# ASD Accessories

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www.asdi.com

ANALYTICAL SPECTRAL DEVICES, INC.

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# Technical Support

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The Technical Support team is committed to providing you with a timely response to your questions. We will work with you to provide solutions to your applications. The Technical Support team is available to answer your questions Monday thru Friday, 8 am to 5 pm Mountain Standard Time. We will happily respond to your e-mail queries as well.

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# Chapter 1 Introduction

In order to utilize the ASD spectroradiometer (such as the FieldSpec3), additional accessories may be required. Your application will dictate which accessory is ideal. Please be certain to discuss the application in detail with your sales representative to ensure correct accessories are purchased.

The accessories available for the spectroradiometer are discussed in the other chapters of this manual. This chapter covers:

- Spectroradiometers
- Computer Requirements

## 1.1 Spectroradiometers

The general-purpose ASD spectroradiometers are useful in many application areas requiring the measurement of either reflectance or transmittance. The ASD instruments are highly portable, yet perform competitively in the laboratory as well.

The RS$^3$ application comes standard with the following ASD spectrometers:

- FieldSpec
- TerraSpec
- AgriSpec
- HandHeld

The RS$^3$ application can be ordered separately and used with the following ASD spectrometers:

- LabSpec
- QualitySpec

Note: A single instrument controller cannot control more than one ASD spectrometers, because the configuration files are calibrated to a specific spectrometer.

## 1.2 Computer Requirements

The instrument controller is a computer which manages the ASD spectroradiometer (such as the FieldSpec3), stores data, and processes the results.

.The minimum set of requirements for the instrument controller are:

- 1.2 GHz Pentium or better notebook or PC-w/monitor
- 256 MB RAM or more
- 20 GB of free disk space
- Microsoft Windows® (95,98,ME,NT,2000,XP)
- 1024 x 768 or better graphics resolution
- 24-bit color or better - 32-bit recommended
- Internet Explorer 6.0 or better
- (Optional) Serial communications port (or USB port) for GPS receiver. Only needed if you want to use GPS.
- (Optional) NMEA compatible GPS receiver

The instrument controller requires the following software:

- Microsoft Windows® 95/98/NT/2000/ME/XP Operating System.

Users need a basic understanding of the Microsoft Windows operating system including software installation.

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

# *Chapter 2 Software*

## 2.1 RS3 Software Package A500250

RS$^3$ is the most recent version of its data acquisition and analysis software engineered for the ASD's portable FieldSpec Pro family of spectroradiometers.

RS$^3$'s Windows friendly advanced features include GPS compatibility. RS$^3$ remembers the user's settings, reports saturation without interfering with workflow, and saves the displayed spectrum, not the current spectrum, meaning the user's final results will represent the most accurate data. Users can now view five different spectra while simultaneously collecting new spectra.

The instrument controller is a computer which manages the ASD spectroradiometer (such as the FieldSpec3), stores data, and processes the results.

.The minimum set of requirements for the instrument controller are:

- 1.2 GHz Pentium or better notebook or PC-w/monitor
- 256 MB RAM or more
- 20 GB of free disk space
- Microsoft Windows® (95,98,ME,NT,2000,XP)
- 1024 x 768 or better graphics resolution
- 24-bit color or better - 32-bit recommended
- Internet Explorer 6.0 or better
- (Optional) Serial communications port (or USB port) for GPS receiver. Only needed if you want to use GPS.
- (Optional) NMEA compatible GPS receiver

The instrument controller requires the following software:

- Microsoft Windows® 95/98/NT/2000/ME/XP Operating System.

Users need a basic understanding of the Microsoft Windows operating system including software installation.

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

## 2.2 Indico Pro Software A500690

Easily configured to work with LabSpec, QualitySpec, and FieldSpec instruments for material qualification and quantification across a variety of applications. Simultaneously analyze multiple parameters. Indico can store and easily recall the calibrations associated with each application.

Indico includes ASD's Rapid Classifier for material qualification.

Indico interfaces with Grams™ PLS plus/IQ and Unscrambler® chemometrics software packages for applications requiring qualification and quantification. Indico allows you to preview and plot collected spectra, then generate, preview, save, and print reports of analytical results.

Indico is fully compliant with FDA 21 CFR Part 11 Electronic Records and Signatures.

## 2.3 Grams AI v.7 w/PLSIQ A500145

Windows version 7 of GRAMS AI and PLSplus/IQ in a suite of spectroscopic software tools for building statistical classification and multivariate quantitative models that interface in real time with ASD Indico software. This suite includes the UV/VIS/NIR application pack as standard.

## 2.4 Software Camo Unscrambler Version 9.1 50015

Unscrambler contains comprehensive analysis for Exploratory Statistics, Regression Analysis, Classification, Prediction, and Design of Experiments. Unscrambler allows you to build statistical classification and multivariate quantitative models that interface in real time with ASD Indico software.

Unscrambler includes PCA and PLS functionality.

## 2.5 Kaleidagraph Graphing for PC 502400

Graphing and Data Analysis Software that uses ASCII text files imported from converted FieldSpec files in post processing.

## 2.6 Specmin Software Version 3.1 500096

Specmin 3.1 is the latest version of SII's spectral data management system for SWIR spectroscopy that includes an extensive and dynamic library of reference spectra for minerals, wavelength search/match tables, physical properties of each species in the data base, and literature references for the infrared active mineral phases.

According to the manufacturer, Specmin can be used on the ASD FieldSpec FR spectrometers and Specmin spectra can also be interfaced into Hyperspectral Remote Sensing Processing as ground truth information. Because Specmin offers such a variety of different minerals from a myriad of environments, it is usually possible to find representative and diagnostic end member spectra to match nearly any unknown.

## 2.7 ENVI and IDL

### *2.7.1 ENVI Software*

ENVI works hand-in-hand with ASD's FieldSpec® line of spectroradiometers, which are sold separately. ENVI, powerful state-of-the-art imaging software, provides seamless processing for spectral image analysis with direct import of ASD binary data. Refine data and improve results ENVI, the researcher's tool for display, manipulation, interpretation, and classification of data.

ENVI is the optimum tool for analysis of both image and field spectral data. ASD offers ENVI for USA and Canada only and only for customers that are also buying ASD Spectrometers.

**ENVI, 1 User, Node-Locked, Windows 500300**

**ENVI, 1 User, HASP, Windows 500301**

**ENVI, 1 User, Network Floating, Windows 500302**

RSI technical support and maintenance for ENVI software are included in the price of a new license - please contact: Research Systems, Inc., 4990 Pearl East Circle, Boulder, CO 80301, PH: 303-786-9900, FX: 303-786-9909, www.rsinc.com. ENVI is provided on CD-ROM, and so a CD-ROM reader is also required and is sold separately.

Customer must provide ASD with the following details for licensing the end-user of the ENVI software: Name, email address, phone number, and snail-mail address.

### 2.7.2 IDL Software

Interactive Data Language (IDL) is a structured, array-based programming language. Using IDL with ENVI provides comprehensive capabilities for adding new, custom functionality.

Users can easily extend ENVI using the IDL software, or by linking to C/C++ or Fortran code through IDL.

**ENVI+IDL, 1 User, Node-Locked, Windows 500303**

**ENVI+IDL, 1 User, HASP, Windows 500304**

**ENVI+IDL, 1 User, Network Float, Windows 500305**

# Chapter 3 Foreoptic Accessories

The fiber optic cable provides the flexibility to adapt the instrument to a wide range of applications. Field measurements can be performed:

- holding the pistol grip by hand, or
- mounting the pistol grip and other foreoptic accessories to a tripod.

Reflected radiance and surface reflectance measurements are typically made using the hand-held configuration. 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 foreoptic is pointed and orienting the foreoptic 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.

### Field of View

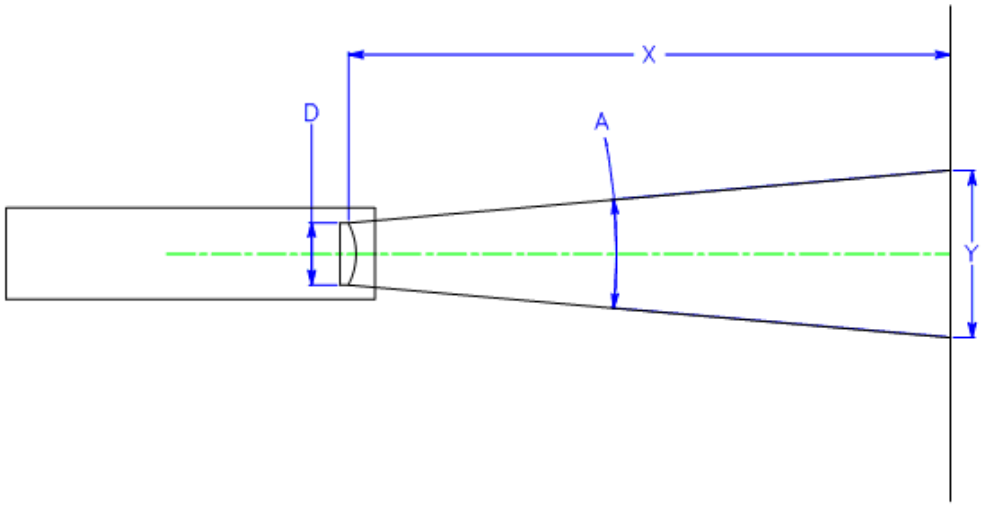
ASD's line of spectroradiometers is available with a wide selection of foreoptics. These interchangeable foreoptics allow the flexibility to adapt the FieldSpec spectroradiometer to a wide range of applications.

The small size of the FieldSpec's foreoptics allows positioning the foreoptics at a greater distance from the surface under observation.

A field spectroradiometer with 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 foreoptics greatly reduce errors associated with instrument self-shadowing. Even when the area viewed by the foreoptic is outside the direct shadow of the spectrometer, 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. Thus, the instrument as well as other objects — including the user — should be placed as far as possible from the surface under observation. This orientation requirement also applies to white reference measurements.

Figure 3-1 Field of View and spot size




D == effective diameter of foreoptic lens
A == foreoptic'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):**

$$Y = 2 * X * \tan( A/2 )$$

Table 3-1 Values of D in mm for ASD Foreoptics

| | FR | VNIR | HH |
|---|---|---|---|
| 1° | 44.1 | 17.7 | 8.6 |
| 2° | | 9.7 | |
| 3° | 16.5 | 7.0 | |
| 3.5° | | | 3.4 |
| 4° | | 5.7 | |
| 7.5° | | | 2.3 |
| 8° | 7.9 | 3.7 | |
| 10° | 6.8 | 3.3 | 2.0 |

**Irradiance Observations**

ASD has several types of foreoptics for irradiance measurements. These include:

- ASD's in-air cosine corrected receptors for measurement of total irradiance
- ASD's accessories for measurement of direct irradiance
- ASD's under-water cosine corrected receptors for measurement of in-water up- and down-welling irradiance

# 3.1 FieldSpec & HandHeld Field-of-View Foreoptics

## *3.1.1 1 Degree HH FOV Lens Foreoptic A119010*

Foreoptic that attaches to FieldSpec HandHeld modes for 1 degree field-of-view.

## *3.1.2 1 Degree VNIR FOV Lens Foreoptic A119000*

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 1 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables, and HH Pistol Grip.

## *3.1.3 1 Degree NIR/FR FOV Lens Foreoptic A119250*

Foreoptic that attaches to the FieldSpec pistol grip of FR, NIR, or JR models for 1 degree field-of-view.

## *3.1.4 2 Degree VNIR FOV Lens Foreoptic A120101*

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 2 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables and HH Pistol Grip.

## *3.1.5 3.5 Degree HH FOV Lens Foreoptic A119310*

Foreoptic that attaches to FieldSpec HandHeld modes for 3.5 degree field-of-view.

### 3.1.6 3 Degree VNIR FOV Lens Foreoptic A120501

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 3 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables and HH Pistol Grip.

### 3.1.7 3 Degree NIR/FR FOV Lens Foreoptic A119300

Foreoptic that attaches to the FieldSpec pistol grip of FR, NIR, or JR models for 3 degree field-of-view.

### 3.1.8 4 Degree VNIR FOV Lens Foreoptic A121601

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 4 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables and HH Pistol Grip.

### 3.1.9 5 Degree NIR/FR FOV Lens Foreoptic A120100

Foreoptic that attaches to the FieldSpec pistol grip of FR, NIR, or JR models for 5 degree field-of-view.

### 3.1.10 5 Degree Underwater VNIR FOV Lens A120150

Attaches to the flange of the VNIR Underwater Fiberoptic Jumper Cable. For measuring radiance. This foreoptic is primarily designed for the FieldSpec VNIR. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter and VNIR Underwater Fiberoptic Jumper Cable.

### 3.1.11 7.5 Degree HH FOV Lens Foreoptic A120210

Foreoptic that attaches to FieldSpec HandHeld modes for 7.5 degree field-of-view.

### 3.1.12 8 Degree VNIR FOV Lens Foreoptic A121701

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 8 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables and HH Pistol Grip.

### 3.1.13 10 Degree HH FOV Lens Foreoptic A121060

Foreoptic that attaches to FieldSpec HandHeld modes for 10 degree field-of-view.

### 3.1.14 8 Degree NIR/FR FOV Lens Foreoptic A120500

Foreoptic that attaches to the FieldSpec pistol grip of FR, NIR, or JR models for 8 degree field-of-view.

### 3.1.15 10 Degree VNIR FOV Lens Foreoptic A121050

Foreoptic that attaches to the pistol grip of FieldSpec VNIR models for 10 degree field-of-view. This foreoptic may also be used with FieldSpec HandHeld models using the SMA FieldSpec HH Adapter, VNIR fiberoptic jumper cables and HH Pistol Grip.

### 3.1.16 10 Degree FR (4 Degree VNIR) Underwater FOV Lens A121100

This foreoptic for measuring radiance is primarily designed for the FieldSpec and requires the flanged underwater jumper cable. However, using the SMA FieldSpec HH Adapter (131205) and the Underwater Fiberoptic Jumper Cable this foreoptic may also be used with the FieldSpec HandHeld.

This foreoptic has 10 degree FOV when attached to the flange of the FR Underwater Fiberoptic Jumper Cable, and has 4 degree FOV when attached to the VNIR Underwater Jumper Cable.

### 3.1.17 10 Degree NIR/FR FOV Lens Foreoptic A121250

Foreoptic that attaches to the FieldSpec pistol grip of FR, NIR, or JR models for 10 degree field-of-view.

### 3.1.18 20 Degree Underwater FOV A121160

Attaches to the flange of the VNIR or FR Underwater (flanged) Fiberoptic Jumper Cables. For measuring radiance.

### 3.1.19 20 Degree HH Field-of-View Tube 121501

Foreoptic that attaches to FieldSpec HandHeld modes for 20 degree field-of-view.

# 3.2 Remote Cosine Receptor

## 3.2.1 HH, Full Sky Irradiance Cosine Receptor A124720

Diffuse transmission type cosine receptor for measuring full-sky irradiance that is durable, compact, and versatile. Attaches directly to the front of the FieldSpec HandHeld instrument or to the FieldSpec HandHeld pistol grip. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm. Radiometric Calibration of RCR [S701551] is also required for irradiance (W/m^2/nm) calculation. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm and above 2200 nm. A reflective type Cosine Collector is recommended for optimal measurements in the region 350 - 400 nm and 2200 - 2500 nm such as A124710.

