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**Chapter 1 - Introduction**

This manual describes the operation of the WaveStar CCD Spectrometer.

**Overview**

The WaveStar CCD Spectrometer is a wavelength and spectrum measurement system for real-time measurement of continuous or pulsed light sources. It provides for the display of the light intensity vs. wavelength while at the same time tagging the peaks with the exact wavelengths. Thus the WaveStar combines the best features of a wavemeter and spectrometer.

All the hardware of the WaveStar, as well as its calibration and configuration is contained in the head. Only the software must be installed in your PC. Therefore WaveStar heads are plug and play with your PC. It is a user-friendly system that presents graphical and numerical information for intuitive interpretation of data in real-time.

Some applications for the WaveStar spectrometer include:

- Laser wavelength and spectrum measurement
- Pulsed light sources
- Broadband light sources
- Spectral sources

**Software Features**

The WaveStar software features include:

- Automatic tagging of peaks with wavelength and spectral width (FWHM)
- Calibrated intensity vs. wavelength
- Storage and recall of files with full manipulation of recalled files.
- Printing of graphs and data
- Shutter control for wide dynamic range
- Photodiode trigger to capture single shot events
Theory of Operation

The WaveStar spectrometer is a dispersive instrument based on light passing through a slit, impinging on a diffraction grating and being imaged onto a linear array CCD detector. The linear CCD is a row of detectors called pixels. The pixels instantly record the amount of energy impinging on their surface, thus recording the optical pattern of spectrum as an intensity distribution corresponding to the spectrum as dispersed by the grating. The WaveStar is calibrated by exposing it to more than 20 known spectral lines over the wavelength range of the head and fitting the best curve to these spectral lines. The intensity is calibrated by exposing the head to a NIST-traceable calibrated continuous light source and adjusting the sensitivity curve to match the known relative sensitivity of the NIST traceable light source. A conventional spectrometer, based on this principle is shown in the figure below. Note that there is a need for either special optics or a nonflat grating to insure that the image plane falls flat onto the CCD.

The Ophir WaveStar uses an innovative optical design, different from the one shown above, (patent applied for) to achieve better resolution in a smaller package. The Ophir WaveStar can resolve spectral lines to 3-4 times better resolution than competing spectrometers. In addition, sophisticated algorithms allow the WaveStar to display the peak wavelength to 0.05nm accuracy – many times what is usually available in a similar instrument.

The WaveStar also has a built-in photodiode trigger which permits the capture of single shot or slowly pulsing events, something not usually available.
Hardware Features

All the electronics associated with the CCD, the raw processing and storage of head calibration and data are in the WaveStar head. The WaveStar electronics consists of the following components:

(i) A Linear CCD Detector (3000 points) with adjustable integration time (Shutter Time Control)
(ii) A fast Analog-to-Digital converter chip (A-to-D)
(iii) A ‘Programmable Logic Device’ chip (PLD)
(iv) Static RAM (SRAM)
(v) A photo-transistor trigger circuit
(vi) Power supply circuit
(vii) Buffer and filter circuits
(viii) Connection to PC host (D-type 15-pin to standard PC parallel port connector, D-type 25-pin)

Functional Description:

The PC host can configure the PLD to control the operating mode of the CCD and the Shutter Time. The Shutter Time setting controls how long the CCD is exposed to light (integration time) during each measurement. The longer this time, the larger the output signal from each pixel of the CCD for a given light level. In order to obtain an accurate measurement of wavelength, it is desirable to maximize the CCD output signal but without saturating the CCD, as this distorts the measurements of power intensity and broadens the width of the wavelength peaks. Therefore it is necessary to adjust the Shutter Time setting according to the incident light level on the head.

Normal (CW) operation is intended for use with continuous or rapidly pulsing light sources. In this mode, the CCD is continuously measuring. At the end of each Shutter Time period, the voltage measured by each pixel of the CCD is read out of the CCD serially, and converted by the A-to-D into a 12-
bit digital value. This digital value is then stored in the SRAM. When the PLD has finished reading all the pixels of the CCD it signals to the PC that data is ready to be uploaded. After the PC has finished uploading the data, it waits until the next available measurements of the CCD are ready to be uploaded, and the cycle continues.

**Pulsed Mode for Long Pulses (>5us)** is intended for use with relatively long and slowly pulsing sources of light. In this mode, the CCD cycle is initiated by the photo-transistor trigger circuit instead of automatically as for the CW mode. As the pulse length of the light source is long compared to the time taken to trigger the CCD (approximately 5us), there is still time for the intensity of the light to be integrated by the CCD after it has been triggered. Note that using this mode, the first few micro-seconds of the pulse may be missed by the CCD, until the CCD integration begins.

