 2.4150 | 0.8010 | -0.0060 |
| 8 | 1555.7359 | 661.20 | 36.07 | 43.7578 | 3.2168 | 0.8018 | -0.0111 |

12. To change the reference channel used in the delta Ref column, select **Ref Channel** function and use the **UP/DOWN** X-Y Control buttons.
13. The **Pause** and **Print** functions work the same way as in the Spectrum Screen.
14. To save a copy of the data table, place a floppy disk in the drive, select the **Save List** function, and press the **ENTER** button.

Note: For more detailed information on these functions, refer to **Section 3, Front Panel Communications**.

15. To move to the **Monitor** tab, press the **MODE** button. The Monitor screen provides a graphical display of wavelength drift over time or power change over time for an individual channel. While collecting data, the time scale expands automatically to accommodate the length of the measurement period by factors of 2, 5, and 10.

A green band across the wavelength versus time display defines the position and width of the channel being measured. Measurement data for that channel is shown at the bottom of the screen, once the data collection is started.




16. To start collecting data, move to the **Start** function and press the **ENTER** button.

    The Start function label changes to **Stop** while collecting data. Data collection is stopped by pressing the Enter button again, and the collected data is erased. Use the **Pause** function to halt the display updating without erasing the data.

17. The **Sample Time** is the time between plotted measurements. To change the time between measurements, move to the Sample Time function and use the **UP/DOWN** X-Y Control buttons to increase or decrease the time in seconds.

    The maximum number of data points is 3600. After you reach that number, the oldest data points are deleted as the new data points come in. For long periods of data collection, use a sample time sufficient to collect the required number of data points.

18. To quickly adjust the wavelength scale to bring the data within range, move to the **Auto Scale** function and press the **ENTER** button.

    The green band will be centered on Channel 1.

19. To select another channel, move to the **Channel Position** function and use the **UP/DOWN** X-Y Control buttons to move the green band over the data from that channel.

20. To change the wavelength range that defines the channel, move to the **Channel Width** function and use the **UP/DOWN** X-Y Control buttons to adjust the width of the green band.

21. To expand the wavelength scale about the mid-point, move to the **WL Expand** function and use the **UP/DOWN** X-Y Control buttons.

22. To shift the wavelength scale, move to the **WL Scroll** function and use the **UP/DOWN** X-Y Control buttons.

23. The **Print** function works the same way as in the Spectrum Screen.

24. To copy the channel data to a floppy disk, move to the **Save** function, and press the **ENTER** button.

25. The **Power** function (on the left of the Auto Scale button) changes the display from Wavelength versus time to Power versus time, when you press the **ENTER** button. You can toggle the display between Power and Wavelength using this function each time you press the **ENTER** button on the front panel of the Wavemeter.
26. To scale the power variation to within 10% of the top and bottom of the screen, move to the Auto Range function and press the **ENTER** button.
27. On the Power versus time display, use the Power Gain and Power Offset functions with the **UP/DOWN** X-Y Control buttons to adjust the Power scale.

    Other functions available on the Power display are equivalent to those on the Wavelength display.
28. Select **Wavelength** to return to the Wavelength versus time graph.

    Note: Continue with the next section if you want to set up the system parameters.

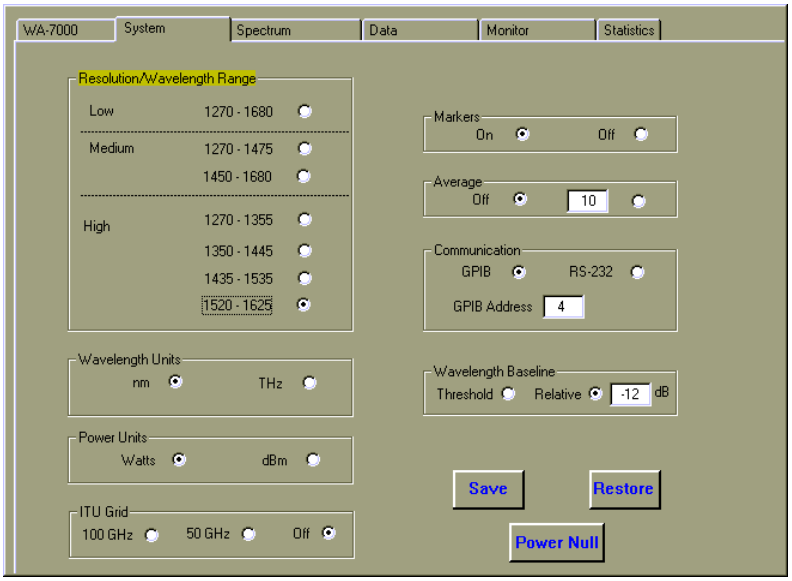
29. To turn off the WA-7000, press the **Power** button on the front panel.

## Setting Up the System

Follow the steps below to change the system parameters:

1. Move to the **System** tab, by pressing the **MODE** button.

   The System screen appears.




2. To change the wavelength range, move to the **Resolution/Wavelength** section of the screen and use the **UP/DOWN** X-Y Control buttons to the select the wavelength range that meets your requirements.

   The full operating range is 1270-1680 nm. To be properly identified, all wavelengths existing in the source must fall within the wavelength range selected. When all wavelengths are within a narrow spectral band, choosing a smaller wavelength range will result in a higher resolution spectral display.

3. To change **Wavelength Units**, move to the Wavelength Units section and select wavelength (nm) or frequency (THz) using the **LEFT/RIGHT** X-Y Control buttons.
4. To change **Power Units**, move to the Power Units section and select the linear scale (Watts) or the decibel/log scale (dBm) using the **LEFT/RIGHT** X-Y Control buttons.
5. To make the **ITU Grid** appear on the Spectrum display, move to the ITU Grid section and select the 100 GHz or 50 GHz grid. If you do not want any grid displayed, select **Off**.
6. To make the **Markers** appear on the Spectrum display, move to the Markers section of the screen and turn them on or off using the **LEFT/RIGHT** X-Y Control buttons. The two markers can be used to identify points on the spectrum.
7. To activate the **Average** function, move to the Average section and use the **RIGHT** X-Y Control buttons to turn it **On**. Then use the **UP/DOWN** X-Y Control buttons to enter a value corresponding to the number of internal update cycles you want to use for the average calculation.

   The Average function is provided to measure the average performance of the source. The WA-7000 updates the wavelength every two seconds. If the source wavelength is fluctuating, it may be difficult to get a perfect measurement. In this case, you may prefer to get an average measurement.
8. The **Communication** section of the screen allows you to select the interface of your choice, GPIB or RS-232. Move to the Communication section and select either GPIB or RS-232 using the **LEFT/RIGHT** X-Y Control buttons. If GPIB is selected, use the **UP/DOWN** X-Y Control buttons to enter a GPIB address in the text box provided.

   Now you have identified the system settings that you want to use.
9. If you decide not to use the new settings, move to the **Restore** function and press the **ENTER** button to return to the last saved configuration.
10. To **Save** the new configuration, you must first leave the System screen**.** You can either use the Mode button to return immediately to the System screen or you can return later. Once you have returned to the System screen, move to the Save function and press the **ENTER** button. Your system settings are now saved.
11. To perform a **Power Null** calibration, move to the Power Null function and press the **ENTER** button.

    The Power Null calibration is provided to zero the background offset for the power detector (Refer to Section 3, **Front Panel Communications** for more information.

Refer to the next section for detailed descriptions of each WA-7000 function.

# Section 3. Front Panel Communications

To use the WA-7000, follow the step-by-step procedure in Section 2, Operation.

To learn more details about the Wavemeter controls, screen displays and parameter values, refer to the information below. This section is meant to be used as a reference for the WA-7000.

## Front Panel Controls

The Wavemeter front panel is shown in Figure 2.1. The controls are described below.

The color VGA display reports all measurement data in a variety of formats. There are several different screens, each with different information and buttons for selecting parameters that affect how the data is collected and how the information is displayed.

The standard 3.5” floppy disk drive allows the operator to save data to a floppy disk and to install any future software upgrades.

| Control | Description |
|---|---|
| POWER | The POWER switch turns the Wavemeter on and off. The LED indicator shows the power status. When lit, the unit is turned on, when not lit, the unit is off. |
| MODE | The MODE button selects the displayed mode of operation. When you press this button, the system scrolls through the five modes of operation in the order WA-7000, System, Spectrum, Data, Monitor. Refer to *Modes of Operation* later in this section for additional information. |
|  | The SELECT UP button selects and highlights the active function/parameter in the current mode of operation. When you press this button, the system scrolls counter clockwise through the various functions/parameters that can be modified by the operator. The value of the selected function/parameter is changed using the X-Y Control buttons. |
|  | The SELECT DOWN button’s function is identical to the Select Up button, except it scrolls through the various functions/parameters in the clockwise direction. |
| ENTER | The ENTER button activates various functions selected by the Select Up or Select Down buttons. |
|  | The X-Y Control buttons control the values of various measurement and display parameters after you select the desired function/parameter with the select buttons. |

## Using the Front Panel Controls

Use the front panel controls to review information and make changes to the available parameters.

