
Spectral Products Catalog


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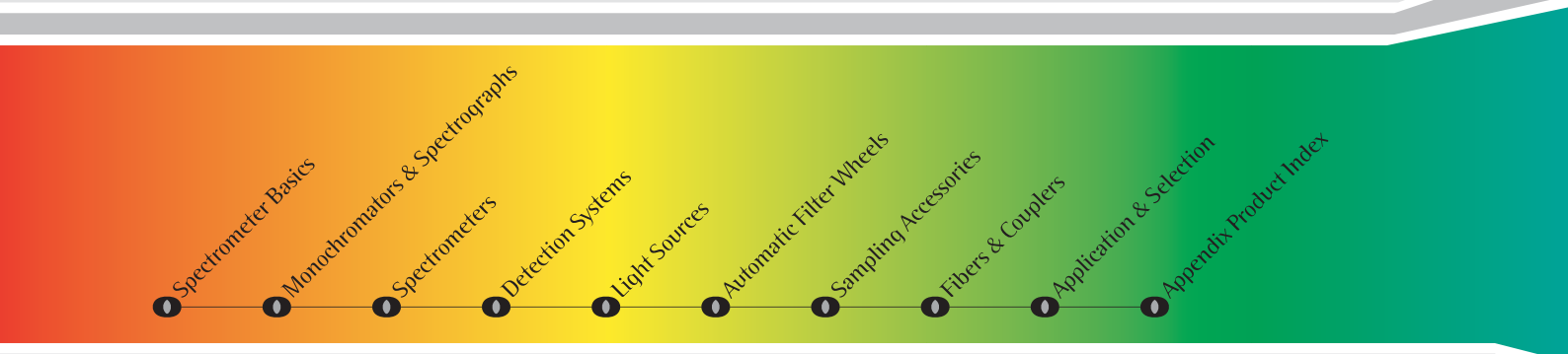


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# Spectral Products Catalog


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## About Spectral Products


Spectral Products is a world leader in optical instrumentation technology and products. Formerly a division of CVI Laser, Spectral Products builds on its rich heritage and extensive technical knowledge to offer a broad range of innovative solutions from components to systems and modules. Spectral Products is an industry leader in the design and manufacture of optical instruments including spectrometers, monochrometers, spectrographs, spectrophotometers, spectrum analyzers, detection systems, light sources, as well as fiber optic cables and couplers.

Spectral Products 'focus on quality, value and service has created an innovative approach to manufacturing and design. With employees in Putnam, Connecticut, Albuquerque, New Mexico and Seoul, South Korea, Spectral Products continues the tradition of design innovation, high quality products and exceptional value.

## Spectral Products is Innovation in Instrumentation

In the 1980s advances in micro-controller technology inspired a revolution in optical instrumentation. Spectral Products introduced the first total microprocessor-controlled, direct drive scanning monochromator in 1987.

The award-winning design eliminated the commonly used, but costly and unreliable, sine-bar drive for wavelength control. Today, the Spectral Products' Digikrom line of monochromators combines microelectronics with precision optics while featuring computer control, direct digital drive, automatic grating changes and motorized slits. This careful marriage of microcomputers with precision opto-mechanics is an example of why we are now the world leader in low-cost high performance spectroscopic systems.

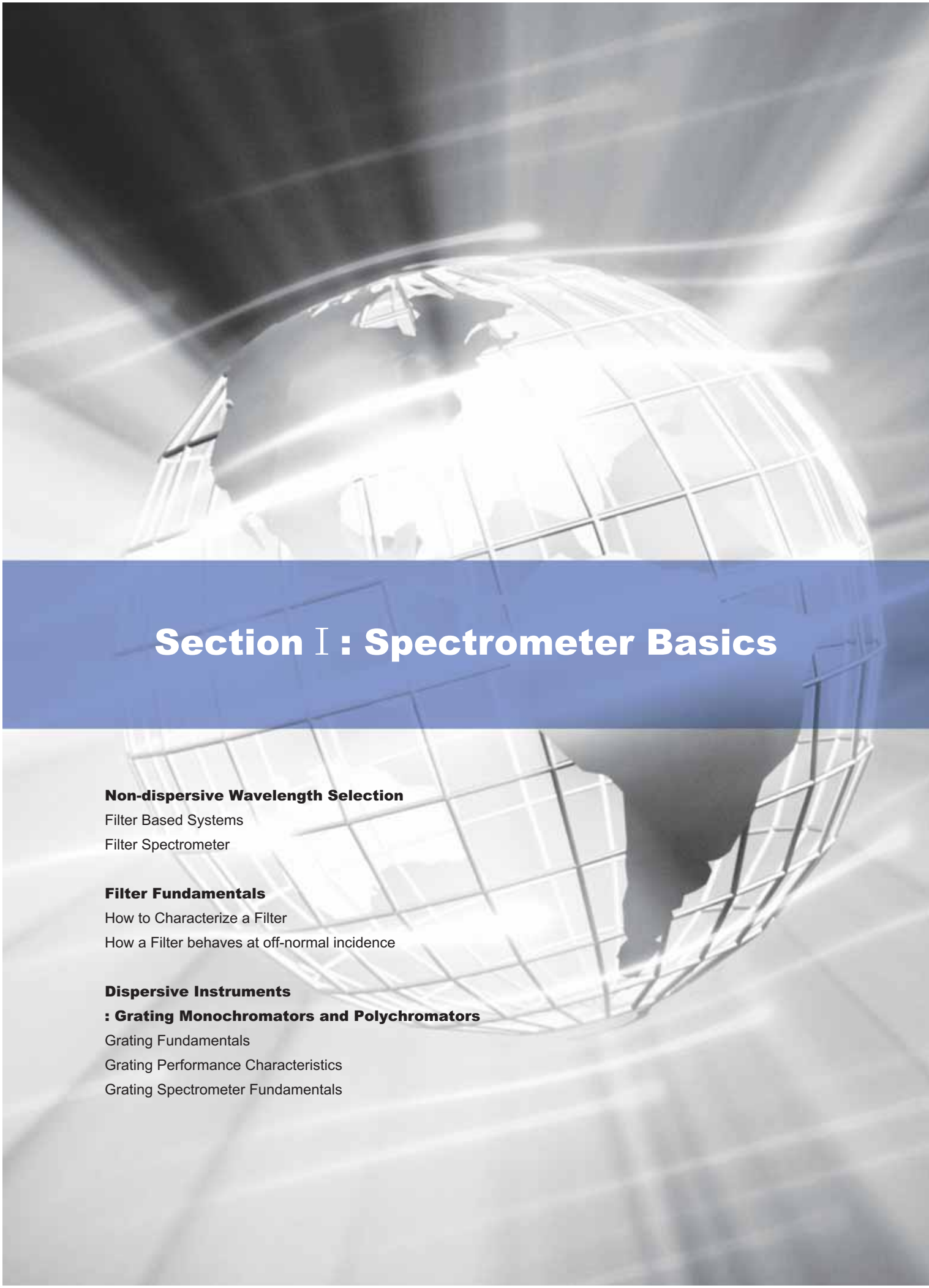
## About Our Products

Monochromators act as tunable bandpass filters for light. They are the critical component for many spectral applications since they can be used to create tunable light sources and also to take high precision spectral measurements. The Digikrom line of monochromators, available in 1/8, 1/4 and 1/2 meter focal lengths, use electronics that are “designed-in”, rather than appended via accessories or other add-ons after the instrument has been manufactured. The direct digital drive is simple and reliable; a microprocessor-controlled stepper motor, moving in wavelength increments as small as .003nm per step, is linked directly to the grating mount by a worm and worm wheel arrangement. This results in improved accuracy, automatic grating changes and exceptional ruggedness. Because each Digikrom contains its own microprocessor, it is controlled via a standard serial port (RS232), IEEE-488 port (GPIB), or with SP’s hand-held controller. This compatibility allows your computer, for example, to make automatic adjustments of bandwidth through motorized slits, to select gratings, choose scan speeds and to store your changes in memory. This versatility is intrinsic to the instrument and available without additional cost.