**Pulsed Mode for Short Pulses (<5us)** is intended for use with short and slowly pulsing sources of light, but it can also be used for longer pulses if so desired. This mode uses a different method from that of the Long Pulse Mode: the CCD is triggered automatically as with the CW mode, but after each integration cycle of the CCD, the PLD checks to see whether the trigger circuit received a pulse while the CCD was measuring. If so, the data is extracted from the CCD, stored in the SRAM and uploaded by the PC as normal; otherwise it is thrown away and another cycle is begun immediately. This creates a situation where a very large fraction of the time (>99.9%) the CCD is integrating and is ready to receive a light pulse; only for a few micro-seconds between each exposure time, while the PLD is determining whether a pulse arrived during the last integration period, is the CCD disabled from receiving pulses. Assuming the Shutter Time setting is long enough (>100ms for example), the statistical chance of catching a single pulse is very high: only for approximately 20us out of 100ms or more (better than 1 in 5000) is the CCD not ready to catch the exposure. When using this mode, the software ensures the Shutter Time will be long enough by allowing adjustment of the frequency of the light source rather than the Shutter Time itself – from 10Hz (100ms) up to single shot (several seconds Shutter Time). In this way, the Shutter Time will always be long enough to give a
very high chance of capturing the pulse. Note that for slowly pulsing sources, the frequency should be correctly adjusted to avoid capturing more than one of the pulses while the shutter is open – in fact, if capturing more than one pulse is desirable (due to low exposure levels, for example) it could be better to use the CW mode instead of the this mode. For Single Shot pulses, the Shutter Time is adjusted accordingly by the software, only limited by the level of noise obtained by leaving the shutter open for too long.

In most cases of pulsed light sources, CW operation will be sufficient (and the intensity can be adjusted by adding filters or reducing the Shutter Time). In that case, the Shutter Time should be adjusted to capture a few pulses of light for each CCD integration, to avoid having ‘empty’ measurement cycles where no light is captured by the CCD. In the case that the pulses are slow, and/or the Shutter Time would have to be excessively long to guarantee capturing at least one pulse each time, the Pulse Mode operation can be used instead.
Chapter 2 - Quick Reference

This chapter provides brief instructions for operating your WaveStar Spectrometer. Full explanations of these various operations can be found throughout this manual.

**Setting the exposure control (Shutter Time)**

To increase or decrease the exposure time, press on the right or left arrows. Press the space next to the arrows for quick change.

**Starting, stopping, gridlines and region of interest**

Press the icon to start and the icon to stop.

**Gridlines:**

Press the icon for gridlines.

**Region of Interest:**

1. Drag the left and right vertical cursors to the first and last wavelength of the desired wavelength region of interest.
2. When the icon is pressed, the display expands to cover only the region of interest.

**Threshold:**

Drag the horizontal threshold bar to the position desired for threshold of displaying numerical data.

**Zooming:** Drag the mouse cursor diagonally over the region you wish to expand. The region will be marked by vertical red dotted lines. Now release the mouse and the marked region will be expanded. You may zoom a number of nested times if you wish.

To return, right click on the mouse and unzoom one level or all levels as desired. Select “unzoom one level” to go back the last level of zoom. Select “reset zoom” to unzoom completely.
Power Correction: To obtain a display which shows the correct relative power over the wavelength region press the **icon. To scale the result over the full screen, press the **icon.

Offset: To offset the background reading, cover the input to the WaveStar and press the **icon. Click on “new offset” and “next” and “save offset” when reading of offset is completed.

Henceforth, press **whenever you wish to subtract the offset from your reading.

Saving and viewing a snapshot

To record a Snapshot, press the **snapshot icon, add a comment if desired, give a filename and save.

To recall a snapshot, select file/open. When the dialog opens, select the directory and click on the file desired. The snapshot file will open.

Spectrometer and diagnostic screen

To access the diagnostic screen, press the **icon. To return to the spectrometer screen, press the **button.

Printing Screen Displays

Printing Files

To print a screen, open the File menu and select Print or From the Control Toolbar, click **. The file screen will be printed. The default setting is landscape but the screen can also be printed in portrait mode and will adjust itself to that format.
Chapter 3 - Installation

This chapter provides instructions for installing the hardware and software for the WaveStar spectrometer.

Package Contents
The WaveStar spectrometer consists of:
- The WaveStar head
- 3 ft connecting cable to PC parallel port
- Wall cube power supply
- A Windows software package on 3 ½" diskette.