## 3.2.2 Full Sky Irradiance Remote Cosine Receptor A124505

This Remote Cosine Receptor (RCR) has two built-in bubble-levels, threaded insert for tripod mounting and quick-connect/disconnect fiberoptic cable snap-in feature (rubber ring restraint in older design is no longer needed). This diffuse transmission type cosine receptor is for measuring full-sky irradiance and it is durable, compact, and versatile. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm and above 2200 nm. A reflective type Cosine Collector is recommended for optimal measurements in the region 350 - 400 nm and 2200 - 2500 nm such as A124710. Radiometric Calibration of RCR [S701550] is also required for irradiance (W/m^2/nm) calculation.

## 3.2.3 RCR Cold Weather A124527

ASD Full Sky Remote Cosine Receptor (RCR) that is designed for the larger diameter Cold Weather fiber optic cable. This is a diffuse transmission type cosine receptor for measuring full-sky irradiance that is durable, compact, and versatile. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm and above 2200 nm. A reflective type Cosine Collector is recommended for optimal measurements in the region 350 - 400 nm and 2200 - 2500 nm such as A124710. Radiometric Calibration of RCR [S701550] is also required for irradiance (W/m^2/nm) calculation.

### 3.2.4 Low Profile Full Sky RCR A124510

This low profile Full Sky Irradiance Remote Cosine Collector is for limited height situations such as in short plant beds. Interfaces to Pro series spectrometers. Also interfaces with HandHeld model using SMA FieldSpec HH Adapter (131205) and VNIR Fiberoptic Jumper cables. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm and above 2200 nm. A reflective type Cosine Collector is recommended for optimal measurements in the region 350 - 400 nm and 2200 - 2500 nm such as A124710.

### 3.2.5 Reflective Cosine Receptor with Dome A124700

For measuring full-sky-irradiance with optimum S/N and optimum cosine accuracy throughout the entire 350 - 2500 nm spectral region. This version of the reflective cosine receptor includes a protective dome 8.656" in horizontal diameter and is designed for long-term installation. Radiometric Calibration of RCR [S701550] is also required for irradiance (W/m^2/nm) calculation.

### 3.2.6 Reflective Cosine Receptor A124710

For measuring irradiance with optimum S/N and optimum cosine accuracy throughout the entire 350 - 2500 nm spectral region. This version of the reflective cosine receptor does not include a protective dome and is not designed for long-term installation. Radiometric Calibration of RCR [S701550] is also required for irradiance (W/m^2/nm) calculation.

### 3.2.7 FS Underwater Cosine Receptor A124250

Fiberoptic input cable attachment for measuring up-welling or down-welling irradiance. Requires optional VNIR or FR Underwater (flanged) jumper cable. The required transmissive material and geometry for proper angular response results in S/N reduction with significant losses below 400 nm and above 2200 nm. A reflective type Cosine Collector is recommended for optimal measurements in the region 350 - 400 nm and 2200 - 2500 nm such as A124710.

### 3.2.8 Direct Irradiance Attachment A119720

This attachment fits over the diffuser-type ASD Full Sky Irradiance Remote Cosine Receptor (RCR). It acts to limit the angular field-of-view (FOV) of the irradiance receptor. Three interchangeable FOV modules are included for 2 Degree, 1.5 Degree, 1 Degree, and 0.5 Degree. FOV aiming sight allows for proper alignment to the solar disk. This accessory is used for measuring the

direct component of solar irradiance. Because it uses the same optics as are used for the RCR relative radiometric errors between total and direct irradiance measurements are minimized.

## 3.3 Fiberoptic Cable Options

The standard fiberoptic cable is 1.5 meters.

***Caution! Fiberoptic cables longer than the standard 1.5 meter length result in signal attenuation in the SWIR2 spectral region.***

Cables which attach to the existing cable on the spectrometer are called *jumper cables*.

***Caution! Jumper cables result in signal attenuation at the jumper junctions.***

The FieldSpec has its standard cable attached in a permanent fashion directly to the spectograph within the instrument, which helps avoid signal attentuation through a jumper. Cables of other lengths can be ordered and installed. All non-standard fiberoptic cables require additional four weeks lead time.

***Caution! Underwater (UW): Signal attentuation will occur at the jumper junction and at the water absorption bands beyond 1 micron.***

### 3.3.1 1.0 m VNIR Low OH Fiberoptic Jumper 135520

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.2 1.0 m FR Low OH Fiberoptic Cable 135050

Permanent fiberoptic cable with standard jacket, installed by ASD. This cable is a replacement cable for the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S70015 FR Cable Replacement Labor.

### 3.3.3 1.0 m FR Low OH Fiberoptic Jumper Cable 135510

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's 'permanent' fiber optic cable. Requires SMA Adapter Kit (A131320.

### 3.3.4 1.5 m VNIR Low OH Fiberoptic Cable 135070

'Permanent' fiberoptic cable with standard jacket, installed by ASD. This cable is a replacement cable for the spectrometer's standard 1.5 meter 'permanent' fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 VNIR Cable Replacement Labor.

### 3.3.5 1.5 m SMA-to-VNIR Low OH FO Jumper 135522

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's 'permanent' fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.6 1.5 m FS Pro FR Low OH Fiberoptic Cable 135052

'Permanent' fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter 'permanent' fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.7 2.0 m VNIR Low OH Fiberoptic Cable 135310

Permanent fiberoptic cable with standard jacket, installed by ASD. This cable is a replacement cable for the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 VNIR Cable Replacement Labor.

### 3.3.8 2.0 m VNIR Low OH Fiberoptic Jumper 135095

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.9 2.0 m FR Low OH Fiberoptic Cable 135340

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle comprised of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.10 2.0 m FR Low OH Cold Weather Fiberoptic Cable 135621

Permanent fiberoptic cable with larger diameter jacket designed for cold weather, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle comprised of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor. Interface with Pistol Grip also requires A145502.

### 3.3.11 2.0 m FR Low OH Fiberoptic Jumper 135090

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320.

### 3.3.12 2.5 m VNIR UW Low OH Fiberoptic Jumper 135410

This fiberoptic cable contains a bundle of seven 200 micron fibers, and attaches to the spectrometer's permanent fiberoptic cable. This cable is made with a fatter stronger jacket and is flanged to accept UWRCR (A124250. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.13 2.5 m VNIR UW UV Enhanced FO Jumper 135415

This jumper cable is for the region 350-1050 nm with slightly better transmission in the region 350-400 nm than the standard low OH version. This fiberoptic cable contains a bundle of seven 200 micron fibers, and attaches to the spectrometer's 'permanent' fiberoptic cable. This cable is made with a fatter stronger jacket and is flanged to accept UWRCR (A124250. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.14 2.5 m VNIR Enhanced UV Fiberoptic Cable 135440

This cable is for the region 350-1050 nm with slightly better transmission in the region 350-400 nm than the standard low OH version.

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 VNIR Cable Replacement Labor.

### 3.3.15 2.5 m FR Low OH Fiberoptic Cable 135210

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle comprised of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.16 3.0 m VNIR Low OH Fiberoptic Cable 135660

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 UV/VNIR Cable Replacement Labor.

### 3.3.17 3.0 m VNIR Low OH Fiberoptic Jumper 135523

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.18 3.0 m UV Enhanced Fiberoptic Jumper 135524

Fibers used in this cable give better transmission in UV region but less in NIR region than standard ASD jumper cables.

### 3.3.19 3.0 m VNIR Enhanced UV Fiberoptic Cable 135650

This cable is for the region 350-1050 nm with slightly better transmission in the region 350-400 nm than the standard low OH version.

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 UV/VNIR Cable Replacement Labor.

### 3.3.20 3.0 m FR Low OH Fiberoptic Cable 135270

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.21 3.0 m SMA to FR Low OH Fiberoptic Jumper 135513

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320).

### 3.3.22 3.0 m FR Low OH Cold Weather Fiberoptic Cable 135615

Permanent fiberoptic cable with larger diameter jacket designed for cold weather, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle comprised of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor. Interface with Pistol Grip also requires A145502.

### 3.3.23 4.0 m VNIR Low OH Fiberoptic Cable 135030

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 UV/VNIR Cable Replacement Labor.

### 3.3.24 4.0 m VNIR Low OH Fiberoptic Jumper 135120

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.25 4.0 m FR Low OH Fiberoptic Cable 135060

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.26 4.6 m VNIR Low OH Fiberoptic Cable 135460

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 VNIR Cable Replacement Labor.

### 3.3.27 4.6 m VNIR Enhanced UV Fiber Cable 135450

This cable is for the region 350-1050 nm with slightly better transmission in the region 350-400 nm than the standard low OH version. Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 VNIR Cable Replacement Labor.

### 3.3.28 5.0 m VNIR Low OH UW Fiberoptic Jumper 135420

This fiberoptic cable contains a bundle of seven 200 micron fibers, and attaches to the spectrometer's 'permanent' fiberoptic cable. This cable is made with a fatter, stronger jacket and is flanged to accept UWRCR (A124250. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.29 5.0 m FR Low OH Fiberoptic Cable 135400

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.30 5.0 m FR Low OH Cold Weather Fiberoptic Cable 135619

Permanent fiberoptic cable with larger diameter jacket designed for cold weather, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle comprised of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor. Interface with Pistol Grip also requires A145502.

### 3.3.31 5.0 m FR Low OH Fiberoptic Jumper 135100

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320.

### 3.3.32 5.0 m FR Low OH UW Fiberoptic Jumper 135640

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. This cable is made with a fatter, stronger jacket and is flanged to accept UWRCR (A124250). Requires SMA Adapter Kit (A131320).

### 3.3.33 6.0 m Low OH to FR Fiberoptic Jumper 135516

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320).

### 3.3.34 10.0 m VNIR UW Low OH Fiberoptic Jumper 135360

This fiberoptic bundle cable contains seven 200 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. This cable is made with a fatter, stronger jacket and is flanged to accept UWRCR (A124250). Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.35 10.0 m VNIR Low OH Fiberoptic Jumper 135160

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.36 10.0 m VNIR Low OH Fiberoptic Cable 135171

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiberoptic cable. This cable contains a bundle of nineteen 100 micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700100 UV/VNIR Cable Replacement Labor.

### 3.3.37 10.0 m FR Low OH Fiberoptic Cable 135180

Permanent fiberoptic cable with standard jacket, installed by ASD instead of the spectrometer's standard 1.5 meter permanent fiber optic cable. This cable contains a bundle of nineteen 100 micron fibers and thirty eight 200-micron fibers. ASD must install this cable either at the time of initial order, or the customer must return the spectrometer and all foreoptics to ASD for the retrofit. Retrofit requires item S700150 FR Cable Replacement Labor.

### 3.3.38 10.0 m FR UW Low OH Fiberoptic Jumper 135630

This fiber optic jumper cable has a standard jacket, contains a bundle of forty-four 200-micron fibers, and attaches to the spectrometer's permanent fiber optic cable. This cable is made with a fatter, stronger jacket and is flanged to accept UWRCR (A124250). Requires SMA Adapter Kit (A131320).

### 3.3.39 15.0 m VNIR Low OH Fiberoptic Jumper 135172

This fiber optic jumper cable has a standard jacket, contains a bundle of nineteen 100 micron fibers, and attaches to the spectrometer's permanent fiber optic cable. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

### 3.3.40 20.0 m VNIR UW Low OH Fiberoptic Jumper 135570

This fiberoptic bundle cable contains seven 200 micron fibers, and attaches to the spectrometer's 'permanent' fiber optic cable. This cable is made with a fatter, stronger jacket and is flanged to accept UWRCR (A124250. Requires SMA Adapter Kit (A131320) or SMA, FieldSpec HH Adapter (131205).

FieldSpec Pro and HandHeld Radiometric Calibrations for Energy Units of Radiance or Irradiance.

# Notes:

# Chapter 4 Contact, Plant and Hi-Bright Probe

The High Intensity Contact and Plant Probe is intended for analysis of raw materials. It can measure samples even through plastic bags. This probe is the new and improved version of our traditional reflectance probe.

This contact probe allows very precise and accurate material analysis in less than one second. Its innovative optical design minimizes measurement errors associated with stray light. It is 10.25” long and weighs only 2 pounds.

The  probe has a 10 mm spot size (High Intensity Contact Probe), which leaves a smaller footprint on your sample and enable you to access samples in tighter spaces.

The Source Probe is powered by the instrument. The probe plugs directly into the spectrometer’s accessory power jack located on some spectrometers adjacent to the fiberoptic cable connection on the front panel or on other spectrometers adjacent to the AC power input on the back side of the instrument.

The High Intensity Contact and Plant Probe use a high intensity bulb for raw materials and a low intensity bulb for vegetation studies, respectively.

Step 1 Connect the probe power cable to the accessory power jack (front of instrument).

Step 2 Attach the SMA end to the instrument using an SMA to FR fiber optic cable.

Step 3 Unscrew and remove the base plate of the source probe using the thumb screw.

Step 4 Detach the strain relief on the side of the source probe.

Step 5 Insert the cable using the FR tip.

Step 6 Feed the cable into the probe tip slot making a 90° turn with the FR tip.

Step 7 Once in place, screw the strain relief down, making certain the cable is snug (do not over tighten) and unable to rotate or shift.

Step 8 Re-attach the base plate.

Step 9 Press the power button located on the side of the probe

Step 10 Check to see that the bulb illuminates properly.

Note: Be certain that the light is properly warmed up for 10 minutes before proceeding with measurements. The probe must be turned over before measurements can be taken.

Figure 4-1 Contact, Plant and Hi-Bright Probe.

# 4.1 Probes

## *4.1.1 High Intensity Contact Probe A122300*

Slim design for contact reflectance measurement of minerals and other solids using the FieldSpec Pro (350 - 2500 nm) or LabSpec Pro (350 - 2500 nm) line of spectrometers. A 1m FR Fiberoptic Jumper Cable is required for interfacing the probe with LabSpec Pro.

An optional Handle Extension is also available at additional cost. This probe is excellent for mineral, leaf, grain, and granule applications. Length 10 inches (including short handle), Weight 1.5 lbs., Lightsource type/Life (approx) Halogen Bulb/1500 hours, Halogen Bulb color temperature 2911 +/- 10 degrees K, Spot size 10 mm, Specular-Reflectance 5% max off flat first surface mirror. Power Requirements 12-18 VDC 6.5 W:

ALSO REQUIRES: External Cable Assembly for powering from FieldSpec Pro or LabSpec Pro Aux Power Jack, or Accessory Power Supply.

### 4.1.2 High Intensity Contact Probe A111206

Includes one each of the following: High Intensity Contact Probe, Spectralon, 3.62"Dia. Round x 5mm Un Cal, 1.0m FR Low OH Fiberoptic Jumper Cable, Accessory Power Supply w/Cord, 12 Volt/Bulb/Reflectorized Substitutions or deletions shall not be allowed.

### 4.1.3 Hi-Brite Contact Probe A122320

FOR HI-RES, JUMPERED, OR ATTENUATED SYSTEMS ONLY (will saturate standard FieldSpec systems). Slim design for very high intensity contact reflectance measurement of minerals and other solids using ASD spectrometers. A Fiberoptic Jumper Cable is required for interfacing with the LabSpec Pro, QualitySpec Pro and TerraSpec.