### Changing Modes of Operation

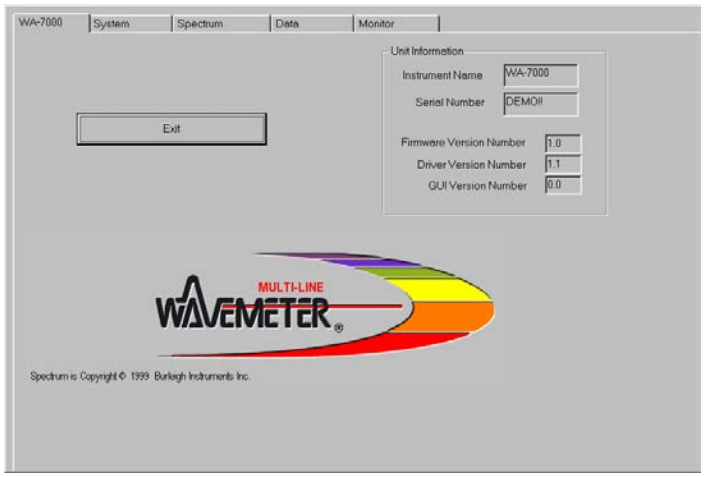
The WA-7000 has five modes of operation: WA-7000, System, Spectrum, Data, and Monitor. Press the MODE button to cycle through the five modes of operation starting with the File tab.

### Changing Parameter Values

Use the SELECT UP/SELECT DOWN Buttons to scroll up or down through the available functions. The selected function will be highlighted in yellow. Then use the UP/DOWN and LEFT/RIGHT X-Y Control buttons to adjust the highlighted function. Some functions on the screen must be activated by pressing the ENTER button .

## WA-7000 Mode

The WA-7000 Wavemeter logo and information about the hardware and software version appear on the system's VGA display when you select the WA-7000 mode. It is also possible to exit the Wavemeter application from this mode.




### Exit

Exit allows you to close the Wavemeter application.

### Unit Information

This function provides information about the WA-7000 including the serial number, firmware version number, driver version number and Graphical User Interface (GUI) version number.

## System Mode

The System mode allows you to set all the measurement and display parameters.

### Resolution/Wavelength Range

This sets the operational wavelength range to be used for measurements. The complete wavelength range of the WA-7000 is 1270 to 1680 nm. When this entire range is selected, the spectral resolution of the measurements is limited to 80 pm (~10 GHz). In order to increase the spectral resolution of the measurements, a more limited wavelength range can be used. Therefore, seven wavelength range choices are available. These choices include complete wavelength coverage with 80 pm spectral resolution (~10 GHz), moderate wavelength coverage with 60 pm spectral resolution (~7.5 GHz), and limited wavelength coverage with 50 pm spectral resolution (~6.6 GHz).

The wavelength ranges and approximate resolution specifications are shown in the table below:

| **Wavelength Range (nm)** | **Spectral Resolution (pm)** |
|---|---|
| 1270 - 1680 | 80 |
| 1270 - 1475 | 60 |
| 1450 - 1680 | 60 |
| 1270 – 1355 | 50 |
| 1350 – 1445 | 50 |
| 1435 – 1535 | 50 |
| 1520 - 1625 | 50 |

### Wavelength Units

This sets the units of wavelength (nm) or frequency (THz) displayed in the Spectrum, Data, and Monitor modes of operation. The units automatically switch from nm to pm, or THz to GHz, for high resolution measurements.

### Power Units

This sets the units of optical power that are displayed in the Spectrum, Data, and Monitor modes of operation. The choices are watts and dBm. When power in watts is chosen, the system automatically scales between mW, μW and nW.

## ITU Grid

This activates or deactivates the use of the International Telecommunications Union (ITU) grid in the Spectrum or Data modes of operation. When operating in the Spectrum Mode, grid lines are displayed that partition the horizontal axis with either the 100 GHz or the 50 GHz ITU grid, whichever is chosen. When operating in the Data Mode, the difference between measured values and the closest value from the chosen ITU grid is automatically calculated.

## Markers

This activates or deactivates two markers used to determine the wavelength and the power of any single point of the displayed spectrum in the Spectrum mode of operation.

## Average

This activates or deactivates the averaging feature of the WA-7000. To set the number of scans to average use the Select Up or Select Down buttons to highlight Average, use the left/right X-Y Control buttons to turn Average on, then use the **UP/DOWN** X-Y Control buttons to set the desired value.

## Communication

This sets the method of instrument interface to either a GPIB or an RS-232. The default setting is RS-232.

## Save

This function saves the current parameter settings of the System Mode and Spectrum Mode. Once this is executed, the saved parameters will be the parameters set at power up.

**IMPORTANT:** **To SAVE the new settings, you must first leave the System screen.** You can either use the Mode button to return immediately to the System screen or you can return later.

To save the parameters, use the SELECT UP or SELECT DOWN buttons to highlight Save, then press the ENTER button.

## Restore

This function restores all parameter settings stored by the last executed Save. To restore the parameters use the Select Up or Select Down buttons to highlight Restore, then press the ENTER button.

### Power Null

This function allows you to perform a power null calibration.

To do the calibration,

1. Use the Select Up or Select Down buttons to highlight Power Null.
2. Press the ENTER button. The system displays a dialog box with instructions.
3. Place the cap on the Input connector.
4. Press Enter. When the power null calibration is complete, the system displays the Power Null *Calibration successful* dialog box.
5. Press the ENTER button.
6. Reconnect the fiber optic cable to the INPUT connector.

## Spectrum Mode

The Spectrum Mode displays the full optical spectrum of the input signal using the units chosen in the System Mode. The units on the horizontal axis are wavelength (nm) or frequency (THz), both increasing in value to the right. The vertical axis of power is displayed in units of mW/μW/nW or dBm. When you first select Spectrum Mode, the entire wavelength range chosen from the seven options in System Mode is displayed. At the upper right corner of the spectrum, a Thumbnail of the full wavelength range (green area) identifies the wavelength range and location of the display.

For convenient reference, the grid lines on the spectrum are plotted and labeled with rounded values that fit between 5 and 10 equally spaced divisions in either axis of the spectrum. It is also possible to display grid lines that partition the horizontal axis with either the 100 GHz or the 50 GHz ITU grid. When the ITU grid lines are selected in the System Mode, they appear in a different color than the standard grid lines.

Peaks are identified as any signal with an intensity greater than the threshold level. All peaks above the threshold level are labeled with a number that increases toward longer wavelength. When frequency units are used, the numerical order of the peak labels is reversed to maintain a consistent label for each peak. Detailed information for any one of the peaks can be listed in the table below the spectrum.

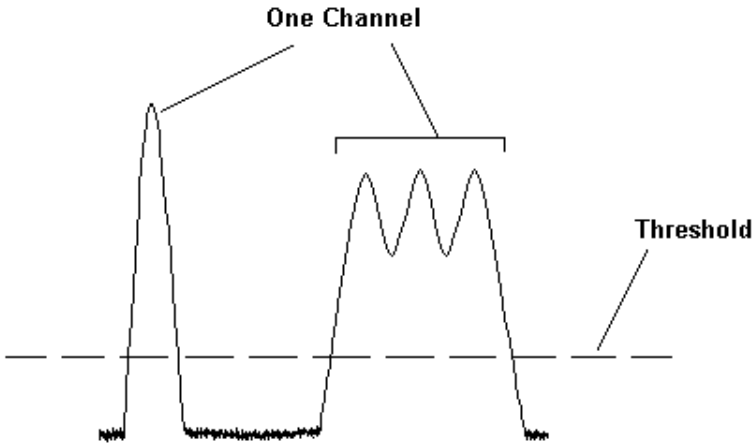
### Total Power

Indicates the total power of the optical input signal.

## Threshold

This function sets and labels the threshold level of measurement. Only peaks with an intensity level greater than the threshold are identified and measured. To adjust the threshold, use the Select Up or Select Down buttons to highlight Threshold, then use the up/down X-Y Control buttons to change the threshold value by an amount equal to one screen pixel at a time. Holding the up/down buttons accelerates the threshold movement.

One channel includes any peaks that fall within the area from the point where the intensity goes above the threshold to the point where the intensity goes below the threshold, as shown below.

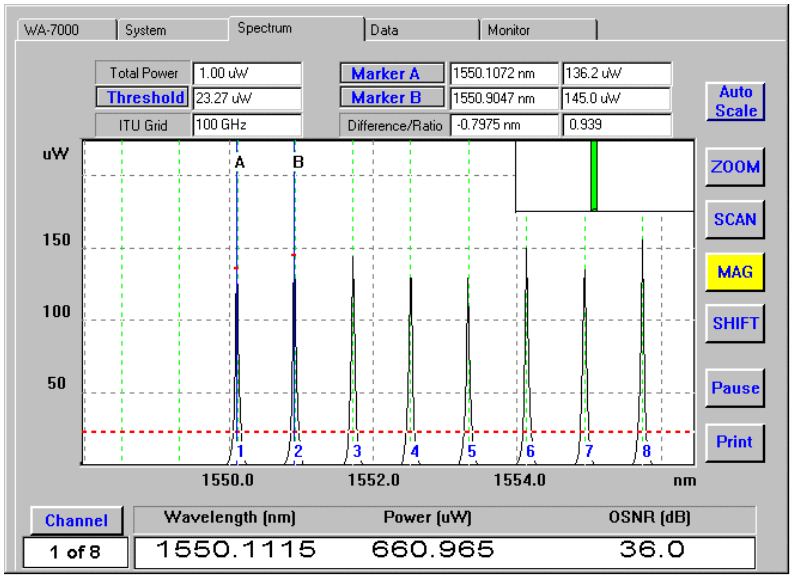



## ITU Grid

Displays the status of the ITU Grid setting on the System screen: 100 GHz, 50 GHz or Off. If the Grids are on and there is not enough resolution of the Spectrum window, then the Grids do not display and the ITU Grid status is “Hidden.”