Spectral Products' SM line of computer-based miniature array spectrometers offer state of the performance yet have compact form factors. Their versatile design and ease use make them a first choice for scientific and industrial applications. SM series optical benches are designed to provide stable operation over a wide range of ambient temperatures. All of Spectral Products’ instruments take advantage of Spectral Products pioneering research in high quality laser optic manufacturing process control.

The Digikrom and SM products lines together with their accessories (light sources, detectors, filters and fiber optic adaptors) are now used throughout the world in such systems as Raman spectroscopy, emission and excitation fluorescence/ luminescence spectroscopy, arc, spark or plasma spectroscopy, spectrophotometry, spectroradiometry, laser breakdown spectroscopy, picosecond laser analysis, ratiometry, infrared measurements, process control and calibration. Wide applications of our instruments include semiconductor, biomedical, manufacturing, petrochemicals, pulp/paper, clinical labs, QC labs, research & development, pharmaceutical, environmental control, polymers, mining/metals. Whether your need is for high resolution, low stray light, high throughput, or compactness, there is a lowcost Spectral Products system to meet your technical requirements and budget.

## Thank you for considering Spectral Products.



# Section Ⅰ: Spectrometer Basics

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# Non-dispersive Wavelength Selection

## Filter Based Systems

In many applications source radiation is required to be sorted out into narrow, discrete wavelength bands. Optical filters of absorptive, reflective or interference types are perhaps the simplest apparatus for performing such a task. An absorption filter relies on its unique optical absorption of certain spectrum by use of colored glasses or sandwiched dyed glasses. It is perhaps the least expensive choice for applications where a narrow bandpass is not critical. Figure 1 shows representative transmittance curves of some typical absorption filters.Reflective filters are usually made with dielectric thin films coated onto a glass substrate. These filters can withstand higher radiation power with better thermal stability at increased cost over the absorption filters. Absorptive and reflective filters are useful in the visible and near infrared region for order sorting, band pass, attenuation and other uses. While coupling with multiple filters, an effective bandwidth of tens to hundreds of nanometers can be achieved, Figure2.

Interference filters differ from absorption and reflective filters in that optical interference phenomenon is utilized for the generation of narrow band outputs. Figure 3 illustrates a typical interference filter consisting of a dielectric spacer and metal layers. When wide band radiation occurs at a normal incidence, reflected light from the first and second metallic film interfere with each other resulting in reinforcement or cancellation of various wavelengths of light passing through them.

The reinforced portion thus transmits through while the other wavelength components suffer destructive interference. The wavelength band passing through is determined by the thickness of the dielectric.Interference filters are available throughout UV, visible and infrared regions. Center wavelength, peak transmittance, full width at half maximum (FWHM) are often the specifications characterizing a filter, Figure 4. Peak wavelength, blocking efficiency and transmission profiles are also used to describe a filter performance. A typical interference filter has a band pass on the order of 1 to 2% of the wavelength at peak transmittance. In some wavelength regions this figure can be reduced to almost 0.1%.

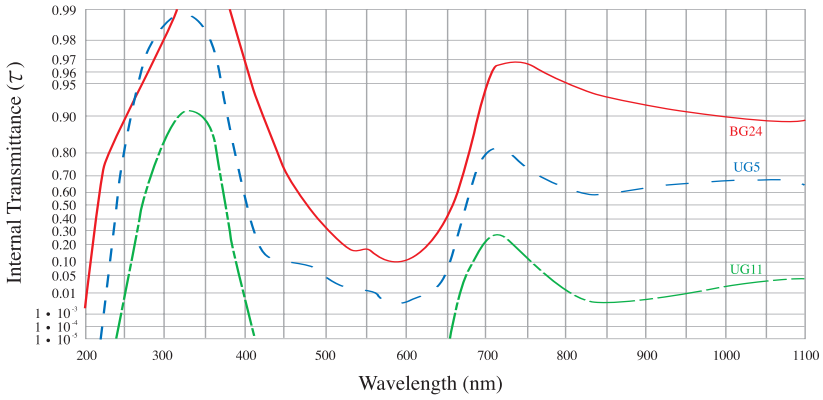



Figure 1. Transmission curves for typical absorption filters.

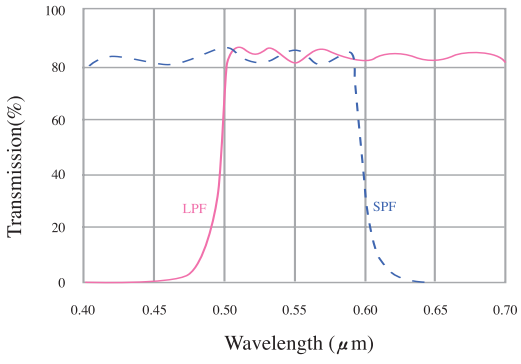



Figure 2. Transmission band by use of multiple filters.

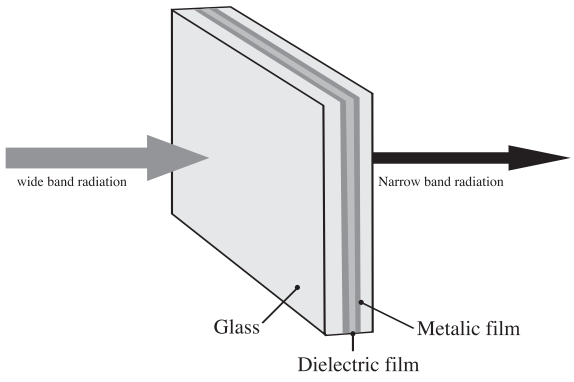



Figure 3. Diagram for a typical interference filter.

## Filter spectrometer

When used in conjunction with appropriate detectors, filters form basic wavelength selective detection systems. A filter spectrometer has the advantages of simplicity, high signal to noise ratio, low cost and high throughput. A rotatable filter wheel allows multiple filters to be mounted and sequentially selected into the light path.

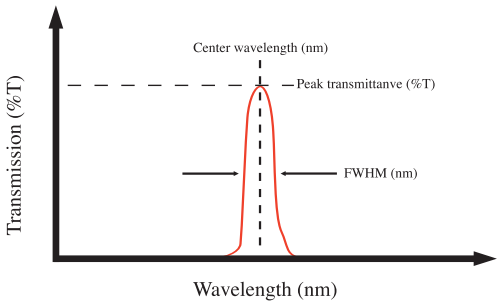



Figure 4. Diagram for fifter characteristics

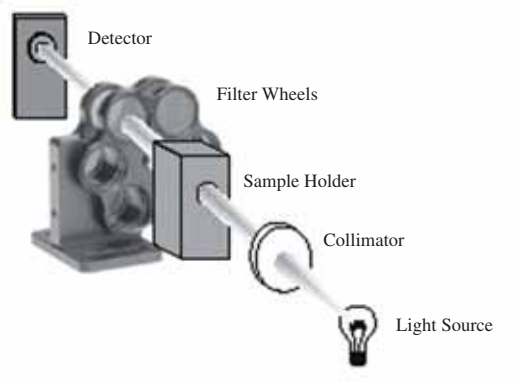



Figure 5. A filter-dased spectrophotometer

Figure 5 depicts a filter transmission spectrophotometer, which uses two wheels in series. The combination of filters in the light path, that have characteristic transmission curves, generates variable pass bands. When equipped with stepping motors and computer interfaces, the filter wheels can be automated to perform programmed sequences. Applications of filter wheels have been found in atomic spectrometry, environmental monitoring, illuminators, laser spectroscopy, and so on.