An optional Handle Extension is also available at additional cost. This probe is excellent for minerals, and other diffuse solids and surfaces (not recommended for materials that would be sensitive to intense light). Length 10 inches (including short handle), Weight 1.5 lbs., Lightsource type/Life (approx) Halogen Bulb/1500 hours, Halogen Bulb color temperature 2911 +/- 10 degrees K, Spot size 10 mm, Specular-Reflectance 5% max off flat first surface mirror. Power Requirements 12-18 VDC 6.5 W:

ALSO REQUIRES: External Cable Assembly for powering from Aux Power Jack, or Accessory Power Supply.

### 4.1.4 Hi-Brite Contact Probe A111207

Includes one each of the following: Hi-Brite Contact Probe, Spectralon, 3.62"Dia. Round x 5mm Un Cal, 1.0m FR Low OH Fiberoptic Jumper Cable, Accessory Power Supply w/Cord, 12 Volt/Bulb/Reflectorized

### 4.1.5 Plant Probe A111208

Includes one each of the following: High Plant Probe, Spectralon, 3.62"Dia. Round x 5mm Un Cal, 1.0m FR Low OH Fiberoptic Jumper Cable, Accessory Power Supply w/Cord, Reflectorized bulb 4.25 VDC MR6 /4W. Substitutions or deletions shall not be allowed.

### 4.1.6 Plant Probe A122317

Developed with the National Renewable Energy Labs / Golden, CO this probe is for contact reflectance measurement of vegetation and other heat sensitive targets using the FieldSpec Pro or LabSpec Pro line of spectrometers. A 1m FR Fiberoptic Jumper Cable is required for interfacing the probe with LabSpec Pro.

An optional Handle Extension / A131303 is also available at additional cost. Length 10 inches (including short handle), Weight 1.5 lbs., Lightsource type/Life (approx) Halogen Bulb/1500 hours, Spot size 10 mm, Specular-Reflectance 5% max off flat first surface mirror. Power Requirements 12-18 VDC 6.5 W:

ALSO REQUIRES: External Cable Assembly for powering from FieldSpec Pro or LabSpec Pro Aux Power Jack, or Accessory Power Supply.

### 4.1.7 Long Probe Handle A131303

42 inch long handle for the ASD High Intensity Contact Probe.

## 4.2 Leafclip Assembly A122325

This accessory interfaces with the ASD Plant Probe and the ASD High Intensity Contact Probe. The Clip comes with replaceable white and black background standards (eight of each including the pre-mounted ones). The white backgrounds are 0.120 mm thick x .935" OD Gor-tex white PTFE reflector material. The black backgrounds are 0.004" thick x 0.935 OD black painted Vinyl.

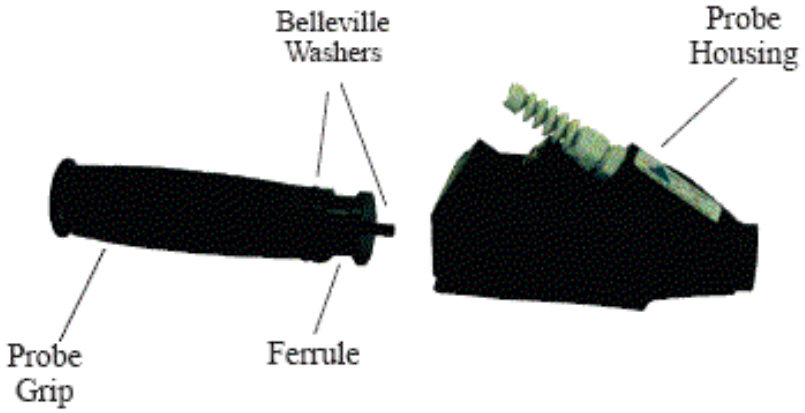
A baseline reference panel is also required.

### 4.2.1 Attaching the Leaf Clip Accessory to the Plant Probe

Step 1 Twist Probe Grip counter clockwise until it separates from the Probe Housing.

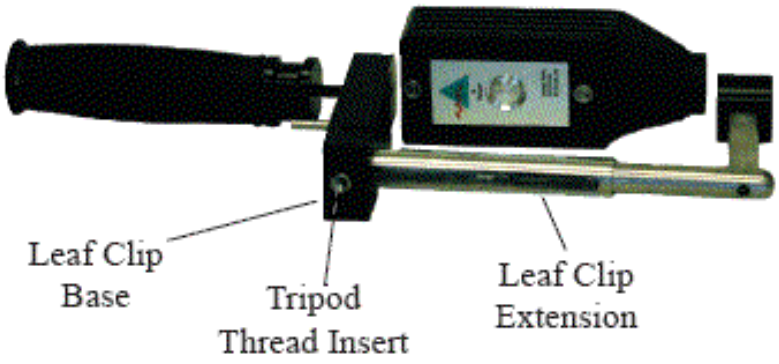
Note: Be careful not to lose the two Belleville washers, one in front and one behind the Ferrule.

Figure 4-2



Step 2 Insert the grip thru the Leaf Clip Base with the Ferrule and Belleville washers in place and twist into the Probe Housing as illustrated.

Figure 4-3




Note: The Probe power on switch is positioned towards the Leaf Clip Extension.

### 4.2.2 Replacing Background Standards

Both the white and black background standards are recessed 0.030” to minimize contamination from repeated contact by samples being measured. Over time, contamination will occur and it will be necessary to replace these standards. Contact Analytical Spectral Devices for replacement background standards.

Step 1 Pull the Leaf Clip barrel up, turn 90-degrees, and release as shown.

Figure 4-4


Two small background extraction holes, one for the white and one for the black, are located just inside the larger hole located on top of the barrel.

Step 2 Push a paperclip or toothpick (with the sharp point removed) thru these holes to extract backgrounds.

### 4.2.3 Using the Background Standard Barrel

To swap from one background standard (black or white) to the other, pull the barrel up, turn 180-degrees and release.

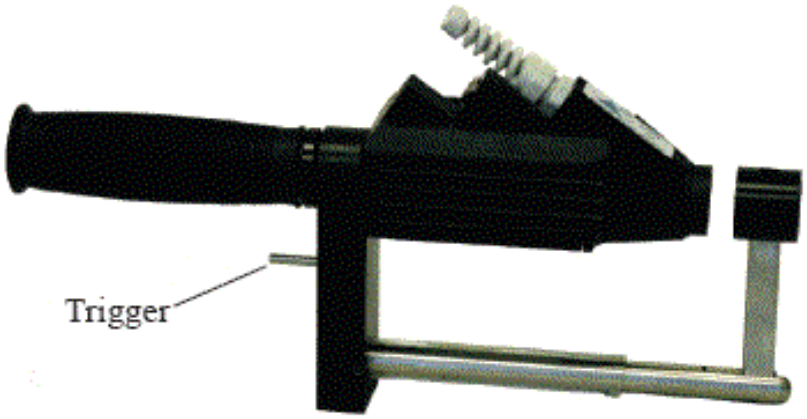
### 4.2.4 Using the Trigger

The trigger mechanism is designed to close on samples from .000 to .400 inches thick.

Samples up to 1/4” (0.250) thick can be held in place and locked into position without damage to the trigger components.

Pull the trigger up and slip into the left slot to lock trigger and keep samples in place.

Figure 4-5




### 4.2.5 Mounting the Leaf Clip to a Tripod

The Leaf Clip is designed to mount to most tripods. A tripod thread insert is located on the bottom of the Leaf Clip base as illustrated. (Exhibit 2)

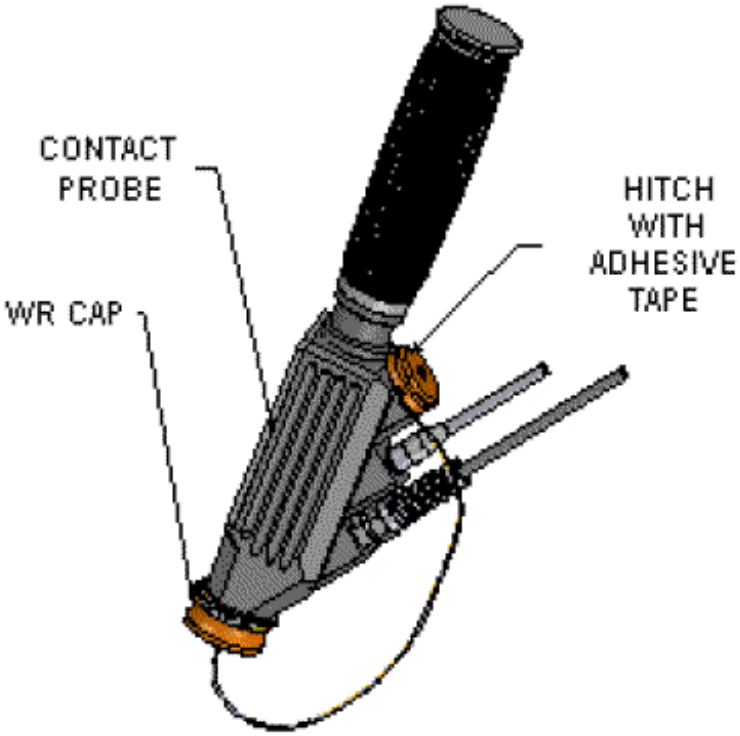
# 4.3 Retrofitting Probes with White Reference Cap

The White Reference Cap (WR Cap) accessory allows the user to take White Reference without having to hold the probe in steady position. The WR Cap is retained on the nose of the probe by friction and once placed over the probe's nose does need to be held by hand. If desired the WR Cap can be placed over the hitch for a stowaway or when taking a sample spectrum.

The WR Cap accessory is supplied with the adhesive tape round attached to the bottom of the hitch.

Take the lining off the adhesive tape round and place the hitch on probe per illustration.

Figure 4-6



# 4.4 Maintenance

## 4.4.1 Bulb Adjustment for Contact and Plant Probe

Use this technique if the spectrometer will not optimize & continuously saturates with the High Intensity and Plant Probe.

Step 1 Insert the spectrometer’s fiber optic into the contact probe and start the spectrometer's software.

Step 2 Optimize the instrument and observe the signal level. The light intensity should now be at a level that allows the instrument to optimize without saturation.

Step 3 If the instrument still saturates, you will have to move the bulb away from the window --- always remember to tighten the setscrew after moving the bulb.

Step 4 Unscrew the 2 front panel screws using a 3/16” blade screwdriver and gently remove the plate with the Probe circuit board attached.

Step 5 Using a 0.050" hex wrench, loosen the setscrew holding the bulb in place. Refer to the illustration for location of the setscrew.

Step 6 Move the bulb back from the plate window about 1-3 mm. You may need to use pliers to get a firm grip on the base of the bulb.

Step 7 Using the same 0.050" hex wrench, tighten the setscrew holding the bulb in place (located in the top of the probe).

Step 8 Replace the front panel and tighten the 2 front panel screws.

## 4.4.2 Contact and Plant Probe A122300, A122317

Step 1 Unscrew the 2 front panel screws using a 3/16” blade screwdriver and gently remove the plate with the Probe circuit board attached.

Step 2 Using a 0.050" hex wrench, loosen the setscrew holding the bulb in place, see illustration for location of the setscrew.

Step 3 Remove and unplug the bulb. You may need to use pliers to get a firm grip on the base of the bulb.

Step 4 Insert a new bulb as illustrated (fully seat the Contact Probe bulb or if you have a Plant Probe insert the bulb until the bulb groove barely shows).

Step 5 If necessary adjust the bulb to remove saturation; see above instructions.

Step 6 Using the same 0.050" hex wrench, tighten the setscrew to hold the bulb in place.

Step 7 Replace the front panel and tighten the 2 front panel screws.

### 4.4.3 Hi-Bright Contact probe A122320

Step 1 Unscrew the 2 front panel screws using a 3/16” blade screwdriver and gently remove the plate with the Probe circuit board attached.

Step 2 Using a 0.050" hex wrench, loosen the setscrew holding the bulb in place, see illustration for location of the setscrew. The setscrew location is different from Contact and Plant Probes.

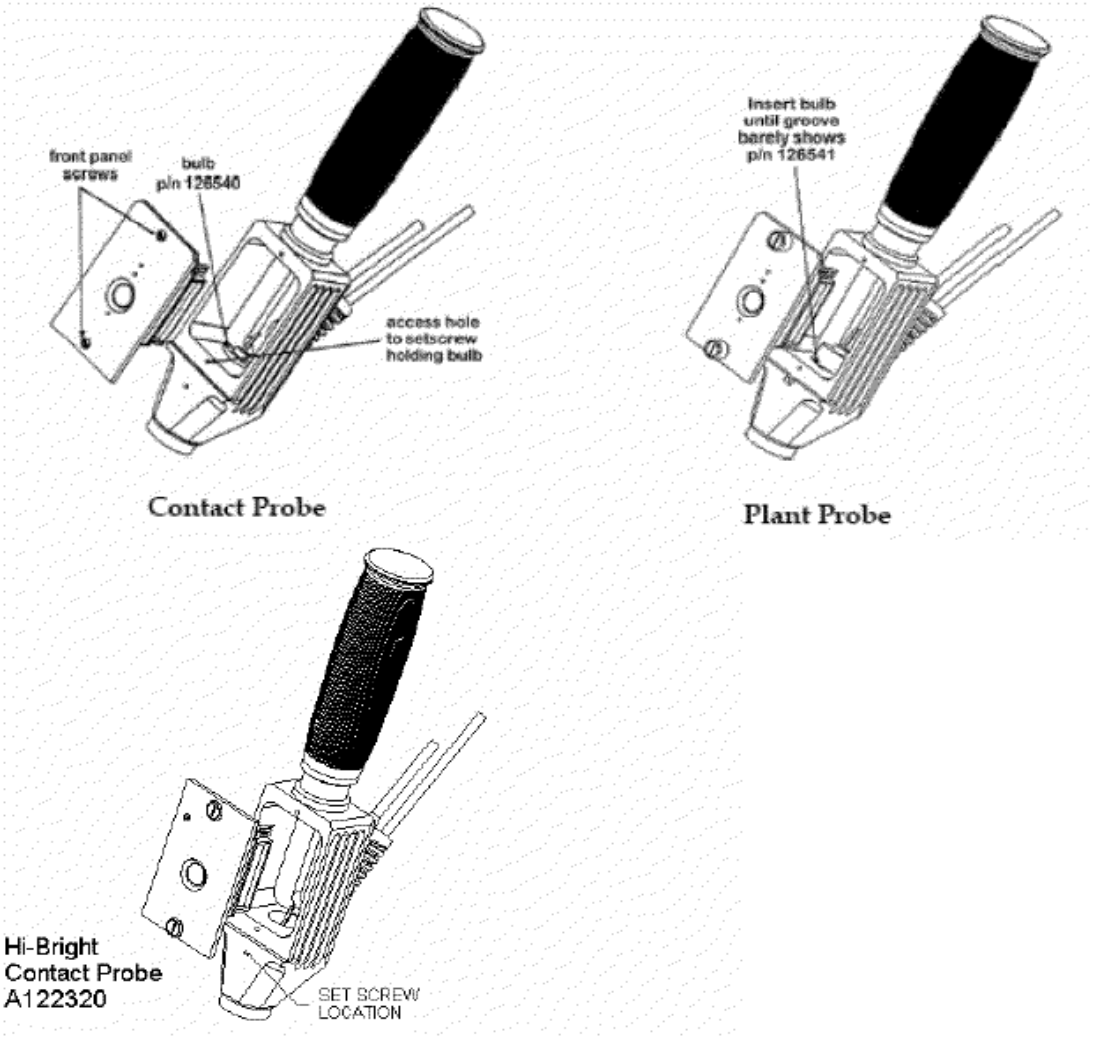
Step 3 Gently pull on the wires to pull the bulb up. Remove and unplug the bulb.

