FieldSpec®4
User Manual

Contents

Chapter 1: Getting Started

The following sections will help you get started using the FieldSpec®4 instrument:

1.1 About This Manual

This manual is for users of the FieldSpec 4 instrument and describes how to set up and use the instrument. It also includes reference information about how the instrument works.

This manual uses the following symbols and typographical conventions.

Convention	Definition
Bold	Words in **bold** show items to select or click, such as menu items or buttons.
File > Open	This notation shows software menu selections. (For example, from the **File** menu, select **Open**.)
NOTICE	This symbol indicates practices not related to personal injury.
⚠ CAUTION	This symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
♻	Items with this symbol indicate that the item should be recycled and not disposed of as general waste.

Cautions and notices throughout this manual are for the convenience of the reader. However, the absence of cautions and notices do not preclude the use of proper caution and handling.

Take the normal precautions at all times, either written or otherwise, to avoid personal injury or equipment damage.

1.2 Technical Support

If you have any questions or concerns, please contact ASD Inc. by phone, fax, or e-mail:

Phone: 303-444-6522 extension 144
Fax: 303-444-6825
e-mail: support@asdi.com
Web: support.asdi.com

Technical support is available to answer your questions Monday through Friday, 8 a.m. to 5 p.m. Mountain Standard Time.

1.3 FieldSpec 4 Instrument Overview

The FieldSpec 4 instrument is a general-purpose spectroradiometer that is useful for many applications requiring the measurement of reflectance, transmittance, radiance, or irradiance.A spectroradiometer is a special kind of spectrometer that can measure radiant energy (radiance and irradiance.) The FieldSpec 4 instrument has a fixed fiber optic cable that lets you calibrate it to units of radiant energy (irradiance and radiance).

The instrument is specifically designed for field environment remote sensing to acquire visible and near-infrared (VNIR) and short-wave infrared (SWIR) spectra. The instrument is a compact, field portable, and precision instrument with a spectral range of 350–2500 nm and a rapid data collection time of 0.2 second per spectrum.

The FieldSpec 4 is available in the following models:

Table 1.1: FieldSpec 4 models and spectral resolutions

	Spectral resolution	
Model	**VINR (nm)**	**SWIR (nm)**
Wide-Res	3	30
Standard-Res	3	10
Hi-Res	3	8

For the complete specifications, see "Appendix A, Specifications and WEEE Compliance" on page 43. For the complete specifications, refer to the *FieldSpec 4 User Manual*.

To use the instrument, you must have a laptop computer (instrument controller) and the appropriate software. The instrument typically comes with both, but if you need to use your own computer, see "2.1 System Requirements" on page 9.

Figure 1.1 shows the front panel of the instrument.
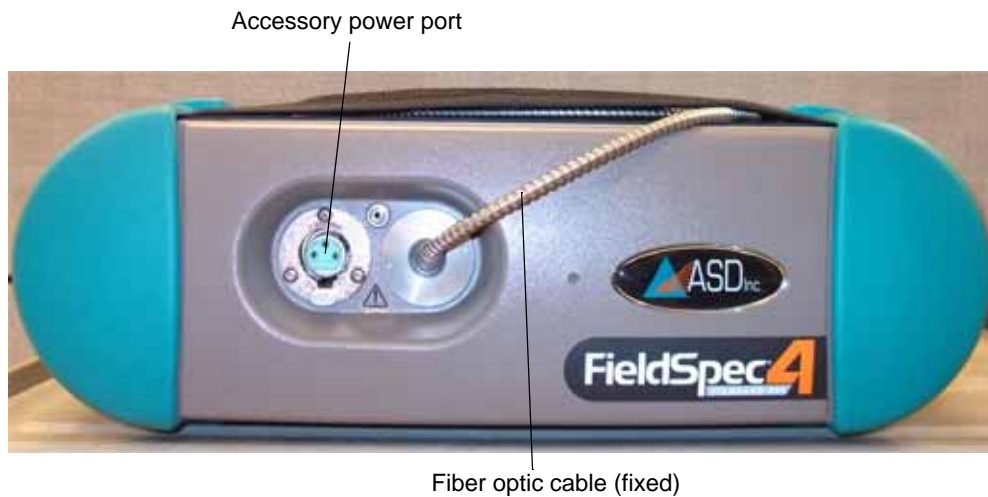
Figure 1.1: FieldSpec 4 instrument front panel

Figure 1.2 shows the back panel of the instrument.
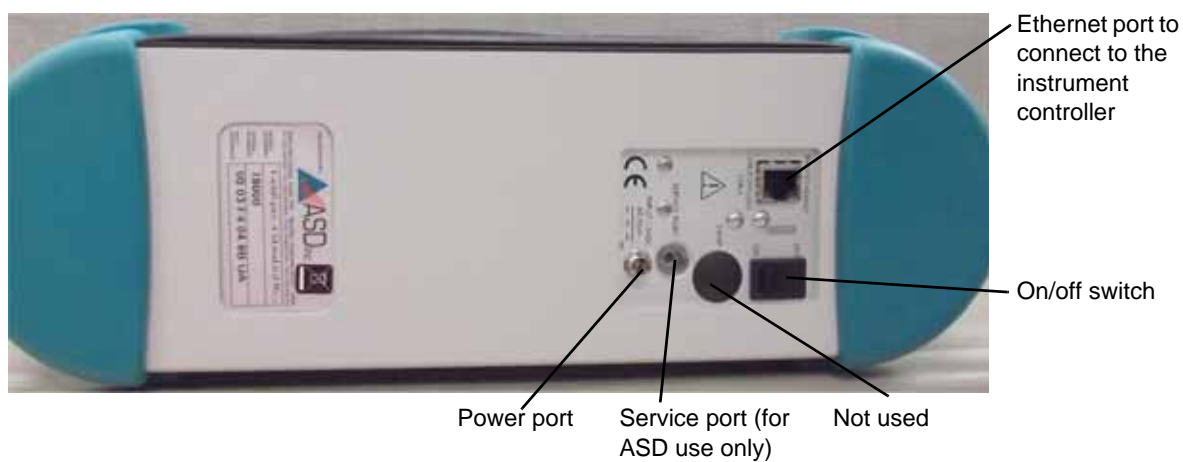
Figure 1.2: FieldSpec 4 instrument back panel

1.4 Unpacking the Instrument

The instrument ships in a hard-shell carrying case, as shown in Figure 1.3.

Figure 1.3: Instrument as it ships

The backpack and laptop carrier ship in a soft-sided case, as shown in Figure 1.4.

Figure 1.4: Backpack in soft-sided case

To unpack the instrument:

1. Inspect the shipping containers and note any damage.

   • Save all packing materials, foam spacers, and paperwork for future use.

2. Open the shipping containers, following all instructions and orientation labels.

3. Remove the instrument from its shipping case and place it on a sturdy bench or counter with an electrical outlet available.

   • If an electrical outlet is not available, you can use the battery instead. The battery was fully charged at the factory, but we recommend that you charge it before use.

4. Remove the instrument controller (computer), which is directly below the instrument between the foam inserts.

5. Remove the cables for the instrument controller, which are directly below the instrument controller.

6. Remove the accessories and backpack from the soft-sided case.

   • Some accessories are optional.

1.5 Setting Up the Instrument

If you plan to use your own computer, see "System Requirements" on page 9. You must connect the instrument, the instrument controller (computer), and accessory light source (if needed). If you plan to use your own computer, see "System Requirements" on page 9.

To set up the instrument:

1. Connect the power cable to the to the back of the instrument (screw it into the port) and to an electrical outlet.
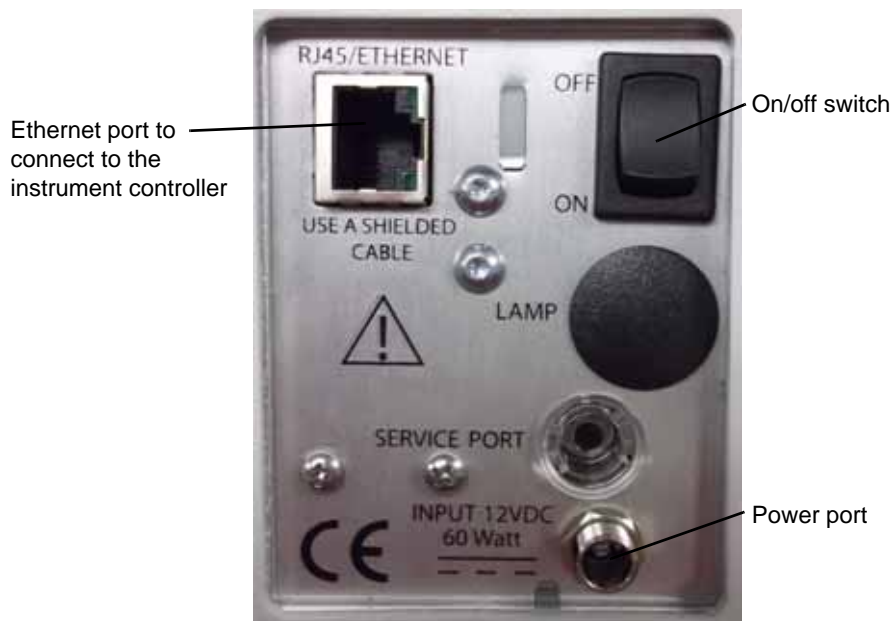
2. If you want to directly connect to the instrument with a cable, connect the Ethernet cable to the instrument controller's Ethernet port and to the back of the instrument.

   - The location of the Ethernet port varies on different instrument controllers.

   - If you want to use wireless communication between the instrument and instrument controller, do not connect the cable. For more information, see "2.4 Setting Up Ethernet or Wireless Communication" on page 13.

3. Connect the power cable to the instrument controller and to an electrical outlet.

   - For information about using the battery instead, see " Using the Battery" on page 11.

4. If you are using an accessory light source, connect it to the accessory power connector and to the fiber optic cable.

   - For more information, see " Using Accessory Light Sources" on page 18.

NOTICE To avoid damaging the fibers, never store the fiber optic cable with a bend of less than 5" in diameter for long periods of time.

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5. If you are using the pistol grip or the remote trigger, connect them now.

   - For more information, see " Using the Remote Trigger" on page 19 and " Using the Pistol Grip" on page 17.

6. Turn on the instrument.

7. If using an optional accessory light source, turn it on.

8. Let the instrument warm up for at least 15 minutes.

   - If you are collecting radiometric spectra, let the instrument warm up for at least one hour before collecting radiance or irradiance data.

9. Turn on the instrument controller.

For information about using the instrument with the backpack and laptop carrier, see " Using the Laptop Carrier (Belly Board)" on page 21 and " Using the Backpack" on page 23.

1.6 Setting Up the Software and Saving Spectra

After you start the RS³™ software, you must optimize and set a white reference. You can then collect and save spectra.

To set up the software and save spectra:

1. Start the RS³ software.

   - Double-click the RS³ icon from the instrument controller's desktop.

   - If you are using one of the default network configurations, RS³ automatically detects and connects to the instrument. For more information, see "2.4 Setting Up Ethernet or Wireless Communication" on page 13.

White reference button

Optimize button
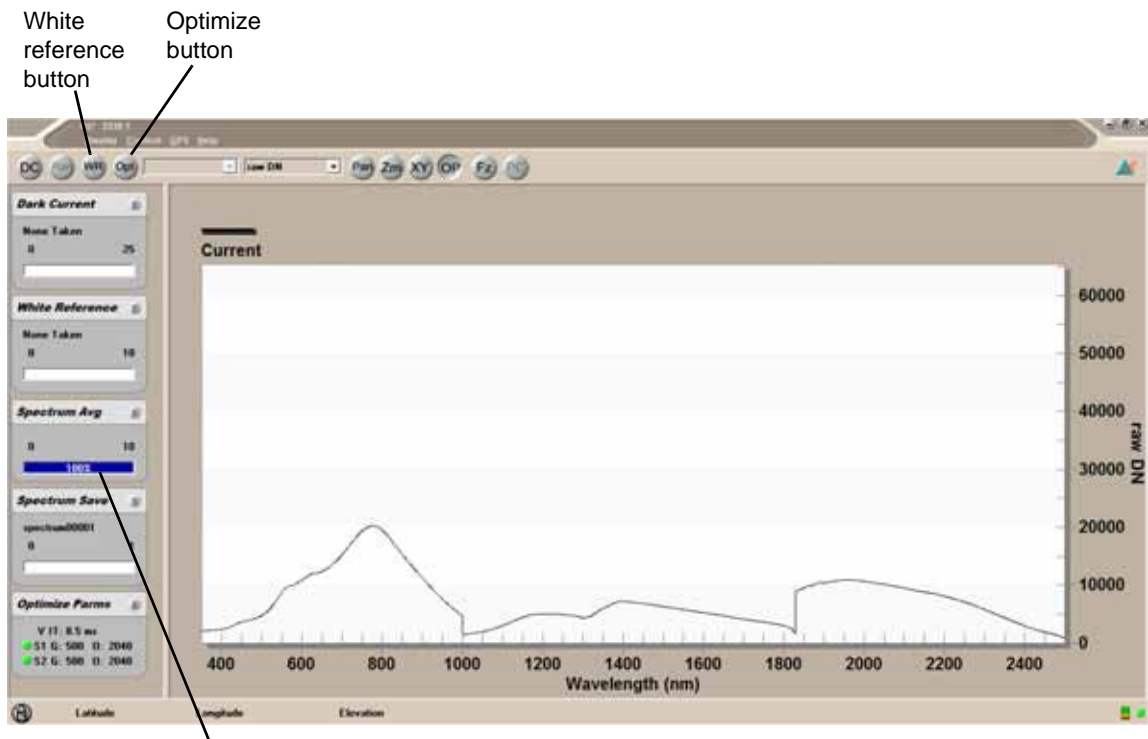
The software starts collecting spectra immediately. The Spectrum Avg progress bar shows the spectra collection.

2. Point the end of the fiber optic cable at the Spectralon® reference panel and hold it there.

3. Click **Opt** to optimize the instrument.

   • The optimization is complete when the Spectrum Avg progress bar resumes.

4. Click **WR** to take a white reference.

   • The white reference is complete when the Spectrum Avg progress bar resumes.

5. Point the end of the fiber optic cable at the sample and hold it there.

6. Select **Control > Save Spectrum**.
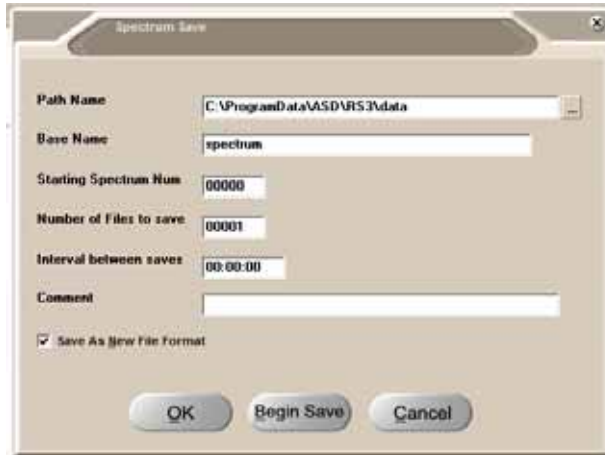
7. Browse to where you want to save the spectrum and enter a file name.

    *   For more information about the Spectrum Save window, refer to the RS³ *User's Guide*.

8. Do one of the following:

    *   To save the settings in the Spectrum Save window but not save any spectra yet, click **OK**. Then use the instrument controller's space bar to save spectra.

    *   To begin saving spectra immediately, click **Begin Save**.

Use the ViewSpec ™ Pro software to view and post-process the saved spectra. For more information about using the RS³ or ViewSpec Pro software, refer to the *RS³ User's Guide* or the *ViewSpec Pro User's Guide*.

Chapter 2: Using and Maintaining the Instrument

The following sections will help you use and maintain your instrument:

2.1 System Requirements

To use the instrument, you must have a laptop computer (instrument controller) and the appropriate software. The instrument comes with both, but if you need to use your own computer, the following sections provide the system requirements:

Computer Requirements

The instrument controller is a computer that manages the instrument, stores data, and processes the results.

The minimum requirements for the instrument controller are:

- 1.2 GHz Pentium or better laptop or PC with monitor

- 256 MB RAM or more

- 20 GB of free disk space

- 1024 x 768 or better graphics resolution

- 24-bit color or better, 32-bit recommended

- 10/100 Base-T Ethernet interface

- (Optional) Ethernet wireless (Wi-Fi) adapter: PCMIA, USB, or built-in that is compatible with the 802.11g standard

- (Optional) Serial communications port (RS-232 COM, Bluetooth®, or USB) (only needed if a GPS is used). Contact ASD for information about using GPS receivers with ASD instruments.