Hardware Requirements
To run the WaveStar spectrometer, the computer system must meet the following minimum requirements:

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Pentium 200MHz</td>
</tr>
<tr>
<td>System RAM</td>
<td>32MB RAM</td>
</tr>
<tr>
<td>Hard disk</td>
<td>10MB HD free</td>
</tr>
<tr>
<td>CD ROM</td>
<td>1 CD ROM drive</td>
</tr>
<tr>
<td>Operating system</td>
<td>Windows 95/98</td>
</tr>
<tr>
<td>Mouse</td>
<td>Microsoft mouse or equivalent</td>
</tr>
<tr>
<td>VGA display</td>
<td>800 x 600 resolution</td>
</tr>
<tr>
<td>Port</td>
<td>One free parallel port</td>
</tr>
</tbody>
</table>

Installing the WaveStar software
To install the software
1. Start your computer.
2. Insert the WaveStar spectrometer installation diskette or CD ROM in the floppy drive.
3. Open the drive with the Windows explorer
4. Find the Setup icon and double click on it
5. The Add New Hardware Wizard guides you through the installation process. At the end of the process, the WaveStar icon will be installed on the PC desktop.
After completing the installation, proceed to **below**.

**Connecting the WaveStar head**

After completing the software, connect the 3 ft. D15 to D25 connector between the WaveStar and the parallel port of your PC. (This is usually used as the printer port. If you want to operate the printer and the WaveStar at the same time, install an extra parallel port in your PC). Connect the wall cube power supply to the AC power and plug in to the round socket of the WaveStar head.

*Fiber adapters, diffusers and attenuators*

If your source is a fiber, you can connect the light source to the WaveStar via an Ophir fiber connector. One SMA adapter is included with the WaveStar head. If the source is too strong, you can use Ophir attenuators and/or diffusers. The diffuser is also helpful if the source is small such as a laser beam. It makes the WaveStar insensitive to the exact position of the beam. If the source is weak, you can use the SMA adapter screwed into the adapter with the focusing lens. The focusing lens focuses the fiber output onto the slit and greatly increases the intensity into the WaveStar.

Below is a list of the connection accessories available from Ophir. All accessories screw into each other and are stackable so for instance you can mount an attenuator on the WaveStar and on top of that a fiber adapter or a lens and on top of that an SMA adapter etc.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Ophir P/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA fiber adapter</td>
<td>Adapter for SMA fiber cable input (one included with WaveStar)</td>
<td>1G01236</td>
</tr>
<tr>
<td>20:1 attenuator</td>
<td>NG9 filter glass attenuator with ~20:1 attenuation in the visible</td>
<td>1Z08200</td>
</tr>
<tr>
<td>200:1 attenuator</td>
<td>NG10 filter glass attenuator with ~200:1 attenuation in the visible</td>
<td>1Z08201</td>
</tr>
<tr>
<td>Diffuser</td>
<td>Fused silica diffuser</td>
<td>1Z08204</td>
</tr>
<tr>
<td>Lens</td>
<td>Lens to focus fiber output onto slit.</td>
<td>1Z08205</td>
</tr>
</tbody>
</table>
Chapter 4 - Setting Up the WaveStar Spectrometer

This chapter provides instructions for setting up the WaveStar spectrometer.

1. From the desktop, double click [image]. The program will open. You will see the following screen:

   - start
   - stop
   - exposure control
   - gridlines
   - print
   - region of interest
   - snap
   - freeze
   - shot
   - power correction
   - spectrometer screen
   - diagnostic screen

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[Image of product]
2. Now go into the setup screen by clicking on “setup/system”. You will see the following screen:

This screen adjusts the type of triggering of the CCD and the shutter opening time (integration time). The longer the Shutter Time, the longer the exposure and the higher the output signal level.

In order to obtain accurate measurements, it is desirable to maximize the CCD output signal by increasing the Shutter Time. However, the Shutter Time should not be set so high as to cause the output signal to enter saturation, as this distorts the measurements of power intensity and broadens the width of the wavelength peaks.

**CW setting:**

When you choose the default CW setting, the Wavestar measures continuously using the chosen Shutter Time. The CW option is the best setting for almost all situations except for single shot events or very slowly pulsing light sources < 1pps. Adjust the Shutter Time to give the maximum signal level without saturation.
Single shot or slowly pulsing: >5us setting:
In this mode, the CCD is triggered by the internal photo-transistor circuit. This mode can be used for a slowly pulsing or a single-shot source, with pulse width greater than 5µs. On condition that the pulse width is long enough, the CCD will still have time to measure the pulse after it is triggered, and before the pulse is finished. In this case, the Shutter Time should be set to the pulse width of the incident pulses, or slightly longer, in order to capture the entire pulse. In a case where this gives excessive exposure, the Shutter Time can be reduced to avoid saturation of the CCD during the integration time.