Step 4 Insert the spectroradiometer fiber-optic tip. Insert plug into the new bulb and then insert the bulb until it touches the tip. Back off the bulb approximately 0.03".

Step 5 Using the same 0.050" hex wrench, tighten the setscrew to hold the bulb in place.

Step 6 Replace the front panel and tighten the two front panel screws.

Figure 4-7 Schematic of the Contact Probe



# Chapter 5 Reflective Probe

Sometimes solar illumination is impractical for collecting field spectra, such as in a cave. Also, sometimes all that is needed is in-situ sample measurements that are not necessarily needed for ground truthing hyperspectral imagery. In those cases, a portable, battery powered, artificial light source that interfaces with the FR fiberoptic input would be just the ticket. ASD offers such an optional device at addition cost, and it is the High Intensity Reflectance Probe, a.k.a, 'potato masher'.

In the picture above right, the High Intensity Reflectance Probe is also equipped with the optional FOV limiter plat for smaller spot sizes. The FieldSpec fiberoptic cable is inserted through the gray strain relief spring, into the illumination cavity to view the sample. Under artificial illumination the following FieldSpec reflectance spectra are of Calcite, Kaolinite, Gypsum, Talc, Calcium Phosphate Tribasic, Oxtriphylline, Diphenehydramine HCL, Sugar, Magnesium Carbonate, Procainamide HCL, Quinapril, and Oil Sand Bitumen.

## 5.1 Probes

### 5.1.1 ASD Pro Reflectance Probe 135680

Large diameter bifurcated fiber optic probe for contact reflectance measurement has the following details: SMA connectors, 156 fibers (200 micron core) on the common end - 78 fibers on each of the bifurcated ends - fibers from each of the bifurcated ends are well mixed in the common end, common portion of the cable is 87 cm in length, total length is 111 cm, the stainless steel tip is 6.3 mm in diameter and 15.2 cm in length, and the cable housing (flexible portion of cable) is 8.3 mm in diameter. Optional spacers A131211 or adjustable 131213 are recommended for optimal baseline.

### 5.1.2 ASD Pro Reflectance Probe Package 1 A111211

Includes one each of the following: ASD Pro Reflectance Probe (bifurcated fiber optic probe), Trumpet Spacer (Cyl) with white Reference, Standoff Reflectance Accessory, Spectralon/ 3.62" Diameter Round x 5 mm Un Cal.

### 5.1.3 High Intensity Reflectance Probe A122000

Features 2900 Degree K color temperature quartz halogen light source and built-in DC current stabilizer circuitry. This probe is powered by a 9.6 V rechargeable Nicad battery that is inserted into the probe handle (1 battery and 1 charger are included). This probe is designed for the FieldSpec FR, NIR and UV/VNIR spectrometers, and is perfect for mineral or other solid reflectance spectra. Replacement Bulb is item.

### 5.1.4 ASD Chem Reflectance Probe 135320

Small diameter bifurcated fiber optic probe for contact reflectance measurements has the following details: SMA connectors, total of 37 fibers (200 micron core) on the common end with 1 fiber in the center - 6 fibers surrounding the central fiber - then 2 more rings of fibers (12 & 18) surrounding those 4 fibers on one of the bifurcated ends - 33 on the other (normally used as 4 collection & 33 illumination) - the 4 collection fibers are centered in the common end (the center fiber and 4 of the surrounding 6 fibers), fiber bundle input cross section is 0.067", common portion of the cable is 93 cm in length, total length is 123 cm the stainless steel tip is 3 mm in diameter and 57 mm in length, the cable housing (flexible portion of cable) is 4.8 mm in diameter. Adjustable, optional spacer A131214 is recommended for optimal baseline.

### 5.1.5 Axiom Diffuse Reflectance Probe 135690

Model FDR 320. Spectral response 900-2500 nm. Illuminated diameter 3.6mm. Sapphire window material with 32cm length and a 32 mm diameter constructed of Nickel plated brass.

### 5.1.6 Right Angle Probe Tip Assembly 10 mm O.D. A122330

This right-angle viewing tip attaches to the ASD Pro Reflectance Probe.

### 5.1.7 Hellma 661.302-QX 2mm Quartz Probe 135701

All-quartz immersion probe (with fiber cables) with stainless steel cap. The quartz measuring head is homogeneously fused to the quartz top. Light paths available: 1 mm, 2 mm, 5 mm, 10 mm, and 20 mm. Diameter of the head is 15 mm. Diameter of the quartz top is 18 mm.

Total length is 200 mm for 10 mm path.

### 5.1.8 Hellma 661.302-QX 1mm Quartz Probe 135702

All quartz immersion probe (with fiber cables) with stainless steel cap. The quartz measuring head is homogeneously fused to the quartz top. Diameter of the head is 15 mm. Diameter of the quartz top is 18 mm.

### 5.1.9 Hellma 661.302-QX 5mm Quartz Probe 135703

All-quartz immersion probe (with fiber cables) with stainless steel cap. The quartz measuring head is homogeneously fused to the quartz top. Diameter of the head is 15mm. Diameter of the quartz top is 18mm.

### 5.1.10 Hellma 661.302-QX 10mm Quartz Probe 135704

All-quartz immersion probe (with fiber cables) with stainless steel cap. The quartz measuring head is homogeneously fused to the quartz top. Diameter of the head is 15mm. Diameter of the quartz top is 18mm. Total length is 200mm for 10mm path.

### 5.1.11 Hellma 661.302-QX 20mm Quartz Probe 135705

All-quartz immersion probe (with fiber cables) with stainless steel cap. The quartz measuring head is homogeneously fused to the quartz top. Diameter of the head is 15mm. Diameter of the quartz top is 18mm.

### 5.1.12 Hellma Process Control Trans Probe 1 mm P/135707

Hellma Process Control Transmission Probe (1mm path). This Hellma transmission probe can be used for in-line measurements in process control applications up to 300 degrees C and 35 bar. The probe is equipped with the exclusive Hellma immersion probe technology with a total reflecting prism made of quartz Suprasil 300 instead of a metal coated mirror.

### 5.1.13 Hellma Flanged Proc. Cntrl Trans Probe 1 mm 135708

Hellma Process Control Transmission Probe, Flanged (1mm path). This Hellma transmission probe can be used for in-line measurements in process control applications up to 300 degrees C and 35 bar. The probe is equipped with the exclusive Hellma immersion probe technology with a total reflecting prism made of quartz Suprasil 300 instead of a metal coated mirror.

### 5.1.14 CS&T, 1mm Dipping Probe 128720

Interfaces with the SMA connectors on the FieldSpec Chem units.

### 5.1.15 FPT 720 NIR Immersion Transmission 128840

Single pass design; Window and internal optics material is fused silica; Optimum spectral range: 0.8 - 2.5 microns; Cell body is 316 stainless steel; Diameter: 0.5 inches; Immersible length is 8 inches; Seals: glass filled Teflon; Max temp: 300 degree C; Max pressure:

2000 psig; Path length: 0.2 to 10 mm, set by interchangeable windows, (one pair provided per customer specs.). Requires two of the Interface Cable (135330). Interfaces with the SMA connectors on the LabSpec Pro units.

## 5.2 Spacers and Standoffs

### 5.2.1 Trumpet Spacer with Flared Cavity A131217

For the large diameter LabSpec Pro Reflectance Probe (135680). This spacer is necessary for optimal baseline when making contact reflectance measurements. This spacer has a flared cavity.

### 5.2.2 Trumpet Spacer with Cylindrical Cavity A131211

For the large diameter LabSpec Pro Reflectance Probe (135680). This spacer is necessary for optimal baseline when making contact reflectance measurements.

### 5.2.3 Trumpet Spacer (Cyl) with White Reference A131215

Trumpet Spacer with Cylindrical Cavity and detachable white reference configuration for the large diameter LabSpec Pro Reflectance Probe (135680). The spacer is necessary for optimal baseline when making contact reflectance measurements. An Allen wrench is included for attaching and detaching the white reference to the spacer.

### 5.2.4 Standoff Reflectance Accessory A121800

Lens foreoptic for the ASD LabSpec Pro Reflectance Probe (135680). The field-of-view and illumination are focused to approximately 5 mm spot at approximately 48 mm from the sample.

# Chapter 6 Source Probe MugLite

The Source Probe MugLite is perfect for mineral reflectance spectra as well as a variety of other applications. It is powered from the accessory power port of the LabSpec and FieldSpec Pro instruments.

Figure 6-1 Source Probe MugLite

## 6.1 MugLite

### 6.1.1 MugLite A122100

Features a tungsten quartz halogen light source with built-in DC current stabilizer circuitry, and Sapphire window. A 1 m FR Fiberoptic Jumper Cable is required for interfacing with the LabSpec Pro.

Optional recommended accessories are as follows: Small Sample Holder, Insert for Small Sample Holder, Small Open Dish for Source Probe, Large Sample Holder, Insert for Large Sample Holder, Large Open Dish for Source Probe, Small White Reference for Source Probe, Adapter Ring, and 1" Diameter Spectralon.

Dimensions 5” x 4", Weight 3 lbs., Lightsource type/Life Halogen Bulb/1500 hours, Halogen Bulb color temperature 2911 +/- 10 degrees K, Spot size 12 mm, Specular-Reflectance 5% max off flat first surface mirror. Power Requirements 12-18 VDC 6.5 W:

Note: Requires external cable assembly for powering from FieldSpec Pro or LabSpec Pro accessory power port, or accessory power supply.

### 6.1.2 Hi-Brite MugLite Package 1 A111209

Includes one each of the following: Hi-Brite MugLite, Small White Reference for MugLite, 1.0m FR Low OH Fiberoptic Jumper Cable, Accessory Power Supply w/Cord 12 Volt, Bulb/ Reflectorized. This package also includes three each of the following items: Small Sample Holder, and Insert for Small Sample Holder. Substitutions or deletions shall not be allowed.

### 6.1.3 MugLite Package 2 A111210

Includes one each of the following: ASD MugLite, Small White Reference for MugLite, 1.0m FR Low OH Fiberoptic Jumper Cable, Accessory Power Supply w/Cord 12 Volt, Bulb/ Reflectorized. This package also includes three each of the following items: Small Sample Holder, and Insert for Small Sample Holder. Substitutions or deletions shall not be allowed.

### 6.1.4 Small Sample Holder A129221

Sample Holder with handle and Quartz window for the ASD MugLites. The sample well has ID of 32 mm. Optional Small Spectralon for Source Probe and 3.62"Dia. Round Spectralon are also recommended for white reference.

### 6.1.5 Small White Reference for MugLite A128003

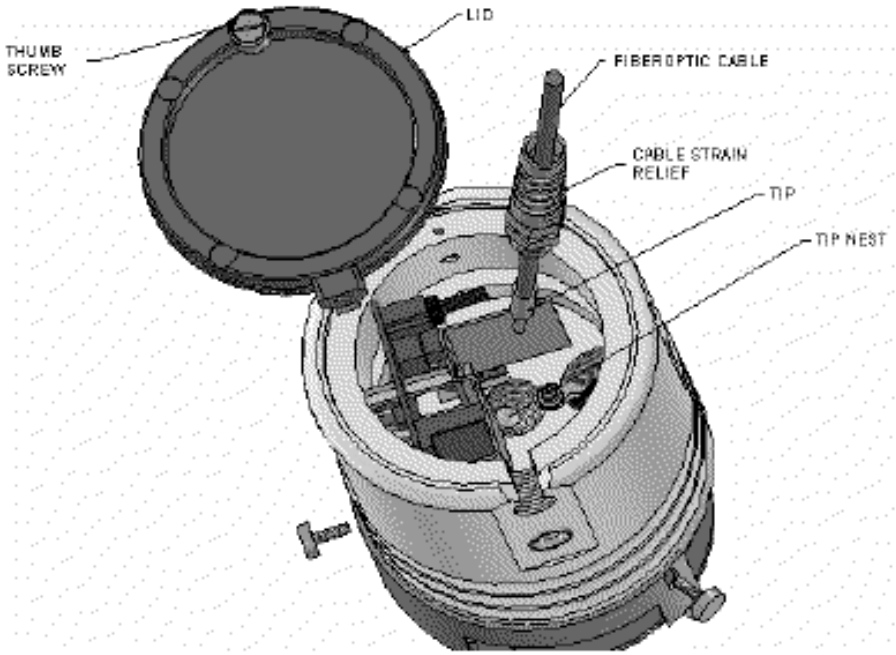
White Reference for Small Sample Holder, for the ASD MugLites. Adapter Ring is also required when using the Large Sample Holder.

# 6.2 Inserting Fiberoptic into MugLite A122100 and A122106

Step 1 Unscrew the lid using single thumb screw and set the lid aside.

Step 2 Back out the strain relief out the body and place it over the fiberoptic cable as shown on the illustration.

Figure 6-2 MugLite with back off.

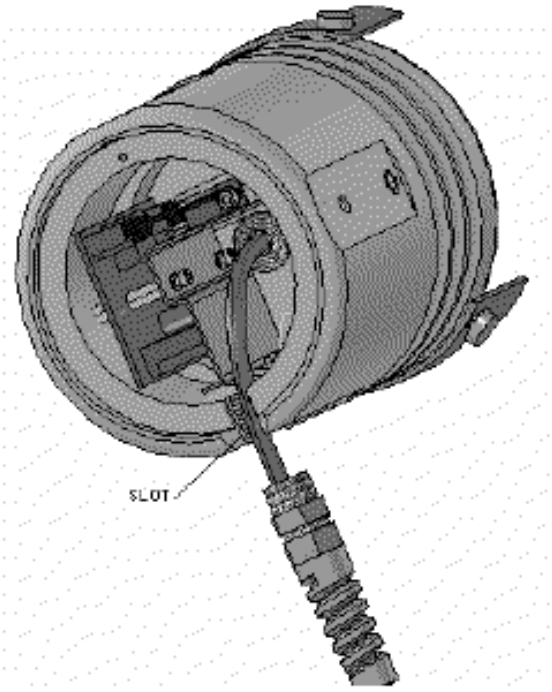



Step 3 Insert fiberoptic tip into the nest hole until the tip reaches the stop in the nest.

Step 4 Bend the Fiber optic to lay the cable into the slot as shown in Figure 6-3.

***Caution! Do not bend Fiberoptic sharply!***

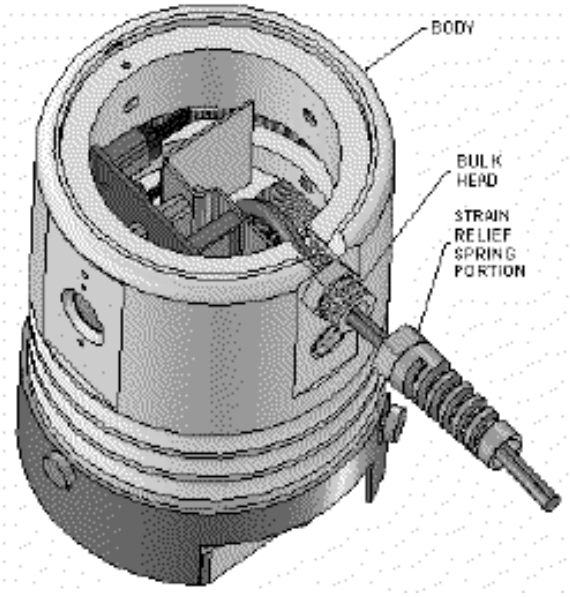
Figure 6-3 MugLite with fiberoptic tip inserted.