Software Requirements

The instrument controller requires the following software:

- Microsoft® Windows® 7

  - If you are using an instrument controller with an older version of Windows, contact ASD technical support for assistance.

- Microsoft Internet Explorer 6.0 or higher

- RS^3 spectral acquisition software from ASD

You should have a basic understanding of the Microsoft Windows operating system, including software installation.

International customers using non-English versions of Windows must change the **Regional Settings** under **Start > Settings > Control Panel**. The default language must be set to English (United States) for the software to be registered and operate correctly. The numbering format must also be set to English.

2.2 Ventilation Requirements

When used inside, provide adequate room ventilation for the instrument. Insufficient ventilation can result in overheating of the instrument, corrupted data, and possible physical damage to the instrument.

Follow these additional tips about using the instrument:

- Do not cover the vents of the instrument. Be sure the vents line up with the mesh in the backpack to ensure adequate ventilation and make sure the mesh and vents are not obstructed.

- Prevent objects from obstructing ventilation holes.

- Keep objects and spills from entering or falling onto the instrument and power supplies.

2.3 Power Options

The instrument requires input power of 12 VDC (60 W). It does not contain an internal power supply or battery.

The three options for providing the instrument with the appropriate DC voltage are:

- A power cable that connects to an electrical outlet (included).

- An external battery pack (included). For more information, see "Using the Battery" on page 11.

- An adapter for vehicle cigarette lighters (included; should not be used with vehicle engine running).

NOTICE — Use only ASD-approved power supplies or connectors to power the instrument.

Using the Battery

When electrical power is not available, use the battery that came with the instrument. The Nickel-Metal Hydride (NiMH) battery can power the instrument and accessories.

⚠ CAUTION — Use only batteries supplied by ASD. Use ASD batteries only as authorized by ASD. Using improper batteries or improper use of ASD batteries could result in bodily injury or damage to the instrument.

A fully charged battery's life depends on the battery age, instrument configuration, environment, and accessories powered by the accessory power port. The expected battery life is over four hours using a contact probe in an ambient environment.

NOTICE — The instrument will stop collecting spectra when the battery drains to about 9.7 volts, and the software displays a message that says it is unable to collect. However, the instrument and any attached accessory will continue to draw current if power is left on. Turn off the instrument and remove any accessory as soon as possible when the above message displays.

For the complete battery specifications, see "A.3 Battery Specifications" on page 44.

The backpack has two pouches on the hip belt, either of which can hold the battery. However, the battery should be on the opposite side from the fiber optic cable.

Charging the Battery

Charge a new battery fully before using it the first time, even if it shows full voltage and power. The battery pack reaches its peak performance after three to five charge-and-discharge cycles. A fully discharged battery takes about eight hours to charge.

After five to ten days from fully charging, the battery starts to lose its charge at the following rates:

- At normal room temperature—Loss of about 1% per day.
- At higher temperatures—Loss increases.
- At lower temperatures (40–60°F)—Loss decreases.

The more you use and charge NiMH batteries, the longer they last. Whether discharged or not, you should charge the NiMH battery at least every 60 days. New NiMH batteries can last from 500 to 1000 charges.

The LED Status indicator on the battery charger has the following states:

- Orange—Indicates one of the following:
    - The battery is not connected.
    - The charger is initializing and analyzing.
- Red—Indicates a fast charge.
- Green with intermittent orange—Indicates a top-off charge.
- Green—Indicates a trickle charge.
- Alternating orange/green—Indicates an error.

The battery charger is designed for indoor use and should not come in contact with water or dust.

NOTICE   Do not unplug the charger and leave the battery in the charger. Remove the battery first, or the battery will discharge through the charger.

For the complete battery charger specifications, see "A.4 Battery Charger Specifications" on page 44. Refer to the charger instruction manual for usage details.

Power Status Icon

The RS[3] software from ASD has a Power Status icon at the bottom of the main window next to the Connection Status. When you hold the mouse pointer over the icon, a pop-up window shows the voltage level of the instrument.

- 11-12 Volts is considered good (full).
- <11 Volts issues a warning.
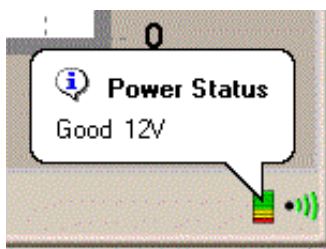
Figure 2.5: Example Power Status

2.4 Setting Up Ethernet or Wireless Communication

The FieldSpec 4 instrument communicates with the instrument controller to collect spectra using standard protocols for computer networks.

By default, the FieldSpec 4 instrument is set up to work in the following network environments:

- Direct wireless connection—The instrument and instrument controller communicate directly with each other using wireless communication.

    - This method does not require the availability of a wireless network in your location. The instrument and instrument controller communicate directly, similar to the direction connection method, only without any cable.

    - The ASD software automatically finds and connects to the instrument using the instrument's default IP address (10.1.1.77).

- Direct connection—Connect the instrument to the instrument controller with the Ethernet cross-over cable provided with the instrument.

    - The ASD software automatically finds and connects to the instrument using the instrument's default IP address (10.1.1.11).

You can configure the FieldSpec 4 instrument to work in the following additional network environments:

- Connection over a LAN—Connect the instrument and the instrument controller to your LAN using standard Ethernet cables.

    - You must the change the network settings of the instrument and instrument controller to conform to your network's standards. Consult your network administrator for the settings to use. For information about changing the network settings, see "Appendix B, Configuring Ethernet and Wireless Communication" on page 49.

    - After you change the network, the instrument controller can access the instrument using the LAN.

- Connection over a wireless network—The instrument and the instrument controller communicate over a wireless network (often called Wi-Fi) that is available in your location.

    - You must the change the network settings of the instrument and instrument controller to conform to your network's standards. Consult your network administrator for the settings to use. For information about changing the network settings, see "Appendix B, Configuring Ethernet and Wireless Communication" on page 49.

    - After you change the network settings, the instrument controller can access the instrument using the wireless network.

2.5 Understanding the Fiber Optic Cable

ASD offers a variety of fiber optic cable lengths to use with the instrument. A single cable, without any interruption in the fiber optic connections, allows for accurate measurement of radiance and irradiance in absolute units, and ensures the highest level of signal throughput.

The fiber optic cable is made up of fifty-seven (57) randomly distributed glass fibers:

- Nineteen 100-micron fibers for the VNIR region.
- Nineteen 200-micron fibers for the SWIR 1 region.
- Nineteen 200-micron fibers for the SWIR 2 region.

Each broken fiber results in a response loss of approximately 5%.

Handling the Fiber Optic Cable

The fibers of the fiber optic cable are well protected inside the cable, but the fibers can be damaged through rough usage. You should periodically inspect the fibers for breakage by following the procedures in "Checking the Fiber Optic Cable for Broken Fibers" on page 14.

NOTICE — The fiber optic cable should never be stored with a bend of less than a 5" diameter for long periods of time.

If left in a tight coil for longer than a week, the fibers may develop longitudinal fractures that will not be detectable. These fractures in the fiber will cause light leakage, resulting in a weaker signal.

Store the fiber optic cable in the netting compartment on the instrument or on the fiber optic spool.

Follow these tips for handling the fiber optic cable:

- Do not pull or hang the instrument by the fiber optic cable.
- Avoid whipping the fiber optic cable, dropping it, or slamming it into objects, as this can cause fractures to the glass fibers.
- Avoid twisting the fiber optic cable, such forces may cause fractures to the fibers.

While the tip of the fiber optic cable is not particularly susceptible to damage, we recommend using the tip cover to protect against abrasion and exposure to contamination. You can make a replacement cover using eighth-inch shrink tubing cut 1.5" and shrinking it onto the fiber cable tip. The tubing will slide on and off the cable easily.

Checking the Fiber Optic Cable for Broken Fibers

In the rare instance that a fiber is broken, you will see a loss in response. Fiber Check is a utility that lets you inspect the fiber optic cable for broken fibers.

| NOTICE | The Fiber Check utility produces rapid flashing lights in the SWIR 1 and 2 regions' optical fibers. If you are susceptible to epileptic seizures, exercise caution or avoid using the Fiber Check utility. |

You can use the instrument with a few broken fibers in each region, but the signal strength is reduced. You should replace the fiber optic cable if the number of broken fibers causes the signal-to-noise ratio to drop below an acceptable level.

To check the fiber optic cable for broken fibers:

1. Remove any fore optic accessories from the instrument's fiber optic cable.

2. Attach the magnifier to the end of the fiber optic cable.

Magnifier

3. On the instrument controller, exit any ASD software that might be running and communicating with the unit.

   • Such software includes RS^3.

4. Ensure that the instrument is turned on.

5. Start the Fiber Check software from the **Start** menu under **All Programs > ASD Programs > RS³ Tools > Fiber Check**.
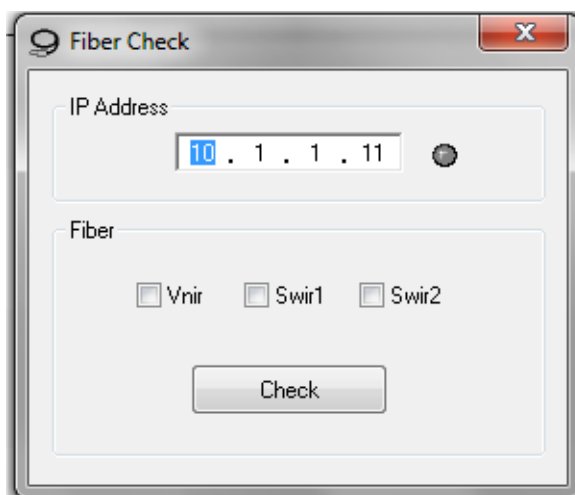
6. Verify the IP address for the instrument.
    - If you are directly connected to the instrument with a cross-over Ethernet cable, the default IP address is 10.1.1.11.
    - If you are directly connected to the instrument using a wireless connection, the default IP address is 10.1.1.77.

7. Select the LEDs to turn on: VNIR, SWIR 1, or SWIR 2.

8. Click **Check** to turn on the selected LEDs.

9. Look through the magnifier to see which fibers light up.
    - Count the number of fibers that light. Refer to "Understanding the Fiber Optic Cable" on page 14.
    - If applicable, change the LED options and click **Check** to turn on and off different LEDs to help determine which range might be affected.
    - The red LED for VNIR may be hard to see when the other ranges are enabled.

10. When you are finished, shut down the Fiber Check software.

11. Carefully remove the magnifier.

2.6 Options for Collecting Spectra

You can use various accessories to aid in collecting spectra, depending on your needs. Some accessories come standard with the instrument, and some require as separate purchase. You can use the remote trigger with any of the collection methods.

You can collect spectra the following ways:

- Without any attachment—Use the fiber optic cable on its own, without any accessory attached to it, using ambient light.

- Pistol grip—Provides a convenient way to hold and aim the fiber optic cable to collect spectra using ambient light. For more information, see "Using the Pistol Grip" on page 17.

- Accessory light sources—Provide external light sources to collect spectra. For more information, see "Using Accessory Light Sources" on page 18.
- Fore optics—Narrow the field of view for collecting spectra. For more information, see "Using Fore Optics" on page 18.
- Remote trigger—Provides a way to start spectra collection without using the keyboard on the instrument controller. For more information, see "Using the Remote Trigger" on page 19.

Using the Pistol Grip

The pistol grip is a convenient way to hold and aim the fiber optic cable. The pistol grip comes standard with the instrument and has a 25° field of view.

To use the pistol grip:

1. Insert the fiber optic cable through the strain relief spring

2. Insert the fiber optic cable all the way through the pistol grip until it clicks.
   - Make sure that the fiber optic cable tip is fully seated into the nose of the pistol grip.

3. If needed, gently tighten the set screw on the top of the pistol grip with a 1/8" flat blade screwdriver.
   - Tighten the set screw just enough to hold the fiber optic cable in place.

NOTICE   Do not pull hard on the cable after tightening the set screw. Pulling hard on the cable could potentially break the cable fibers. Loosen the set screw to remove the fiber optic cable from the pistol grip.

NOTICE   Do not adjust the factory set screw.

Chapter 2: Using and Maintaining the Instrument

Set screw

Factory
set screw
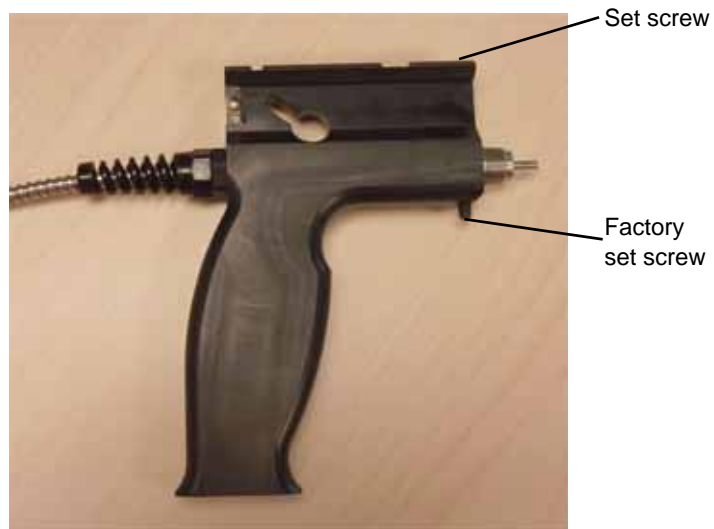
Using Accessory Light Sources

If needed for your application, you can use an accessory light source, such as the Contact Probe or other ASD-approved accessory, with your instrument.

Use the accessory power port on the front of the instrument to connect accessories to power.

Accessory
power port
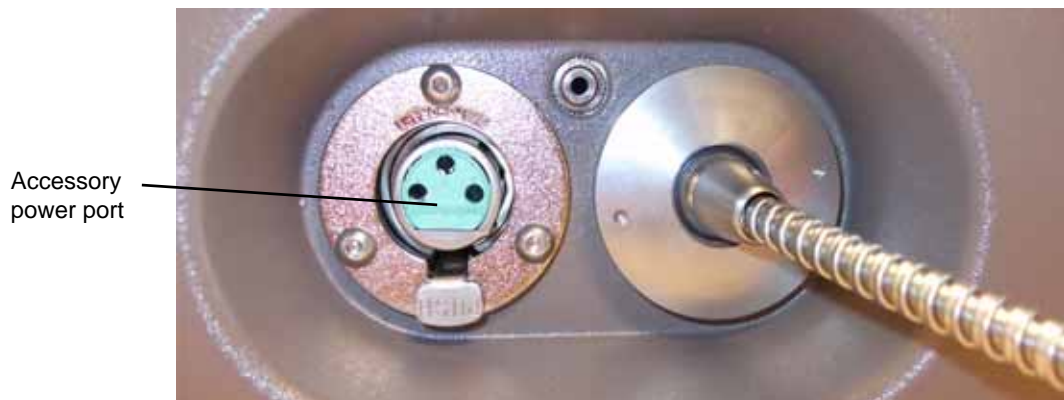
Figure 2.6: Accessory power port

Contact ASD or refer to the manual for the accessory for more information.

Using Fore Optics

ASD offers a wide selection of fore optic accessories to meet a variety of application needs, including:

- Lenses that limit the field of view from 1° to 25°

- Radiometric calibration for radiance (W/m^2/sr/nm) measurements

- Diffuse transmission and reflective-type cosine receptors and radiometric calibrations for measuring full sky irradiance (W/m^2/nm)

For more information about field of view, see "Understanding the Field of View" on page 19. For more information about fore optic accessories, contact ASD.

Understanding the Field of View

The field of view determines the size of the data collection area. Using just the bare fiber optic cable or the pistol grip accessory, the field of view is 25°.

As a general rule, the field of view is half the diameter of the distance the fiber optic cable is from the sample. For example, if the cable is four feet from the sample, the field of view is about two feet wide.

When collecting data, be sure that the sample or reference panel is the only object within the field of view.

Using the Remote Trigger

A remote trigger comes with the instrument to let you save spectra without pressing the spacebar on the instrument controller (the normal method of saving spectra). This is convenient when you have both hands holding the sample and the fiber optic cable. You can attach the remote trigger to the pistol grip and save spectrum by pressing the button on the trigger.