## Marker A and Marker B

These functions activate and display two markers that can be set to determine the wavelength and the power of two selected points of the displayed spectrum. The wavelength and Power values for each marker are listed next to the Marker A and Marker B boxes.




To use the markers, use the Select Up or Select Down buttons to highlight Marker A or Marker B then use the left/right X-Y Control buttons to change the marker position by an amount equal to one screen pixel. Holding the left/right buttons accelerates the marker movement. If the markers are turned off in the System Mode, this function is not active.

## Difference/Ratio

Displays the difference between the wavelength of the peak under Marker A and the peak under Marker B, and the ratio of the respective powers.

## Auto Scale

The Auto Scale function resets the vertical scale of the displayed spectrum. The peak with greatest intensity is set to approximately two thirds of the full scale display. In addition, the threshold level is set to approximately 1/100 of the peak with greatest intensity. To activate this function, use the Select Up or Select Down buttons to highlight Auto Scale, then press the ENTER button.

## ZOOM

The ZOOM function sets and labels the horizontal scale of the displayed spectrum. When you first select Spectrum Mode, the complete wavelength range is automatically displayed. To view a smaller wavelength range, use the Select Up or Select Down buttons to highlight ZOOM, then use the left/right X-Y Control buttons to increase/decrease the display's horizontal scale. The ZOOM function expands and shrinks the display horizontally relative to the center of the display.

## SCAN

The SCAN function adjusts which portion of the measured spectrum is displayed. To view a different portion of the spectrum, use the Select Up or Select Down buttons to highlight SCAN, then use the left/right X-Y Control buttons to shift the horizontal scale by 1 division in the appropriate direction. Holding the left/right buttons accelerates the shift.

## MAG

The MAG function sets and labels the vertical scale of the displayed spectrum. To change the scale, use the Select Up or Select Down buttons to highlight MAG, then use the up/down X-Y Control buttons to decrease/increase the display's vertical scale. The magnify function is done relative to zero intensity for the linear scale.

## SHIFT

The SHIFT function adjusts which portion of the vertical scale is displayed. To change the vertical scale, use the Select Up or Select Down buttons to highlight SHIFT, then use the up/down X-Y Control buttons to shift the vertical scale by 1 division in the appropriate direction. Holding the up/down buttons accelerates the shift.

## Pause/Go

The PAUSE function stops the display update. To pause the display, use the Select Up or Select Down buttons to highlight Pause and press the ENTER button. The display stops updating, and the button label changes to Go. All other functions can be used when Pause is activated. To deactivate the Pause function and update the display with new information, use the Select Up or Select Down buttons to highlight Go and press the ENTER button.

## Print

The PRINT function prints the current display on a printer connected to the parallel printer port. To print the current display, use the Select Up or Select Down buttons to highlight Print and press the ENTER button. If the Pause function is activated, the display will print as it is shown. If the Pause function is not activated, the system will finish the current update, and print the resulting display.

Note: To use the Print function, it is first necessary to install the correct printer driver. Refer to Appendix E.

## Channel

This function allows you to view information about individual peaks, including the peak number with the total number of peaks found above the threshold level, the wavelength or frequency of the peak, the intensity of the peak in the chosen units, and the signal-to-noise ratio. To view data on a peak, use the Select Up or Select Down buttons to highlight Channel. Then use the up/down or the left/right X-Y Control buttons to change the identified peak by one at a time.

## Data Mode

The Data mode of operation displays a table that lists various numerical data for all of the peaks with an intensity greater than the threshold level.

1. If the number of peaks is greater than the number of rows that can be shown on the screen, use the Select Up or Select Down buttons to highlight the Ch column, and then use the up/down X-Y Control buttons to move through the table. With a mouse, use the scroll bar on the right side of the table to view the desired rows.
2. Use Ref Channel to select the peak used as a reference to calculate various wavelength differences listed in the table.

| Parameter | Description |
|---|---|
| Ch | Labels the number of each of the peaks identified with an intensity greater than the threshold level. |
| WL | Lists the wavelength (nm) or the frequency (THz) of each of the peaks identified with an intensity greater than the threshold level. The units used are chosen in the System Mode. |
| P | Lists the power in the units chosen in the System Mode of each of the peaks identified with an intensity greater than the threshold level. |
| OSNR | Lists the optical signal-to-noise ratio of each of the peaks identified with an intensity greater than the threshold level. |
| FWHM | Lists the full width at half intensity of each of the peaks identified with an intensity greater than the threshold level. |
| Delta Ref | Lists the difference between the wavelength or the frequency of each peak and the reference peak. For the reference peak, the column displays "----------." |
| Delta Ch | Lists the absolute value of the difference between the wavelength or the frequency of each peak and its adjacent lower numbered peak. |
| Delta ITU | Lists the difference between the wavelength or the frequency of each peak and the nearest ITU grid. If an ITU grid is not selected in the System Mode, the column will display "----------." |

## Threshold

The Threshold box lists the power level of the threshold in the units selected in the System Mode. All peaks listed will have power greater than the Threshold level.

## Total Power

Indicates the total power of the optical input signal.

## Channels Found

Lists the number of peaks identified with an intensity greater than the threshold level.

### Ref Channel

Identifies the peak that is used as a reference to calculate various wavelength differences listed in the table. To change the reference peak, use the Select Up or Select Down buttons to highlight Ref Channel, then use the up/down X-Y Control buttons to change the identified peak by one increment at a time.

### Pause/Go

The Pause function stops the display update. To pause the display, use the Select Up or Select Down buttons to highlight Pause and press the ENTER button. The display stops updating, and the button label changes to Go. All other functions can be used when Pause is activated. To deactivate the Pause function and update the display with new information, use the Select Up or Select Down buttons to highlight Go and press the ENTER button.

### Print

The Print function prints the current display on a printer connected to the parallel printer port. To print the current display, use the Select Up or Select Down buttons to highlight Print and press the ENTER button. If the Pause function is activated, the display will print as it is shown. If the Pause function is not activated, the system will finish the current update, and print the resulting display.

Note: To use the Print function, it is first necessary to install the correct printer driver. Refer to Appendix E.

### Save List

The Save List function saves the current display to the floppy disk drive in .CSV format. To save the current display, use the Select Up or Select Down buttons to highlight Save List and press the ENTER button. If the Pause function is activated, the data will be saved as it is shown. If the Pause function is not activated, the system will finish the current update, and save the resulting data.

The data is saved in comma separated value (CSV) format that is easily loaded into programs such as Microsoft Excel for analysis.

The file is identified by a label consisting of the letters "ch" followed by the year, date and time (24-hour military time). For example, a "Save List" file recorded on September 27, 1999 at 10:22:41 would have the label: "ch1999 927102241.csv".

## Monitor Mode

The Monitor mode shows a graphical display of wavelength over time or power over time. While collecting data, the time scale expands automatically to accommodate the length of the measurement period by factors of 2, 5, and 10.

### Start/Stop

The Start button allows you to start collecting data. When you select Start, the button label changes to Stop.

The Stop button erases the current data and resets the Elapsed Time clock to 00:00:00. When you select Stop, the button label changes to Start.

## Pause/Go

The Pause function stops the display update but does not stop data collection. To pause the display, use the Select Up or Select Down buttons to highlight Pause and press the ENTER button. The display stops updating, and the button label changes to Go. All other functions can be used when Pause is activated. To deactivate the Pause function and update the display with new information, use the Select Up or Select Down buttons to highlight Go and press the ENTER button.

## Sample Time

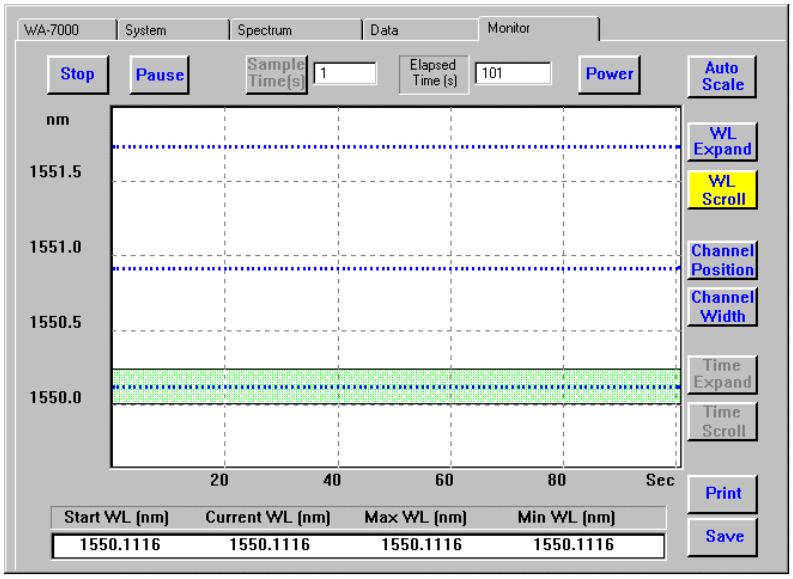
Displays the time period between samples (in seconds). The default value is 2 seconds. To change the sample time use the Select Up or Select Down buttons to highlight Sample Time, then use the up/down X-Y Control buttons to set the desired value.