Single shot or slowly pulsing: <5us setting:
In a case where the pulses are short, less than approximately 5µs, the Long Pulse mode cannot be used, because once the CCD is triggered the pulse will already be finished. In this case, a second mode of operation is available. Using the Short Pulse mode, the CCD is triggered automatically and measures continually as for the CW mode. However, in this mode, at the end of each CCD integration time the PLD checks to see if the photo-transistor trigger circuit received a trigger while the CCD was integrating. If there was a trigger, the data is stored in the SRAM, downloaded to the PC and displayed on the screen; if there was no trigger, the data is discarded and another integration period is commenced immediately.

Using this mode, the Shutter Time control is replaced by an adjustment of the 'Pulse Repetition Rate', between 10Hz and single-shot. Adjust the setting to match the light source being used in practice. In this way, the software adjusts the Shutter Time setting automatically in order to match it to the incident pulses – so that only one pulse can be received for every exposure time of the CCD. The Shutter Time is maximized according to the pulse rate of the incident pulses in order to increase to a maximum the chances of capturing each pulse – which are already very good (better than 99.98%).
This mode can also be useful for long pulses, for example in a case where the beginning of the pulse must not be missed – as in that case the Long Pulse mode is not adequate. If using the Short Pulse mode for long pulses, the mode of operation is identical to that described for short pulses.

3. After having chosen the trigger mode, go to setup/display.

Region of Interest: Choose the wavelength region of interest or leave it at the default maximum. (You may also vary the region of interest from the main screen as described later).

Peak Detect: This exclusive and sophisticated feature tags the wavelength peaks with the peak wavelength value to a high degree of precision. The software interpolates between pixels to get even higher accuracy than the pixel spacing. The wavelength value will be shown in red on top of the peak. If the peak is saturated, the value will be shown at the top of the screen.

Note: If the wavelength peak is saturated, the accuracy will be less.

FWHM: This feature displays the full width half maximum of the peak. This is the width of the peak at half its maximum value.
**Note:** The software shows the FWHM as measured by the WaveStar. The FWHM includes any inherent width due to the resolution of the instrument and this has to be subtracted from the value shown. For instance, if the value shown is 2.5nm and the instrumental line width is 0.5nm then the true value is really 2.0nm. Since the instrumental line width is on the order of 0.2 – 0.5nm, the FWHM measurement is of value only for line widths greater than about 1nm.

**Threshold:** In many cases, the screen could be cluttered up with many overlapping wavelength values on the screen if the spectrum has many peaks. This feature allows you to only display those peaks which are above a chosen threshold (from 1 to 100% of full scale). This feature is also operable from the main screen using the horizontal bar on the screen. After you have chosen the settings, save and exit.
Chapter 5 - General WaveStar Spectrometer Operations

This chapter discusses the following WaveStar spectrometer operations:

- Setting the exposure control
- Starting, stopping and freezing measurement
- Gridlines, setting the region of interest and threshold
- Zooming
- Saving and viewing a snapshot
- Spectrometer and diagnostic screen
- Printing Screen Displays
- Exporting data

![Diagram showing various control elements related to spectrometer operations.]

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Setting the exposure control
The WaveStar is able to vary the exposure time of the CCD camera so as to be more or less sensitive to the light. If the light source is strong, we want to have a short exposure, if it is weak we want a long exposure. To change the exposure time do as follows:

To increase the exposure time, press on the right arrows or drag the icon right. Press next to the arrow for quick change. To decrease the exposure time, press on the left arrows or drag the icon left. Press next to the arrow for quick change. The screen will update with the new exposure times but remember it takes some time for the screen to react, especially for long exposures. The above description applies to the CW setting on the trigger. For pulsed trigger settings, see page 20

Starting, stopping and freezing measurement
The default startup setting is for the WaveStar to be in measurement mode with the start button depressed. If you want to stop the measurement, press the stop button next to it. This will stop the measurement and leave the last measurement on the screen. You can still do all the manipulations on the stopped screen as on the live screen such as zoom, region of interest and threshold (see these functions below). You can also now print the screen if you wish.

Gridlines, setting the region of interest and threshold
Gridlines: If you wish to have gridlines on the screen press the icon. Press again to remove the gridlines.
Region of Interest: With the WaveStar it is possible to select a wavelength band as the region of interest. This is done by dragging the left and right vertical cursors to the first and last wavelength of the desired wavelength region of interest. The
cursors are dragged by clicking on the triangles at the bottom of the screen. When the dragging is active, the triangles become red.