To use the remote trigger:

1. Attached the remote trigger cable to the instrument.
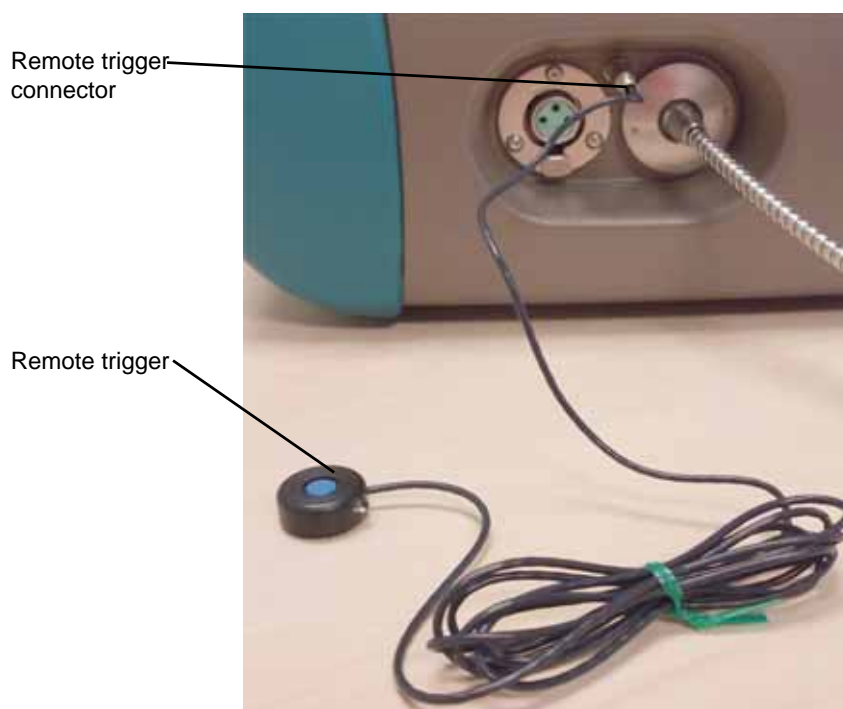
2. Use the hook and loop fasteners that come with the remote trigger to attach it to the pistol grip.

   - Place a piece of hook fastener on the back side of the remote trigger button.

   - Place a piece of loop fastener on each side of accessories, such as the pistol grip, so you can use the trigger with either hand.

Remote trigger on the pistol grip
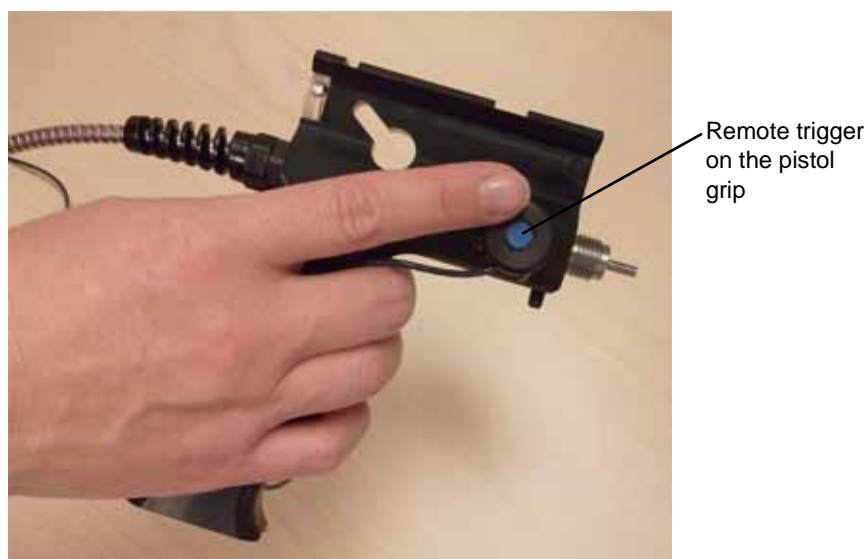
3. When collecting spectra, press the trigger button to collect spectra, instead of pressing the spacebar on the instrument controller.

  • The LEDs on the trigger are bright enough to be seen even on a sunny day. The LEDs light when the trigger is pushed (briefly) and turn off when the capture is complete.

2.7 Shipping and Carrying the Instrument

The following sections describe how to ship and carry the instrument:

- ■ "Shipping the Instrument" on page 20
- ■ "Carrying the Instrument in the Field" on page 21
- ■ "Using the Laptop Carrier (Belly Board)" on page 21
- ■ "Setting Up the Laptop Carrier for First Use" on page 22
- ■ "Using the Backpack" on page 23
- ■ "Adjusting the Backpack Straps to Fit" on page 27
- ■ "Carrying Accessories and Supplies" on page 29
- ■ "Protecting the Instrument from Bad Weather" on page 29

Shipping the Instrument

The instrument ships in a hard-shell container that you should use whenever you ship the instrument to different locations. Pack the instrument and its accessories as shown in Figure 1.3 on page 4. Store the fiber optic cable in the netting on top of the instrument, not in the fiber optic spool. Remove the pistol grip holder when storing the laptop carrier in the container (see Figure 2.7 on page 21).

Use the soft-sided case only for nonbreakable items such as the backpack and laptop carrier.

Carrying the Instrument in the Field

The instrument comes with a laptop carrier and backpack that let you carry all of the equipment you need to collect spectra in the field.

To use the instrument in this way, you must complete the following tasks:

1. Set up the laptop carrier.

   - You only need to do this the first time you use the laptop carrier. See "Using the Laptop Carrier (Belly Board)" on page 21.

2. Set up the instrument in the backpack.

   - See "Using the Backpack" on page 23.

3. Adjust the backpack straps.

   - See "Adjusting the Backpack Straps to Fit" on page 27.

For additional information about using the backpack in the field, see:

- "Carrying Accessories and Supplies" on page 29

- "Protecting the Instrument from Bad Weather" on page 29

Using the Laptop Carrier (Belly Board)

The laptop carrier or belly board lets you carry the instrument controller in the field as you collect spectra. You can use it the following ways:

- With the neck strap—The laptop carrier can hold the instrument controller without the backpack when two people are operating the equipment.

- Without the neck strap—You can attach the laptop carrier directly to the shoulder straps of the backpack to let one person operate the instrument.

If you are using the pistol grip with the instrument, the laptop carrier has a pistol grip holder on the right-hand side. If needed, you can unscrew the pistol grip holder and move it to the left-hand side of the laptop carrier.
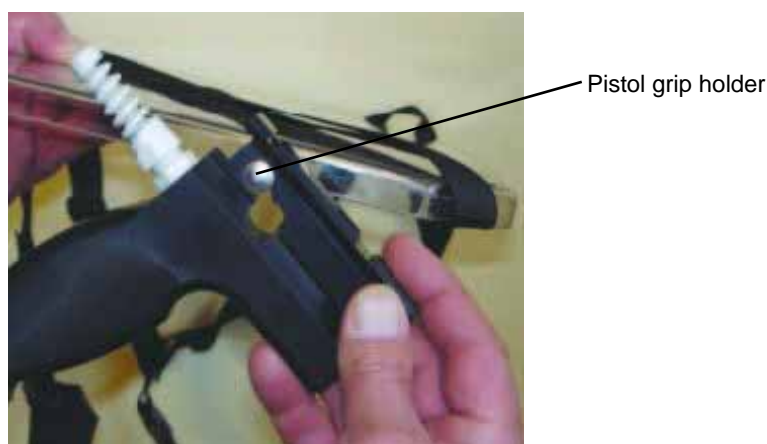
Figure 2.7: Pistol grip holder

Setting Up the Laptop Carrier for First Use

Before using the laptop carrier for the first time, you must place matching hook and loop strips on the instrument controller (bottom) and laptop carrier (top).

To attach the hook and loop strips to the instrument controller and laptop carrier:

1. Remove the instrument and instrument controller from the backpack.

2. Put on the empty backpack and fasten the belt and adjust the shoulder straps for comfort.

3. Detach the laptop carrier from the neck strap and attach it to the shoulder straps of the backpack.

Strap to attach laptop carrier to backpack
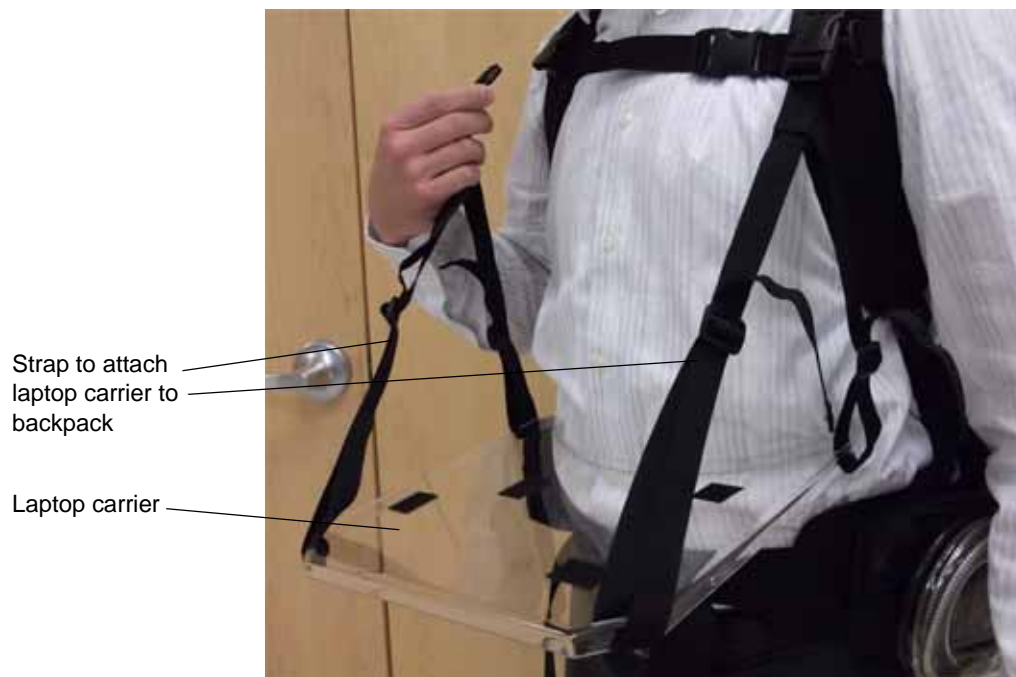
Laptop carrier

4. Adjust the straps of the laptop carrier for comfort and location.

NOTICE   Hold the instrument controller securely at all times.

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5. Place the instrument controller on the laptop carrier temporarily and observe its location.

   • Determine where on the laptop carrier to place the instrument controller and allow for comfortable use of the keyboard.

6. Remember this placement and place the instrument controller on a table.

7. Detach the laptop carrier from the backpack.

8. Locate the two pairs of hook and loop strips (mating hook side and loop side) supplied with the laptop carrier.

9. Leave the hook and loop strips mated.

10. Remove the backing from the adhesive on the hook side of one strip and press it in place, adhesive side down, onto the laptop carrier an inch or so away from the straight edge.

11. Repeat step 10 with the other hook and loop strip, but place it a couple of inches or so away from the other strip.
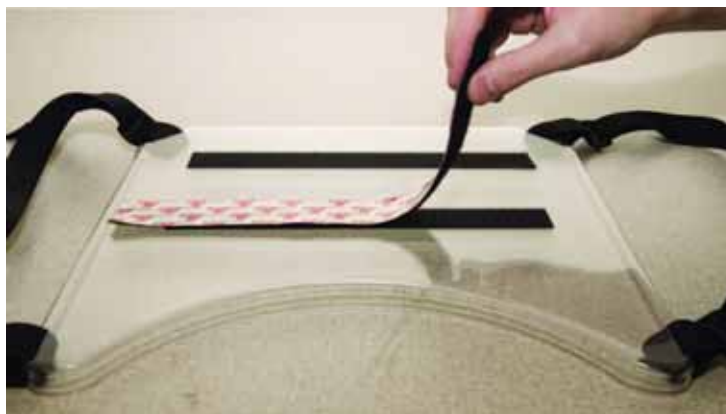
12. With the hook and loop strips still mated, remove the backing from the adhesive side of one strip.

13. Remembering the placement of the instrument controller on the laptop carrier, place the instrument controller onto the exposed adhesive and press down firmly.

NOTICE	Make sure the hook and loop strip will not cover the battery compartment on the instrument controller. This will interfere with battery replacement.

14. Gently separate the hook and loop material of the instrument controller from that of the laptop carrier.

15. Smooth over the strips on both the instrument controller and laptop carrier.

16. Repeat steps 12 through 15 for the other strip.

Using the Backpack

When arriving on site, unpack the instrument from the shipping case, and set up the instrument in the backpack before use.

You can use the instrument in the backpack with either hand. Determine which hand you want to use for collecting spectra with the fiber optic cable and which you need available to type on the keyboard and handle samples.

Aiming the fiber optic cable or accessory will probably require less dexterity than operating the instrument controller and typing. You may want to set up the instrument with the fiber optic cable on the side of your nondominant hand and keep your dominant hand free for other tasks, like one-handed typing.

To set up the instrument in the backpack:

1. Follow the instructions for unpacking the instrument from the shipping case.

   - See "1.4 Unpacking the Instrument" on page 4.

2. Place the backpack on a flat surface with the shoulder straps down.

3. Determine which hand you want to use for the fiber optic cable.

4. Orient the instrument in the backpack with the fiber optic cable on that side.

    •   The only requirement for orienting the instrument is that the plastic end-caps must be at the top and bottom of the backpack.

5. Close the five strap connectors to secure the instrument in the backpack.

Fiber optic cable on right side

Two of the five straps to secure the instrument

6. If you are using the fiber optic spool, feed the fiber optic cable into the spool.

7. If you are using the fiber optic spool, attach it to the backpack one of the following ways:

    •   With the hook and loop material to the back of the backpack. If needed you can run the fiber optic cable through the loop on one of the battery pouches. The hip belt of the backpack has a battery pouch on each side.

    •   With a snap to a battery pouch.

    •   If the fiber optic cable is short, it can go directly from the instrument through the loop on the battery pouch.

Fiber optic cable runs from the spool through the loop on the battery pouch.

Fiber optic spool (attached to back of backpack with hook and loop material)

Loop on battery pouch

Fiber optic cable

Fiber optic spool snaps onto the battery pouch on the belt of the backpack.

Fiber optic spool

Battery pouch

8. Place the battery into the pouch on the opposite side of the backpack from where the fiber optic cable is.

9. Feed the battery cable from the battery pouch under the cross strap to the power port of the instrument.

Battery cable

10. Attach the laptop carrier to the plastic connectors on the shoulder straps of the backpack.

11. Place the instrument controller onto the laptop carrier, matching the strips of hook and loop material.

   • The laptop carrier is equipped with a pistol grip holder.

Adjusting the Backpack Straps to Fit

For better weight distribution and comfort, adjust the shoulder straps and yoke to your height while wearing the fully loaded backpack.

To shorten the torso adjustment:

1. Pull the strap on left of backpack (as shown) until the yoke and shoulder straps raise up to the desired position, and the weight is comfortably distributed.

2. Repeat step 1 on the right side.

To lengthen torso adjustment:

1. Push up on the plastic speed grip clamp on the left of the backpack to release the strap, lower pack, and lengthen straps, as shown.

2. Repeat step 1 on the right side.

Carrying Accessories and Supplies

The backpack is designed specifically for the FieldSpec 4 instrument. The large mesh pocket at the bottom of the pack provides ventilation to keep the instrument from overheating.

NOTICE	Do not block the lower mesh pocket with clothing or other supplies.

The straps on the outside of the pack are intended for tying on clothing or other large items.

Included with the backpack is a pistol grip holster with a fore optics pouch. This black nylon holster is for use with the pistol grip and any fore optics. You can attach the holster to several locations on the backpack to securely hold the pistol grip and fore optics.

Protecting the Instrument from Bad Weather

The backpack has a small interior pocket near its top that holds a rain flap, as shown in Figure 2.8. The rain flap is water resistant, but not waterproof.

NOTICE	Do not use the instrument with the rain flap deployed. The instrument may overheat, because the rain flap prevents adequate air circulation.

In bad weather, place the instrument controller into its compartment on the outside of the backpack. Turn off both the instrument and instrument controller. Then pull the rain flap out of its compartment and over the outside of the pack.

Rain flap stored in backpack

Figure 2.8: Rain flap

2.8 Setting Up GPS

If you want to include location data when you collect spectra, you must use a GPS device and configure it to work with your instrument controller. If you purchased the instrument controller and GPS device from ASD, you should not have to configure anything. You can begin using the GPS device as you collect spectra with no additional configuration. See "Using a GPS Device While Collecting Spectra" on page 35.

If you purchased your GPS device or instrument controller from a third party, you must configure both to use GPS while collecting spectra.

GPS devices communicate with a computer different ways, depending on the GPS device's and the computer's available connections. Table 2.2 lists each combination of connection and includes the applicable setup steps.