## Elapsed Time

Indicates the elapsed time since data collection started (in seconds). The elapsed time updates each time the system samples the data.

## Wavelength Graph

When the Power button is visible on the screen, the system displays a Wavelength or Frequency versus time graph over the same time interval for all channels.




## Power

This button is visible only in the Wavelength graph. The Power button switches the display to a power versus time graph over the same time interval for the selected channel. The power is all the power recorded within the channel width defined by the green band displayed on the wavelength versus time graph. Use the Select Up or Select Down buttons to highlight Power and press the ENTER button. The Power button label changes to Wavelength.

## Auto Scale

This button is visible only in the Wavelength graph. When the system is collecting data, Auto Scale selects the first channel and expands the vertical scale. When the system is not collecting data, Auto Scale resets the vertical scale of the displayed graph with the wavelength range displayed reset to the entire wavelength range chosen from the seven options in the System Mode. To activate this function, use the Select Up or Select Down buttons to highlight Auto Scale, then press the ENTER button.

## WL Expand

In the Wavelength graph, this function allows you to expand the vertical scale about the mid-point. When you first select the Monitor Mode, the screen automatically displays the entire wavelength range chosen in the System Mode. To view a narrower wavelength range, use the Select Up or Select Down buttons to highlight WL Expand, then use the up/down X-Y Control buttons to change the vertical scale.

## WL Scroll

In the Wavelength graph, once you change the vertical scale, the WL Scroll function allows you to scroll up and down through the entire wavelength range. To view a specific wavelength range, use the Select Up or Select Down buttons to highlight WL Scroll, then use the up/down X-Y Control buttons to change the desired wavelength range.

## Channel Position

The Channel Position function allows you to move the channel selector (green band) up and down to identify the data for any channel. To view data on a specific channel, use the Select Up or Select Down buttons to highlight Channel Position, then use the up/down X-Y Control buttons to move the channel indicator over the desired channel. The box at the bottom of the screen shows the starting wavelength, current wavelength, maximum wavelength and minimum wavelength of the selected channel.

## Channel Width

The Channel Width function allows you to change the width of the channel selector (green band). To do this, use the Select Up or Select Down buttons to highlight Channel Width, then use the up/down X-Y Control buttons to adjust the width of the green band to cover all data plotted for that channel.

## Time Expand

When the system is paused, the Time Expand function allows you to contract or expand the time scale at the bottom of the screen so you can view a smaller time period than the total elapsed time.

## Time Scroll

When the system is paused and the time scale is expanded, the Time Scroll function allows you to scroll through the reduced time scale at the bottom of the screen to view a selected time period.

## Print

The Print function prints a record of elapsed time, wavelength and power for the selected channel in .CSV format on a printer connected to the parallel printer port. To print the current data, use the Select Up or Select Down buttons to highlight Print and press the ENTER button. If the Pause function is activated, the data will be printed as it is shown. If the Pause function is not activated, the system will finish the current update, and then print the data.

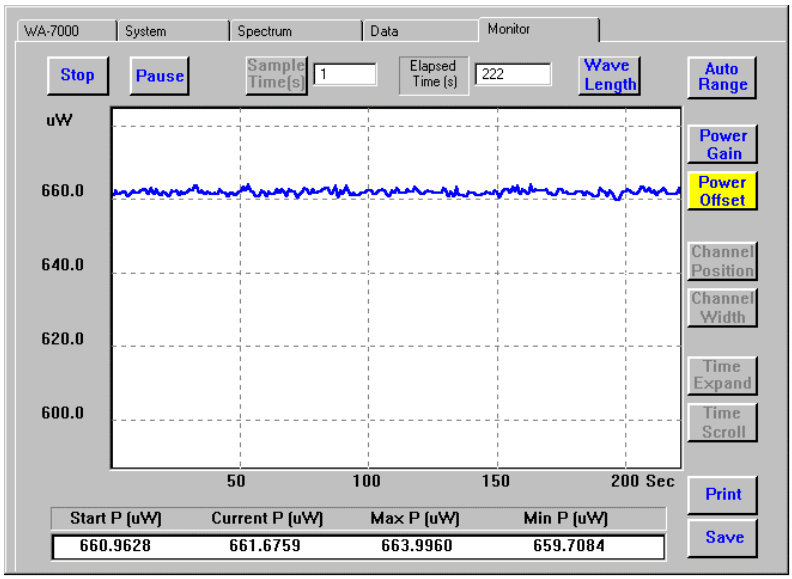
## Save

The Save function saves a record of elapsed time, wavelength and power for the selected channel in Excel™ compatible .CSV format on the floppy disk. To save the current data, use the Select Up or Select Down buttons to highlight Save and press the ENTER button. If the Pause function is activated, the data will be saved as it is shown. The data is stored in THz and milliwatt units only.

The file label is the letter "m" followed by the year, date and time. For example, a "Save" file recorded on September 27, 1999 at 11:22:33 would have the label: “m1999 927112233.csv.”

## Power Graph

When the Wavelength button is visible on the screen, the system displays a Power versus time graph over the same time interval as the wavelength graph for the selected channel.




## Wavelength

This button is visible only in the Power graph. The Wavelength button switches the display to a wavelength versus time graph over the same time interval. Use the Select Up or Select Down buttons to highlight Wavelength and press the ENTER button. The Wavelength button label changes to Power. Pressing the ENTER button again returns the display to Power versus Time.

## Auto Range

The Auto Range function in the Power graph resets the maximum and minimum peaks to within 10% of the top and bottom of the screen. To activate this function, use the Select Up or Select Down buttons to highlight Auto Range, then press the ENTER button.

## Power Gain

In the Power graph, this function allows you to expand the vertical scale about the mid-point. To change the power range, use the Select Up or Select Down buttons to highlight Power Gain, then use the up/down X-Y Control buttons to change the vertical scale.

## Power Offset

In the Power graph, once you change the vertical scale, the Power Offset function allows you to scroll up and down through the entire vertical scale. To use this function, use the Select Up or Select Down buttons to highlight Power Offset, then use the up/down X-Y Control buttons to shift the power range.

# Section 4. Remote Communications

This section discusses the use of remote communications to review and control the Wavemeter.

## Overview

You can control the Wavemeter remotely using either an RS-232 or a GPIB interface using the SCPI communications protocol. Connections for both interfaces are provided on the rear panel of the Wavemeter as shown later in this section.

You must use the Wavemeter front panel controls to enable remote communications for the specific type of interface. Refer to the description of System Mode in Section 2 of this manual for information.

## RS-232 Interface

The RS-232 port is a 9-pin, female, D-sub style connector, with the pinout described in Table 3-1. The connector housing provides connection to the earth ground inside the Wavemeter.

The pin configuration complements that of the Personal Computer (PC). To connect the Wavemeter to a PC, use a serial extension cable with 1:1 pin correlation. To facilitate the connecting of the serial port, use the signal descriptions.

Baud: 19200

Data Bits: 8

Parity: None

Stop Bits: 1

Handshaking: None

Figure 4-1. RS-232 Serial Interface Connector

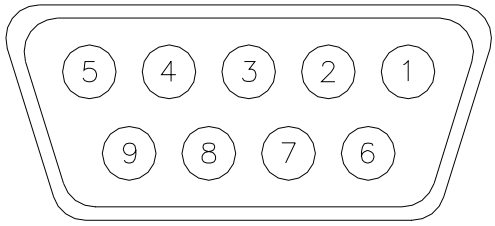



Table 4-1. RS-232 Serial Port Pinout

| Pin Number | Signal Name | Signal Source | Description |
|---|---|---|---|
| 1 | - | - | N/C |
| 2 | TxD | WA-7000 | Transmit Data. Data from the Wavemeter is output on this signal pin. |
| 3 | RxD | User | Receive Data. Data from the user is received on this signal pin. |
| 4 | DSR | User | Data Set Ready. This input signal must be held active by the user for the Wavemeter to consider the serial port connected to an external device. |

| | | | |
|---|---|---|---|
| 5 | GND | - | Signal Ground. Required for proper RS-232 operation. |
| 6 | DTR | WA-7000 | Data Terminal Ready. This output signal is active whenever the Wavemeter is powered and is not in internal reset. |
| 7 | CTS | User | Clear To Send. An input signal indicates to the Wavemeter when the user device is able to accept additional data. |
| 8 | RTS | WA-7000 | Request To Send. The Wavemeter makes this signal active as long as its internal command buffer has room in it. When the internal command buffer is full, the Wavemeter sets RTS inactive. |
| 9 | - | - | N/C |

## GPIB Interface

The Wavemeter has a GPIB communications port on the back panel as shown in Figure 3-2. The GPIB port uses the standard IEEE-488 connector, with the pinout described in Table 3-2.