Selecting a region of interest causes two things to happen:

1. The wavelengths and FWHM are not displayed outside of the region of interest.
2. When the icon is pressed, the display expands to cover only the region of interest. This is illustrated in the pictures below. Note that the region of interest is from 750nm to 900nm and no peaks are tagged outside of that region.
Threshold:
The threshold is a value set by the horizontal bar on the screen. If the peaks are below the threshold setting the wavelengths and FWHM are not displayed. If the peaks are above the threshold they are displayed.

Note: very small peaks which are determined not to be sufficiently above noise are not tagged even if they are above the threshold value set.

Zooming
It is also possible to select and expand the wavelength scale in a quick and simple manner by zooming in with the mouse. Simply drag the mouse cursor diagonally over the region you wish to expand. The region will be marked by vertical red dotted lines. Now release the mouse and the marked region will be expanded. You may zoom a number of nested times if you wish.
Region selected by mouse shows vertical red dotted lines.

Expanded wavelength scale after releasing mouse button.

To return, right click on the mouse and the following screen will open:

Mouse Dragging Actions:
- Zoom
- Area Under Curve
- Unzoom One Level
- Reset Zoom
- Reset Area Under Curve
Select “unzoom one level” to go back the last level of zoom.
Select “reset zoom” to unzoom completely.
Note: Zooming can only be done within region of interest

**Power Correction**

The WaveStar allows you to exhibit the spectrum corrected for relative power levels. This means that the true intensity vs. wavelength will be displayed. This is particularly useful for broadband spectral sources.

**Note**: Due to the widely varying sensitivity of the WaveStar for different wavelengths, in the power corrected screen some parts of the spectrum which have been amplified greatly to give the correct relative intensity may be noisy.

To display the power corrected spectrum do as follows:

1. Adjust the non power corrected screen so that the intensity is not in saturation (80% of full screen is good).

2. Press the icon to enter the power corrected screen then the icon to expand the display to maximum available screen size. Note how the display is noisy at the right due to low signal intensity (the CCD is not sensitive in the long wavelength range – see the previous non power corrected screen).
power corrected screen.

**Background Offset**

With the WaveStar it is possible to offset the background and eliminate spurious signals. This is especially useful when long exposures are necessary since with long exposures you may have "hot pixels" which give spurious output even with no signal. This is illustrated below with a weak source requiring a long exposure (7s).

To offset the background do as follows:

1. Press the icon and when the pop up menu appears, press "new offset".
2. Block the light source you wish to measure and press "next". When the offset measurement is finished, press "save offset" and the offset will be saved.
long exposure screen without offset.

same screen with background offset subtracted.

**Saving and viewing a snapshot**
The WaveStar allows you to take a *Snapshot* of the file you are working on, store it and recall it. The snapshot actually stores the raw data from the WaveStar head so when you recall it you can manipulate it just like with a live measurement. You can zoom, select threshold etc. You cannot, of course, change the exposure.
To record a Snapshot:

1. Press the snapshot icon.
2. The following screen will open.
3. Add a comment if you wish and press OK.
4. Give a filename and save in the directory you choose.

To recall a snapshot:

Select file/open. When the dialog opens, select the directory and click on the file desired. The snapshot file will open.

Note that now the setup menu is not available since you cannot change measurement settings but instead there is an “info” menu. This gives information on the snapshot as follows:

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Spectrometer and diagnostic screen

Until now we have described the operation of the WaveStar and the display of the information on the spectrometer screen. There is another screen available which will show the raw data as it comes from the linear CCD camera. This is sometimes useful as a diagnostic tool. In order to access the diagnostic screen, press the \text{D} icon. To return to the spectrometer screen, press the \text{S} button. Below we show how the same information is displayed on the spectrometer screen and the diagnostic screen. Note that in the diagnostic screen, positive light levels are displayed as a negative on the screen and the x axis is in pixels instead of wavelength.
Printing Screen Displays

Printing Files

WaveStar spectrometer provides you with the ability to print an active screen or snapshot screen.

To print a screen:

1. Open the File menu and select **Print…**

   OR

   From the **Control** Toolbar, click ✎.

2. The file screen will be printed. The default setting is landscape but the screen can also be printed in portrait mode and will adjust itself to that format.

Exporting Data

Using the WaveStar software, you can export data to files in two ways: you can export the intensity vs. wavelength into a text file and you can export the screen into a bitmap file.
To export an intensity vs. wavelength file:
1. Open the file menu and select Export to Text
   The following menu will open:
   ![Export to Text Menu]
2. When the save as menu opens, either save the file as the
   default file location and name given or give it a new file name and
   location and then save.