Table 2.2: GPS device and instrument controller connection options and setup

GPS device connection	Instrument controller connection	Additional hardware or software	Setup required

Serial	Serial	None	1. Configure the GPS device to output NMEA data.
			  • See "Configuring the GPS Device" on page 31.
			2. Configure the COM port on the instrument controller.
			  • See "Configuring the Instrument Controller COM Port" on page 33.
			3. Configure the COM port in RS^3.
			  • See "Configuring the RS^3 Software for GPS Use" on page 34.

Serial	USB	USB-to-serial converter (hardware and software)	1. Configure the GPS device to output NMEA data.
			  • See "Configuring the GPS Device" on page 31.
			2. Install the USB-to-serial converter.
			  • See "Setting Up a USB-to-Serial Converter" on page 31.
			3. Configure the COM port on the instrument controller.
			  • See "Configuring the Instrument Controller COM Port" on page 33.
			4. Set the COM port in RS^3.
			  • See "Configuring the RS^3 Software for GPS Use" on page 34.

Table 2.2: GPS device and instrument controller connection options and setup (Continued)

GPS device connection	Instrument controller connection	Additional hardware or software	Setup required
USB	USB	GPSGate Client software (free)	1. Configure the GPS device to output NMEA data. • See "Configuring the GPS Device" on page 31. 2. Install and configure the GPSGate Client software. • See "Install and Configure the GPSGate Client Software" on page 32. 3. Configure the COM port on the instrument controller. • See "Configuring the Instrument Controller COM Port" on page 33. 4. Set the COM port in RS^3. • See "Configuring the RS^3 Software for GPS Use" on page 34.
Bluetooth	Bluetooth	None	1. Configure the Bluetooth connection. • "Configuring a Bluetooth Connection" on page 32. 2. Configure the COM port on the instrument controller. • See "Configuring the Instrument Controller COM Port" on page 33. 3. Set the COM port in RS^3. • See "Configuring the RS^3 Software for GPS Use" on page 34.

Configuring the GPS Device

If you purchased your GPS device from ASD, it should already be configured properly.

If you purchased your GPS device from a third party, you must configure the GPS device output format, based on the type of connection you are using:

- Serial or USB-to-serial connection—Configure the GPS device to output National Marine Electronics Association (NMEA) 018 GGA text.

- USB connection

  - Garmin® devices—Configure to use the Spanner Interface option.

  - Other GPS devices—Configure to use the NMEA format, but it may require additional configuration to communicate with RS^3.

- Bluetooth connection—No configuration needed. Bluetooth GPS devices automatically output in NMEA format.

Consult the documentation for your device for how to configure it for the output needed.

Setting Up a USB-to-Serial Converter

If you purchased your GPS device and instrument controller from ASD, they should already be configured properly.

If you purchased your instrument controller or GPS device from a third party and your GPS device outputs serial data and your computer does not have a serial connection, you must purchase a USB-to-serial converter. The NMEA format sends data in a serial format. Most computers no longer have serial connections, but a USB-to-serial converter lets you use a USB connection with a serial GPS device.

To set up a USB-to-serial converter:

1. Install the software that came with USB-to-serial converter.

2. Connect the USB-to-serial cable to the USB port on the instrument controller and to the GPS device.

    - Be sure to select a USB connection on the instrument controller that you normally want to use for the GPS device. The configuration is specific to this port. To use a different port, you must repeat the port configuration.

Continue the GPS setup process with "Configuring the Instrument Controller COM Port" on page 33.

Install and Configure the GPSGate Client Software

If you purchased your GPS device and instrument controller from ASD, they should already be configured properly.

If you purchased your instrument controller or GPS device from a third party and your GPS devices uses a USB connection to your instrument controller, you must install the GPSGate Client software. This software "translates" the NMEA serial data from the GPS device to communicate through the USB port.

To install and configure the GPSGate Client software:

1. Download and install GPSGate Client.

    - The software is available from: http://gpsgate.com/products/gpsgate_client

2. Turn on the GPS device.

3. Start the GPSGate Client software and start the setup wizard.

4. Accept the defaults on the first screen and click **Next**.

    - The wizard should find the GPS device and list it by name.

5. In the Select Output window of the wizard, deselect the option related to nRoute/ MapSource and click **Next**.

6. Note the numbers of the COM ports listed in the Summary window and click **Finish**.

    - The GPSGate icon displays in the system tray (lower-right corner of your screen) and is one of the following colors:

        - Green—GPSGate detects a valid GPS position.

        - Yellow—GPSGate detects valid GPS data, but the GPS data has no fix, that is, it cannot determine its position.

        - Red—GPSGate does not detect valid GPS data.

Continue the GPS setup process with "Configuring the Instrument Controller COM Port" on page 33.

Configuring a Bluetooth Connection

If you purchased your instrument controller or GPS device from a third party and your GPS device uses Bluetooth, you must set up the Bluetooth connection.

To configure a Bluetooth connection:

1. Turn on the GPS device and make sure it is discoverable.

   - Refer to the documentation for the GPS device.

2. Enable Bluetooth on your instrument controller.

   - How you do this varies by computer/Bluetooth combination.

   - On a Lenovo™ laptop, press and hold **Fn** and press **F5**, then click **Power On** next to Bluetooth Radio. This puts a Bluetooth icon in your system tray (lower-right corner of your screen.)

3. On the instrument controller, display the Add a Device window.

   - How you do this various by computer/Bluetooth combination. The following should work on Windows 7 computers: Select **Start > Devices and Printers**, then click **Add a Device**.

   - On a Lenovo laptop, click the Bluetooth icon in the system tray and select **Add a Device**.

4. Select your GPS device and click **Next**.

5. Enter the device's pairing code and click **Next**.

   - Refer to the documentation for the GPS device.

   - A message tells you that the device was added successfully.

6. Click **Finish**.

Continue the GPS setup process with

Configuring the Instrument Controller COM Port

If you purchased your GPS device and instrument controller from ASD, they should already be configured properly.

If you are setting up an instrument controller purchased from a third party, you must configure the COM port for the GPS device.

If your GPS device is not communicating with the RS^3 software, check the COM port as described below.

To configure the instrument controller COM port:

1. With the instrument controller turned on, connect to your GPS device.

   - For USB connections, be sure to select a USB port on the instrument controller that you normally want to use for the GPS device. The configuration is specific to this port. To use a different port, you must repeat the port configuration.

2. Turn on the GPS device.

3. From the instrument controller, select **Start > Control Panel**.

4. Click **Hardware and Sound**.

5. Click **Device Manager**.

6. Double-click **Ports (COM & LPT)**.

7. Select the port you want.

  - If you are using a USB-to-serial cable, select the port that says something similar to: USB-to-Serial COMM Port (COMx).

  - If you are using Bluetooth, select one of the Bluetooth ports.

8. Verify that the port number is between 1 and 9.

  - The port number is in parentheses. For example, it may show (COM4). If the number is higher than 9, you must change the port number. The RS³ software only supports port numbers between 1 and 9.

9. If you need to change the port number, right-click the port, select **Properties**, click the **Port Settings** tab, click **Advanced**, select a new number from the COM Port Number drop-down list, and click **OK**.

  - Select a number that is not in use.

Continue the GPS setup process with

Configuring the RS³ Software for GPS Use

If you purchased your GPS device and instrument controller from ASD, they should already be configured properly.

If you purchased your instrument controller from a third party, you must set up the RS³ software to communicate with the correct port.

If you are not seeing GPS data in the RS³ software, make sure the COM port number in the software matches the COM port set up in Device Manager. See

The default COM port settings usually work, but if you require unique GPS settings, look in the documentation for your GPS device for the following information:

  - Baud rate

  - Data bits

  - Parity

  - Stop bits

To configure RS³ software for GPS use:

1. Start the RS³ software.

2. Select **GPS > Settings**.

3. From the Port drop-down list, select the COM port number that corresponds to the port you found or set up in the Device Manager.

  - See

4. Based on the information for your GPS device, change the other settings in the GPS Settings window to match the device.

5. Click **OK**.

6. Select **GPS > Enabled**.

   - Be sure you see a check mark next to Enabled. This turns on the GPS function in the software.

   - Your GPS device and instrument controller are now ready for use. See "Using a GPS Device While Collecting Spectra" on page 35.

Using a GPS Device While Collecting Spectra

If you purchased the GPS device and instrument controller from ASD or if you have already completed the GPS setup, you can now use the GPS device while you collect spectra.

Be sure that you have a clear view of the sky to let the GPS device lock on to at least three satellites.

To use the GPS device:

1. Connect the instrument controller and GPS device.

2. Turn on the instrument controller.

3. Turn on the GPS device.

4. From the instrument controller, start the RS^3 software.

5. Select **GPS > Enabled**.

   - Be sure you see a check mark next to Enabled. This turns on the GPS function in the software.

6. See if the lock icon on bottom-left corner looks locked and if the Latitude, Longitude, and Altitude information displays across the bottom of the window.

   - You may need to wait a brief period for the GPS device to lock on to three satellites for the data to display. Refer to the GPS device documentation for how long this may take.

   - If you do not see the GPS data, see Table 2.2 on page 30 and refer to the GPS device documentation. If the GPS device is showing location data, check that the device is set to output NMEA format. See "Configuring the GPS Device" on page 31 and check the device documentation.

2.9 Maintaining the Instrument

The following topics describe how to maintain the instrument and white references:

- "Cleaning the Fiber Optic Tip" on page 36

- "Maintaining the Fan Vents" on page 36

- "Maintaining Spectralon Reference Panels" on page 36

- "Annual Maintenance" on page 37

- "Returning the Instrument for Service" on page 37

Cleaning the Fiber Optic Tip

You can clean the fiber optic tip if it has dirt or debris on it.

To clean the fiber optic tip:

- Use a soft cloth and isopropyl alcohol to clean off the tip.

Maintaining the Fan Vents

You should make sure fan vents are clear of dust and debris.

To maintain the fan vents:

1. Periodically check the fan vents for debris or dust.
2. If the vents need cleaning, remove the end caps using the six screws on the top, bottom, and handle of instrument.
3. Gently wipe fan vents with a soft cloth.
4. Reattached end caps.
5. Check the instrument by turning it on and viewing the fan vents.

Maintaining Spectralon Reference Panels

Spectralon reference panels are an optical standard and should be handled in much the same way as other optical standards. Although the reference panel is very durable, take care to prevent contaminants such as finger oils from contacting the reference panel's surface. Always wear clean gloves when handling Spectralon reference panels.

To clean a lightly soiled Spectralon reference panel

- If the reference panel is lightly soiled, clean it with a jet of clean dry air or nitrogen.

NOTICE   Do not use any freon or compressed gas with freon propellant to clean or dry a Spectralon panel. Freon will damage the Spectralon surface.

According to the manufacturer of the Spectralon reference panel, Labsphere®, use the following procedure to clean your heavily soiled Spectralon reference panel.

Sand the Spectralon reference panel under running water with a 220-240 grit waterproof emery cloth or sandpaper until the surface is totally hydrophobic (water beads and runs off immediately).

To clean a heavily soiled Spectralon reference panel:

1. Use a flat surface, such as a thick, flat piece of glass.
2. Place the glass into the sink.
3. Place 220 grade wet sandpaper onto the glass.
4. Gently move the Spectralon reference panel in a figure-eight motion on the sandpaper, using water as needed to wash away the thin layer that is sanded off.
5. Blow dry with clean air or nitrogen or allow the reference panel to air dry.
6. If the reference panel requires high resistance to deep UV radiation, doe one of the following:

- Flush the reference panel with >18 milli-ohm distilled, de-ionized water for 24 hours.
- Vacuum bake the reference panel at 75° C for a 12-hour period at a vacuum of 1 Torr or less. Then purge the vacuum oven with clean dry air or nitrogen.

Annual Maintenance

ASD recommends that the instrument be serviced once a year. This will ensure the proper functioning of the instrument. Annual maintenance is covered under the ASD warranty or the extended service contract. You can purchase annual maintenance separately. To purchase annual maintenance or an extended service contract, contact your sales representative.

Returning the Instrument for Service

To return the instrument to ASD for maintenance or repair, contact ASD technical support for a Return Merchandise Authorization (RMA). The RMA includes scheduling details, contact information, shipping instructions, and a brief description of the maintenance or repair requirements. For contact information, see "Technical Support" on page 2.

Chapter 3: Troubleshooting

The following sections will help you troubleshoot the FieldSpec 4 instrument:

■ "3.1 Common Communication Fixes" on page 38

■ "3.2 Instrument Controller Does Not Connect to the Instrument" on page 39

■ "3.3 Instrument Controller Does Not Connect Wirelessly to the Instrument" on page 40

■ "3.4 Cannot Connect Using a Wireless Access Point" on page 41

■ "3.5 Instrument Loses its Wireless Connection" on page 41

■ "3.6 Windows Firewall Messages Display When You Try to Connect" on page 41

3.1 Common Communication Fixes

To fix many communication errors (particularly if the instrument has been functioning at some point), below are steps to try:

1. Power cycle the instrument and/or the instrument controller.

2. For a wireless connection, make sure you have a clear line of sight between the instrument and instrument controller.

   • Obstructions between the and instrument controller or radio frequency interference in close proximity can cause loss of communication or significantly shorten the communication range.

   • The instrument uses industry-standard components. You should see the same general connection speed and distance capabilities as other wireless devices.

3. For a wireless connection, make sure the wireless function is turned on.

   • The instrument controller may have a button on the side that turns the wireless function on and off. Be sure it is turned on.


Wireless function button. Be sure it is on for wireless communication.

4. If you receive a 400 command error while starting the RS^3 software, you need to reload the instrument ini file to the instrument.

- Use the Instrument Configuration utility from ASD to do this. A video tutorial is available from the support website that describes this procedure. The website is at http://support.asdi.com. Go to the Downloads page, then to the FieldSpec 4 page, and to the tutorial section.

3.2 Instrument Controller Does Not Connect to the Instrument

1. See the section: "3.1 Common Communication Fixes" on page 38.

2. Check that the Ethernet cable is securely connected to the instrument and instrument controller.

3. Check that the Ethernet LED near each connection is on.

4. For a direct connection, check that the Ethernet cable is a cross-over Ethernet cable.

5. For a LAN connection, check that the Ethernet cable is a standard Ethernet cable.

6. Check that the IP addresses of the instrument and the instrument controller are in the same range or subnet.

- The same range or subnet means that the first three octets of the IP address (xxx.xxx.xxx.___) match.

- The default IP address for the instrument is:

  - For an Ethernet connection: 10.1.1.11

  - For a wireless connection: 10.1.1.77

- The default subnet mask is 255.255.255.0.

- The instrument controller must have a corresponding, unique IP address in the same range as the instrument, such as 10.1.1.x where x is a unique number. The subnet mask must be the same as the instrument, such as 255.255.255.0.

- If you are connecting using your organization's LAN or wireless network, contact your network administrator for the network settings to use. To change the settings, see "Appendix B, Configuring Ethernet and Wireless Communication" on page 49.

7. Do a ping test to make sure the instrument is responding.

- Open up a command window by selecting **Start > Run**

- Type **cmd** in the Run window.
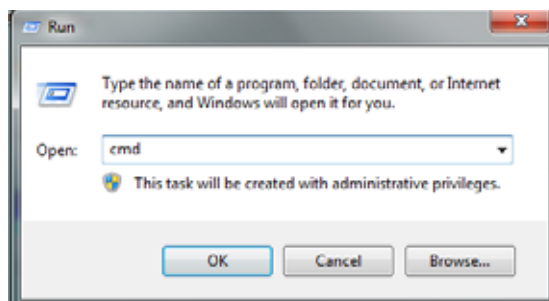
- Click **OK**.
  - For an Ethernet connection, type: **ping 10.1.1.11**
  - For a wireless connection, type: **ping 10.1.1.77**

Successful ping example

3.3 Instrument Controller Does Not Connect Wirelessly to the Instrument

1. See the section: "Common Communication Fixes" on page 38.

2. Disconnect the Ethernet cable from the instrument controller and instrument, then turn the instrument off and back on.

3. Connect the instrument controller to the instrument's wireless connection.

   - If you see one of these two icons or in the lower-right corner of your screen, click the icon.
     - If you do not see the icons, select **Start > Control Panel**, click **Network and Internet**, click **Connect to a Network**.

List of available wireless connections.

The default connection for the instrument is the instrument's serial number.

4. Select the connection you want and click **Connect**.

   - If you are using encryption, make sure you are using the same WEP (security) key as set for the connection.

   - The instrument has a default WEP of 0123456789.