# Filter Fundamentals

## How to Characterize a Filter

**Center Wavelength:**

The arithmetic mean of the pass band expressed in nanometers. For instance, a HeNe laser filter would have a center wavelength of 632.8nm. By definition, the center wavelength is the arithmetic mean of the half-power wavelength.

**Percent Transmission:**

The amount of power received by the detector compared to the total power available. The traditional formula is %T = I/I0 x (100), where I0, is the incident power and I is the transmitted power. Transmission can be specified as power at the center wavelength or peak power that may occur at wavelengths slightly removed from the center wavelength.

**Half Bandwidth:**

The width of the pass band in nanometers at the half-power points of the pass band. It is often expressed as full width at half maximum (FWHM).

**Out-of-Band Rejection (Blocking):**

The amount of energy, outside the filter pass band, reaching the detector. It is often expressed as an absolute level, such as 10-4, meaning there are no transmission peaks outside the pass band exceeding 0.0001 T or 0.01%T. The rejection range in nanometers must accompany this specification. The rejection range is usually chosen to cover the range of the detector in use (PMT, Si, PbS).

**Size:**

Sizes of the filters are specified in inches or millimeters, along with tolerances. Typical sizes are 0.50",1.00" and 2.00" diameters. Typical maximum thickness is 0.25".

**Optical Density:**

Neutral Density Filters vary the intensity of the beam over a wide spectral region by either absorption or a combination of absorption and reflection. Values are specified in units of Optical Density (O.D.).

$$O.D. = \log_{10}\frac{1}{T}$$

Where T=transmission. Neutral Density Filters have a range of spectral neutrality that defines the bandwidth over which the O.D. values apply.

**Band Pass Shape:**

Pass band shapes can vary from triangular to nearly square. The number of cavities involved determines the overall shape. In general the morecavities, the more square the band shape.

## How a Filter behaves at off-normal incidence

If a beam incidents a filter at an angle other than normal, certain characteristics will change with incidence angle. Center wavelength, the most important parameter of a filter, varies approximately as a cosine function,shifting towards shorter wavelengths with increasing angle.

Therefore it is a good practice to use a collimated beam in the filter instrumentation, as in Figure 5. The exact amount of the shift is highly dependent on the internal design of the filter. The following equation may be used to determine the wavelength at a certain angle of incidence.

$$\lambda = \lambda_0 \sqrt{1 - \left(\frac{n_0}{n_{eff}}\right)^2 \mathrm{Sin}^2 \phi}$$

Where:

$\lambda$=Wavelength at Angle of Incidence

$\lambda_0$=Wavelength at Normal Incidence

$\emptyset$=Angle of Incidence

$n_0$=Refractive Index of External Medium

$n_{eff}$=Effective Refractive Index of Filter

Figure 6 illustrates a plot showing the relationship between the incident angle and the shifting of the wavelength. $\lambda_0$ is assumed to be at 632nm, $n_0$ and $n_{eff}$ are 1.00 and 1.35 respectively.

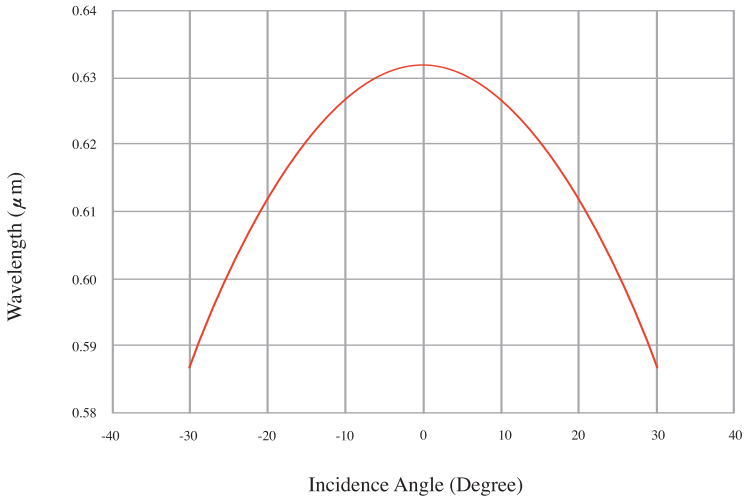



Figure 6. Filter wavelength shift as a function of incident angle

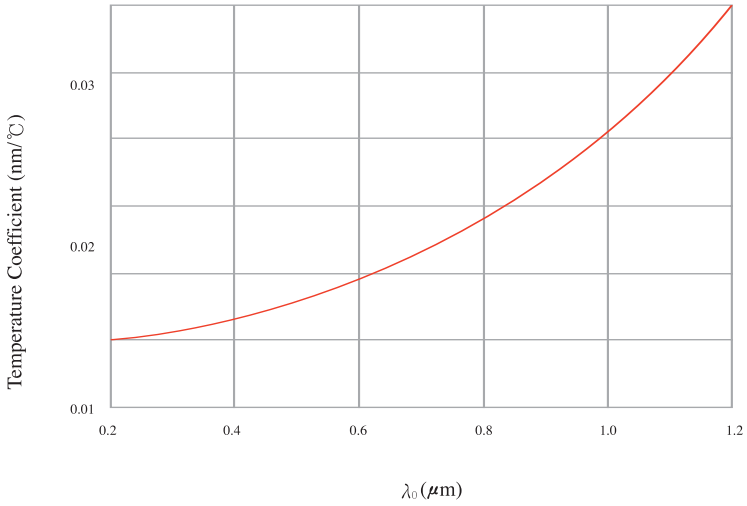



Figure 7. Filter wavelength shift as a function of incident angle

## How does a filter respond to Environmental Condition Changes?

Filters are sensitive to changes in environment, with temperature and humidity being the most critical factors. Temperature change causes the center wavelength to shift approximately 0.02nm per degree Celsius. Meanwhile optical cements used in the filters may be broken down when the temperature exceeds a certain limit. It is recommended that wherever possible the filters should be placed away from heat sources such as quartz tungsten halogen lamps. Figure 7 shows the approximate behavior of the Temperature Coefficient. Long-term exposure to extreme humidity may cause filter deterioration, although there is no precise correlation between humidity and filter life. Temperature/humidity cycling tests indicate filters that survive the most cycles last longer under normal operating conditions.