   The saved file will save the values vs. wavelength of the entire
   spectral range of the WaveStar as shown on the screen.

   An excerpt of a file is shown below

   WaveStar's exported text file.
   Head name: WAVESTAR-V.
   Sample #14, diode laser.
   Wavelength(nm)   Intensity(%)  FWHM(nm)
   678.93          0.76          1.08
   677.12          1.11          
   677.48          2.03          
   677.85          4.61          
   678.03          12.78         
   678.21          62.62         
   678.40          85.44         
   678.66          42.50         
   678.85          33.69         
   679.13          69.23         
   679.31          62.62         
   679.49          85.44         
   679.67          42.50         
   679.86          33.69         

   Region of interest - minimum: 650.86(nm).
   Region of interest - maximum: 700.40(nm).
   Threshold: 0.00(%) .

   Additional information:
   Date & Time: March 29, 2001, 07:53.
   Trigger type: CW.
   Shutter time: 35.24 ms.
   Power corrected: No.
   Offset applied: No.
To save a bitmap file of the screen:

1. Open the file menu and select **Export to Bitmap**

The following menu will open:

2. When the save as menu opens, either save the file as the default file location and name given or give it a new file name and location and then save.

The saved file will save the entire WaveStar screen as a bitmap picture.
Chapter 6 - Customer Support

If you need assistance, refer to your nearest customer support center. Please have your WaveStar spectrometer serial and the PC software version number available before you contact us. Include this information in all your correspondence. Please do one of the following:

1. Contact your local Ophir representative
2. Contact us through our website www.ophiropt.com. Click on “services/problem solving” and fill out the form provided.
3. You may contact us at the e-mail address sales@ophiropt.com in the US and support@ophiropt.co.il in other countries.
# Chapter 7 - Specifications

This section describes the technical and system performance specifications.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector</td>
<td>3000 element CCD</td>
</tr>
<tr>
<td>Optics</td>
<td>Proprietary optical design (patent applied for)</td>
</tr>
<tr>
<td>Spectral Response:</td>
<td>Model WaveStar-V 570 - 1100nm</td>
</tr>
<tr>
<td></td>
<td>Model WaveStar-U 350 - 630nm</td>
</tr>
<tr>
<td>Wavelength resolution</td>
<td>FWHM 0.9nm</td>
</tr>
<tr>
<td>Wavelength peak detection</td>
<td>Proprietary algorithm interpolates pixels and tags peaks with wavelength to accuracy of 0.05nm. FWHM of each peak also shown if desired.</td>
</tr>
<tr>
<td>Mounting thread intensity accuracy vs. wavelength</td>
<td>1/4” threaded mounting hole</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>80mm x 70mm x 100mm</td>
</tr>
<tr>
<td>Optional accessories</td>
<td>SMA fiber adapter, diffusers, ND filters</td>
</tr>
<tr>
<td>Connections to PC</td>
<td>Connects to standard parallel port via 3 meter cable.</td>
</tr>
<tr>
<td>Trigger</td>
<td>Photodiode trigger allows capture of single shot events.</td>
</tr>
<tr>
<td>Minimum host system requirements</td>
<td>Pentium 200 32MB RAM 10MB HD free, Windows 95/98, 2MB 16bit color VGA card one free parallel port</td>
</tr>
<tr>
<td>Performance with pulsed sources</td>
<td>Operates with continuous or pulsed sources at pulse rates from &lt;1Hz up. Special trigger photodiode allows measurement of single pulse events.</td>
</tr>
<tr>
<td>Temperature dependence</td>
<td>0.025nm/°C</td>
</tr>
</tbody>
</table>

**CE Compliance**

The system, as installed on a CE compliant PC, will comply with all pertinent CE requirements.
Appendix A – ActiveX Automation

Introduction
Besides its use as a stand-alone, fully featured spectrometer, the WaveStar can also be used through an ActiveX interface. This allows system integrators to integrate the data capture capabilities of the WaveStar with legacy analysis packages.

The automation components of the WaveStar have been tested in LabWindows 5.5 and LabVIEW 6i (both from National Instruments) as well as Visual Basic 6.0 (Microsoft). In practice, these components can be used in any environment that allow interaction with COM automation servers (although it hasn’t been tested with tools other than those mentioned)

Registration
WaveStar COM automation server will be registered the first time that the WaveStar is run. They will be unregistered if the WaveStar is uninstalled.