5. If you still cannot connect, check the network settings of both the instrument and instrument controller.

   - See "Appendix B, Configuring Ethernet and Wireless Communication" on page 49.

3.4 Cannot Connect Using a Wireless Access Point

1. See the section: "Common Communication Fixes" on page 38.

2. Make sure the SSID of the instrument is the same as the access point.

   - For information about configuring the network settings on the instrument, see "Changing the Network Settings on the Instrument" on page 52.

3. If access point uses encryption, make sure you are using the same WEP (security) key in the instrument as the access point.

4. Move the access point, instrument, and instrument controller to the same room to test the connection.

3.5 Instrument Loses its Wireless Connection

1. See section "Common Communication Fixes" on page 38.

2. Try to minimize the radio frequency noise in your environment.

   - Radio frequency noise interference can come from: 2.4 GHz cordless phones, microwaves, monitors, electric motors, ceiling fan, lights, security systems, etc.

3. Minimize obstructions between the instrument and the instrument controller.

   - Positioning of the instrument and instrument controller can affect the wireless range. Walls, ceilings, doors, buildings, hills, etc. can degrade the signal.

3.6 Windows Firewall Messages Display When You Try to Connect

The Windows firewall must be set to permit connections to specific ports on the instrument controller. Without these inbound and outbound rules for the ports, you the firewall displays messages when you try to connect and when you try to configure the network settings using the ASD IP Setup software.
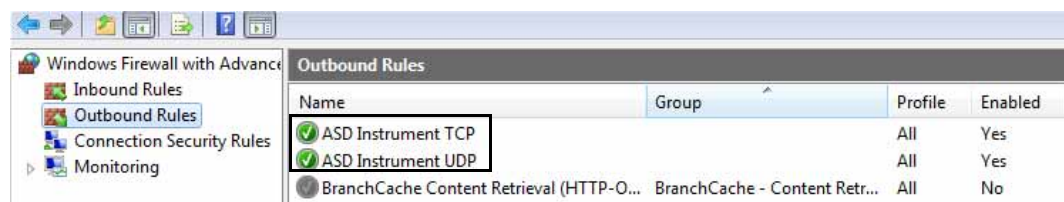
You may want to contact your network administrator about these settings.

To troubleshoot the Windows firewall:

1. Select **Start > Control Panel**.

2. Click **System and Security**.

3. Click **Windows Firewall**.

4. Click **Advanced Settings**.

5. Click I**nbound Rules.**

6. Make sure you see the two ASD rules.
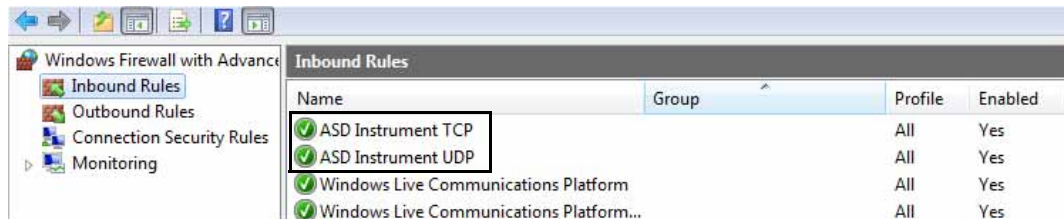
7. Click **Outbound Rules**.

8. Make sure you see the two ASD rules.

9. If the rules are there, but are not enabled, right-click each rule and select **Enable Rule**.

10. If these rules are not listed at all, you must add them using the following settings:

    - Inbound rule settings:

        - Port, TCP, port number 8080, allow the connection, select Domain, Private, and Public, and give it a name you will recognize.

        - Port, UDP, port number 2034, allow the connection, select Domain, Private, and Public, and give it a name you will recognize.

    - Outbound rule settings:

        - Port, TCP, port number 8080, allow the connection, select Domain, Private, and Public, and give it a name you will recognize.

        - Port, UDP, port number 2034, allow the connection, select Domain, Private, and Public, and give it a name you will recognize.

Appendix A: Specifications and WEEE Compliance

The following sections contain the specifications and WEEE compliance:

A.1 Physical Specifications

Below are the physical specifications of the instrument.

Height	12.7 cm	5 inches
Width	35.6 cm	14.5 inches
Depth	29.2 cm	11.5 inches
Weight	5.6 kg	12 lbs

- Enclosure is made of durable satin powder-coat finish with teal urethane end-caps and handles.

- All vital components are in a dust-proof enclosure and EMI sealed.

- Fiber optic inputs directly to the instrument.

A.2 Power Input and Output

Below are the power input and output.

AC Power Supply Type	Auto ranging, Switching, SELV
AC Input	90-240 VAC, 50/60 Hz
DC Input	+12 VDC, 60 W
Accessory Power Port (front of instrument)	Output, +12 VDC, 27 W (max).

A.3 Battery Specifications

Below are the battery specifications.

Type	NiMH (Nickel-Metal Hydride)
Rating	12 V 9 amp hour
Life	Over four hours using a contact probe in an ambient environment.
	Recycle batteries and do not dispose of as general waste.

A.4 Battery Charger Specifications

Below are the battery charger specifications.

Type	External desktop
AC input	90-240 VAC, 50/60 Hz
DC input	12 V 1.5 A
Charge time	Under 8 hours for a fully discharged 9 AH battery

A.5 Environmental Specifications

Below are the environmental specifications.

Operating Temperature	0 to 40°C
Operating and Storage Humidity	Non-condensing
Storage Temperature	-15 to 45°C

A.6 Wavelength Configuration

Below is the wavelength configuration.

Wavelength Name	Wavelength Range
VNIR-SWIR 1-SWIR 2	350 - 2500 nm

The spectral resolution is:

- 3 nm at@ 700 nm.

- 10 nm (at@ 1400 nm for the Standard-Res model; 30 nm for Wide -Res and 8 nm for High-Res.

- 10 nm at@ 2100 nm; 30 nm for Wide- Res and 8 nm for High-Res.

The sampling interval is:

- 1.4 nm for the spectral region 350-1000 nm.

- 2 nm for the spectral region 1000-2500 nm.

The spectrometer may be configured to have three separate holographic diffraction gratings with three separate detectors. Each detector is also covered with the appropriate order separation filters to eliminate second and higher order light.

- VNIR: 512 element silicon photo-diode array for the spectral region 350 to 1000 nm.

- SWIR 1: graded index, TE-cooled, extended range, InGaAs, photo-diode for the spectral region 1001 nm to 1800 nm.

- SWIR 2: graded index, TE-cooled, extended range, InGaAs, photo-diode for the spectral region 1801 nm to 2500 nm.

A.7 Network Interface Requirements

The instrument has 10/100 Base T Ethernet port. You an connect the instrument to the instrument controller use an Ethernet cross-over cable.

The instrument can also communicate with the instrument controller using the 802.11g wireless card. If you are not using the instrument controller that comes with the instrument, the instrument controller needs to be 802.11g compatible.

A.8 WEEE Compliance

Recycle. Items with this symbol indicate that the item should be recycled and not disposed of as general waste.

Appendix B: Configuring Ethernet and Wireless Communication

The instrument and instrument controller, when you purchase both from ASD, are configured to work when directly connected using either a wireless connection or an Ethernet cross-over cable.

If you need to connect to the instrument using your LAN or a wireless network, you must change the IP addresses and other settings of both the instrument and instrument controller.

The following sections will help you configure the Ethernet and wireless communication of the FieldSpec®4 instrument:

■ "B.1 Using the Instrument Configuration Utility (Recommended)" on page 47

■ "B.2 Changing the Network Settings on the Instrument Controller Using Windows" on page 52

■ "B.3 Setting Up and Using a Wireless Connection Using Windows" on page 53

B.1 Using the Instrument Configuration Utility (Recommended)

The Instrument Configuration Utility from ASD can automatically perform the following functions:

■ Update the instrument's firmware.

• Use only when directed to do so by ASD support personnel.

■ Update the instrument's .ini file.

• Use only when directed to do so by ASD support personnel.

■ Automatically configure a wireless connection on the instrument controller.

• See "Automatically Configuring a Wireless Connection on the Instrument Controller" on page 48.

You can also do the following manually using the Configuration Utility:

■ Update the instrument's firmware.

• Use only when directed to do so by ASD support personnel.

■ Update the instrument's .ini file.

• Use only when directed to do so by ASD support personnel.

- Change the LAN network settings on the instrument.
  - See "Changing the Network Settings on the Instrument Using the Instrument Configuration Utility" on page 51.
- Configure a wireless connection on the instrument controller.
  - See "Setting Up a Wireless Connection on the Instrument Controller Using the Instrument Configuration Utility" on page 49.
- Change the wireless network settings on the instrument.
 - See "Changing the Network Settings on the Instrument Using the Instrument Configuration Utility" on page 51.

Automatically Configuring a Wireless Connection on the Instrument Controller

The instrument and instrument controller, when you purchase both from ASD, are configured to connect automatically when connecting them wirelessly.

If the instrument controller and instrument do not connect successfully, or if you purchased the instrument controller from a third party, you can use the Configuration Utility from ASD to set up the wireless connection on your instrument controller.

To automatically configure a wireless connection on the instrument controller:

1. Connect an Ethernet cross-over cable to the instrument controller's Ethernet port and to the back of the instrument.

2. If not already installed, install the Instrument Configuration utility on the instrument controller from the USB flash drive that came with the instrument.
   - If you purchased your instrument controller from ASD, the Instrument Configuration utility is already installed on it.

3. From the instrument controller, select **Start > All Programs > ASD Programs > Instrument Configuration > Instrument Configuration**.
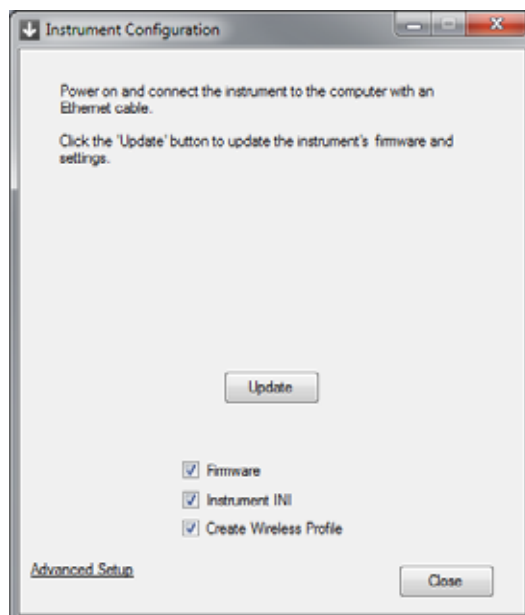
4. Deselect the Firmware and Instrument INI options.

   • Select these options only if ASD support personnel have said to update the firmware and .ini file.

5. Click **Update**.

   • The utility sets up the wireless connection on the instrument controller.

6. After the process finishes, turn off the instrument.

7. Disconnect the Ethernet cable from the instrument and instrument controller.

8. Turn the instrument turn on.

9. On the instrument controller, click the Network icon 🖳 in the system tray.

   • The system tray is in the lower-right corner of your screen.

   • You should see the instrument's wireless connection listed, showing a status of Connected. The name of instrument's wireless connection is based on the instrument's serial number.

   • If the connection status says "Waiting on users," wait a minute or two until the instrument completes its startup and connects to the instrument controller.

   • If the instrument's wireless connection shows a **Connect** button, click the button.

   • If instrument's wireless connection never shows the Connected status, you can use the Advanced Setup to configure the wireless connection. See "Setting Up a Wireless Connection on the Instrument Controller Using the Instrument Configuration Utility" on page 49.

Setting Up a Wireless Connection on the Instrument Controller Using the Instrument Configuration Utility

If the automatic setup did not work using the Instrument Configuration utility, you can set up the wireless connection on the instrument controller manually.

To set up a wireless connection on the instrument controller using the Instrument Configuration Utility:

1. Connect an Ethernet cross-over cable to the instrument controller's Ethernet port and to the back of the instrument.

2. From the instrument controller, select **Start > All Programs > ASD Programs > Instrument Configuration > Instrument Configuration**.

3. Click **Advanced Setup**.

4. Click the **Computer Wireless Network** tab.

5. If you see a profile in the Wireless Profiles list, select it and click **Remove**.

6. In the SSID field, enter the instrument's serial number.

   • This field must match the SSID field on the Instrument Wireless Setup tab.

7. In the WEP field, enter 0123456789.

   • This is the default security key (WEP) for the instrument. This field must match the WEP field on the Instrument Wireless Setup tab.

8. Leave the Automatically Connect option selected.

9. Click **Add**.

   • After a a few seconds, the instrument and instrument controller should connect.

10. On the instrument controller, click the Network icon in the system tray.

   - The system tray is in the lower-right corner of your screen.

   - You should see the instrument's wireless connection listed, showing a status of Connected. The name of instrument's wireless connection is based on the instrument's serial number.

   - If the connection status says "Waiting on users," wait a minute or two.

   - If the instrument's wireless connection shows a **Connect** button, click the button.

11. Disconnect the Ethernet cable from the instrument and instrument controller.

Changing the Network Settings on the Instrument Using the Instrument Configuration Utility

To connect directly from the instrument controller to the instrument, either using an Ethernet cross-over cable or direct wireless connection, you can use the default network settings.

If you need to connect to the instrument using your LAN or a wireless network, you must change the network settings of instrument. Contact your network administrator for the required settings.

After you have the settings, you can change them to conform to your network's configuration. Be sure to make the corresponding changes on the instrument controller.

The default network settings for the instrument are:

- IP address
  - Wireless—10.1.1.77
  - Ethernet—10.1.1.11
- Network mask—255.255.255.0
- Gateway, DNS, DHCP—0.0.0.0
- Wireless only fields
  - SSID—Serial number of the instrument
  - WEP—0123456789 (This is an encryption security key.)

To change the network settings of the instrument using the Instrument Configuration utility:

1. Connect an Ethernet cross-over cable to the instrument controller's Ethernet port and to the back of the instrument.

2. From the instrument controller, select **Start > All Programs > ASD Programs > Instrument Configuration > Instrument Configuration**.

3. Click **Advanced Setup**.

4. Configure the network settings.

For a LAN connection	For a wireless connection
1. Click the **Instrument Ethernet Setup** tab. 2. If needed, click **Search** to find the instrument's current Ethernet settings. 3. Edit the fields based on the information from your network administrator,	1. Click the **Instrument Wireless Setup** tab. 2. If needed, click **Search** to find the instrument's current wireless settings. 3. Edit the fields based on the information from your network administrator, • SSID—This is the name of the wireless network (hotspot). • WEP—This is a security key that you must enter when you connect to the wireless network.

5. Click **Save**.

   - If you want to go back to the default network settings for the instrument, click **Reset**.

B.2 Changing the Network Settings on the Instrument Controller Using Windows

To connect directly from the instrument controller to the instrument, either using an Ethernet cross-over cable or direct wireless connection, you can use the default network settings.

If you need to connect to the instrument using your LAN or a wireless network, you must change the network settings of instrument controller. Contact your network administrator for the required settings.

After you have the settings, you can change them to conform to you network's configuration. Be sure to make the corresponding changes on the instrument.

The default IP address of the instrument controller is: 10.1.1.11.

To change the network settings on the instrument controller:

1. Connect an Ethernet cross-over cable to the instrument controller's Ethernet port and to the back of the instrument.

2. Select **Start > Control Panel**.

3. Click **Network and Internet**.

4. Click **Network and Sharing Center**.

5. Click **Change Adapter Settings**.

Ethernet connection   Wireless connection
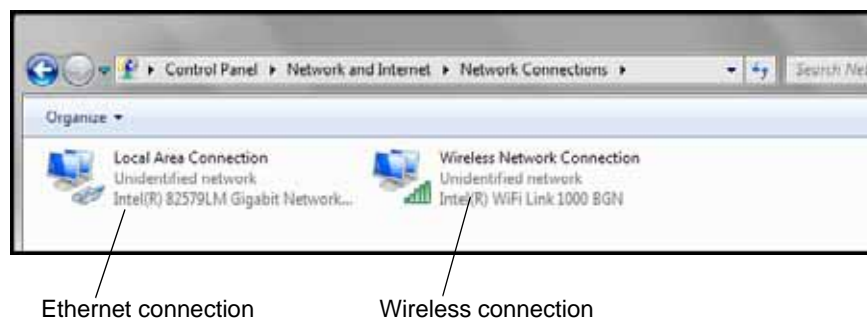
6. Right-click the connection you want to configure, and select **Properties**.

   • If you want to configure a wireless connect and do not see one here, you must set up a wireless connection. See "Setting Up a Wireless Connection Using Windows" on page 53.