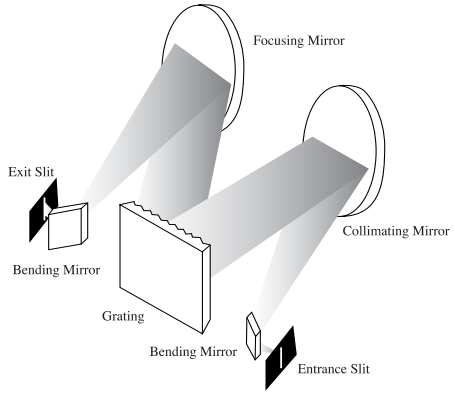



Figure 8. Diagram of a grating monochromator

## Dispersive Instruments: Grating Monochromators and Polychromators

In many spectroscopic applications, a scanning wavelength selection device is essential, which can be tuned to isolate a narrow spectral radiation continuously over a wide spectral range. This can be accomplished by employing a dispersive element such as a grating together with a scanning mechanism, Figure 8. Diffraction gratings are widely used as the wavelengthdispersing element today

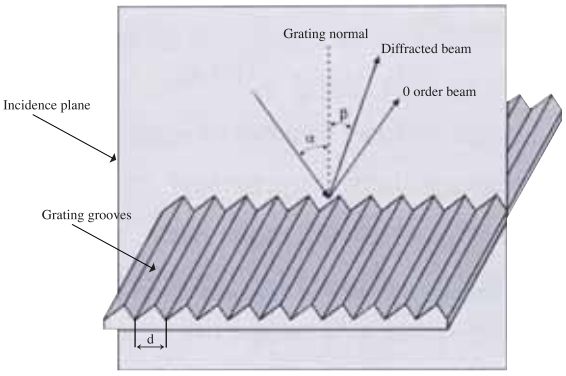



Figure 9. A reflective diffraction grating

## Grating Fundamentals

### How Does a Grating Work?

Gratings demonstrate a unique dispersion phenomenon by which a spectrum of light is separated in space by wavelength. A reflective diffraction grating has microscopic periodic structures, grooves, corrugated on a substrate material, Figure 9. The series of parallel grooves are spaced at about the wavelength of light. The grating surface is usually coated with a metal for high reflectivity.

Interaction of light with a grating possessing grooves the same size as the wavelength of the radiation exhibits diffraction. Light reflected from the grating surface is diffracted by the grooves. A monochromatic light incident on a reflective grating is diffracted first and then undergoes a destructive interference in most directions resulting in a cancellation at these angles. It is only along certain finite number of direction that rays from grooves survive as a result of constructive interference. These directions are termed as diffraction orders. In Figure 9, the grooves of the grating are shown perpendicular to the plane of incidence. The light strikes the grating at an incident angle $\alpha$ to the grating normal, is then diffracted at an angle $\beta$ When defining integer m as the diffraction order and d as groove spacing, maximum constructive interference is found to occur under the condition:

$$m\lambda = d(\sin\alpha + \sin\beta)$$

Several important characteristics are revealed by the above grating equation:

1. For a given diffraction angle βseveral values of λmay satisfy the equation with corresponding order m.First order radiation (m=1) of 900nm shares the same diffraction angle with that from a second order 450nm and from a third order 300nm radiation lines.
2. The diffraction order m may carry a sign of either positive or negative to reflect the fact that the incident light may be diffracted on either side of the grating normal.
3. If parallel rays carrying multiple wavelength components fall on the grating, each wavelength within the same order will have a distinctive value of β determined by the grating equation. Consequently, a polychromatic light is spatially dispersed.

## GratingPerformance Characteristics

Gratings are primarily characterized by their groove density, blaze (peak efficiency) wavelength and manufacturing method. For example a 1200 x 300 ghost-free ruled grating would have a groove density of 1200 grooves per millimeter, a peak efficiency at 300 nanometers, and would have been manufactured by an interferometrically controlled process that eliminated spectral ghosts.

### Groove Density

Groove density, groove frequency or pitch of a grating, G, is defined as the reciprocal of groove spacing, 1/d. If the groove spacing is in a unit of millimeters, G is commonly referred to as grooves per millimeter.

### Grating Type

Commercially available gratings are manufactured by processes including ruling, replication, holographic methods, etcetera. Ruled gratings are mechanically ruled with a diamond-ruling engine on a surface coated with thin metal. Replicated gratings are produced by the replication of a master diffraction grating. Ruled and replicated gratings typically have grooves in a triangle format. The production of holographic gratings involves the photographic recording of laser generated interference patterns. Holographic gratings usually contain sinusoidal shaped grooves.

### Reflective Coatings

Aluminum is primarily used as the reflective material for gratings throughout ultra-violet (UV), visible and near infrared regions. Protected aluminum coating is more resistant to oxidation, thus is more suitable for UV use. For near infrared and infrared applications, gold overcoating demonstrates superior reflectance performance over aluminum.

### Blaze Wavelength

Shaping individual grooves can alter the distribution of light into different orders. The optimization of groove profile to maximize grating efficiency in a certain spectral region is often referred to as blazing. The maximum grating efficiency occurs at the blaze wavelength. See Figure 10.

### Grating Efficiency

Grating efficiency is expressed as the ratio between monochromatic light diffracted into a given order and the incident monochromatic radiation. As the incident wavelength differs from the blaze wavelength, the two polarizations will exhibit different diffraction efficiency. Figure 10 shows a typical grating efficiency curve. The dashed line represents the " P " polarized radiation while the thin solid line is for" S " polarization and the bold solid line is the average.

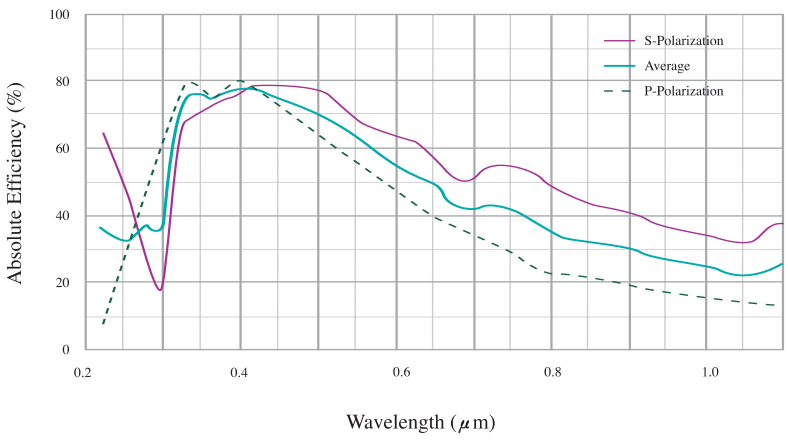



Figure 10. Typical grating efficiency curves

## Resolving Power

The resolving power of a grating, R, is the measure of its ability to separate two close wavelength lines. It can be expressed as the product of the diffraction order m and N, the number of grooves being illuminated by the incident radiation.

R = mN

## Stray Light

Grating stray light is the unwanted spurious spectral lines arising from imperfection in groove profile, spacing and depth. Holographic gratings exhibit superior stray light performance over ruled gratings. The use of optical recording eliminates the error source originating from the ruling processes and minimizes the manufacturing inconsistency.