Figure 4-2. GPIB Interface Connector

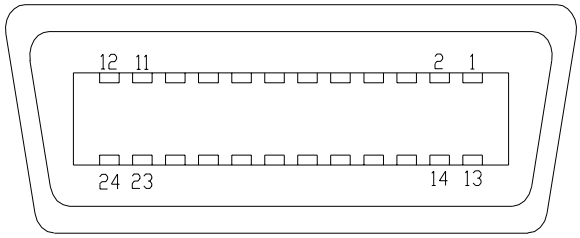



Table 4-2. Standard IEEE-488 Connector Pinout

| Pin Number | Signal Name |
|---|---|
| 1 | DIO1 |
| 2 | DIO2 |
| 3 | DIO3 |
| 4 | DIO4 |
| 5 | EOI |
| 6 | DAV |
| 7 | NRFD |
| 8 | NDAC |
| 9 | IFC |
| 10 | SRQ |
| 11 | ATN |
| 12 | SHIELD |

| Pin Number | Signal Name |
|---|---|
| 13 | DIO5 |
| 14 | DIO6 |
| 15 | DIO7 |
| 16 | DIO8 |
| 17 | REN |
| 18 | GND (TW W/ DAV) |
| 19 | GND (TW W/ NRFD) |
| 20 | GND (TW W/ NDAC) |
| 21 | GND (TW W/ FC) |
| 22 | GND (TW W/ SRQ) |
| 23 | GND (TW W/ ATN) |
| 24 | SIGNAL GROUND |

## GPIB System Controller Settings

This section describes how to set up your GPIB system controller for proper message termination and bus timing to communicate with the WA-7000 Wavemeter. Other settings may also work, but these are the settings that usually work the best.

**Set EOI at End of Write = Yes**

This causes the system controller to assert the EOI signal during the last byte of a message written to the Wavemeter.

**Set EOI With EOS on Write = No**

The system controller should not assert the EOI signal when it writes an EOS character. The system controller should instead assert the EOI signal when sending the last byte of the message (which will be an EOS character anyway).

**EOS Byte = 10**

The Wavemeter uses a linefeed character (10, 0x0a, or \n) to identify the end of a message.

**8-Bit EOS Compare = Yes**

This causes the system controller to examine all eight bits of a received character to determine if it is an EOS character.

**Terminate Read on EOS = Yes**

The Wavemeter terminates all of its messages with an EOS character. It never uses the EOS character within a message. Therefore, when the system controller receives an EOS character from the Wavemeter, it can assume that it has received the last character of the message.

**GPIB Bus Timing = 2000ns or 2µs**

This sets the minimum time that the system controller will assert the DAV signal after driving a byte onto the bus.

**Use Board's FIFOs = Never**

It is unnecessary to use the FIFOs on the controller board for this application.

## SCPI Communications Scheme

This topic provides information on the communication scheme that follows the Standard Commands for Programmable Instruments (SCPI) Syntax and Style Guidelines.

Table 3-3 provides a summary of commands by subsystem and the information after the table describes each command in detail.

Note: […] indicates an optional argument. {…|…|…} indicates a choice from a set of arguments.

Table 4-3. SCPI Command Summary

| Group & Command | Description |
|---|---|
| **Common Commands** | These commands are defined by IEEE 488.2 and control some functions that are common to all IEEE 488.2 instruments. |
| *CLS | Clears all event registers and the error queue. |
| *IDN? | Queries Wavemeter model number, serial number and firmware version. |
| *RCL | Restores Wavemeter settings. [1] |
| *RST | Resets Wavemeter to default settings. [1] |
| *WAI | Simply a “No operation” function for the WA-7000 wavemeter. |
| **Measurement Instructions** | These commands configure and obtain measurements from the Wavemeter. |
| :FETCh{:SCALar \| :ARRay}{:POWer \| :WAVelength \| :FREQuency \| :WPO}? | Queries power, wavelength, frequency and the WPO (wavelength, power, and optical signal to noise ratio in a single reading) that have already been captured during the last scan. |
| :MEASure{:SCALar \| :ARRay}{:POWer \| :WAVelength \| :FREQuency \| :WPO}? | Queries power, wavelength, frequency and the WPO (wavelength, power, and optical signal to noise ratio in a single reading) that will be captured during the next scan.<br>Measure is the equivalent of ABORt; INITiate; FETch. |
| :READ{:SCALar \| :ARRay}{:POWer \| :WAVelength \| :FREQuency \| :WPO}? | Queries power, wavelength, frequency and the WPO (wavelength, power, and optical signal to noise ratio in a single reading) that will be captured during the next scan.<br>READ is the equivalent of ABORt; INITiate; FETCh.<br>READ is interpreted to mean, “Initiate a new reading and return the value when the reading is complete.” |
| **SYSTem Subsystem** | These commands control system-wide parameters. |
| :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 Wavemeter. |
| :SYSTem:VERSion? | Returns the year and revision of the SCPI standard that the Wavemeter follows. |
| **TRIGger Subsystem** | These commands control the triggering of the Wavemeter. Since the Wavemeter is fundamentally not a triggered instrument, these commands have little effect on the Wavemeter's operation. |
| :ABORt | Aborts a current measurement. |
| :INITiate[:IMMediate] | Initiates a new reading. |

[1] The WA-7000 Wavemeter does not allow remote control of its operation settings. These commands perform no function at this time.

## SCPI Command Detail

This section provides detailed information for all Wavemeter SCPI programming commands. The commands are organized by subsystem.

### Common Commands

| | |
|---|---|
| ***CLS** | The *CLS (clear status) command clears the event status register and the error queue. |
| ***IDN?** | The *IDN (identification number) query returns a string value which contains the Wavemeter type, serial number, and firmware version. The third value is the Wavemeter serial number. The last value is the software version and will reflect the actual version number.<br>Return data example: BURLEIGH WAVEMETER, WA-7000, 1001, 1.0 |
| ***RCL** | The *RCL (recall) command restores Wavemeter settings. |
| ***RST** | The *RST (reset) command returns the Wavemeter's settings to a known state. |
| ***WAI?** | The WA-7000 Wavemeter is a device that only implements sequential commands, therefore this is simply a "No operation" function. |

### Measurement Instructions

Use the measurement instructions to return a reading to the remote monitoring software. The three basic measurement instructions are FETCh, READ, and MEASure. Functions for these instructions are POWer, WAVelength, FREQuency, and WPO (Wavelength, Power, and Optical signal to noise ratio).

The WA-7000 measures input continuously, it does not measure on a "one-shot" basis. New data is ready every 2 seconds.

A :FETCh will return a reading based on the last complete scan. However, if :FETCh queries are made faster than new data is available, it is possible to get the same reading twice. Old readings are indicated by a bit in the questionable status register.

:MEASure and :READ get a new reading after the next complete scan. :MEASure and :READ guarantee that each reading returned is a new one. If you want to get multiple measurement types from a single scan (i.e. WAVelength, POWer, etc.), you should use :READ followed by one or more :FETCh queries. Or use the measure command WPO, see below.

:MEASure and :READ are actually macros that execute multiple SCPI commands in the instrument. :READ is equivalent to:

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

and :MEASure is equivalent to:

```
:ABORt
:CONFigure <function>
:READ?
```

For the Wavemeter, :MEASure and :READ perform essentially the same function.

**Arrays**

The SCALar/ARRay subcommand provides a mechanism by which data can be read from the WA-7000 either in a single data element format or multiple data elements respectively. When the instrument returns an Array of ASCII data, commas will separate the data elements.

**Operational Note**:

When the instrument is in the Monitor screen mode and the monitor function has been started, then the channels have been "locked" into placed. That is, even if the power level of one of the channels happens to fall below the threshold, the Measure command will still return its data.

**:MEASure:SCALar:POWer? [<parameter>] or**
**:READ:SCALar:POWer? [<parameter>] or**
**:FETCh:SCALar:POWer? [<parameter>]**

Returns a power reading. The addition of an optional <parameter> can be one of following:

**none** – if no parameter is given then it assumes MAX

**MAX** – MAXimum, returns the power reading of the highest Peak Power signal.

**MIN** – MINimum, returns the power reading of the lowest Peak Power signal (above the threshold).

The return power reading is in W.

If no peaks are above threshold (i.e. no channels) then MAX an MIN parameters will return 0.

**:MEASure:ARRay:POWer? or**
**:READ:ARRay:POWer? or**
**:FETCh:ARRay:POWer?**

Returns the power reading of all channels with a Peak Power signal greater than the current threshold value.

The return power reading is in W.

The return string is the <number of channels> followed by each of the channels power reading <channel 1> through <channel n> all separated by commas. Example:

4, -1.1934E+001, -9.025E+000, -6.825E+000, -1.1543E+001

If no Peak Power signal is above the threshold then the instrument simply returns 0, for 0 readings.

**:MEASure:SCALar:FREQuency? [<parameter>] or**
**:READ:SCALar:FREQuency? [<parameter>] or**
**:FETCh:SCALar:FREQuency? [<parameter>]**

Returns a frequency. The addition of an optional <parameter> can be one of following:

**none** – if no parameter is given then it assumes MAX.

**MAX** – MAXimum, returns the frequency of the highest frequency signal.

**MIN** – MINimum, returns the frequency of the lowest frequency signal.

The return value is in THz.

If no peaks are above threshold (i.e. no channels) then MAX and MIN will return 0.

**:MEASure:ARRay:FREQuency? or**
**:READ:ARRay:FREQuency?or**
**:FETCh:ARRay:FREQuency?**

Returns the frequencies of all channels with a Peak Power signal greater than the current <threshold value>.

The return values are in THz.

The return string is the <number of channels> followed by each of the channels frequency <channel 1> through <channel n> all separated by commas.

Example: 4, 1.93824E+014, 1.93623E+014, 1.93419E+014, 1.93214E+014

If no Peak Power signal is above the threshold then the instrument simply returns 0, for 0 readings.

**:MEASure:SCALar:WAVelength? [<parameter>] or**
**:READ:SCALar:WAVelength? [<parameter>] or**
**:FETCh:SCALar:WAVelength? [<parameter>]**

Returns a wavelength. The addition of an optional <parameter> can be one of following:

**none** – if no parameter is given then it assumes MAX.

**MAX** – MAXimum, returns the wavelength of the highest wavelength signal.

**MIN** – MINimum, returns the wavelength of the lowest wavelength signal.

The return value is in nm.