7. On the Networking tab, select **Internet Protocol Version 4 (TCP/IPv4)**.

8. Click **Properties**.

9. Based on the information from your network administrator, configure the network settings.

10. Click **OK**.

11. Click **Close**.

12. Repeat steps 6 through 11 for the other connection, as needed.

B.3 Setting Up and Using a Wireless Connection Using Windows

To communicate with the instrument through its wireless interface, you must set up a wireless network connection on the instrument controller. The following sections describe how to create the wireless connection in Windows 7.

If you must set up the wireless connection manually using Windows, use the information in the following sections:

- "Setting Up a Wireless Connection Using Windows" on page 53
- "Connecting to the Wireless Connection" on page 54
- "Disconnecting from the Wireless Connection" on page 54

Setting Up a Wireless Connection Using Windows

If you have never used a wireless connection on your instrument controller or if the wireless connection does not appear on the list of connections, you must set up the wireless connection.

To set up a wireless connection:

1. Click the Network icon [icon] in the system tray.

   - The system tray is in the lower-right corner of your screen.

2. Click **Open Network and Sharing Center**.

3. Click **Manage wireless networks**.

4. Click **Add**.

5. Click **Create an ad hoc network**.
6. Click **Next**.
7. In the Network name field, enter the instrument's serial number.
8. From the Security type drop-down list, select WEP.
9. In the Security key field, enter 0123456789.
   - This is the default security key (WEP) for the instrument.
10. Select the Save this network option.
11. Click **Next**.
12. Click **Close**.
    - You should now see the connection you set up in the Manage wireless networks window.

13. Click the Network icon ![icon] in the system tray.
    - The window should contain the instrument number entered above with the status as: Waiting for users. If the instrument is on, the status should change to Connected.

Connecting to the Wireless Connection

After you set up the wireless connection, you can connect to the instrument.

To connect to the wireless connection:

1. Turn on the instrument.

2. From the instrument controller, click the Network icon ![icon] in the system tray.
   - The system tray is in the lower-right corner of your screen.
3. Select the instrument's wireless network.
4. Click **Connect**.

Disconnecting from the Wireless Connection

When you are finished using the instrument, you can disconnect from the wireless connection.

To disconnect from the wireless connection:

1. Click the Network icon ▯ in the system tray.

   • The system tray is in the lower-right corner of your screen.

2. Select the instrument's wireless network.

3. Click **Disconnect**.

Chapter C: FAQs

The following sections will help you with questions about the FieldSpec®4 instrument:

C.1 General

What Is a Spectrometer?

Spectrometer — An optical instrument that uses detectors, other than photographic film, to measure the distribution of radiation in a particular wavelength region. All ASD instruments are spectrometers. The SWIR component of the ASD spectrometer is a scanning spectrometer, while the VNIR component is an array spectrometer.

Spectroradiometer — An optical instrument for measuring the radiant energy (radiance or irradiance) from a source at each wavelength throughout the spectrum. A spectroradiometer is a special kind of spectrometer.

Spectrograph — An optical instrument for forming the spectrum of a light source and recording it on a film. The dispersing medium may be a prism or a diffraction grating. This term was common prior to the digital age. ASD instruments do not use film.

How Long Does It Take for the Instrument to Warm Up?

The warm-up time of the instrument depends on the environment in which it is used.

One hour is recommended for radiometric work.

Only 15 minutes is needed for reflectance measurements, especially if you need to conserve the battery life.

What Does a Broken Fiber Mean?

The fiber optic cable is made up of fifty-seven (57) randomly distributed glass fibers:

- Nineteen 100-micron fibers for the VNIR region.
- Nineteen 200-micron fibers for the SWIR 1 region.
- Nineteen 200-micron fibers for the SWIR 2 region.

Each broken fiber results in a response loss of approximately 5%.

A few broken fibers are not critical when measuring reflectance, because this is a ratio. However, if too many fibers are broken, the signal decreases too much and the spectra will be excessively noisy. How many broken fibers are too many depends on the application and types of samples you are using the instrument for.

Radiance and irradiance are measured using the raw data and comparing to numbers that exist in the calibration file. Therefore, a few broken fibers will result in lower values.

The fibers are well protected by the cable casing. If there are kinks in your cable, the fibers are not necessarily damaged. However, if your cable has been severely damaged, chances are high that the fibers have been damaged, too. To determine if any fibers are broken, see "Checking for Broken Fibers in the Fiber Optic Cable" on page 11.

The fibers can be damaged by coiling the cable up too tightly. If left in a tight coil for longer than a week, the fibers are likely to develop longitudinal fractures that will not be detectable. These fractures in the fiber will cause light leakage, resulting in a weaker signal. Store the fiber optic cables loosely in the netting compartment on the instrument.

NOTICE   The fiber cable should never be stored with a bend of less than a 5" diameter for long periods of time.

How Long Is the Battery Life?

A fully charged battery's life depends on the battery age, instrument configuration, environment, and accessories powered by the accessory power port. The expected battery life is over four hours using a contact probe in an ambient environment.

The limiting factor for how long you can work in the field may be the battery in the instrument controller rather than the instrument's battery.

What Is Remote Sensing?

Remote sensing is the art and science of obtaining information about an object without being in direct physical contact with the object.

The ASD spectrometers achieve this using visible and near-infrared (VNIR) and short-wave infrared (SWIR) spectra.

Where Is My Serial Number?

The serial number is a five-digit number located on a label on the back of the instrument where the power switch is, as shown in Figure C.1. The label also contains the model number and MAC address for the instrument.

The serial number is also accessible in the RS³ software by selecting **Help > About**. When corresponding with ASD about any instrument questions, you should provide the instrument serial number.

Figure C.1: Label with serial number

C.2 Collecting Spectra

- " How Often Do I Need to Optimize?" on page 59
- " How Often Do I Need a Baseline or White Reference?" on page 59
- " What Spectrum Average (or Sample Count) Should I Use?" on page 60
- " How Do I Collect a Reference with a Spot Size Larger Than the Spectralon Panel?" on page 60
- " When Do I Use Absolute Reflectance?" on page 60
- " How Do I Know the Field of View That I'm Using?" on page 60
- " What Are the Units of Radiance?" on page 61

How Often Do I Need to Optimize?

Optimization is the process of setting the instrument's electronics to optimally process the incoming signal. This means that the digitalization of the light signal is within a range of values that provide good signal-to-noise performance and does not allow the instrument to saturate at the current light levels.

The instrument must be re-optimized if:

- Atmospheric conditions change.

- The light source changes.

- The instrument is in the process of warming up and the response changes substantially.

- The instrument is saturating.

Outdoor conditions can change rapidly or slowly. It all depends on clouds, wind (affecting temperature), instrument warm-up time, etc.

Use the Spectralon reference panel when optimizing and for taking a white reference measurement. The position of the reference panel when taking a white reference should be as similar as possible to the position for collecting data from the samples.

When saving reflectance data, point the fiber optic cable at the Spectralon panel once every few measurements for a minute or two with the same viewing geometry. If the relative reflectance of the Spectralon panel is less than or greater than one, a new white reference may be needed. If the relative reflectance of the Spectralon panel is greater than one, reoptimization is recommended.

The ASD RS^3 software provides a saturation warning. We recommend leaving the volume on the instrument controller loud enough to hear the warning.

How Often Do I Need a Baseline or White Reference?

Inside Use or Using an Accessory Light Source

When using the instrument inside under constant lighting conditions or when using an accessory with its own light source, collect a white reference every 10 to 15 minutes while the instrument is warming up and every 30 minutes thereafter.

Outside Use

When using the instrument outside, you should collect a new white reference at least every ten minutes.

The more frequent the white references, the better the resulting reflectance spectra will be. You need more frequent white references outdoors because of changing illumination, atmospheric conditions, and temperatures.

The light intensity when collecting the white reference should be the same when collecting spectra of samples.

When outside, continue to take measurements of the white reference panel and observe the stability of the white reference line. This will give you an idea of how the current fluctuations in weather affect your measurements.

What Spectrum Average (or Sample Count) Should I Use?

The default averages are as follows:

- Spectrum—10
- White reference—25
- Dark current—10

When outside, these defaults may work well for you. In general, we suggest that the white reference be set to about double the spectrum and dark current averages.

The noise decreases at the square root of the number of scans used in the averaging.

The actual spectrum average will be a compromise between noise reduction through spectra averaging and the time required for each spectra collection. For example, if you are using the instrument to measure a large number of samples, you want a smaller number of spectra in the average to decrease the collection time required. If you are collecting a few spectra, you'll want to increase the number of spectra in the averaging to obtain the cleanest spectra possible.

How Do I Collect a Reference with a Spot Size Larger Than the Spectralon Panel?

Purchase a bigger reference panel or move the fiber optic cable closer to it.

If you are indoors using artificial light, make sure that the distance and angle from the reference panel is the same as for samples.

If you are outdoors and the sun is your light source, the reference panel can be closer to the fiber optic cable than the samples.

When Do I Use Absolute Reflectance?

It depends on how you are analyzing your data. An absolute reflectance most likely will not be needed when using an accessory with its own light source.

It can't hurt to use absolute reflectance. The difference between absolute and relative reflectance is small for wavelengths less than 2000 nm.

Because relative reflectance relies on a physical white reference, you will see deviations from the absolute below 350-400 nm and above 2000-2500 nm.

How Do I Know the Field of View That I'm Using?

The field of view is labeled on the fore optic that you use. The bare fiber has a 25° field of view.

When you are measuring radiance, set the correct field of view in the RS³ software using the fore optics drop-down list.
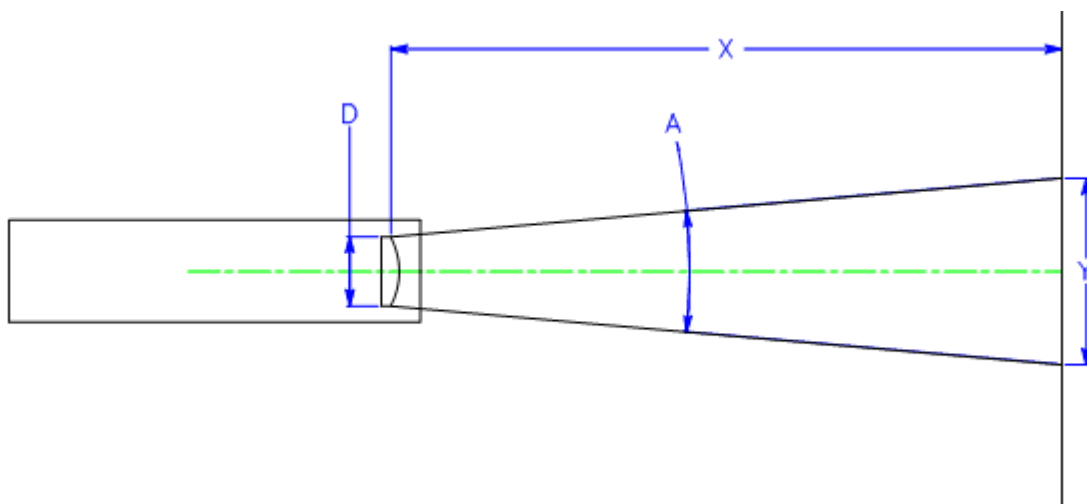
Figure C.2: Field of view

D = effective diameter of fore optic lens

A = fore optic's angular field of view

X = distance to viewed surface

Y = diameter of field-of-view

Near field (less than 1 meter):

Y = D + 2 * X * Tan(A/2)

Far field (greater than 1 meter):

Y = 2 * X * Tan(A/2)

What Are the Units of Radiance?

Radiance is measured in Watts per square meter per steradian (W/m^2/sr).

However, the instrument measures spectral radiance, which is the amount of radiance per unit wavelength. Spectral radiance is measured in Watts per square meter per steradian per nanometer (W/m^2/sr/nm).

Reflectance and transmission measurements are ratios of the optical energy from a sample compared to the optical energy from a reference panel. The units cancel out, so these measurements do not use the calibration files to calculate radiance.

The instrument measures irradiance in Watts per square meter per nanometer (W/m^2/nm).

C.3 Working with Data

- "Can I Post-process My Data?" on page 62
- "Why Do I See Oscillations (Sine Wave) in My Data?" on page 62
- "What Are These Two Large Noise Bands in My Data?" on page 62
- "What Are These Upward or Downward Spikes in VNIR Data?" on page 63

Can I Post-process My Data?

Yes. The ViewSpec Pro software is one of many programs that can post-process your data. You can import the spectral data into many different programs or export to ASCII text files for incorporation into other applications.

The complete specification of the ASD file format is available upon request.

Why Do I See Oscillations (Sine Wave) in My Data?

Your light source may use AC power. A single SWIR band is about 100 ms. If you observe five or six waves in a single SWIR, the AC light source is the cause.

Waves can also occur if the lamp reflector and/or cover glass behave as a white-light interferometer. Solution: remove the glass and/or use a more diffuse reflector.

What Are These Two Large Noise Bands in My Data?

Water vapor in the atmosphere absorbs light in the 1400 nm and 1800 nm bands. This results in little to no signal at these wavelengths. When the reference and target spectra are ratioed to create reflectance measurements, very small, randomly fluctuating numbers (that is, noise) create large fluctuations in the spectra.
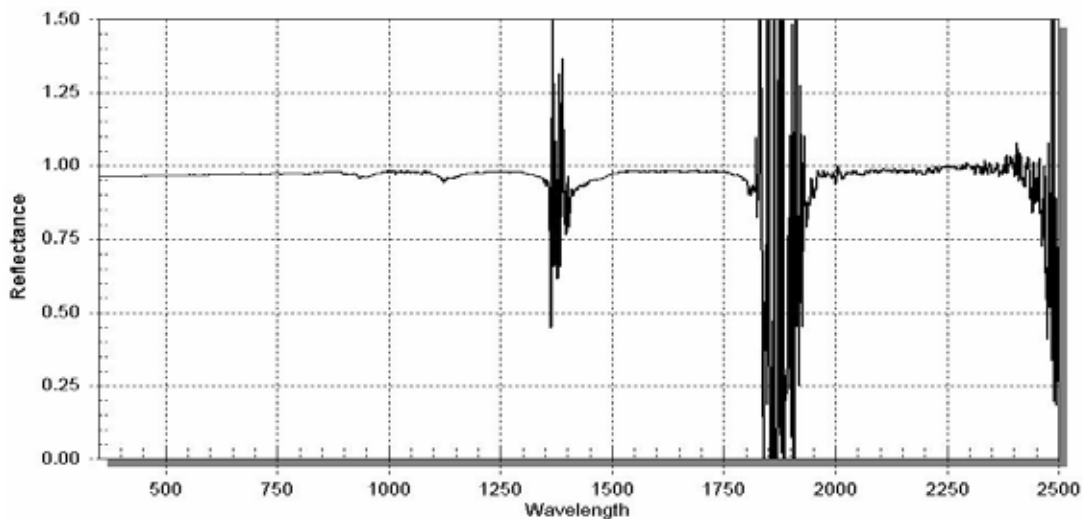
Figure C.3: Examples of water vapor absorbing light.

What Are These Upward or Downward Spikes in VNIR Data?

Figure C.4 shows upward spikes resulting from artificial light sources, in particular fluorescent lights.
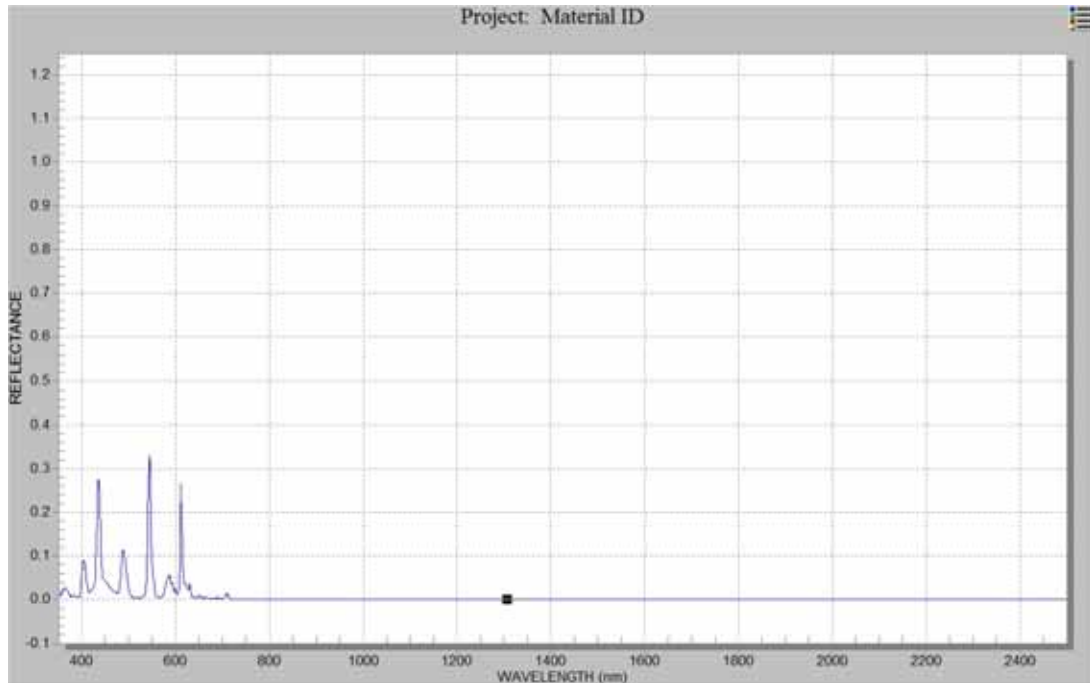
Figure C.4: Spectrum of fluorescent lights.