## Practical Grating Instruments

Many spectrometers, including monochromators, and spectrographs employ gratings as the dispersing elements. A grating monochromator, for example,consists of the following key elements:

1. An entrance slit
2. Collimating/focusing optics
3. A grating dispersing element
4. An exit slit
5. Driving mechanisms

Both monochromators and spectrographs share the same optical recipe; they are usually one-to-one imaging systems in which one image of the entrance slit appears at the exit for each wavelength passed through the instrument. If the incident radiation is a continuous source, an infinite series of overlapping monochromatic images of the entrance slit are found at the exit-slit focal plane. Figure 8 shows a diagram of a typical monochromator. The incident radiation consisting of three wavelength components enters through an entrance slit, forms a narrow optical image, and is then directed to a collimating mirror by a folding mirror. The collimating mirror produces a parallel beam and projects it onto the grating. The grating disperses the radiation into its component wavelengths at different angles in the plane of incidence. The focusing mirror then reforms the image (of the slit) and focuses it on a focal plane. The exit slit isolates the desired spectral band by spatially discriminating against the unwanted bands as shown. Mechanical rotation of the grating about its vertical axis scans the images through the exit slit.

A spectrograph differs from the device shown by removing the exit slit, thus allowing a multi-channel array detector to be mounted along the focal plane as shown in Figure 11. In this case the array detector elements see a signal that is proportional to the amount of the entrance-slit image that falls on the element. The wavelength "scanning" is accomplished by electric read-out means

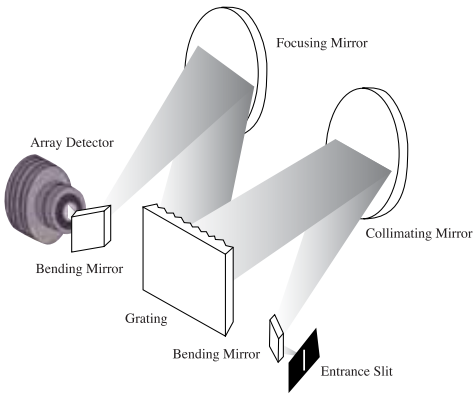



Figure 11. Diagram of a typical array spectrometer

of the multi-channel detector.

Figure 12 shows a low-pressuremercury lamp emission spectrum recorded by an array spectrometer consisting of 512 sensing elements. The detector pixel numbers can be

linked to wavelengths via a process called calibration, in which known wavelength peaks are used to establish a relationship. An array spectrometer demonstrates high readout speed and stable wavelength calibration when using fixed grating

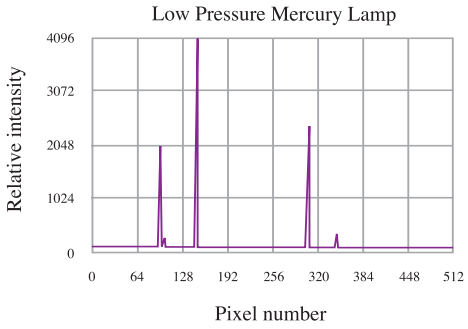



Figure 12. A typical spectrum recorded with a 512-pixel CCD spectrometer

position.

# Grating Spectrometer Fundamentals

## Grating Instrument Performance Characteristics

Important spectrometer performance characteristics include wavelength resolution, stray light rejection ratio, throughput and many others.

## Dispersion

Dispersion of a grating spectrometer determines its ability to separate wavelengths. The reciprocal linear dispersion of a spectrometer can be found by calculating the change in wavelength λ with respect to change in distance x along its focal plane.

That is: $\frac{\Delta\lambda}{\Delta x} = \frac{d\cos\beta}{nF}$

d, βand F are the grating groove spacing, diffraction angle, and effective system focal length, respectively. Reciprocal linear dispersion is not a constant; it varies with wavelength as the equation shows. The variation can exceed a factor of two over the useful spectral range. A mid-value of the dispersion for a 1200g/mm grating, typically at 514.5nm, is used throughout this catalog.

## Resolution

The resolution R of a grating monochromator is a measure of its ability to separate two close together spectral lines. By use of Raleigh criteria it is:

$$R = \frac{\lambda}{\Delta\lambda}$$

One practical definition for resolution of a spectrometer is the fullwidth- at-half-maximum (FWHM) measured for a single monochromatic spectral line. In practice, the resolution depends upon the resolving power of the grating, effective system focal length, slit width setting, system optical aberration characteristics and other parameters.

Because of the dependence of resolution on the measurement parameters, specific measurement methods are used for most of our discussion in this catalog. Typically, resolution is defined as the FWHM derived from the fewest amount of squares fit into a spectral scan assuming a gaussian profile. Illumination is at 514.5nm and is uniform on a 1200g/mm grating. Entrance and exit slits are .010mm apertures. Obviously, the resolution number resulting from this measurement is a guide to performance only.

## Bandpass

Bandpass is the wavelength band exiting the spectrometer at a given wavelength under conditions where optical aberrations, diffraction, scanning method, detector pixel width, slit height, uniformity of illumination and the like are neglected. (It is then the reciprocal dispersion times the slit width). For example, a monochromator configured with 0.25 millimeter slits and a grating displaying a reciprocal dispersion of 8nm/mm has a bandpass of 8 * 0.25 = 2nm.

## Wavelength Precision, Reproducibility and Accuracy

Wavelength precision is the gradation on the scale that the spectrometer uses in determining wavelength. Nanometers, angstroms and tenths of angstroms are typical units of precision. Frequently, precision is a function of wavelength and will vary by a factor of three over the useful spectral range. SP quotes a worst-case precision for each of its instruments.

Wavelength reproducibility is the ability of a spectrometer, which has been set to a given wavelength, to change settings then return to the original wavelength. This is a measure of the mechanics of the wavelength drive and the over-all stability of the instrument. SP's spectrometers have excellent wavelength drives and mechanical stability; their reproducibility always exceeds their precision.

Wavelength accuracy is the difference between the spectrometer's set wavelength and the true wavelength. It is not meaningful to apply a wavelength accuracy specification to spectrographs because a wide band of wavelengths exit onto the detector array in a spectrograph. In checking wavelength accuracy in monochromators, the accuracy must be checked against known spectral line wavelengths. SP typically checks its monochromators at 10 to 20 wavelengths across the spectral region.

## Etendue and Transmission efficiency

The percentage of light that can be sent from a light source through a spectrometer would be a desirable measure of its throughput. Unfortunately, the properties of sources vary so much that this measure would not provide a useful standard. Instead, two separate specifications are useful; **etendue** - a measure of the degree of coupling that can be achieved, and **transmission efficiency** - a measure of how much of the input light exits the monochromator.

The etendue of an instrument is the product of an instrument's physical aperture [cm2] and its angular aperture [steradians]. For a source of a given brightness [watts/(cm2*steradian)], the maximum power [watts] that can be coupled into an instrument is the product of the brightness and the etendue. This is true because the brightness of a source cannot be changed; changing the apparent emission angle changes the apparent size in inverse proportion. The brightness (a Lagrange Invariant) is unchanged. For a monochromator, the etendue is:

$E = S_w * S_h * W_g^2 / F^2$

Where $S_w$ = Slit Width

$S_h$ = Slit Height

$W_g$ = Grating Width

F= Instrumental Focal Length

In a chain of optics or optical instruments, the component with the smallest etendue will determine the etendue of the system.

For spectrometers it is useful to find the spectral energy density [watts/nanometer] that can be coupled. This can be found by dividing the etendue by the spectral bandwidth:

$D = E / (S_w / (F * A))$

$D = (S_h / F) * W_g^2 * A$

A is the angular dispersion of the grating. The ratio of usable slit height to focal length is approximately constant across all monochromators; it is limited by the aberrations. Therefore, the spectral energy density depends primarily on the grating width, and secondarily on the dispersion. To get the maximum throughput, use the widest highest dispersion grating available.