If no peaks are above threshold (i.e. no channels) then MAX and MIN will return 0.

**:MEASure:ARRay:WAVelength? or**
**:READ:ARRay:WAVelength? or**
**:FETCh:ARRay:WAVelength?**

Returns the wavelengths of all channels with a Peak Power signal greater than the current <threshold value>.

The return value is in nm.

The return string is the <number of channels> followed by each of the channels wavelength <channel 1> through <channel n> all separated by commas.

Example: 4, 1.5284E-006, 1.5302E-006, 1.5285E-006, 1.5264E-006

If no Peak Power signal is above the threshold then the instrument simply returns 0, for 0 readings.

**:MEASure:SCALar:WPO? [<parameter>] or**
**:READ:SCALar:WPO? [<parameter>] or**
**:FETCh:SCALar:WPO? [<parameter>]**

Returns wavelength, power, and optical signal to noise ratio in a single reading. WPO is an acronym for Wavelength, Power, Optical SNR. The addition of an optional <parameter> can be one of following:

**none** – if no parameter is given then it assumes MAX

**MAX** – MAXimum, returns the wavelength, power, and optical signal to noise ratio of the highest wavelength signal.

**MIN** – MINimum, returns the wavelength, power, and optical signal to noise ratio of the lowest wavelength signal.

The return value is nm, W, dBm.

The return string is <wavelength value>, <power value>, <SNR value>.

Example: 1.5284E-006, -1.1934E+001, 3.043+001

If no peaks are above threshold (i.e. no channels) then MAX and MIN will return 0.

**:MEASure:ARRay:WPO? or**
**:READ:ARRay:WPO? or**
**:FETCh:ARRay:WPO?**

Returns wavelength, power, and optical signal to noise ratio SNR readings of all channels with a Peak Power signal greater than the current <threshold value>. WPO is an acronym for Wavelength, Power, Optical SNR.

The return value is nm, W, dBm.

The return string is the <number of channels> followed by each of the channels readings <wavelength channel 1>, <power channel 1>, <SNR channel 1>, <wavelength channel 2>, <power channel 2>, <SNR channel 2>, etc; all separated by commas. So for 4 channels there will be a 4 (for number of channels) and 12 separate data elements.

Example: 4, 1.5284E-006, -1.1934E+001, 3.043+001, 1.5302E-006, -9.025E+000, 2.612+001, 1.5285E-006, -6.825E+000, 2.239+001, 1.5264E-006, -1.1543E+001, 2.972+001

If no Peak Power signal is above the threshold then the instrument simply returns 0, for 0 readings.

## SYSTem Subsystem

**:SYSTem:ERRor?**

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 Wavemeter 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.

Returns <integer>, <string> (ex. –104, “Data type error”)

Example: 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 |

**:SYSTem:HELP:HEADers?**

Reads a list of all commands and queries supported by the Wavemeter. 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.

Returns #<integer>
<string>
<string>
<string>
...
<string>

**:SYSTem:VERSion?**

Returns the version of the SCPI specification that the Wavemeter's SCPI interface is based on. The first integer is the year and the second integer is the approved revision number for that year.

Returns <integer>.<integer>

Examples :SYST:VERS?

## TRIGger Subsystem.

The Wavemeter is unlike most SCPI instruments in that as it takes continuous readings, the scan engine controls the reading, not the user. As a result, the user should not attempt to control the Wavemeter though the Trigger subsystem. The commands below are listed only for the sake of completeness.

**:ABORt**

Halts acquisition of the current reading and returns the Wavemeter to an idle state.

Example: :ABOR

**:INITiate[:IMMediate]**

Starts the acquisition of a new reading

Examples:
:INIT
:INIT:IMM

# Section 5. Theory of Operation & Calibration

This section reviews the theory behind the operation of the WA-7000 Multi-line Wavemeter. It also discusses the factors that influence the accuracy of the measurement.

## Operating Principles

The WA-7000 Multi-line Wavemeter uses a Michelson interferometer to generate interference fringes from the input radiation. The input laser beam enters the Wavemeter through a fiber optic connector on the front panel. After collimation, the beam is directed into the Michelson interferometer. At the beamsplitter, the input beam is divided into two beams that follow separate optical paths. One beam reflects off the moving retro-reflector assembly and returns to the beamsplitter. The other beam reflects off of a fixed retroreflector and returns to the beamsplitter where it interferes with the first beam. The intensity reaching the input photodetector depends on the relative lengths of the two paths, which govern whether constructive or destructive interference occurs at the beamsplitter. As the retro-reflector moves back and forth, the detected intensity for each wavelength of the input beam varies sinusoidally. If multiple wavelengths exist in the input beam, the fringe pattern is the superposition of sinusoidal contributions from all the wavelengths.

In order to extract all the spectral components in the input beam from the Michelson interferometer fringe pattern, it is necessary to sample the detected intensity at precisely calibrated intervals in the scan of the interferometer. This is accomplished by introducing a second “reference” laser into the interferometer with an accurately known wavelength. This laser measures the displacement of the moving arm of the interferometer and provides a signal for accurately sampling the input laser fringe pattern.

After a large number of intensity values have been recorded from one scan of the interferometer, a Fast Fourier Transform is performed on the data to produce the spectrum of the input laser source. Both the wavelength and the relative power of each spectral component is obtained from the Fourier Transform.

A small portion of the input beam entering the Wavemeter is split off into a power meter. This measurement of the total input power, together with the spectral distribution from the Fourier Transform, is used to calculate the absolute power in each spectral component of the input laser source.

## Wavelength Accuracy

The wavelength accuracy of the peaks in the Wavemeter spectrum is dependent on the knowledge of the reference laser wavelength and appropriate corrections for the dispersion in the refractive index of air. The WA-7000 Wavemeter uses a HeNe reference laser with refractive index correction based on temperature and pressure measurements inside the interferometer. The absolute accuracy of the reference laser wavelength is better than 0.5 parts per million.

Wavelength accuracy also depends on the alignment of the reference laser beam and the input laser beam in the Michelson interferometer. Fiber optic input coupling and stable opto-mechanical design ensure that the interferometer alignment does not change significantly with time and environmental conditions.

At the time of manufacturing, the wavelength accuracy of each WA-7000 Multi-line Wavemeter is verified with an accurately known laser source, such as a Distributed Feedback (DFB) diode laser locked to the R(3) band of acetylene ($^{12}C_2H_2$). The center of this absorption line has been characterized to 196,832.341 GHz ± 150 KHz by K. Nakagawa et al. in "Accurate optical frequency atlas of the 1.5m bands of Acetylene", JOSA, B, 13, 2708 (1996) using an absorption line of Rubidium as the reference standard.

## Power Accuracy

The WA-7000 internal power meter is designed with excellent linearity over the full specified power range. Correction for the power detector responsivity also ensures that good power measurement flatness is achieved over the operating wavelength range.

With the complete spectrum normalized to the total power measurement, the power in each spectral peak is computed from the integrated intensity under that peak relative to the average local baseline.

The internal power meter in every WA-7000 Multi-line Wavemeter is calibrated at the time of manufacturing using a high precision power meter that is regularly certified accurate traceable to NIST.

## Optical Signal-to-Noise Ratio

The optical signal-to-noise ratio (OSNR) is an important parameter for determining the strength of the optical signal at a certain wavelength relative to the background signal in the same spectral region. The WA-7000 measures the OSNR as the ratio of the intensity in the peak to the local noise floor. The local noise floor is determined as the average of the three lowest consecutive points in the spectrum on either side of the peak, within 50 GHz.

# Appendix A. Specifications & Labeling

This Appendix provides specifications, dimensional drawings and labeling information.

Table A-1. Specifications

| | | |
|---|---|---|
| **Wavelength Measurement** | | |
| Range | 1270 to 1680 nm (178 to 236 THz) | |
| Absolute Accuracy | ± 1.0 ppm<br>± 0.0015 nm at 1500 nm<br>± 0.0013 nm at 1300 nm | |
| Repeatability | ± 1.0 ppm | |
| Minimum Resolvable Separation | 1270 to 1680 nm | *80 pm* |
| | 1270 to 1475 nm<br>1450 to 1680 nm | *60 pm* |
| | 1270 to 1355 nm<br>1350 to 1445 nm<br>1435 to 1535 nm<br>1520 to 1625 nm | *50 pm* |
| Display Resolution | 0.0001 nm | |
| Units | nm (vacuum or standard air), THz | |
| **Power Measurement** | | |
| Absolute Accuracy | ± 0.5 dB (at ± 30 nm from 1310 and 1550 nm) | |
| Repeatability | 0.1 dB | |
| Linearity | *± 0.3 dB* | |
| Display Resolution | 0.01 dB | |
| Units | dBm, mW | |
| **Sensitivity** | | |
| 1270–1680 nm, single line input | -30 dBm (1 μW) | |