Examples
Examples of a LabWindows project, LabVIEW VI’s, and a Visual Basic application are provided with the installation package. All examples assume a rudimentary knowledge of the respective development platforms

Details
Error Codes (complete details in the next section)

- 0x00000000: No Error
- 0x80040400: WaveStar in Short Pulse Mode
- 0x80040401: Shutter Time selected is less than the WaveStar minimum
- 0x80040402: Shutter Time selected is greater than the WaveStar maximum
- 0x80040410: WaveStar not in short pulse mode
- 0x80040411: Frequency selected is less than the WaveStar minimum
- 0x80040412: Frequency selected is greater than the WaveStar maximum
- 0x80040420: Wavelength Offset is less than WaveStar minimum
- 0x80040421: Wavelength Offset is greater than WaveStar maximum
- 0x80040430: Unrecognized source type
- 0x80040440: Spectrum Scan not complete
- 0x80040441: WaveStar is performing power offset calibration and cannot perform a scan
- 0x80040450: Power Offset calibration not complete
- 0x80040451: WaveStar is performing a spectrum scan and cannot perform power offset calibration
- 0x80040460: Power Correction not available
- 0x80040470: Power Offset not available
- 0x80040480: Failed to save change in settings to WaveStar hardware
- 0x80080490: No head connected
Methods

Information Methods

Name: GetErrorFromCode (long lErrorCode, VARIANT *varErrorString)

Details:
Given an error code, will pass back a string explanation of the error. Note, varErrorString is VARIANT pointer to a BSTR. This was done in order to make the string easily accessible in all languages

Returns: 0x00000000

Name: GetInfo

Details:
Passes back general information about the WaveStar head. This includes the head name (as a Variant pointer to BSTR), serial number, number of pixels, wavelength limits of the WaveStar, shutter time limits of the WaveStar, frequency limits (when working with a short pulse light source), and wavelength-offset limits (for the user adjustable wavelength offset factor).

Returns: 0x0 on success
0x80040490 if no head connected

Name: ShowWindow (VARIANT_BOOL show)

Details: Show the WaveStar screen if parameter is true; otherwise hide it.

Returns: nothing
Setup Methods

Name: GetOffset (VARIANT_BOOL *CurrentOffset)
Details: Passes back if WaveStar is currently applying power offset to its measurements.
Returns: 0x0 (no error)

Name: GetPowerCorrection (VARIANT_BOOL *CurrentPowerCorrection)
Details: Passes back if WaveStar is currently applying power correction to its measurements.
Returns: 0x0 (no error)

Name: GetShutterTime (long *CurrentShutterTime)
Details: Passes back current shutter time setting, in microseconds.
Returns: 0x0 (no error)

Name: GetSourceFrequency (short *CurrentSourceFrequency)
Details: Passes back current frequency setting in Hertz. Note, the WaveStar only works with frequency when working with a Short Pulse source type. For CW or Long Pulse source types, the WaveStar works with shutter time.
Returns: 0x0 (no error)
Name: GetSourceType (short *CurrentSourceType)
Details: Passes back present source type setting (0 for CW, 1 for Long Pulse, 2 for Short Pulse)
Returns: 0x0 (no error)

Name: GetWavelengthOffset (single *CurrentWavelengthOffset)
Details: Passes back present setting of the user adjustable wavelength offset factor.
Returns: 0x0 (no error)

Name: SetOffset (VARIANT_BOOL OffsetOn)
Details: Instructs WaveStar to apply/not apply the power offset calibration factor to its measurements.
Returns: 0x0 (no error)
0x80040470 (No offset available)
0x80040480 (Failed to save change to head)
0x80040490 (No head connected)

Name: SetPowerCorrection (VARIANT_BOOL PowerCorrectionOn)
Details: Instructs WaveStar apply/not apply power correction to it measurements
Returns: 0x0 (no error)
0x80040460 (No correction available)
0x80040480 (Failed to save change to head)
0x80040490 (No head connected)
Name: SetShutterTime (long NewShutterTime)
Details: Instructs WaveStar to increase/decrease amount of time that its CCD array is exposed to the light source.
Returns: 0x0 (no error)
  0x80040400 (WaveStar in Short Pulse mode)
  0x80040401 (Shutter Time less than minShutterTime returned in GetInfo)
  0x80040402 (Shutter Time greater than maxShutterTime returned in GetInfo)
  0x80040480 (Failed to save change to head)
  0x80040490 (No head connected)