Step 5 Separate the bulk head of the strain relief by turning the spring portion CCW.

Step 6 Screw the bulk head into the body of MugLite as shown in Figure 6-4.

Figure 6-4 MugLite with bulk head screwed into body.

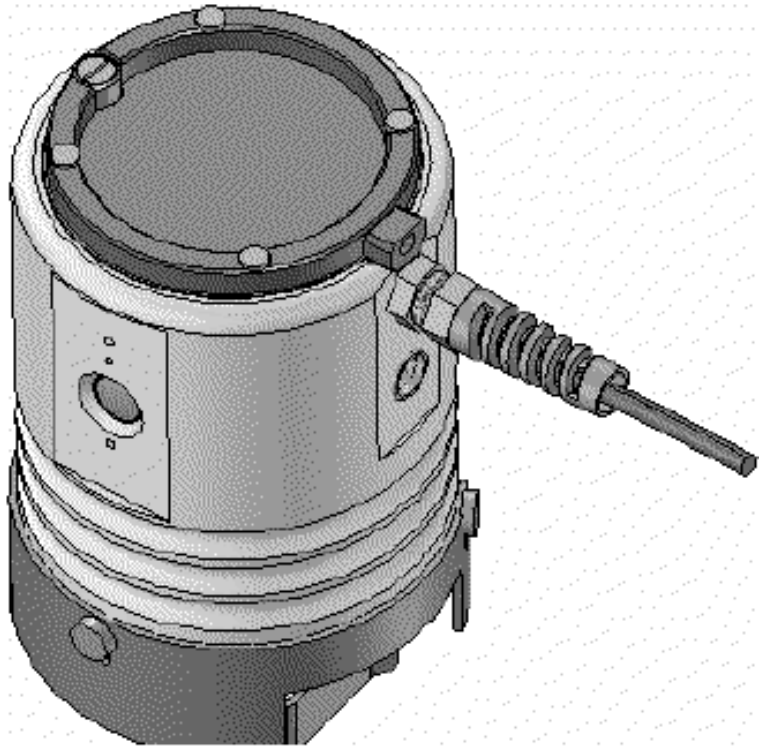



Step 7 After tightning the bulk head finger tight, screw the spring portion of the strain relief to the bulk head.

Step 8 Turn the spring portion until the fiberoptic cable has been captivated.

Step 9 Re-place the lid and tighten the thumb screw.

Figure 6-5 MugLite with



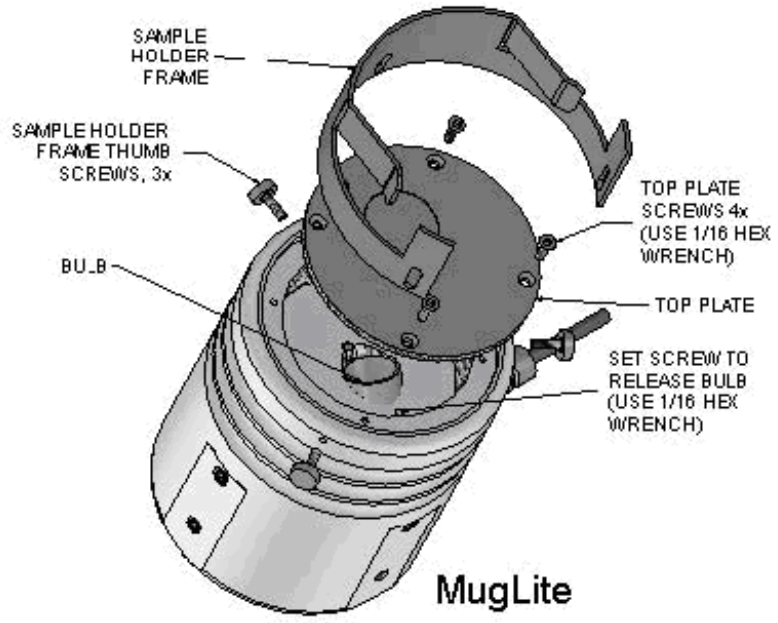
**To remove the fiberoptic cable follow the steps in reverse order.**

Note: To unscrew the bulk head may require 14 mm wrench if finger strength is not enough.

## 6.3 Maintenance MugLite A122100 and Hi-Bright MugLite A122106

The standard MugLite A122100 and Hi-Bright MugLite A122106 measures solids, pastes, powders, and granular materials. The Hi-Brite MugLite is not designed to be used for plant measurements. The probes feature a built-in light source and act as a workstation, so samples can be placed on top of the probes. They also include a sample dish attachment to keep the samples in place, or probe can be inverted to view sample dishes from above. The probes allow the measurement of very high SNR spectra in less than 1 second.

Figure 6-6 Schematic of the MugLite.




Note: Removal of MugLite Bulb requires 0.062" Hex Wrench

Step 1 Loosen sample holder frame screw and slide sample holder frame upward.

Step 2 Unscrew 4 top plate screws (where sapphire window located) and remove top plate.

Step 3 Loosen setscrew adjacent to light bulb. Slide bulb upward and unplug.

Note: You may have to push the bulb from the bottom side.

Step 4 Remove bottom plate by turning the thumbscrew.

Step 5 To replace the new bulb follow the steps in reverse order. The new bulb shall be inserted till it reaches the stop inside the body.

# *Chapter 7 Multi-Purpose Fixture*

## 7.1 Multi-Purpose Fiberoptic Fixture A128755

Adjustable jig for a variety of rectangular cuvette and slide sizes. Also works as a holder for the LabSpec Pro Reflectance Probe. Requires 1 m SMA-to-SMA Fiberoptic Interface Cables/135330.

## 7.2 Filter Wheel Assembly A128757

The ASD Filter Wheel performs tests on wavelength, linearity, and noise. These tests allow ASD customers to rapidly verify whether their instruments are in compliance with NIR spectroscopy standards, such as those recently established by The United States Pharmacopeial Convention, Inc. (USP), a non-government organization that establishes standards to ensure the quality of health care technologies.

Customers can quickly prove that their instrument is in compliance and meets GMP and ISO requirements. A wizard-enhanced software program leads the user through the 2-3 minute test process. The tests can be run individually or as a suite, and users can view individual results during the test process, or they can view the overall results once the tests are complete. In addition, the filter wheel maintains a log of past results, allowing users to track and analyze performance trends.

The Filter Wheel measures 4.5" x 2.5" x 4", weighs 1.5 lbs. Internally, the Filter Wheel consists of six filters of different density-one NIST traceable polystyrene, four neutral and one empty. Accompanying software shows the user how to properly use each filter. Four positions are for linearity tests, 1 position covers the 4 different wavelengths of polystyrene, and two positions are for photometric noise tests.

The ASD Filter Wheel is designed for the 1000 - 2500 nm spectral range. ASD Indico software, appropriate fiberoptic jumper cables, and an SMA Illumination Attenuator (or Cuvette Adapter for FieldSpec Pro) are required to interface the ASD Filter Wheel with the ASD spectrometers. An ASD Fiberoptic Illuminator is also required when using the ASD Filter Wheel with QualitySpec Pro or FieldSpec Pro.

### 7.2.1 USP Calibration Procedure

The Filter Wheel consists of six positions: a blank position, a series of four neutral density (ND) filters and a polystyrene wavelength reference filter. Based upon the spectra the software "sees" through the instrument and the series of filters involved, Pass/Fail grades are given on wavelength accuracy, photometric linearity, and photometric noise (along with a log of the 'specifics'). The filter wheel test is fast and can be run as often as you like. This document defines the procedure for calibrating and using the USP Filter Wheel software. The USP test software must first be calibrated to perform periodic USP tests. During the calibration procedure steps an uspcal.ini and usplog file are created. The USP software requires the uspcal.ini file to be present to test the Photometric Linearity values.

### 7.2.2 Materials Needed

- ASD LabSpec Pro Spectrometer
- Operating Computer with LabSpec Pro Version 5.0 or higher installed
- Two 1 meter SMA-to-SMA low OH fiber optic interface cables (ASD part 135330: standard jacketed fiber optic cable contains one 600 micron fiber for the region 350 – 2500nm)
- One SMA-to-SMA attenuator (ASD part A131321)

### 7.2.3 Set-Up

Step 1 Refer to the LabSpec Pro Manual for Spectrometer Unpacking and Power Up (Sec 4-1 – 4-6)

Step 2 Attach the SMA-to-SMA attenuator to the spectrometer’s Fiber Optic Input – insure the attenuator is completely threaded down

Step 3 Attach one SMA-to-SMA fiber optic jumper cable to the Attenuator.

Step 4 Attach the second SMA-to-SMA fiber optic jumper cable to the spectrometer’s Light Source SMA Connector

Step 5 Attach the “loose” end of the jumper cable attached to LabSpec’s Attenuator to the connector on the back side of the filter wheel.

Step 6 Attach the “loose” end of the jumper cable attached to LabSpec’s Light Source to the connector on the front side of the filter wheel.

Step 7 Ensure the filter wheel is in position 1.

Step 8 Turn on the spectrometer’s internal light source and allow the instrument and the illumination source to warm-up and stabilize for 60 minutes.

### 7.2.4 Filter Wheel and Fiber Optic Interface Cable Care

- Do not flex SMA-to-SMA interface cable to a diameter of less than 5 inches
- Store the SMA-to-SMA interface cable with connector covers in place
- Store the Filter Wheel in a low dust or dust-free enclosure, for example, a laboratory cabinet
- Do not store the Filter Wheel in a plastic bag - the out-gassing plastic could fog the filters
- Be sure to always completely thread down the SMA attenuator prior to each USP calibration
- Never move or adjust the fiber optic interface cables once the Filter Wheel tests have begun. The movement of the fiber can result in a throughput change of the fiber, resulting in the test failing one or more tests.

### 7.2.5 Calibration procedure

This procedure performs the USP calibration.

#### Creating the Calibration Shortcut

Step 1 Warm instrument up for 60 minutes.

Step 2 Create a shortcut of the usp.exe executable and name it **usp calibration**.

Step 3 Right click on the shortcut and select the **Shortcut** tab.

Step 4 Enter " -c" at the end of the target text.

Step 5 The target text should read "c:\Program Files\LabSpec Pro\Usp.exe" –c

Step 6 Select **OK** to save changes.

Step 7 Verify the file uspcal.ini and usplog file do not exist in the install directory.

#### Running the Calibration Test

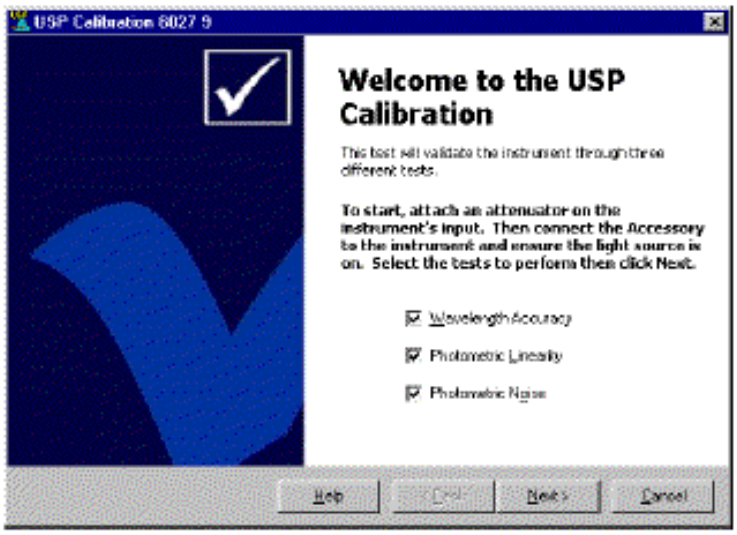
Step 1 Launch application using the newly created shortcut.

Step 2 Enter the Accessory Wheel's serial number found on the bottom of the filter wheel.

Step 3 Verify a window like the following is opened and has a title **UPS Test #### !!**.

Step 4 Verify that **####** and **!!** are the same serial and calibration as recorded in the asdhw.ini file located under c:\Program Files\LabSpec Pro.

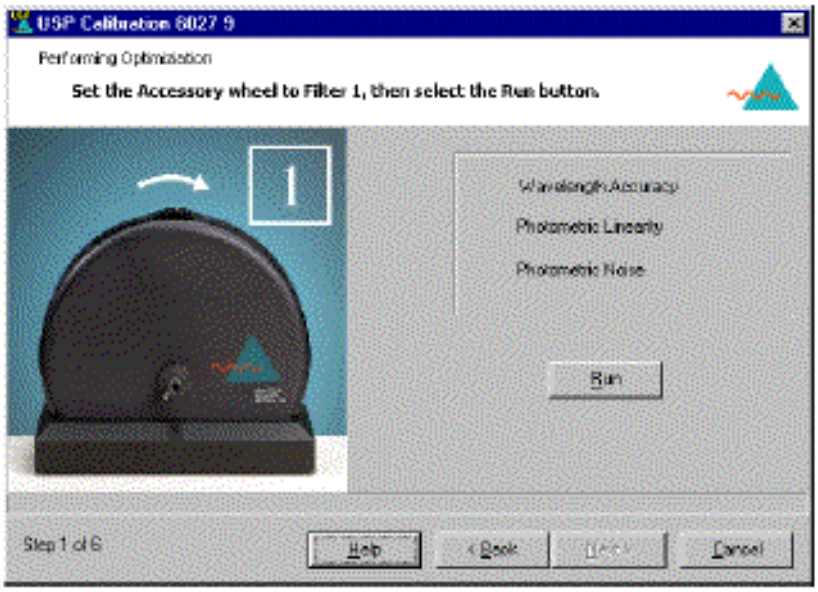
Figure 7-1




Step 5 Check all tests and select the **Next** button.

Step 6 Verify that the next screen looks similar to the following.

Figure 7-2




Step 7 Ensure the filter wheel is in position 1

Step 8 Select the **Run** button.

Step 9 Verify that the application optimizes and gives the status of the progress.

Step 10 Follow the USP instructions to set the accessory wheel to the correct filter positions and complete the tests.

Step 11 Verify that the application displays a **Pass** or **Fail** results on the last screen of the calibration.

Note: If there is **Fail** logged for any of the tests, do not finish the validation test and contact Technical Support.

## Creating the USPCAL.INI File

Step 1 Select the **Create Calibration File** button

Step 2 Verify the following message is displayed. This button creates the uspcal.ini file and logs the calibration record in the usplog file.

Figure 7-3


Step 3 Select the **Print Report** button and print the report.

## USP Test procedure

This procedure performs the USP Test.

Step 1 Use the shortcut on the desktop to run all normal USP tests. This shortcut does not include the ‘ –c’ command line parameter.

Step 2 Ensure the instrument has been warmed up for 60 minutes.

Step 3 Verify the file uspcal.ini and usplog file exist in the install directory: C:\Program Files\LabSpec Pro

## Running the Test

Step 1 Launch application using the shortcut on the desktop.

Step 2 Verify a window like the following is opened and has a title **USP Calibration #### !!**.