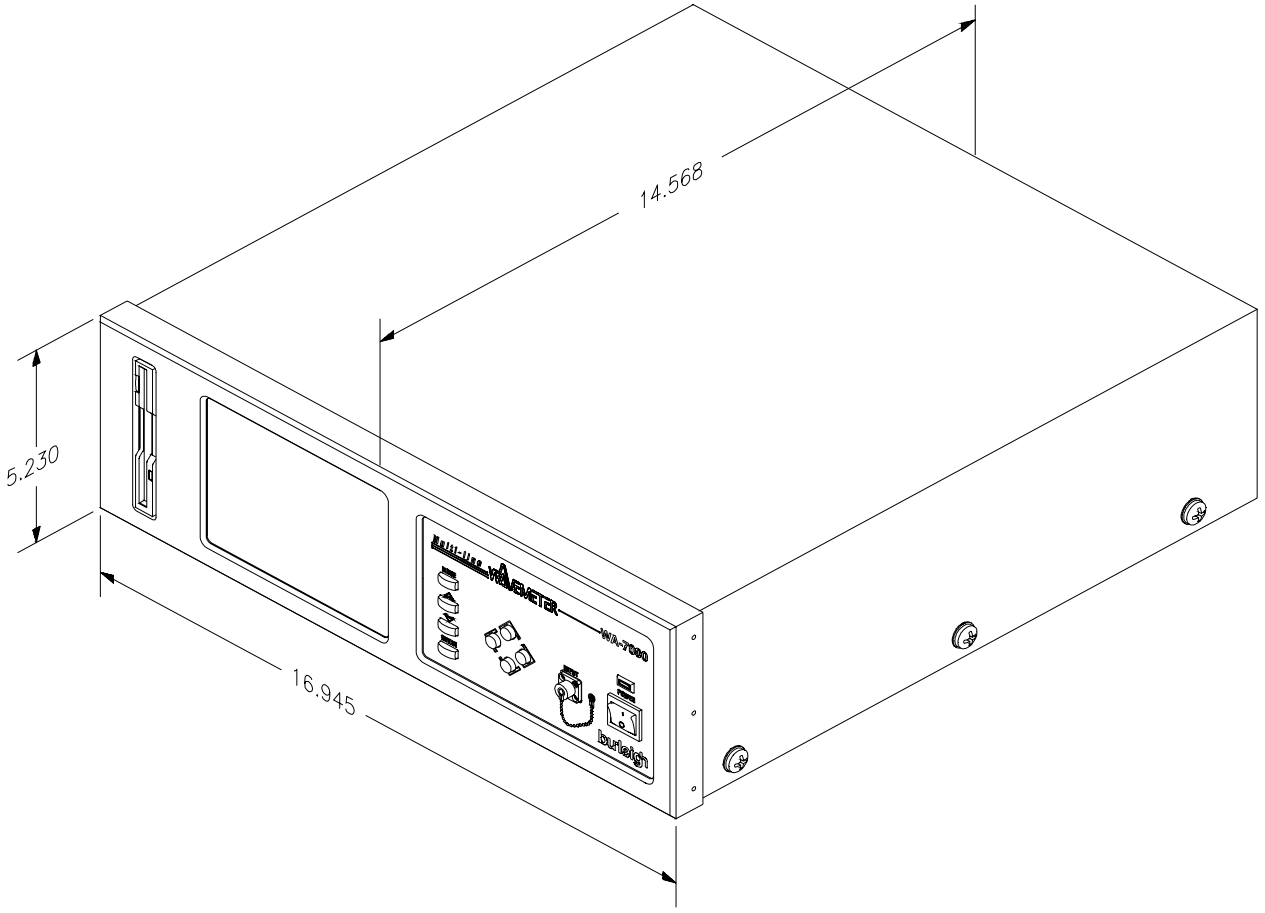
| | |
|---|---|
| **Selectivity** | |
| 2 lines input separated by ≥ 50 GHz | *25 dB* |
| 2 lines input separated by ≥ 15 GHz | *10 dB* |
| **Optical Dynamic Range** | |
| Signal-to-Noise Ratio<br>(lines above –25 dBm) | *>30 dB, channel spacing ≥ 100GHz* |
| **Input Power** | |
| Maximum Displayed Level (sum of all lines input) | +10 dBm (10 mW) |
| Maximum Safe Level (sum of all lines input) | *+18 dBm (63 mW)* |
| **Number of Laser Lines Input** | |
| Maximum | *200* |
| **Input Return Loss** | |
| With FC/PC connector | 35 dB |
| With FC/APC connector | 40 dB |
| **Measurement Cycle Time** | |
| Time (Rate) | 2.0 s (0.5 measurements/s) |
| **Inputs/Outputs** | |
| Optical Input | 9/125 μm fiber<br>FC/PC connector standard<br>FC/APC connector optional |
| Instrument Interfaces | GPIB (IEEE-488.2), RS-232 |
| Printer Port | Parallel Printer Port |
| Mouse | PS/2 |
| Video Port | VGA Monitor |
| Signal Monitor | ± 7 V Analog, TTL Digital |
| **Environmental** | |
| Temperature Range | *10 to +40 ℃ Operating, -10 to 70 ℃ Storage* |
| Pressure Range | *500 – 900 mm Hg* |
| Relative Humidity | ≤ 90% (no condensation) |
| **Dimensions and Weight** | |
| Dimensions (HxWxD) | 5.75" x 17.0" x 15.25" |
| Weight | 10.5 kgm |
| **Power Requirements** | |
| Voltage and Frequency | 90 to 260 VAC, 50/60 Hz |
| Current | *1.3 A* |
| Fuse | 1.5 A slow-blow, .25" x 1.25" or 5 x 20 mm |

* Sensitivity defines the optical input power required over most of the wavelength range. More power may be necessary at either end of the range, depending on the photodetector.

Non-Italics = Guaranteed Specifications Italics = Typical Specifications

## Dimensional Drawing

Figure A-1. Dimensions



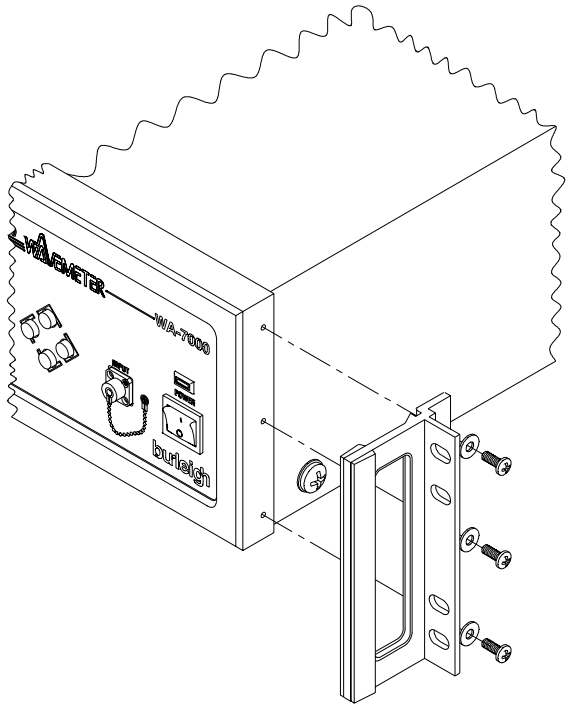
## Rack Mounting Option

The WA-7000 Wavemeter can be mounted in a standard 19" electronics rack by attaching the rack mounting brackets as shown in Figure A-2.

When the WA-7000 is mounted in an enclosed rack, be careful not to block the fan on the rear panel and provide adequate ventilation inside the rack to prevent overheating.

For proper fit, you may want to remove the feet under the chassis.

Figure A-2. Attaching Rack Mounting Brackets



# Appendix B. Warranty & Service

## Warranty

The Burleigh WA-7000 Multi-line Wavemeter is warranted against defects in material and workmanship for a period of one year after date of delivery. Optical components are warranted for 90 days. During the warranty period, Burleigh will repair, or at its option, replace parts that prove to be defective when the instrument is returned prepaid to Burleigh Instruments, Inc. **Before returning an instrument, always call Burleigh 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 Burleigh personnel.

It is important to call Burleigh Instruments or your local sales representative in advance of returning a 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 Burleigh Instruments, (except as to title) arising out of supplying of 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 WA-7000 Multi-line Wavemeter. Removing the cover of the Wavemeter will void the warranty.

# Appendix C. Status Messages

The WA-7000 Wavemeter may occasionally display a message in a "pop-up" box on the screen. The table below lists the messages that may appear and explains their meaning.

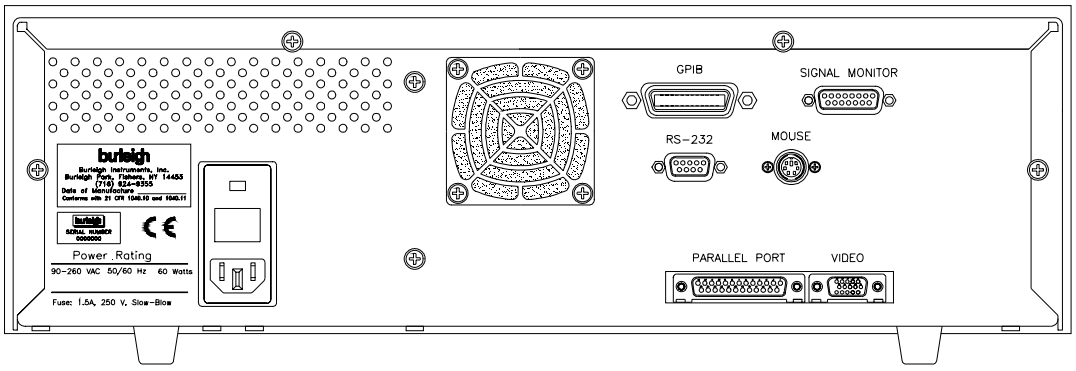
Table C-1. Status Messages

| **Message** | **Meaning and Instructions** |
|---|---|
| Place the cap on the Input connector and press ENTER. | During the Power Null operation, the cap must be on the fiber optic INPUT connector on the front panel to eliminate any input signal. |
| Input power is too high … place the cap on the input connector and press ENTER. | Power Null operation failed. Input power is too high for zero level calibration of power meter. Place the cap on the fiber optic INPUT connector and press ENTER to perform the Power Null. |
| Power Null calibration successful | Power Null operation succeeded. |
| System error … service required | A system error has been detected. Turn off the power switch, wait a few seconds and turn on the instrument again. If the same message appears, contact Burleigh's Service Department for instructions. |

# Appendix D. Rear Panel Controls

The WA-7000 rear panel contains an AC power connector and six interface connectors. This Appendix describes the function of the SIGNAL MONITOR, MOUSE, PARALLEL PORT, and VIDEO connectors on the WA-7000 rear panel. For information on the function of the RS-232 and GPIB connectors, refer to Section 3, Remote Communications.