What Are These Steps in My Data?

Light is brought into the instrument by various combinations of the strands in the fiber optic cable. Each strand has its own field of view. When the cable is held close to the sample, each strand views slightly different portions of the sample. This can result in the stepped data.

Hold the end of the fiber cable farther away from the sample to allow the field of view of the individual strands to overlap and mesh together.

Stepping of data is common when the fore optic has a lens and less common when using the bare fiber optic cable or sampling devices. Large persistent steps can indicate broken fibers. The ViewSpec Pro software can remove large steps in reflectance data through the Splice Correction utility.

What Can Cause More Noise in My Data from Last Time?

Many factors can cause noise in your data from one session to another. Noise in a measurement is related to the instrument, the signal level, and noise in the light source. Many times the appearance of noise is actually a decrease in the strength of the signal, as opposed to an increase in noise.

Under normal operating conditions, noise visible in a spectrum is always the result of a trade-off between the inherent noise in the system and the signal.

The angle of the sun at high noon in the fall has a reduced light level than at high noon in high summer. Likewise, the time of day and the sun's position affect light levels, as well as atmospheric conditions.

Also, broken fibers in the fiber optic cable can contribute to noise. Perform a fiber optic check to verify. See "Checking the Fiber Optic Cable for Broken Fibers" on page 14.

An increase in noise can be due to a problem in the instrument such as an electronic component malfunction or a grounding problem. This is usually indicated by a regular pattern to the noise or periodic bursts of noise that are visible over the normal spectra.

Why Does the VNIR Drop to Zero after a Dark Current Collection?

When the VNIR drops to zero after a dark current has been collected, this may indicate a problem with the VNIR shutter or dark current collection routine. To verify, do one of the following:

- Observe if you have a normal response curve in the VNIR before optimizing or before taking a dark current and see a flat line after optimization.

- Optimize the instrument and listen for the click of the shutter activating. If you do not hear the shutter click, contact technical support and obtain an RMA to send the instrument in for repairs.

How Can I Convert My Data?

The ViewSpec Pro software can convert spectral data to ASCII text files and several other file formats. Refer to the user manual for the ViewSpec Pro software for more details.

Conversion can be done one file at a time. Or, several files can be merged into a single text file, which is a useful feature when inputting data into other analysis software.

C.4 Network and GPS

- " How Do I Set Up GPS?" on page 64
- " What Type of Ethernet Cable Can I Use for the Static IP Configuration?" on page 65

How Do I Set Up GPS?

See "2.8 Setting Up GPS" on page 30.

What Type of Ethernet Cable Can I Use for the Static IP Configuration?

You can connect the instrument directly to the instrument controller using a Ethernet cross-over cable.

When the instrument and instrument controller communicate over a network, use standard Ethernet cables and IP addresses compatible with the network. The instrument imposes significant traffic on the network, which can cause packet delays to other users. More importantly, network traffic from other users can negatively impact the reliability of the communication between instrument and instrument controller.

C.5 Instrument Controller

- " Can I Install Additional Software on the Instrument Controller?" on page 65
- " Why Does the Software Seem to Do Unexpected Things?" on page 65

Can I Install Additional Software on the Instrument Controller?

Yes, but with qualifications.

The types of software that can interfere with the measurement of data are utilities, network software, and those working in the background, such as virus checkers.

ASD software requires real-time access to the data that is being streamed from the instrument at a high rate of speed. Software running in the background can cause packets to be lost.

Microsoft Office software, image processing software, and other software generally do not interfere with ASD software, particularly if they are not running and competing for CPU cycles and RAM at the same time that data is being collected from the instrument.

Why Does the Software Seem to Do Unexpected Things?

To ensure accuracy in the collection and processing of data, the ASD software finishes its current operation before moving on. The instrument outputs a lot of data at a high rate of speed for the ASD software to collect.

In addition, the ASD software will stack up your keystroke entries and execute them later, in the order they were received.

Wait for the collection to finish before entering the commands to launch another operation. Don't rush into new operations or into issuing new commands until you see the results of the current command.

Appendix D: Standard Accessories

- FieldSpec 4 User Manual (printed and PDF on flash drive)

- Instrument controller: ASD-approved laptop computer

- RS^3 software

- 1.5 meter full-range low OH fiber optic cable

- Power supply 12 V

- NiMh battery (12 V, 9000 mA hour) with charger and 6 ft. battery-to-instrument power cable

- Power adapter with 6 m (20 ft) cable for automobile cigarette lighter

  - When using this adapter, turn off the engine to the vehicle. Electromagnetic fields from the engine can generate noise in the acquired signals.

- 1.5 meter Instrument-to-probe accessory power cable

- Remote trigger with LEDs and hook and loop strips

- RJ45 CAT 5e UTP Ethernet, shielded, cross-over cable

- 4 GB flash drive memory USB flash drive

- Mylar wavelength reference

- Pistol grip

- Pro laptop carrier

- Magnifier for Fiber Checker

- Shipping trunk: Durable, air tight, wheeled, fold-down handle, and foam filled with cutouts to protect the instrument and many accessories

D.1 Accessories for Light Sources and Probes

ASD offers several accessories for:

- Delivering illumination to the sample.

- Collecting reflected or transmitted light from the sample.

- Collecting reflected or transmitted radiance and irradiance from the sample (where solar light is the primary source of illumination).

- Transmitting the collected light to the instrument.

Some accessories, such as many of the optional fore optic probes, rely on other illumination sources, and even solar light.

Appendix E: Understanding Field Measurement Conditions

Field spectrometry is the quantitative measurement of radiance, irradiance, reflectance, or transmission in the field. It involves the collection of accurate spectra and requires an awareness of the influences of:

- Sources of illumination
- Instrument field of view
- Sample viewing and illumination geometry
- Instrument scanning time
- Spatial and temporal variability of the sample characteristics

Many of these parameters are controlled when using one of the ASD standard sampling interfaces (for example., MugLite or Contact Probe).

To develop a field experiment, you must first define of the overall experimental design. Unfortunately, the formulation of an appropriate experimental design is not always obvious.

In light of the objectives of the study, you must consider issues such as the:

- Timing of the data collections
- Spatial scale of the field measurement
- Target viewing and illumination geometry
- Collection of ancillary data sets

Without appropriate ancillary data sets may make previously collected data sets unusable for a new application.

Frequently, you must change the experimental design to account for the characteristics of the available instrumentation.

For example, vegetation canopy spectra collected using a slow scanning instrument will sometimes have small wind-induced "absorption" features in those portions of the spectra when the instrument was viewing more shadow.

The following sections describe more about collecting spectra in the field:

E.1 Illumination

To determine the reflectance or transmittance of a material, two measurements are required:

- The spectral response of a reference sample
- The spectral response of the target material

You must compute the reflectance or transmittance spectrum by dividing the spectral response of the target material by that of a reference sample. The ASD software handles both the collection of the two spectral responses and the calculation of reflectance or transmittance.

Using this method, all parameters that are multiplicative in nature and present in both the spectral response of a reference sample and the target material, are ratio-ed out, such as:

- The spectral irradiance of the illumination source
- The optical throughput of the field spectrometer

This process assumes that the characteristics of the illumination are the same for the reference and target materials. Variability of the illumination characteristics between the time the reference and target materials are measured will result in errors in the resultant spectra.

Characteristics of Natural Illumination

Field spectrometry typically involves ambient solar illumination. As such, the target can be illuminated by three or more sources (see Figure E.1), each with its own spectral characteristics. Unless the target is in a shadow, the direct solar illumination is the dominant source of illumination.
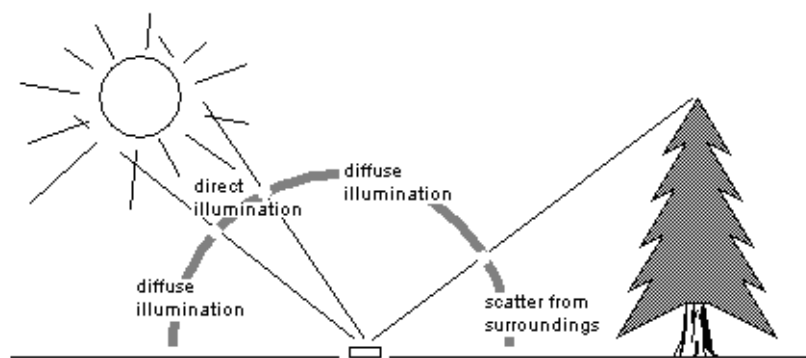
Figure E.1: The major sources of illumination.

You may have several sources of light scattered off surrounding objects, each with its own unique spectral distribution.

Parameters such as solar elevation angle and atmospheric conditions will effect the overall intensity and spectral characteristics of direct solar illumination. Diffuse skylight illumination

can contribute as much as 5-10% of the total illumination reaching a surface. At shorter wavelengths, diffuse skylight can contribute as much as 20-25% of the total.

The spectral characteristics of the illumination scattered off surrounding objects is determined by their reflectance characteristics. In the case of a forest clearing, as much as 20% of the illumination in the 750-1200 nm wavelength range can be attributed to sunlight scattered off the surrounding forest canopy.

One important source of surrounding scattered light is the person and the instrumentation making the measurement. Objects in the surroundings also affect the overall illumination of the target surface by obscuring a portion of the diffuse skylight and, possibly, shading the target from direct solar illumination.

The magnitude of both the diffuse skylight and scattered light is determined by the solid angle subtended by these sources when viewed from the reference frame of the target surface.

The surface texture of the material being measured also affects the relative portion of the various sources of illumination. When compared to a smooth surface, a surface with a rough texture will tend to have a higher portion of illumination from the diffuse and scattered light relative to the direct solar illumination.

Characteristics of Artificial Illumination

The use of artificial illumination allows:

- More control over illumination and viewing geometry.
- More control over sample geometry.
- Measurements during non-optimal conditions (for example, cloud cover or at night).
- Measurement of reflectance and transmittance in the deep atmospheric absorption bands.

Several problems with using artificial illumination include:

- Difficulty in maintaining a constant distance between the sample or reference and the light source when measuring samples with irregular geometry.
- "Cooking" vegetation samples under the lights (water loss, chlorophyll degradation).

In a typical lamp configuration for indoor use, you view the sample with the collecting optics of the spectrometer nadir to the sample. Use one or two 200 to 500 Watt quartz-halogen cycle tungsten filament lamps (~3400°K color temperature) in housings with aluminum reflectors about one meter above the surface being measured.

Alternatively, the light source can be either incorporated into the field spectrometer (often precluding the use of solar illumination) or can be provided in the form of an optional accessory that mounts to the light collecting optics of the instrument.

E.2 Atmospheric Characteristics

Absorbing molecules in the atmosphere strongly modify the incoming solar irradiance. All of the absorption features will increase in intensity as the atmospheric path length of the incoming solar radiation increases (e.g. with changing solar elevation angle).

By far, water vapor is the strongest modifier of the incoming solar spectrum. Water vapor has absorption features spanning the solar reflected region of the spectrum (see Figure E.2), and varies both spatially and temporally.
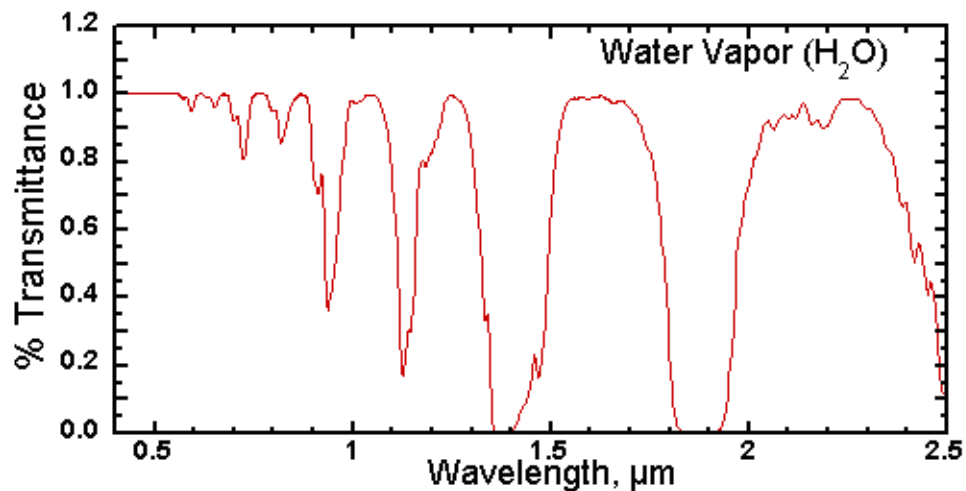
Figure E.2: Transmission spectrum of carbon dioxide for typical atmospheric conditions

Carbon dioxide has strong features in the 2000-2200 nm range (see Figure E.3), a region of major interest for the identification of layered silicate minerals. Carbon dioxide is a well mixed gas, thus the intensity of the absorption features associated with carbon dioxide are not as variable as those of water vapor, but they do decrease with increasing altitude.
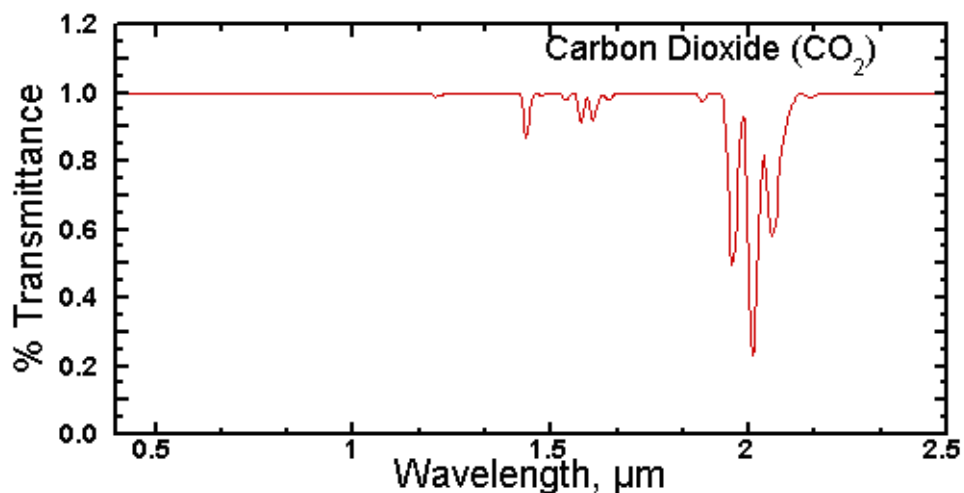
Figure E.3: Transmission spectrum of carbon dioxide for typical atmospheric conditions.