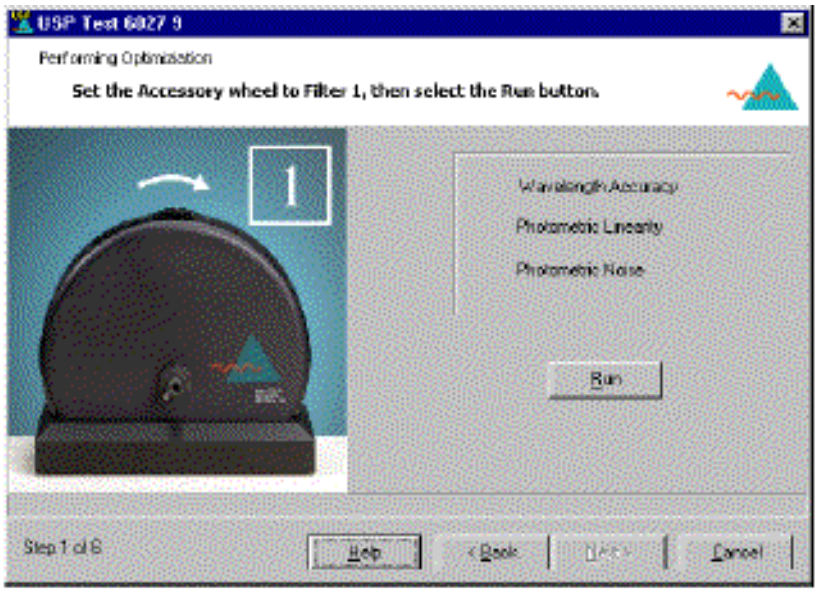
Step 3 Verify that **####** and **!!** are the same serial and calibration as recorded in the asdhw.ini file.

Figure 7-4


Step 4 Check all tests and select the **Next** button.

Step 5 Verify that the next screen looks similar to the following.

Figure 7-5




Step 6 Select the **Run** button and verify that the application optimizes and gives the status of the progress.

Step 7 Follow the USP instructions to set the accessory wheel to the correct filter positions and complete the tests.

Step 8 Verify that the application displays a **Pass** or **Fail** results on the last screen of the tests.

Note: If there is **Fail** logged for any of the tests, finish the validation test to make a record of the failure and contact Technical Support.

## 7.3 Cuvette Adapter A131322

Allows standard FieldSpec fiberoptic input to interface with Cuvette Holder, ASD Multi-Purpose Fiberoptic Fixture, Long Path Cell Holder, and Filter Whee).

## 7.4 Fiberoptic Illuminator A126515

The Fiberoptic Illuminator is a portable light source designed to be used with FieldSpec Pro or QualitySpec Pro, or as an auxiliary light source for LabSpec Pro. Power Requirement 12-18 VDC 6.5 W:

Note: Requires external cable assembly for powering from FieldSpec Pro or LabSpec Pro accessory power port, or accessory power supply.

## 7.5 SMA Illumination Attenuator A131321

The light sources of the ASD LabSpec Pro or ASD Fiberoptic Illuminator are sometimes too bright for some samples being measured with fiberoptic probes or cuvette holders. To avoid signal saturation this Attenuator should be attached at the illumination source SMA and then the fiberoptic attaches to this Attenuator.

## 7.6 1m SMAtoSMA Low OH Fiberoptic Interface Cbl/135330

This standard jacketed fiberoptic cable contains one 600 micron fiber for the region 350 - 2500 nm.

# Chapter 8 Turntable Accessory A128797

This accessory is for use with LabSpec, QualitySpec, TerraSpec, AgriSpec, or FieldSpec and permits highly accurate and repeatable analysis of irregular or non-homogeneous samples. Samples are placed in a 150 mm x 15 mm or 100 mm x 15 mm petri dish and then placed in a recessed area of a rotating plate. One of each petri dish is included.

The rotating motion enables the spectrometer to view multiple orientations and effectively average out non-uniform surfaces. An appropriate fiberoptic interface is also required.

# Notes:

# Chapter 9 Pistol Grip

**SMA, FieldSpec HH Adapter 131205**

Interfaces the FieldSpec HandHeld to SMA jumper cables & probes.

**Pistol Grip For HH A145653**

This Pistol Grip has a built-in bulls-eye level and quick-connect/disconnect fiberoptic cable snap-in feature. Built-in rail is ready to receive optional red-dot-scope, which is sold separately. Allows the use of FieldSpec HandHeld foreoptics when used in conjunction with fiber optic jumper cables.

**FieldSpec HH spotting sight A127300**

This electronic reflex sight provides more accurate aiming. This sight uses a red LED to produce a bright red dot in the center of the instrument's field of view. Unlike a standard laser sight, this sight works well in bright sunlight. Please indicate distance for reticule calibration such as, (infinity) or (1.5 m). Mounts directly on the FieldSpec HandHeld instrument with the provided mounting.

**FS Pistol Grip A145650**

This Pistol grip has a built-in bulls-eye level and quick-connect/disconnect fiberoptic cable snap-in feature. Built-in rail is ready to receive optional Red-Dot-Scope.

**Pistol Grip with Red Dot Scope A145652**

This Pistol grip includes Red Dot Scope, built-in bulls-eye level, and quick-connect/disconnect fiberoptic cable snap-in feature.

**Pistol Grip Cold Weather A145651**

Required for the larger diameter cold-weather fiberoptic cables.

**Pack of Ten Strain Reliefs A205000**

Replacement strain reliefs for the pistol grip and RCR.

### Inclination Gauge 119650

For setting the pistol grip to a desired angle to the horizon.

### Foreoptic Equatorial Mount A119735

For FieldSpec Pro's with Serial Number 6222 and after, and for LabSpec Pro's with Serial Number 4023 and after. The pro style instrument battery (sold separately) powers the equatorial mount. This mount is used to maintain the orientation of the Direct Irradiance Attachment (A119720) and the Full Sky Irradiance RCR (A124500) relative to the sun.

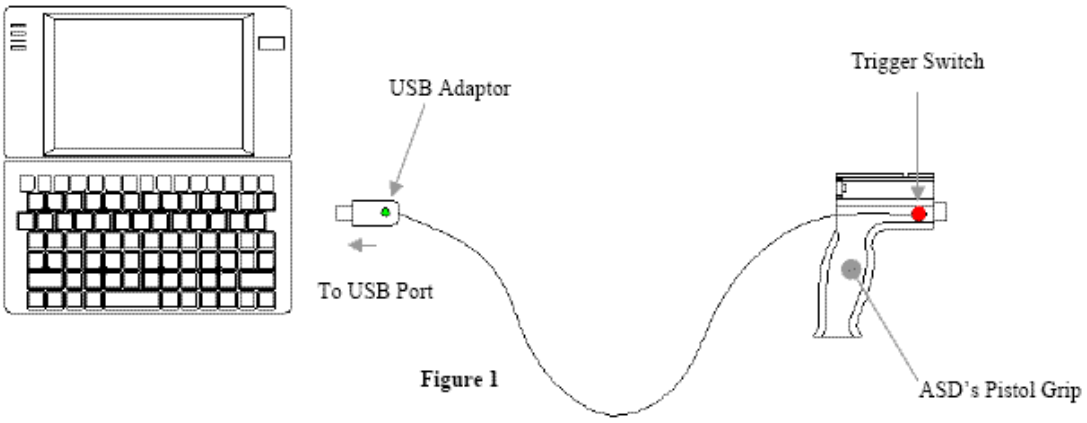
Once proper manual aiming at the sun is set, this mount scans in synchronization with the motion of the sun through the sky.

# Chapter 10 Remote Trigger

This device is a switch mechanism that performs the same function as the laptop space bar. Pressing the switch signals the PC/laptop to collect and store a spectrum or a collection of spectra. The trigger can attach to most anything including ASD's Pistol Grip, Plant Probe or Contact Probe. Among other advantages, this trigger enables the user to point and capture a spectrum with one hand and use his/her free hand to stabilize samples.

The switch attaches to the side (right hand or left hand) of a pistol grip or a probe with a ¾" diameter self sticking Velcro Pad. Five Velcro pads are included allowing users to attach the switch to multiple devices. The cord attached to the switch routes to a small inline USB adaptor. This adaptor attaches directly to any PC/laptop USB port.

Figure 10-1 Remote Trigger




The USB adapter is actually an embedded RS-232 to USB adapter. The trigger switch generates a pulse that simulates an ASCII character into the RS-232 section of the adapter. The adapter converts this pulse to a USB communications protocol which is then handled by the software within the Laptop PC. A user accessible jack connector is designed into the USB adaptor (Figure 2), which will output a signal upon completion of a spectrum save. This output signal is a NULL ASCII character (basically a pulse) This feature can be used to activate a strobe, conveyor, camera or other device. The 2-pin jack connector (Figure 3) is wired to an electronic switch (N channel MOSFET) and will momentarily switch off for a short time (pulse) at the end of each spectrum save. The drain of the MOSFET is connected to pin-1. The source is connected to pin-2 (USB ground). The MOSFET will switch up to 1

amp @ 24VDC. The switch off time is calculated as follows: 1/baud rate x 9. Changing the baud rate will change the off time. Baud rate can be changed using the Serial Pulse settings screen (Figure 6) in the Laptop PC. A mating plug connector is included if a user wishes to take advantage of this feature.

Figure 10-2

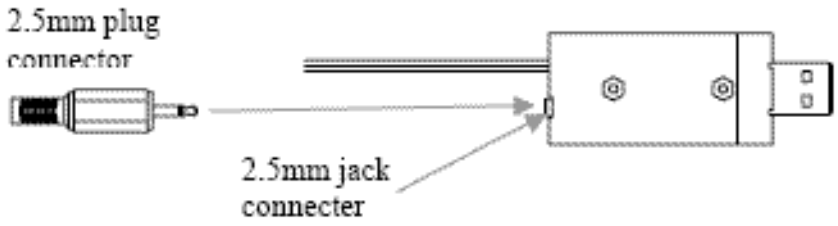
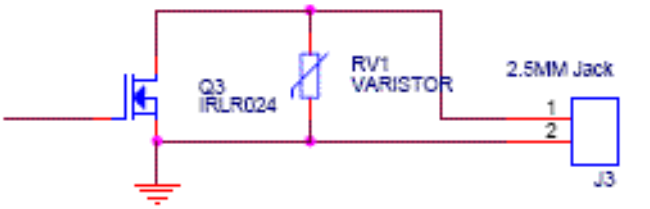



Figure 10-3




MOSFET Q3 is normally on, switching pin 1 of J2 to ground (pin2, J3). When a spectrum is saved, Q3 switches off momentarily.

**Helpful Notes**

- Make sure the PC/laptop volume is turned up. An audible bell designed into ASD's RS3 and Indico software will sound at the end of each Spectrum save. The bell insures the user that a spectrum collection was performed and saved.
- Figures 4 & 5 illustrate how a customer might wire this device to a logic circuit. A circuit might include a design to momentarily turn on a light emitting diode (LED) at the end of a long cord. This would be helpful to a user too far away from the PC/laptop to hear the audible bell.

Figure 10-4

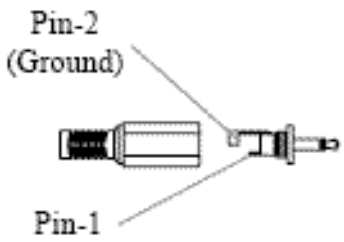



Figure 10-5

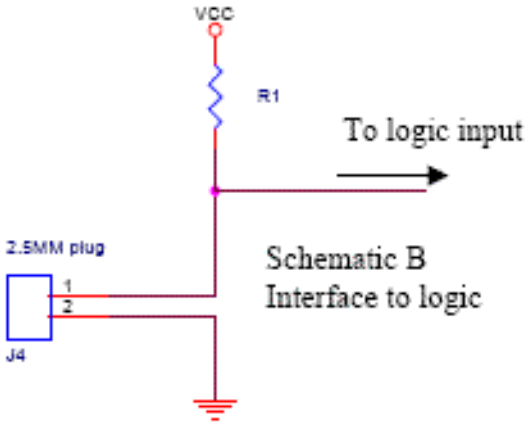
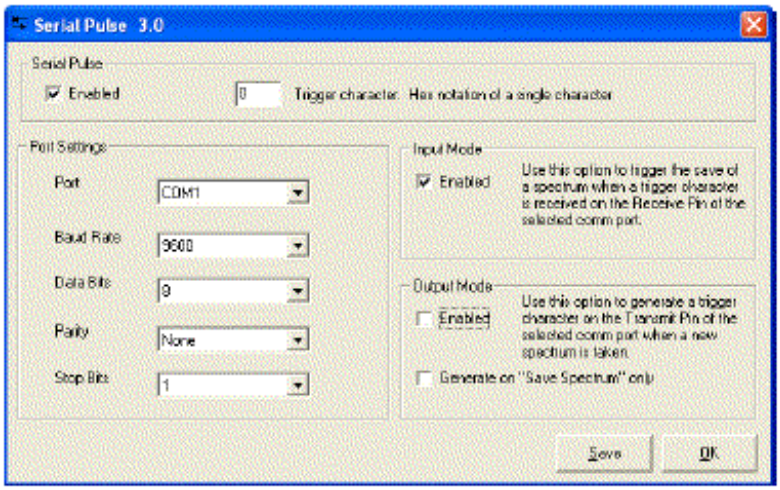



Figure 10-6



## 10.1 Remote Trigger, 1.5M (4.92ft.) A354295

The Remote Trigger is a convenient switch, which allows collection of spectra at the accessory or pistol grip in place of the space bar on the computer. Cable length is 1.5 meters. This trigger uses a USB interface. Includes configuration manual and driver CD and Velcro peel-n-stick pads.

## 10.2 Remote Trigger, 3M (9.84 Ft.) A354296

The Remote Trigger is a convenient switch, which allows collection of spectra at the accessory or pistol grip in place of the space bar on the computer. Cable length is 3 meters. This trigger uses a USB interface. Includes configuration manual, driver CD, and Velcro peel-n-stick pads.

## 10.3 Remote Trigger, 5M (16.4 Ft.) A354297

The Remote Trigger is a convenient switch, which allows collection of spectra at the accessory or pistol grip in place of the space bar on the computer. Cable length is 5 meters. This trigger uses a USB interface. Includes configuration manual, driver CD, and Velcro peel-n-stick pads.

## 10.4 Remote Trigger, 6M (19.68 Ft.) A354298

The Remote Trigger is a convenient switch, which allows collection of spectra at the accessory or pistol grip in place of the space bar on the computer. Cable length is 6 meters. This trigger uses a USB interface. Includes configuration manual, driver CD, and Velcro peel-n-stick pads.

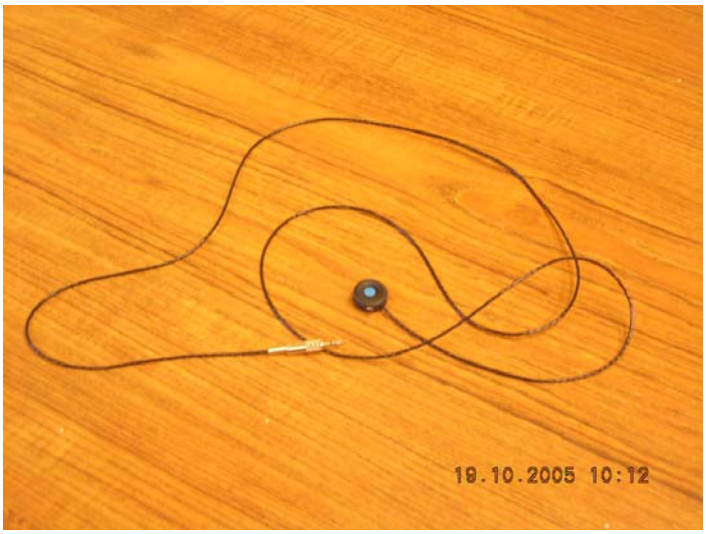
## 10.5 External Trigger with the FieldSpec

An external trigger is standard with the FieldSpec, as is shown in Figure 10-7.