Figure D-1. Wavemeter Rear Panel




## Signal Monitor Connector

The Signal Monitor connector on the back panel of the Wavemeter provides a combination of analog and digital signals for observing the fringe signals and measuring timing signals using an oscilloscope. The signals have the characteristics described in Table D-2.

The Signal Monitor output is a 15-pin, female, D-sub style connector shown in Figure D-1 and with the pinout described in Table D-2.

Table D-1. Signal Monitor Characteristics

| | **Analog Signals** | **Digital (TTL) Signals** |
|---|---|---|
| Output Voltage | ± 7 V maximum | $V_{OL}$ = 0.4V max, $V_{OH}$ = 2.4V min |
| Output Current | 100 mA maximum | $I_{OL}$ = 16 mA max, $I_{OH}$ = -0.4 mA |
| Output Timing | NA | $t_r \leq 7$ nsec, $t_f \leq 7$ nsec |

Figure D-2. Signal Monitor Output Connector

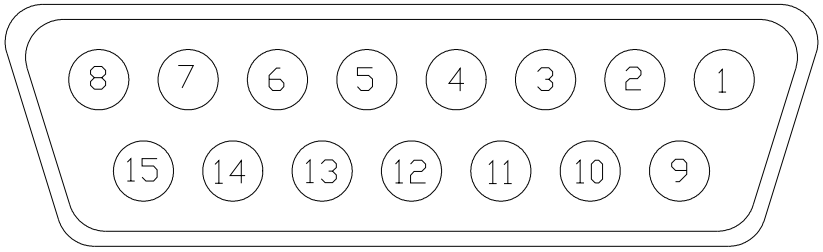


Table D-2. Monitor Pinout

| Pin Number | Signal Name | Signal Type | Description |
|---|---|---|---|
| 1 | INPUT | Analog | Input laser sinusoidal fringe signal. |
| 2 | REFERENCE | Analog | Reference laser sinusoidal fringe signal. |
| 3 | VREF | TTL | Valid reference laser fringe amplitude. |
| 4 | ZOP 1 | TTL | Not used |
| 5 | 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. |
| 6 | DGND | - | Digital Ground |
| 7 | 1 TRIG | TTL | Not used |
| 8 | ZOP | TTL | Zero Optical Path (ZOP) is a digital pulse derived from the interferometer scanner that produces a low to high transition at the point in the scan where the difference between the two optical paths in the interferometer is zero. |
| 9 | AGND | - | Analog Ground |
| 10 | AGND | - | Analog Ground |
| 11 | | | N/C |
| 12 | | | N/C |
| 13 | | | N/C |
| 14 | DGND | - | Digital Ground |
| 15 | WINDOW | TTL | Not used |

## Mouse Connector

Allows you to connect a PS/2 mouse to the WA-7000 in order to move freely about the display screen to select the mode of operation or to select and highlight the active function/parameter in the current mode of operation. The mouse can be used instead of the Mode, Select Up, and Select Down buttons.

## Parallel Port

Allows you to connect a printer to the WA-7000 to print data and display screens. Operation with your printer requires installation of the appropriate printer driver software. See Appendix E for instructions.

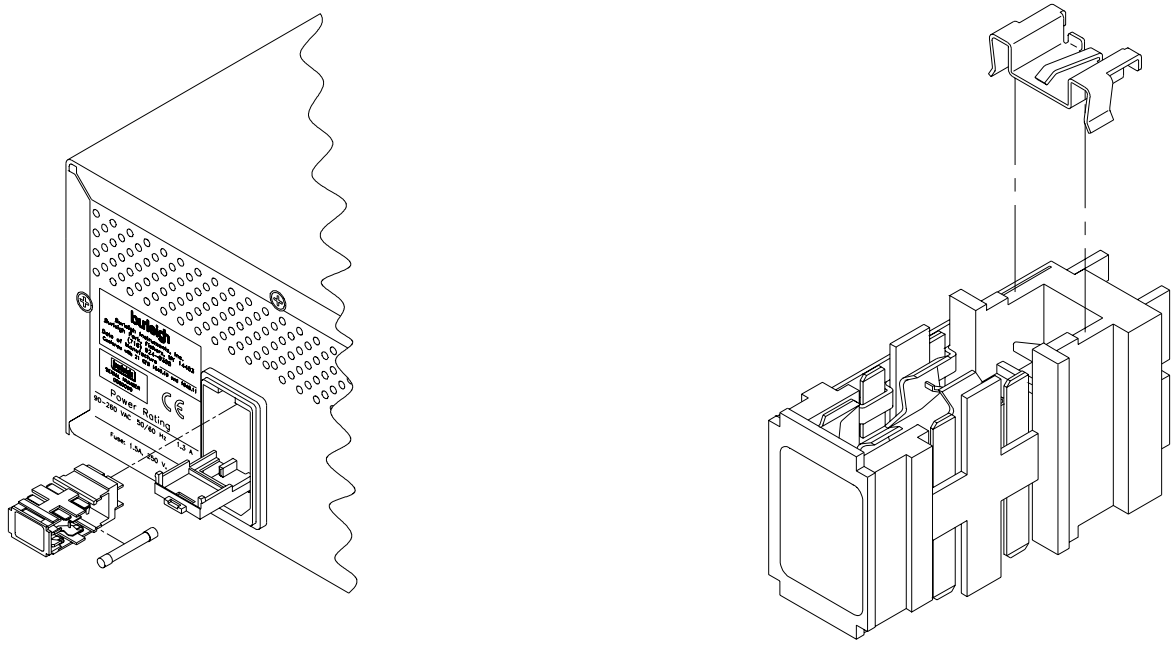
## Video Connector

Allows you to connect a standard VGA video monitor to the WA-7000 to provide a larger display equivalent to the front panel display.

## Changing Fuses

The WA-7000 Wavemeter can accept either single or dual line fuses as required by local regulations. The fuses are accessible at the rear panel of the instrument. The method for changing fuses is shown in Figure D-3 below.

Figure D-3. Changing Fuses



The fuse holder can be used for either single line or dual line fusing. The WA-7000 comes from the factory with only one line fused. Removing the adapter clip (Figure D-2) allows dual fuses.

The fuse holder can hold 1.5 Amp, slow-blow, ¼" x 1¼" or 5 x 20mm style fuses.

# Appendix E. Installing a Printer Driver

The WA-7000 requires installation of the correct printer driver software to interface to your printer. Follow the instructions below to install a printer driver.

The requirements for installing a printer driver are:

- Knowledge of installing printer drivers for Microsoft Windows operating systems.
- Knowledge of moving files from a diskette to a hard disk in a computer.
- A PS/2 Mouse.
- 3.5" Diskette(s) containing the needed files for the printer driver.

If the drivers fit onto a single diskette then you may install directly from the diskette. Select the A: drive when browsing for the necessary files.

If the drivers are too large for a single diskette then move all of the files from several diskettes to the directory C:\WINDOWS\TEMP. Then select the C:\WINDOWS\TEMP drive and directory path when browsing for the necessary files.

Installation Instructions:

1) Move the Mouse Pointer to the lower left-hand corner of the screen.
2) After the Task Bar appears, click the Start button.
3) From the Start menu select Settings/Printers.
4) From the Printers window, double-click the Add Printer icon.
5) Follow the Wizard installation instructions for adding your specific printer to the WA-7000.
6) Using the above information to describe where the files can be found, select the correct drive and directory path to obtain the needed driver file.

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# *Declaration of Conformity*

**Manufacturer's Name:** Burleigh Instruments, Inc.

**Manufacturer's Address:** Burleigh Park
Fishers, NY 14453-0755
USA

*declares this product:*

**Product Name:** Multi-line Wavemeter

**Model Number(s):** WA-7000

*conforms to the following standards:*

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

**EMC:** EN-50081-1: EN-55011; Group 1, Class A : Emissions
EN-50082-1: IEC 1000-4-2: ESD Immunity; 4kV CD, 8kV AD
IEC 1000-4-3: RFI Immunity; 3V/m, 80-1000 MHz, 80% AM
IEC 1000-4-4: Electrical Fast Transient Immunity; 1 kV (peak)

**Supplementary Information:** "The product complies with the requirements of the **Low Voltage Directive 73/23/EEC** and the **EMC Directive 89/336/EEC**."

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CE

*signed:*

David J. Farrell, President

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