Etendue defines the coupling between a light source and a spectrometer. Transmission efficiency describes the light loss within the spectrometer. The transmission efficiency becomes:

$T = (R_m)^N * R_g$

Where $R_m$ is the reflectance of a single mirror, N is the number of mirrors and $R_g$ is the diffraction efficiency of the grating.

Mirror reflectance is typically 0.92 for a protected aluminum mirror. (See the SP optics catalog for a spectral profile of the reflectance). In a 4-mirror system, about 70% is transmitted by the mirrors. In a 2-mirror system this is about 85%. SP offers custom broadband high reflectance coatings that can boost this efficiency to almost 95% in a 4-mirror system over about a wavelength octave.

Grating diffraction is quite complicated; it is both wavelength and polarization dependent. Grating diffraction efficiency for a ruled grating typically reaches 90% at the blaze wavelength, falling off to 20% at 0.6 $l_B$ and 1.5$l_B$. Holographic gratings typically have a flatter 30% efficiency. More information on grating efficiency is presented in the Selection Guide Section. Due to the strong wavelength dependence of diffraction efficiency, SP stocks a wide variety of diffraction gratings. This allows good transmission efficiency at any wavelength.

## Throughput

We can get a measure of total spectrometer throughput per nanometer by multiplying the spectral energy density by the transmission efficiency. The result is:

$H=(S_h/F) * W_g^2 * A * (R_m)^N * R_g$

## The f/#

The f/# is defined as the ratio of diameter to focal length of an optic. It is a measure of the acceptance angle of an optical instrument. f/# is a useful concept in judging optimum coupling between spectrometers and sources or detectors. When f/#s are matched, the full aperture of the spectrometer will be utilized. Unfortunately, there is no agreement in how f/# should be defined for the rectangular optics that appear in most monochromators. The most conservative method defines the f/# to be the ratio of width to focal length. Some companies define the ratio as being the diagonal measurement divided by focal length. SP uses the ratio of the equivalent diameter to focal length where the equivalent diameter of the rectangular optics is the diameter of the circle that has the same area. These are illustrated in the Figure 13. SP uses this definition because this is the point at which the maximum coupling occurs between a Lambertian source and a spectrometer.

## Spectral Purity, Stray Light, and their Antecedents: Rediffracted Light, Secondary Sources,Higher-Order Diffraction, Ghosts and Scatter.

Spectral purity can be defined as the ratio of the in-band light passed by the spectrometer to that light transmitted which falls outside of the selected spectral band. Stray light is all spurious radiation transmitted by a spectrometer. The stray radiation sources include rediffracted light, secondary sources, higher order diffraction, ghosts, scatters and imperfection in gratings.

Two methods for stray light measurement are generally used. The first involves a laser source at a spectrometer entrance and the measurement of the exiting radiation at the peak of the line as well as at five band-passes from the peak. The stray light is then expressed as the inverse ratio of the two values. This method measures the contribution of stray light originating near the bandpass region when using a line source. Due to the simplicity, reliability,and comparability of this measurement method, SP uses this method as its stray light measurement.

The second method uses an incandescent lamp together with calibrated long and short pass blocking filters. This is useful for measuring the contribution of stray light originating far from the bandpass region when using a continuum source.

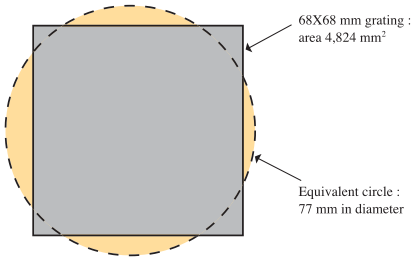



Figure 13. The f/# definition used by SP for rectangular optics

## Understanding the Slit Function

As discussed in the previous sections, the width of slits in a spectrometer plays a significant role in determining the instrument 's bandpass and resolution. Figure 14 shows a " slit function " plot that depicts the spectrometer bandpass characteristics. In most cases entrance and exit slits are set at the same width. Under the assumption that the magnification of the optics is one, the image of the entrance slit is formed at the exit focal plane at same size as the exit. Now let us introduce monochromatic light at a wavelength of $\lambda_0$ through the entrance and start rotating the grating for a wavelength scan. The image of the entrance slit will sweep across the exit slit as is shown in Figure 15.

The light intensity passing through is a function of the overlap of the entrance slit image with the exit slit. At the grating setting where the image of the entrance does not enter into the exit slit, essentially zero light intensity is exiting. When the image of the entrance slit is filling up the exit as in Figure 15B, a maximum light intensity passing through is seen. The light intensity will drop to half when the overlap is only 50% as the cases in Figure 15A and C. The energy distribution curve passing through the exit slit can thus be constructed as a triangle, Figure 14. This is also referred to as slit function. The bandpass of a spectrometer is conventionally defined as the full width (of wavelength band) measured at half maximum $\triangle\lambda$, or FWHM as illustrated in Figure 14. In the situation where the incident radiation is a continuous source, a series of overlapping images of the entrance slit for each wavelength present are found at the exit focal plane. The triangular intensity distribution applies in a way that it determines the range of the wavelength passing through.