The trigger plugs into the ASD spectroradiometer (such as the FieldSpec3) near the fiber optic cable.

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

Figure 10-7 External trigger.




The trigger comes with several pieces of mated velcro, which are intended for use with several accessories. Place a piece of hook velcro onto the trigger; place pieces of mesh velcro onto the accessories.

Note: Accessories such as the pistol grip should probably have pieces of mesh velcro placed on both sides so that the trigger can be used right- or left-handed.

# Chapter 11 Power Accessories

## 11.1 Power Supplies

### 11.1.1 Power Supply with Cord 12 Volt 30 Watt A350610

This is the AC desk top power supply for the ASD QualitySpec Pro only.

### 11.1.2 Accessory Power Supply with Cord 12 Volt A146540

This desk top supply powers the Contact Probe, Plant Probe, Mug Light and the Fiber Optic Illuminator.

### 11.1.3 Power Supply, 15VDC 70 Watt 350535

Replacement power supply for Pro Lamp A128931.

### 11.1.4 Power Supply, DC For Lowell Pro Lamp 350530

Power supply for older Lowell Pro-lamp Interior Light Assembly A128930.

### 11.1.5 Ault, 24V Power Supply with Power Cord A146550

Required for older Pro Style Battery Charger A122250 and Classic Style Auxiliary Battery Charger/A147020.

### 11.1.6 AUX. Power Supply, 18VDC,>=130 WATT A146570

AC/DC Power Supply w/cord for all LabSpec Pro and FieldSpec Pro series spectrometers. Not for older 'Classic' Versions.

### 11.1.7 Power Supply Assembly for HH A146510

AC/DC power supply for the FieldSpec HandHeld.

## 11.2 Batteries

### 11.2.1 BattBelt 12VGellCell with Charger for Access A147025

Electrolyte battery with charger system and power cord for powering any ASD 12V accessory. This is an excellent option for powering ASD Contact Probes, Mug Lights and Fiberoptic Illuminator.

### 11.2.2 Aux. HH Rechargeable Battery 145101

For extended power duration between re-charging.

### 11.2.3 Battery Belt, 12V Electrolyte w/ Charger A147030

Gell cell electrolyte battery with charger is an optional accessory for TerraSpec and AgriSpec.

Includes pouch and 6-ft extension with main power jack connector for AgriSpec. Power output duration is 4 hours.

### 11.2.4 Battery Charger, Lithium Ion A145111

Auxiliary charger for FieldSpec HandHeld batteries.

### 11.2.5 Makita, 9.6V Rechargeable Battery 140190

Auxiliary battery for old style ASD High Intensity Reflectance Probe.

### 11.2.6 Aux. Pro Battery, NiMH High Current 160304

Spectrometer Battery for FieldSpec Pro's with SN 6222 and later, and for LabSpec Pro's with SN 4023 and later. For extended power duration between re-charging. FieldSpec Pro series with SN before 6222 also require High Current to Silver Pro Connector/A110078. FieldSpec 'Classic' series require Cable, NiMH Batt to Classic Inst Adapter/A354485.

### 11.2.7 Aux.12VBat Charger (PRO) A122250

A122250 also appears under A147080.

Requires Ault 18V Power Supply Assembly with Power Cord, item no. A146570. Spectrometer Battery Charger for FieldSpec Pro FR with Serial Number before 6222, FieldSpec Pro VNIR with Serial Number before 7054 and for LabSpec Pro's with Serial Number before 4023.

### 11.2.8 Battery Charger, Auxiliary (High Current) A122255

Requires Aux Power Supply 18VDC, >=130 WATT. Spectrometer Battery Charger for FieldSpec Pro FR with Serial Number 6222 and after, FieldSpec Pro VNIR with Serial Number 7054 and after, and for LabSpec Pro's with Serial Number 4023 and after.

## 11.3 Power Cables

### 11.3.1 Cable, NiMH Batt to Classic Inst Adapter A354485

Required to adapt 'classic' 12 volt spectrometer connector to Aux. Pro Battery, NiMH High Current / 160304.

Battery Charger, Auxiliary (High Current) and Aux Power Supply 18VDC, >=130 WATT are also required at additional cost. WARNING:

Do NOT charge Aux. Pro Battery, NiMH High Current / 160304 with older 'classic' charger and do NOT charge older 'classic' battery with new Charger,Auxiliary (High Current) / A122255.

### 11.3.2 Pro-Accessory Port Splitter Cable A354481

This splitter cable enables the user to power a laptop and one accessory from the single accessory port located on the back of the instrument (power upgrade might also be required at additional cost).

### 11.3.3 Pro Silver Battery To Accessory Cable A354484

This adapter allows the user to power Pro version accessories directly from a battery that is not high current type.

### 11.3.4 Pro Red Battery To Accessory Cable A354483

This adapter allows the user to power Pro version accessories directly from Aux. Pro Battery, NiMH High Current 160304.

### 11.3.5 Classic-Accessory Port Splitter Cable A354482

This splitter cable enables the user to power the Classic instrument the laptop (thru their auto adapter) and one accessory from a single classic battery. Note: All accessories can plug directly into any classic battery.

### 11.3.6 High Current to Silver Pro Connector A110078

Small adapter cable that adapts the older silver Pro battery connector to newer high current (red connector) batteries.

### 11.3.7 Cable, External Power A354213

This cable powers the Contact Probe, Leaf Probe, Mug Light and the Fiber Optic Illuminator from the auxiliary power port of LabSpec Pro and FieldSpec Pro instruments only (this cable is not included with the probes).

# Chapter 12 Spectralon Reference Panels

## 12.1 White Reference

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

Because the spectrometer only measures the intensity of a light field through a given point in space, a white reference is one method to correlate that measurement with the physical properties of the sample. Reflectance and transmittance are inherent properties of all materials and are independent of the light source.

The ASD application software, such as RS$^3$ and Indico, can calculate the ratios for reflectance or transmittance of the material being sampled by the FieldSpec (or AgriSpec, TerraSpec, LabSpec, QualitySpec, or other ASD Spectroradiometer) using the white reference as the standard.

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

Spectralon is made of polytetraflouroethylene (PFTE) and 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.

### 12.1.1 Spectralon Reflectance Data

Table 12-1 shows the published reflectance data for an uncalibrated SRM-990. When SRM-990 is used as the white reference for a reflectance measurement with the FieldSpec (or AgriSpec, TerraSpec, LabSpec, QualitySpec, or other ASD Spectroradiometer), an even closer reflectance value for the sample can be calculated.

Table 12-1 Labsphere's published reflectance data for uncalibrated Spectralon® (+/- 0.5%)

| Wavelength (nm) | SRM-990 “Uncalibrated” Spectralon® Reflectance |
|---|---|
| 250 | 0.950 |
| 300 | 0.985 |
| 400 | 0.990 |
| 500 | 0.991 |
| 600 | 0.992 |
| 700 | 0.992 |
| 800 | 0.991 |
| 900 | 0.991 |
| 1000 | 0.993 |
| 1100 | 0.993 |
| 1200 | 0.992 |
| 1300 | 0.992 |
| 1400 | 0.991 |
| 1500 | 0.991 |
| 1600 | 0.991 |
| 1700 | 0.988 |
| 1800 | 0.989 |
| 1900 | 0.981 |
| 2000 | 0.976 |
| 2100 | 0.953 |
| 2200 | 0.973 |
| 2300 | 0.972 |
| 2400 | 0.955 |
| 2500 | 0.950 |

Reflectance = Energy reflected from target/energy incident on target

### 12.1.2 Maintaining Spectralon References

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

**To clean a lightly soiled Spectralon white reference**

If the material is lightly soiled, it may be air brushed with a jet of clean dry air or nitrogen.

**WARNING! DO NOT use Freon.**

**To clean a heavily soiled Spectralon white reference**

Sand the Spectralon material under running water1 with a 220-240 grit waterproof emery cloth until the surface is totally hydrophobic (water beads and runs off immediately).

Step 1 Use a flat surface, such as a thick, flat piece of glass.

Step 2 Place the glass into the sink.

Step 3 Place 220 grade wet sandpaper onto the glass.

Step 4 Gently move the Spectralon reference in a figure 8 motion on the sandpaper, using water as needed to wash away the thin layer that is sanded off.

Step 5 Blow dry with clean air or nitrogen or allow the material to air dry.

Step 6 If the material requires high resistance to deep UV radiation, the piece should be prepared as above, then either of the following two treatments performed.

1 Flush the Spectralon piece with >18 m½ distilled, deionized water for 24 hours.

2 Vacuum bake the Spectralon piece 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.

**WARNING! Do not use oils or soaps to clean the Spectralon white reference.**

### 12.1.3 White Reference Procedures

White references should be collected approximately every ten (10) minutes and can be varied depending on whether conditions are changing rapidly or not changing very much. The Spectralon puck should be used when optimizing and taking a white reference measurement.

Note: For best results, the Spectralon puck should be at the same distance and angle from the foreoptic as the sample will be during measurements.

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

You can change the screen in the RS$^3$ application to view the spectra in raw DN mode without leaving real-time reflectance. This will give you an idea if you are nearing saturation levels in any of the spectrometers. If you are nearing a saturation level or your response has dropped off to a low level, then you would want to re-optimize.

The ASD spectroradiometer (such as the FieldSpec3) should be re-optimized for:

- Light changes.
- Any atmospheric changes or changes in temperature.

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

## 12.2 Spectralon Reference Panels

**Spectralon, 1" Diameter 128003**

Particularly useful as an auxiliary white reference plate for the ASD Mug Light (sold separately).

**Spectralon, 2x2 inch (5x5cm) Uncal. White 128000**

Diffuse white reference panel. Includes plastic case with molded foam padding.

**Spectralon, 2x2 inch (5x5cm) Cal. White 128150**

Diffuse white reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals. Also includes plastic case with molded foam padding.

**Spectralon 2 X 2 Inch Cal. Black 128151**

Includes certificate of std dev & reflectance factors to 3 decimal places for 50 nm intervals.

**Spectralon, 3.62"Dia. Round x 5mm Un Cal. 128001**

Diffuse white reference panel.

**Spectralon, 5x5 inch (12.7x12.7cm) Uncal. 128030**

Diffuse white reference panel.

**Spectralon, 5x5 in (12.7x12.7cm) Cal. White 128160**

Diffuse white reference panel. Includes certificate of std dev & reflectance factors to 3 decimal places for 50 nm intervals.

**Spectralon, 10x10 in (25.4x25.4cm) Cal. 128170**

Diffuse white reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals.

**Spectralon, 12x12 inch (35x35cm) Uncal. 128050**

Diffuse white reference panel.

**Spectralon 12x12 in (35x35cm) Cal. White 128180**

Diffuse white reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals.

**Spectralon, 18x18 in (45.6x45) Uncal. 128060**

Diffuse white reference panel.

**Spectralon, 18x18 in (45.6x45.6cm) Cal. 128190**

Diffuse white reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals.

**Spectralon, 24x24 inch (61x) Uncal. 128070**

Diffuse white reference panel.

**Spectralon, 24x24 in (61x61cm) Cal. 128200**

Diffuse white reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals.

**Spectralon, 2x2 Cal. 50% Gray 128100**

Diffuse gray reference panel. Comes with Certificate of Calibration.

**Spectralon, 5x5 inch Cal. 50% Gray 128110**

Diffuse gray reference panel. Includes plastic case with molded foam padding and calibration certificate.

**Spectralon, 5x5 inch Cal. 12% Gray 128120**

Diffuse gray reference panel. Includes certificate and documentation showing standard deviation and reflectance factors to three decimal places for 50 nm intervals.

**Spectralon, 10X10 inch Cal. 10% Gray 128350**

Diffuse gray reference panel.

**Spectralon, 10X10 inch Cal. 25% Gray 128360**

Diffuse gray reference panel.

**Spectralon, 10x10 inch Uncal. 10% 128370**

Gray reference panel.

**Spectralon, 10x10 inch Uncal. 25% G 128380**

Diffuse gray reference panel.

**Spectralon, Wooden Case for 5 x 5 128300**

Wooden case with internal padding for 5x5 inch Spectralon.

**Spectralon, Wooden Case for 10 x 10 128310**

Wooden case with internal padding for 10x10 inch Spectralon.

**Spectralon, Wooden Case for 12 x 12 128320**

Wooden case with internal padding for 12x12 inch Spectralon.

# Chapter 13 Miscellaneous Accessories

## 13.1 Lamp Assembly

### 13.1.1 Pro Lamp Assembly A128931

14.5 Volt 50 Watt Lamp that is tripod mountable for indoor lab diffuse reflectance measurements over the region 350 - 2500 nm. Includes 1 of item 350535 Power Supply DC For Pro Lamp, and 1 of item 128690 bulb.

### 13.1.2 Hg/Ar VIS Lamp Box Assembly A125000

Combination Hg/Ar glow discharge tubes housed in a lightweight portable unit FOR CHECKING WAVELENGTH CALIBRATION IN VISIBLE REGION.

## 13.2 Carrying Cases

### 13.2.1 Wheeled Cloth Carrier A109800

Wheeled carrier for LabSpec Pro and FieldSpec Pro.

### 13.2.2 Universal Carrier/Shipping Case A109804

NEW! Durable, air-tight, wheeled case for LabSpec Pro and FieldSpec Pro spectrometers and some accessories. Made of high impact structural co-polymer. Includes internal foam cutouts to house and protect.

### 13.2.3 Shipping Trunk 900250

Large gray internally padded shipping trunk for spectrometer and accessories.

Figure 13-1 Shipping case with Ergonomic Pro-Pack with ASD spectroradiometer (such as the FieldSpec3) and instrument controller.


## 13.3 Ergonomic Pro-Pack

The Ergonomic Pro-Pack is designed for the ASD spectroradiometer (such as the FieldSpec3).

Figure 13-2 Ergonomic Pro-Pack with fiber optic cable spool.

Figure 13-3 Ergonomic Pro-Pack with the instrument controller.

### 13.3.1 Fiber Optic Cable Spool and Battery Pouches

Figure 13-4 Fiber optic spool and where it attaches with snaps to the battery pouch on the hip belt.


Figure 13-5 Fiber optic cable spool on the battery pouch on the hip belt.

### 13.3.2 Belly Board

The belly board has two intended configurations:

- With the neck strap, the belly board can hold the instrument controller without the Ergonomic Pro-Pack, such as when the equipment is carried in the field by two people.
- Without the neck strap, the belly board can be attached directly to the shoulder straps of the Ergonomic Pro-Pack, such as when one person operates the instrument.

Figure 13-6 The belly board with instrument controller (not included) and neck strap.

Figure 13-7 Belly board attaches to the shoulder straps of the Ergonomic Pro-Pack.