Appendix E: Understanding Field Measurement Conditions

Other major atmospheric components that influence the atmospheric transmission spectrum are shown in Figure E.4.
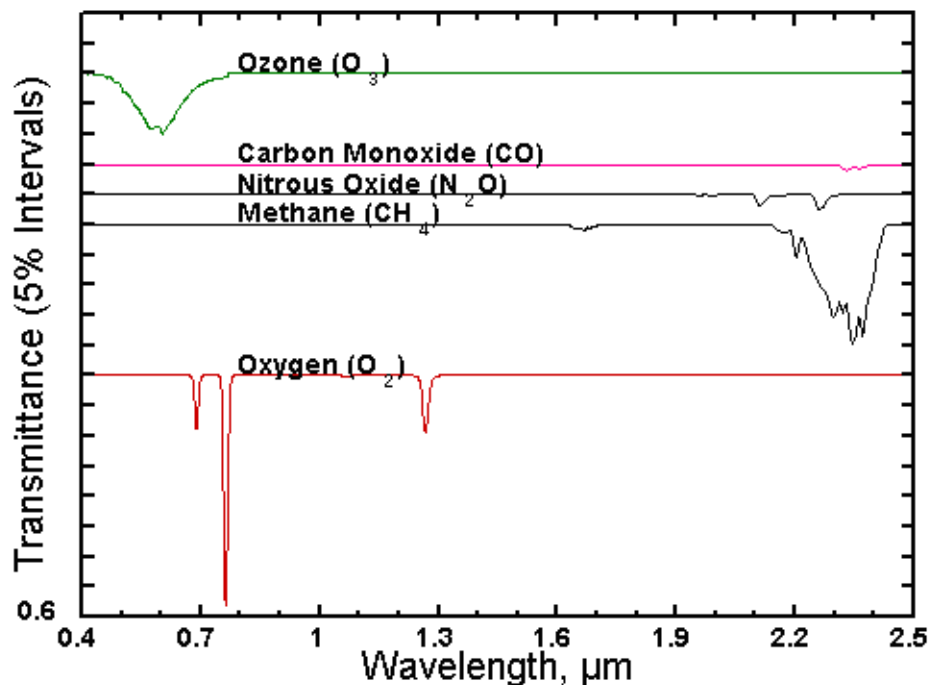
Figure E.4: Transmission spectrum of various gases for a typical atmospheric conditions

E.3 Clouds

Partial cloud cover is indicative of highly spatially and temporally variable atmospheric water vapor.

Because of the large influence of water vapor on the atmospheric transmission, variability of atmospheric water vapor between the time when the reference and target measurements are made will result in errors in the resultant spectrum.

You can reduce this error by minimizing the length of time between the measurement of the reference sample and the target.

While they are difficult to see and often appear inconsequential, the presence of cirrus clouds tends to produce significant variability in atmospheric water vapor.

Partial cloud cover also greatly increases the intensity of diffuse skylight illumination. This tends to "fill in" shadows and reduce the contrast between surfaces with dissimilar surface textures.

If you want to collect field spectra for image calibration or interpretation, collect spectra under

illumination conditions similar to those at the time the image was collected.

Measure the Magnitude of the Effect Cirrus Clouds

Here is a way to measure how much cirrus clouds affect spectra collection:

1. Standardize the field spectrometer on the reference panel.
2. Continue to view the reference panel with the instrument.
   - If the atmospheric conditions are stable, the computed reflectance of the panel will be a flat spectrum with near 100% reflectance.
   - If atmospheric conditions are unstable, the computed reflectance of the panel will vary over time and will show absorption minima or maxima (depending on whether atmospheric water vapor is increasing or decreasing) at the wavelengths corresponding to the water vapor absorption features.

With this method, you can determine if you can collect sufficiently accurate spectral data.

E.4 Wind

Wind can be a source of error if the material being measured moves as you collect spectrum.

If a spectrum is slowly scanned, changes in the amount of shadow in the instrument field of view will result in erroneous "features" in the spectrum.

Vegetation canopies, with their large portion of shadow, are especially susceptible to wind-induced errors.

Instruments using an array detector or that scan the spectrum rapidly are not significantly affected by wind.

E.5 Vegetation

The absorption features seen in vegetation spectra are all related to organic compounds common to the majority of plant species.

Thus, the information about a plant canopy is contained in the relative intensity of the various absorption features, rather than in the presence or absence of a specific absorption feature.

The major spectral absorption features can be attributed to:

- Water
- Plant pigments
  - Chlorophyll
  - Zanthophyll
  - Carotenoids

Other, minor, absorption features are attributable to other chemical components, including:

- Cellulose
- Lignin
- Proteins

- ■ Starches
- ■ Sugars

Non-photosynthetic components of the canopy have spectra that are dominated by absorption features attributed to lignin and cellulose.

The spectral radiance leaving a vegetation canopy is significantly impacted by many factors, such as those listed in Figure E.1.

Table E.1: Major variables affecting the spectral radiance of a vegetation canopy

Illumination	• Geometry
	   • Angle-of-incidence of sun (or radar)
	   • Azimuth
	• Spectral characteristics

Sensor	• Canopy
	   • Type (plant or tree nominal class)
	   • Closure
	   • Orientation
	     • Systematic (for example, rows)
	     • Unsystematic (random)
	• Crown
	   • Shape (or example, circular, conical)
	   • Diameter (m)
	• Trunk or stem
	   • Density (units per m^2)
	   • Tree diameter-at-breast-height: tree trunks or plant stems have a certain density.
	• Leaf
	   • Leaf-area-index: defines the area that interacts with solar radiation; the surface that is responsible for carbon absorption and exchange with the atmosphere.
	   • Leaf-angle-distribution: may change throughout the day as the leaves orient themselves toward or away from the incident radiation.

Understory	Same as vegetation
Soil	• Texture • Color • Moisture content

E.6 Rocks, Soils, and Man-Made Materials

The shape of the spectral signature of rocks and soil tends not to change with respect to the viewing geometry. The overall brightness of the observed spectrum does change with illumination and viewing geometry, due to changes in the amount of shadow in the field of view of the spectrometer.

Absorption features in the spectra of rocks and minerals are due to the presence of specific molecular groups and are often diagnostic of the minerals present in the sample.

E.7 White Reference

A material with 95-99% reflectance across the entire spectrum is called a white reference panel or white reference standard.

The raw measurement made by the spectrometer is influenced by both the sample and the light source. You need an independent measure of the light source illumination on a reference of known reflectance to calculate the reflectance of the sample. The use of a white reference standard with near 100% reflectance simplifies this calculation.

The ASD software, such as RS[3], can calculate the ratios for reflectance or transmittance of the material being sampled by the spectrometer using the white reference as the standard.

Spectralon reference standard from Labsphere is the white reference panel that is very suitable for the VNIR and SWIR spectral ranges of ASD instruments.

Spectralon reference panels are made of polytetraflouroethylene (PTFE) and cintered halon. It has the characteristic of being nearly 100% reflective within the wavelength range of 350 nm to 2500 nm. A Spectralon white reference scatters light uniformly in all directions within that wavelength range.

Appendix F: Theory of Operation

The following sections describe the instrument's theory of operation:

F.1 Overview

The instrument measures the optical energy that is reflected by, absorbed into, or transmitted through a sample. Optical energy refers to a wavelength range that is greater than the visible wavelengths, and is often called electromagnetic radiation or optical radiation.

In its most basic configuration, the instrument views and detects the form of radiant energy defined as radiance. With accessories, various set-ups, and built-in processing of the radiance signal, the instrument can measure:

- Spectral reflectance

- Spectral transmittance

- Spectral absorbance

- Spectral radiance

- Spectral irradiance

F.2 Fiber Optic Collection of Reflected/Transmitted Light

Optical energy is collected through a bundle of specially formulated optical fibers that are precisely cut, polished, and sealed for extremely efficient energy collection. The fibers themselves are of low hydroxyl molecule composition providing the maximum transmission available across the wavelength range of the instrument.

F.3 Inside the Instrument

The fiber cable delivers the collected optical energy to the instrument, where it is projected onto a holographic diffraction grating. The grating separates and reflects the wavelength components for independent measurement by the detectors.

F.4 Visible and Near-Infrared (VNIR)

The visible and near-infrared (VNIR: 350-1000 nm wavelength) portion of the spectrum is measured by a 512-channel silicon photodiode array overlaid with an order separation filter. Each channel (or detector) is geometrically positioned to receive light within a narrow (1.4 nm) range. The VNIR spectrometer has a spectral resolution (full-width half-maximum of a single emission line) of approximately 3 nm at around 700 nm.

Each detector converts incident photons into electrons. This photocurrent is continually converted to a voltage and is periodically digitized by a 16-bit analog-to-digital converter. This digitized spectral data is then transmitted to the instrument controller for further processing and analysis.

The 512-channel array can scan the entire VNIR spectrum in parallel at 1.4 nm wavelength intervals. A single sample can be acquired in as little as 8.5 ms.

F.5 Short-Wave Infrared (SWIR)

The near-infrared (NIR), also called short-wave infrared (SWIR), portion of the spectrum is acquired with two scanning spectrometers:

- SWIR 1 for the wavelength range of 1000 nm to 1800 nm.
- SWIR 2 for the wavelength range of 1801 nm to 2500 nm.

The SWIR scanning spectrometer has one detector for SWIR 1 and another for SWIR 2. This is different from the VNIR spectrometer that has an array of 512 detectors. The SWIR spectrometer collects wavelength information sequentially rather than in parallel.

Each SWIR spectrometer consists of a concave holographic grating and a single thermo-electrically cooled indium gallium arsenide (InGaAs) detector. The gratings are mounted about a common shaft that oscillates back and forth through a 15° swing. As the grating moves, it exposes the SWIR 1 and SWIR 2 detectors to different wavelengths of optical energy. Each SWIR spectrometer has ~600 channels or ~2 nm sampling interval per SWIR channel. The spectrometer firmware automatically compensates for the overlap in wavelength intervals.

Like the VNIR detectors, the SWIR 1 and SWIR 2 detectors convert incident photons into electrons. This photocurrent is continually converted to a voltage and is periodically digitized by a 16-bit analog-to-digital converter. This digitized spectral data is then transmitted to the instrument controller for further processing and analysis.

The grating is physically oscillating with a period of 200 ms. It performs a forward scan and a backward scan, resulting in 100 ms per scan. This is the minimum time required for any SWIR samples or full-range samples.

F.6 Fore Optics

You typically collect reflected radiance and surface reflectance measurements using a hand-held configuration, though you can use a tripod. The pistol grip is available with both a sighting scope and leveling device when required for more precise orientation.

These accessories allow viewing the exact spot where the fore optic is pointed and orienting the fore optic in precise, nadir-viewing, geometry. The majority of irradiance measurements are performed with the irradiance receptor mounted level on a tripod because of the need for precise geometric orientation.

The small size of the instrument's fore optics allows positioning the fore optics at a greater distance from the surface under observation.

A larger field of view means that fewer measurements are needed to approximate the spatial resolution of the imaging sensor, because the pixel size of most imaging sensor systems is several meters or more.

The small size of the pistol grip and fore optics greatly reduce errors associated with instrument self shadowing. Even when the area viewed by the fore optic is outside the direct shadow of the instrument, the instrument still blocks some of the illumination that would normally be striking the surface under observation, either diffuse skylight or light scattered off surrounding objects. Position the instrument as well as other objects — including the user — as far as possible from the surface under observation. This also applies to white reference measurements.

F.7 Dark Current Measurement

Dark current refers to current generated within a detector in the absence of any external photons. Dark current is the amount of electrical current that is inherent in the spectrometer detectors and other electrical components and is additive to the signal generated by the measured external optical radiation.

Noise is the uncertainty in a given measurement, one channel at a time. Noise, by definition, is random. You can reduce noise by using more samples and averaging the signal. Dark current is different from noise; it is relatively stable and can be characterized.

This manual uses dark current to refer to all systematic contributions to the detector signal. Dark current is a property of the detector and the associated electronics (not the light source). Dark current varies with temperature. In the VNIR region, dark current also varies with integration time.

Whenever you take dark current, a mechanical shutter blocks off the entrance slit of the VNIR spectrometer so the signal can be measured. This signal is subtracted from each subsequent spectrum until another dark current is taken. The SWIR spectrometers take and subtract dark current on every scan.

You can update the dark current measurement at any time, but should update it more frequently in the beginning of a given session while the instrument warms up.

The VNIR spectrometer is fitted with a unique software and hardware combination called driftlock. Driftlock corrects for dark current changes over time. It automatically updates dark current for every measurement by looking at a series of masked pixels at the front portion of the VNIR array. The driftlock feature corrects for the majority of dark current variation over time.

F.8 White Reference

A material with approximately 100% reflectance across the entire spectrum is called a white reference panel or white reference standard:

The raw measurement made by the spectrometer is influenced by both the sample and the light source. An independent measure of the light source illumination on a reference of known reflectance is required to calculate the reflectance of the sample. The use of a white reference standard with near 100% reflectance simplifies this calculation.

Reflectance and transmittance are inherent properties of all materials and are independent of the light source.

- Reflectance is the ratio of energy reflected from a sample to the energy incident on the sample. Spectral reflectance is the reflectance as a function of wavelength.

- Transmittance is the ratio of the radiant energy transmitted through a sample to the radiant energy incident on the surface of the sample. Spectral transmittance is the transmittance as a function of wavelength.

- Relative reflectance is computed by dividing the energy reflected from the sample by the energy reflected off a white reference panel or standard.

Spectralon from LabSphere is a white reference standard that is very suitable for the VNIR and SWIR spectral ranges of ASD instruments.

Spectralon Reflectance Data

Figure F.1 shows reflectance data for an uncalibrated white Spectralon panel. When using an uncalibrated white Spectralon panel as the white reference for a reflectance measurement with the instrument, an even closer reflectance value for the sample can be calculated.
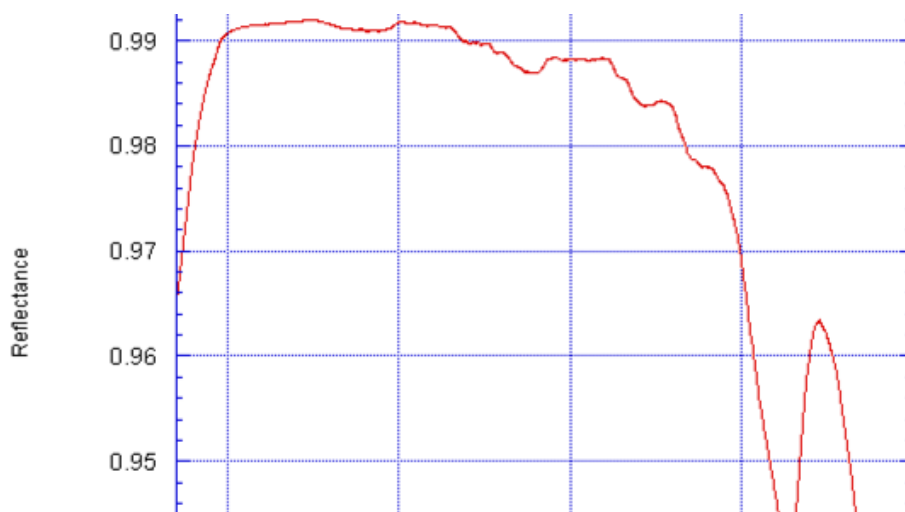
Figure F.1: Typical 350–2500 nm spectral response of Labsphere 99% Spectralon

F.9 Gain and Offset

The gain value is the inverse of actual gain. A decrease in gain value will produce a higher gain. The maximum gain value is 16. Under the low light levels that create such a gain, small changes in offset will translate into large changes in dynamic range.

Offset causes a downward shift (from Y=32,768 DN) in a SWIR spectrum such that the maximum value of the spectrum and the minimum value of the spectrum (dark current - off screen) are equidistant from the line y=32,768. Under ideal conditions, where there is enough light, there will be about 32,768 DN of signal immediately after optimization, +/- 1,000.

This means that optimization "creates" about 16,000 DN of dark current and about 16,000 DN of dynamic range. But this dynamic range will disappear with either a slight increase in signal (if the signal started out low to begin with) or a slight increase in dark current (increases with ambient temperature).

Appendix G: Declaration of Conformity

Declaration of Conformity

According to EN ISO/IEC 17050

Manufacturer's Name:	ASD Inc.
Manufacturer's Address:	2555 55th St, Suite 100, Boulder, CO 80301 USA

Declares that the product:

Product Name:	FieldSpec® 4
Product Number:	FS4S-C-1-C-1-L-0 (Standard-Res), FS4H-J-1-D-1-L-0 (Hi-Res), FS4W-G-1-C-1-L-0 (Wide-Res)

Conforms to the following EU Directives:

Safety: Low Voltage Directive, 2006/95/EC

EMC: Electromagnetic Compatibility Directive, 2004/108/EC

Supplementary Information:

The product complies with the requirements of the following Harmonized Product Standards and carries the CE-Marking accordingly:
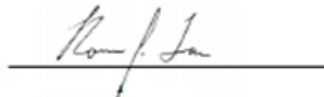
EN61010-1:2001 2nd Edition

Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory use

EN61326-1:2006

Class A, Electrical Equipment for Measurement, control and Laboratory use-EMC Requirements

Signatures: _____

Name: Robert J. Faus

Title: Vice President of Engineering

Date: 10-24-2011

For compliance information ONLY, contact:

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USA Contact:	Product Regulations Manager, ASD Inc.
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FieldSpec 4 User Manual

ASD Document 600979 |Rev. A | December 2011

To obtain a copy of this instruction manual online,
visit our website at http://support.asdi.com