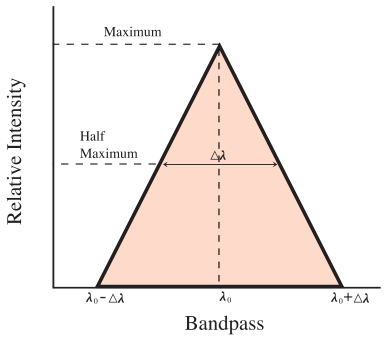



Figure 14. Illustration of a slit function

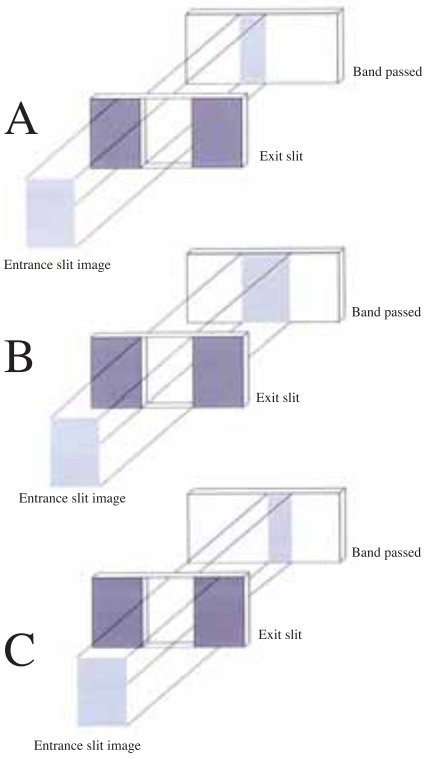
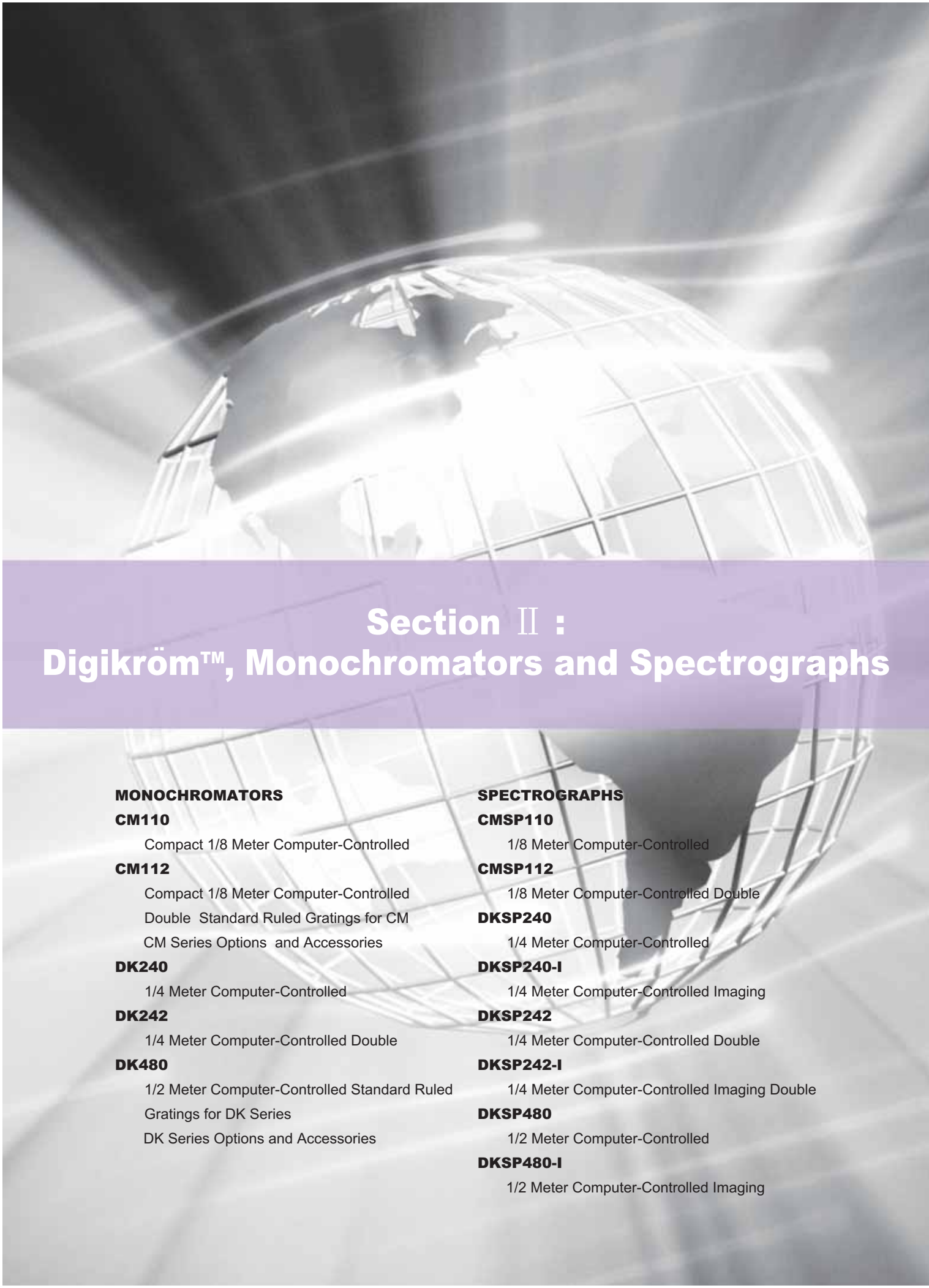



Figure 15.Bandpass versus grating settings



# Section Ⅱ :
# Digikröm™, Monochromators and Spectrographs

**MONOCHROMATORS**

**CM110**

Compact 1/8 Meter Computer-Controlled

**CM112**

Compact 1/8 Meter Computer-Controlled

Double Standard Ruled Gratings for CM

CM Series Options and Accessories

**DK240**

1/4 Meter Computer-Controlled

**DK242**

1/4 Meter Computer-Controlled Double

**DK480**

1/2 Meter Computer-Controlled Standard Ruled

Gratings for DK Series

DK Series Options and Accessories

**SPECTROGRAPHS**

**CMSP110**

1/8 Meter Computer-Controlled

**CMSP112**

1/8 Meter Computer-Controlled Double

**DKSP240**

1/4 Meter Computer-Controlled

**DKSP240-I**

1/4 Meter Computer-Controlled Imaging

**DKSP242**

1/4 Meter Computer-Controlled Double

**DKSP242-I**

1/4 Meter Computer-Controlled Imaging Double

**DKSP480**

1/2 Meter Computer-Controlled

**DKSP480-I**

1/2 Meter Computer-Controlled Imaging

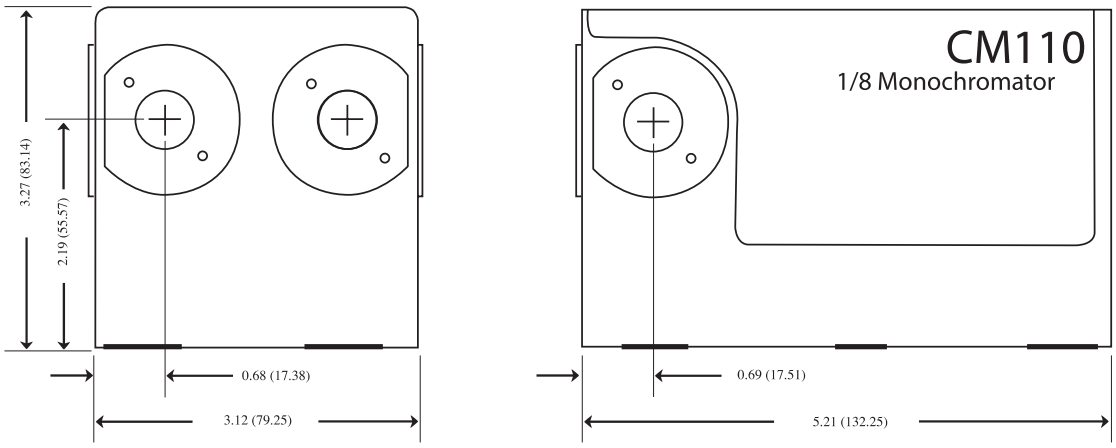
# Digikröm CM110

## Compact 1/8 Meter Computer-Controlled monochromator/Spectrograph

- Compact size - Only
  5¼ ”x 3¼ ”x 3¼ ”
- Connects to any computer via standard RS232 interface.
- Double grating turret allows for a broad spectral range coverage.
- May be factory configured as a monochromator or a spectrograph.
- Yields average efficiency TRIPLE that of a concave holographic grating monochromator/spectrograph.
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV.
- Change slits on the fly.
- Monochromator may be factory configured for right angle or straight through beam path.
- Suitable for fluorescence, radiometry, process control, colorimetry, tunable filtering, Raman spectroscopy, among others.


## The Leader : Price, Performance, Versatility

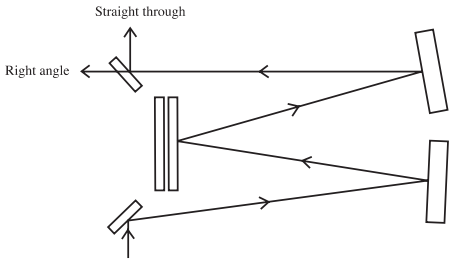
Single piece base construction, direct grating drive, and anit-backlash gearing ensure this unit is rugged and stable enough for demanding applications. Loaded with SP Optics and able to hold two high quality gratings, the CM110 is ideal for spectrometry in the UV to IR spectrums. Each instrument is calibrated and certified prior to delivery and comes with easy-to-use software.