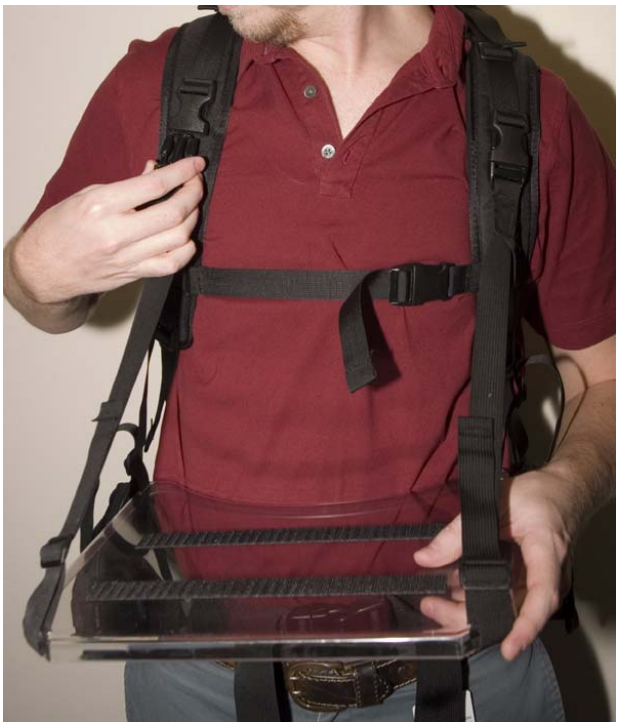


Figure 13-8 ASD spectroradiometer (such as the FieldSpec3) in the Ergonomic Pro-Pack and instrument controller on the belly board.

### 13.3.3 Rain Flap

The Ergonomic Pro-Pack has a small interior pocket near its top which holds a rain flap, as is shown in Figure 13-9 and Figure 13-10.

***Caution! The rain flap is water resistant, but not water proof.***

Figure 13-9 Rain flap storage in the Ergonomic Pro-Pack.

Figure 13-10 Rain flap covering the unit.

# 13.4 Tripods

## 13.4.1 Tripod, Alum. Lt. Weight All Purpose 128780

Aluminum Lt. Weight tripod for use with FieldSpec Handheld Spectrometer, Pro Lamp Assembly, pistol grip, or the HH pistol grip.

## 13.4.2 Tripod, Bogen 3001 w/3025 Head 128560

With a 5 kg. load capacity, this sturdy tripod is ideal for the larger (10"x10" and 12"x12") Spectralon panels and for the FieldSpec Handheld. The legs are made of sturdy, tubular hard-finish aluminum and each leg has sure-grip, quick-acting lever locks that don't foul in sand or mud. Height is adjustable in the range 32 cm to 140 cm. Legs have three different separately settable click-stopped spread angles for easy leveling.

## 13.4.3 Ultra Pod II (Mini Tripod) 128770

The Ultra Pod is a lightweight mini-tripod that stands on fold-out, no-slip feet, or attaches to solid objects with a Velcro strap. The ball and socket camera mount attaches to the FieldSpec pistol grip and adjusts to multiple positions quickly and easily.

# 13.5 Miscellaneous

## 13.5.1 Backpack rain protector 109820

For FieldSpec Pro pack.

## 13.5.2 SMA, Adapter Kit for Jumpers A131320

Interfaces std. FieldSpec fiberoptic cables to SMA jumper cables & probes.

## 13.5.3 Driver, 7/64" ball point hex key 127232

For changing the FieldSpec Pro internal lamp.

## 13.5.4 Nutdriver, 3/8 in. 129160

For adjusting the bundle matcher of the QualitySpec Pro.

# *Appendix A Wavelength and Calibration Methods*

## A.1 Introduction

Reliable spectrometry data collection depends, to perhaps the greatest extent, upon accurate calibration of the instruments used. The ASD line of spectroradiometers are commonly used in the analysis and cross-referencing of reflectance, transmittance, and absorption characteristics of materials and land/sea surfaces. For this reason, accurate wavelength calibration is a necessity and a standard feature included in the acquisition of any spectroradiometer instrument package. Periodic examination of the absorption features in the spectra of materials with known characteristics is highly recommended for the SWIR (short wave infrared; 1000 - 2500 nm) detectors. A mercury discharge tube or other known discrete emission light source works well for verifying calibration in the VNIR (visible and near infrared; 350 - 1000 nm) portion of the spectrum. After the instruments are calibrated at the ASD factory with a 0.1 nm band pass monochromator, their responses to several known elements and emission sources are checked, before shipment, as a verification of method and equipment.

## A.2 Wavelength Calibration

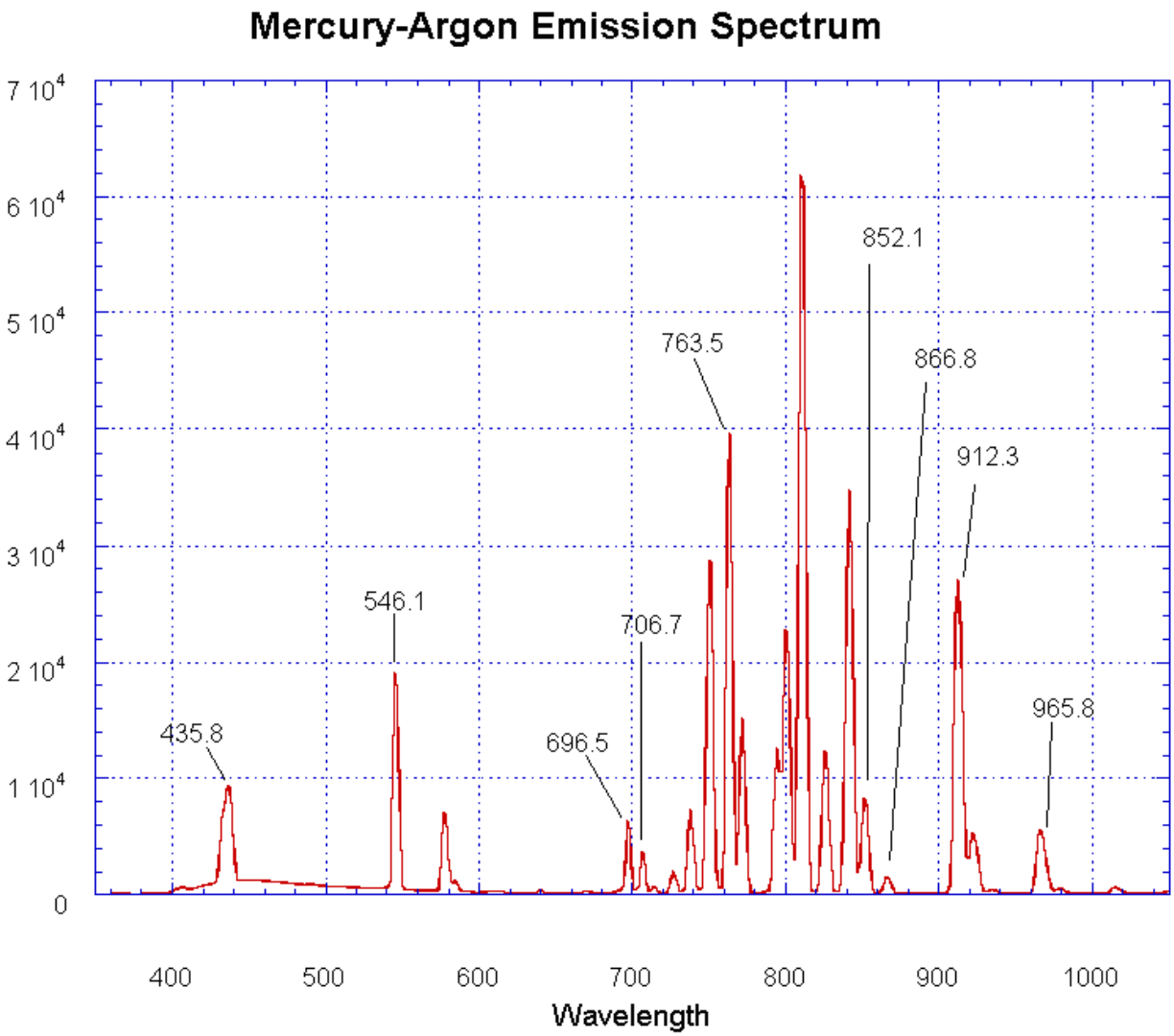
Wavelength calibration is a standard feature of all ASD instruments. Typically, one calibration will be accurate to within one nanometer and is guaranteed for one year. ASD will always recalibrate wavelength values once, within that time, at no extra charge.

The UV/VNIR detector array and housing combine to provide a simple linear relationship between wavelength and channel number. For this reason, all that is needed for calibration is a few well-characterized emission lines, spread throughout the region from 350 - 1000 nm wavelength, and a finely focused instrument. At ASD, the emission lines come from a separate monochromator, set to emit at 50 nm intervals, which are plotted against the responding channel numbers, and the first channel number's wavelength is extrapolated from a linear regression fit of the data. The final equation is a simple linear formula, in the form:

wavelength = lamstart + (lamstep)(channelnumber)

The constants, lamstart and lamstep, are calculated as above, at the ASD factory and installed into the controlling computer's asd.ini file for access by the controlling software. The channelnumber domain is 0 to 511. Wavelengths of certain emission lines from a Mercury-Argon source lamp are then measured as a cross-calibration of the monochromator values. Some of the HgAr lines may be used for the calibration itself. But the presence of doublets means that not all of the lines should be used. Contact ASD for the purchase price of your own HgAr portable emission source. The monochromator is also frequently cross-calibrated using up to four orders of Helium-Neon laser diffraction.

Figure A-1 Example of the Mercury-Argon emission spectrum.




The SWIR scanning spectrometers, covering the range from 1000 - 2500 nm, use much the same calibration principles, with two major differences: 1. We use a monochromator as our only emission source, and 2. Two third order

polynomials are calculated for each SWIR detector, to account for both forward and backward scans of the gratings. This amounts to the calculation of eight constants for each detector, listed in the ini file, as noted above. We then check the SWIR wavelength calibrations with well-defined absorption features in a material such as Mylar or Polystyrene.

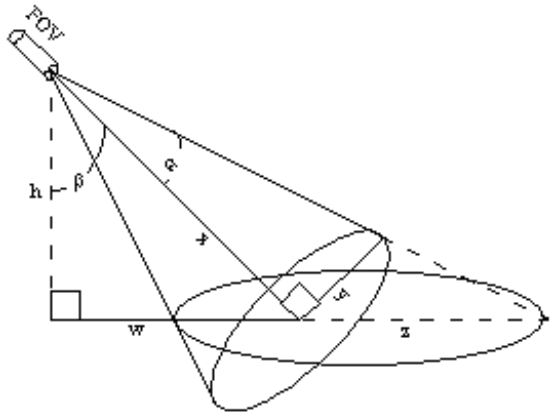
If you would like any further information on wavelength calibration, please contact Sales or Technical Support at ASD.

### A.2.1 Artificial Illumination

Sometimes solar illumination is impractical for collecting field spectra or all that is needed is in-situ sample measurements that are not necessarily needed for ground truthing hyperspectral imagery. In those cases, a portable, artificial light source that interfaces with the FR fiberoptic input is necessary. ASD offers two such light sources: the High Intensity Contact probe and the High Intensity Source probe.

### A.2.2 Approximating Spot Size

Figure A-2 Diagram to explain the approximation of the spot size.




$\arctan(y/x) = \alpha = (\text{FOV full angle})/2$
$y/x = \tan\alpha$
$y = x \tan\alpha$

$z + w = h \tan(\beta + \alpha)$
$w = [h \tan(\beta + \alpha)] - z$

and

$w = h \tan\beta$

Therefore:

$$z = h[\tan((\beta) + \tan(\beta + \alpha))]$$

$$w = \sqrt{(x^2 + h^2 - 2xh(\cos\beta))}$$

**Example:**

1 degree FOV Tube at x = 2 meters from perpendicular target (small ellipse):

y = (2 meters) tan (0.5 deg) = 0.0175 meters = 1.75 cm

So, for a perpendicular target the spot has a diameter of 3.5 cm.

**Example:**

Suppose we were limited to a 12.7 x 12.7 cm (.127 x .127 m) oblique target. So, to be on the safe side we will want z = 0.635 m. For h = 1 meter = 45 deg, 1 degree foreoptic:

$$w = [h\tan(\beta + \alpha)] - z = [\tan(45.5°)] - 0.635m = 0.38m$$

Also, in this case

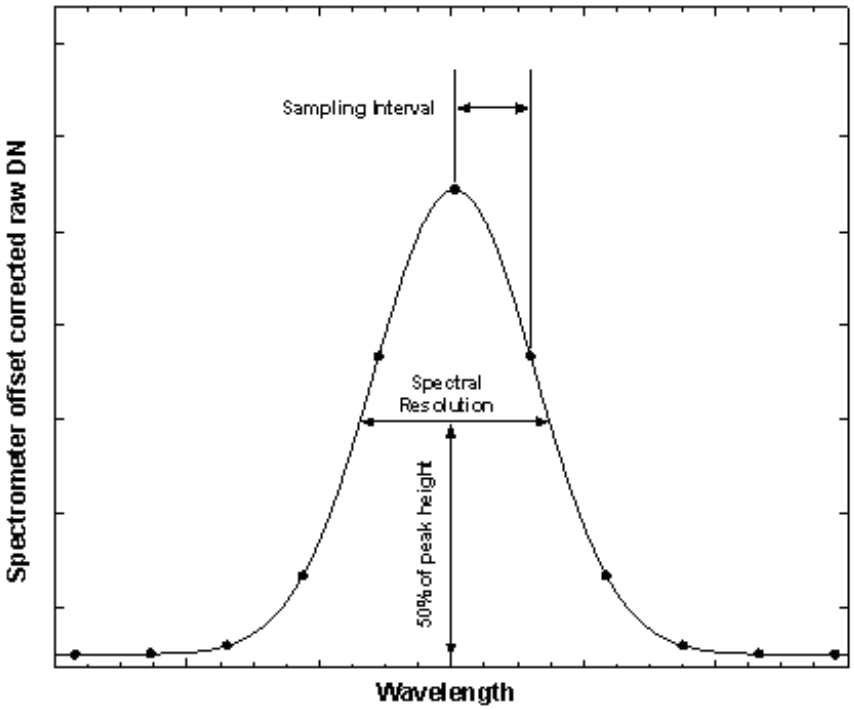
x2 = h2 + w2 = 1.144

## A.3 Sampling Interval and Spectral Resolution

Spectral sampling interval is the spacing between sample points in the spectrum. Sampling is independent of resolution and in ASD spectroradiometers is between 2 and 5 times per FWHM. The sampling interval for full range instrument is 1.4 nm for the region 350 - 1000 nm and 2 nm for the region 1000 - 2500 nm.

Spectral resolution is defined as the full-width-half-maximum (FWHM) of the instrument response to a monochromatic source. This is in fact the definition ASD uses when stating spectral resolution specifications. When reading manufacturers specifications, do not mistake of sampling interval as resolution. The FWHM spectral resolution of the spectroradiometer is 3 nm for the region 350 - 1000 nm and 6 nm for the region 1000 - 2500 nm. These spectral resolution values have been measured by calculating the FWHM of a near monochromatic peak in a spectrum acquired when viewing the output of a monochromator with the spectroradiometer.

Figure A-3 Graph of offset versus wavelength.



# Notes:

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**A**