Name: SetSourceFrequency (short NewSourceFrequency)
Details: Instructs WaveStar to increase/decrease amount of time that its CCD array is exposed to the light source based on frequency of the light source.
Returns: 0x0 (no error)
  0x80040410 (WaveStar not in Short Pulse mode)
  0x80040411 (Frequency less than minFrequency returned in GetInfo)
  0x80040412 (Frequency greater than maxFrequency returned in GetInfo)
  0x80040480 (Failed to save change to head)
  0x80040490 (No head connected)
Name: SetSourceType (short NewSourceType)
Details: Instructs WaveStar to work in CW (0), Long Pulse (1) or Short Pulse (2) mode.
Returns: 0x0 (no error)
          0x80040430 (Unknown Source Type)
          0x80040480 (Failed to save change to head)
          0x80040490 (No head connected)

Name: SetWavelengthOffset (single NewWavelengthOffset)
Details: Instructs WaveStar to increase/decrease user-adjustable wavelength offset factor
Returns: 0x0 (no error)
          0x80040420 (Factor less than minOffset returned in GetInfo)
          0x80040421 (Factor greater than maxOffset returned in GetInfo)
          0x80040480 (Failed to save change to head)
          0x80040490 (No head connected)
**Measurement Methods**

**Name:** GetIntensityArray (VARIANT *var)

**Details:** Will pass back all pixels and their intensities. This is a VARIANT pointer to an array of singles. All even indexes are wavelengths and the odd indexes are their respective intensities. The length of the array will always be the number of pixels returned in GetInfo times 2. WaveStar will prepare this array after receiving a StartScan request and setting the ScanReady flag to TRUE. It will not release this array until after another StartScan request is issued.

**Returns:**
- 0x0 (no error)
- 0x80040440 (Scan not completed)
- 0x80040490 (No head connected)

**Name:** GetOffsetReady (VARIANT_BOOL *OffsetReady)

**Details:** WaveStar will set this Boolean TRUE, signaling that it has finished the power offset calibration that the client application has requested when it called the MeasureOffset method.

**Returns:**
- 0x0 (no error)
- 0x80040451 (WaveStar performing spectrum scan)
- 0x80040490 (No head connected)

**Name:** GetIPeakArray (VARIANT *var, short *NumberOfPeaks)

**Details:** Will pass back all peaks as triplets of wavelength, intensity, and FWHM (full width half maximum). This is a VARIANT pointer to an array of singles. The length of the array is dependent on the number of peaks found (3 * NumberOfPeaks) Index 0, 3, etc. is the wavelength of the peak; 1, 4, etc. is the intensity
of that peak; and 2, 5, etc. is the FWHM (in nanometers). WaveStar will prepare this array after receiving a StartScan request and setting the ScanReady flag to TRUE. It will not release this array until after another StartScan request is issued.

Returns: 0x0 (no error)

- 0x80040440 (Scan not completed)
- 0x80040490 (No head connected)

Name: GetScanReady (VARIANT_BOOL *ScanReady)

Details: WaveStar will set this Boolean TRUE, signaling that it has finished a scan that the client application has requested when it called the StartScan method.

Returns: 0x0 (no error)

- 0x80040441 (WaveStar performing power offset calibration)
- 0x80040490 (No head connected)

Name: MeasureOffset

Details: Instructs WaveStar to initiate a power offset calibration. This sets the OffsetReady flag to FALSE, until the WaveStar has completed the process and sets it to TRUE.

Returns: 0x0 (no error)

- 0x80040451 (WaveStar performing spectrum scan)
- 0x80040490 (No head connected)
Name: StartScan

Details: Instructs WaveStar to initiate a spectrum scan. This sets the ScanReady flag to FALSE, until the WaveStar has completed the process and sets it to TRUE.

Returns: 0x0 (no error)
- 0x80040441 (WaveStar performing power offset calibration)
- 0x80040490 (No head connected)

Pseudo-Code of Spectrum Scan

```plaintext
Result = WaveStar.StartScan {Initialize Scan}
If Result != 0
Quit {failed to start scan, quit function}
Else
While WaveStar.GetScanReady NOT TRUE {Wait for flag that data is ready}
WaveStar.GetIntensityArray (IA) {upload intensity array}
For x = 0 to numPixels-1
Wavelength[x] = IA[x*2]
Height[x] = IA[x*2 + 1]
End For
WaveStar.GetPeakArray (PA, numPeaks) {upload peak array}
For x = 0 to numPeaks-1
PeakWavelength[x] = PA[x *3]
PeakHeight[x] = PA[x *3 + 1]
PeakFWHM[x] = PA [x*3 + 2]
End For
End If
```

Wavestar User Manual
Ophir P/N 1J06029
Rev 1.05-2