Dimensions - Inches (millimeters)

Front View

Side View




Optical Path



## Specifications :

Design : Czerny-Turner, dual-grating turrets
Focal Length : 110mm
f/# : 3.9
Beam Path : Straight Through standard,
Right Angle provided on request.
Wavelength Drive : Worm and wheel with microprocessor control and anti-backlash gearing. Bi-directional. Usable in positive or negative grating orders.
Wavelength Precision : 0.2nm
Wavelength Accuracy : ± 0.6nm
Slewing Speed : >100nm/second
Stray Light : $<10^{-5}$
Slits : Standard Set includes; 0.125mm, 0.15mm, 0.30mm, 0.6mm, 1.2mm and 2.4mm x 4.0mm. For other sizes, consult SP.
Max Resolution : <1nm w/1200G/mm grating and standard slits
Gratings : One to two gratings (30 x 30mm) must be purchased. See Appendix A for options.
Software : Demonstration control program and LabView driver included.
Power : UL listed 110/220V power pack
Interface : RS232 standard
Warranty : One year
Options :

- Hand-held control module with function keys and display for local control
- IEEE-488 interface
- Interface cables
- Gold optics

See options and accessories

Ordering Information: Please indicate product number plus description when ordering.

CM110 Dual Grating Turret, 1/8 meter Monochromator
CMSP110 Dual Grating Turret, 1/8 meter Spectrograph

# Digikröm CM112

## Compact 1/8 Meter Computer-Controlled Double Monochromator/Spectrograph

- Compact size - Only
  5¼ ”x 6¼ ”x 3¼ ”
- Connects to any computer via RS232.
- Scans in both directions. Programmable in angstroms, nanometers, microns, wavenumbers, or eV.
- Dual double-grating turrets with automatic grating change allows for broad spectral range coverage.
- Subtractive dispersion mode minimizes image distortion and pulse spread, with sub-picosecond residual broadening versus nanosecond pulse broadening of regular monochromators.
- Additive mode gives increased dispersion and low stray light for Raman and fluorescence studies.
- May be configured as a monochromator or a spectrograph.
- Monochromator may be factory configured for right angle or straight through beam path.

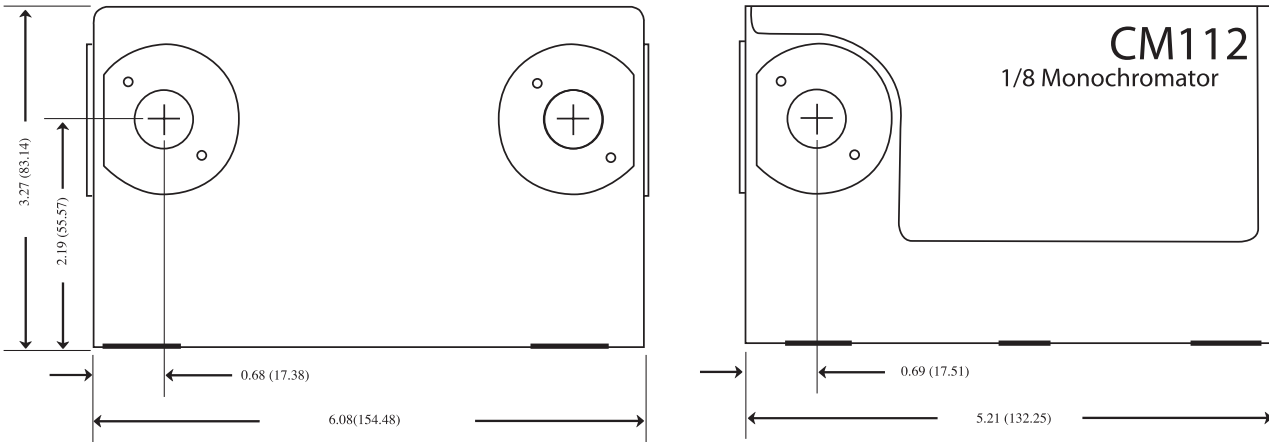

## The Digikröm CM112 : Much More than a Monochromator

The CM112 is two single monochromators in series. The exit slit of the first monochromator is the entrance slit of the second. The two monochromators act as a double filter with the rejection of stray light being almost the square of the single monochromator value.

The CM112 may be factory configured as an additive or subtractive dispersion double monochromator. As an additive instrument, the first grating spreads the spectrum over an angular range; the second grating then doubles this dispersion. The result is twice the resolution of a single 1/8 meter monochromator. As a subtractive instrument, the first monochromator selects a bandpass, the second monochromator then removes the temporal and angular aberrations introduced by the angular spectral dispersion in the first monochromator.

The CM112 offers a solution to practical problems in monochromatic imaging. Selecting a monochromatic image with an ordinary monochromator fails because multiple wavelengths in the bandpass create multiple, overlapping images. In the CM112, the second subtractive monochromator recombines these multiple images, creating a clear image.

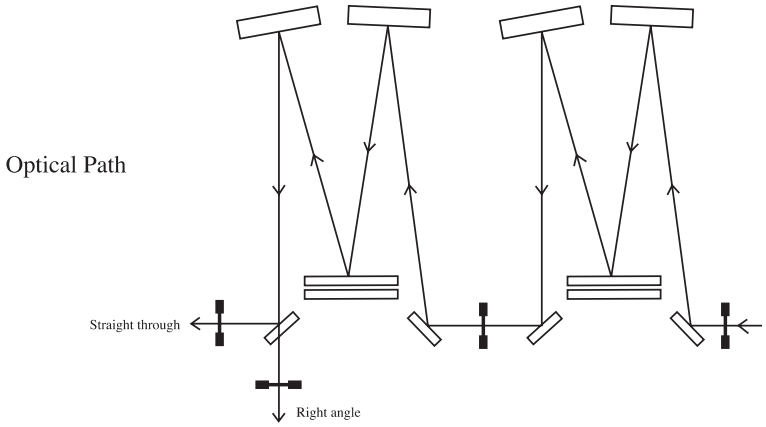
Finally, the CM112 is a unique solution to practical problems in the spectroscopy of pulsed sources. An ordinary monochromator has a spread in the internal optical path lengths that will introduce a 25 to 100 picosecond broadening in light pulses that are passed through the monochromator. In the subtractive dispersion CM112, the second monochromator equalizes the optical path lengths so that broadening is reduced to a minimum.




Dimensions - Inches (millimeters)

Front View

Side View






## Specifications :

Design : Double cascaded Czerny-Turner.
Double-grating turrets standard in each section.

Focal Length : 110mm each section.

f/# : 3.9 overall

Beam Path : Right angle or straight through.

Wavelength Drive : Dual worm and wheel with electronic synchronization and computer control. Programable in additive or subtractive dispersion with positive or negative grating orders.

| | Additive | Subtractive |
|---|---|---|
| Wavelength Precision : | 0.1nm | 0.2nm |
| Wavelength Accuracy : | ± 0.3nm | ± 0.6nm |
| Max Resolution : | <0.5nm | <1nm |
| Bandpass : With standard slits | 0.25nm | 0.50nm |

Slewing Speed : >100nm/second

Stray Light : $<10^{-9}$

Slits : Standard Set includes: 0.125mm, 0.15mm, 0.30mm, 0.6mm, 1.2mm and 2.4mm x 4.0mm. For other sizes, consult SP.

Gratings : Two or four gratings (30 x 30mm) must be purchased. See Appendix A for options

Software : Demonstration control program and LabView driver included.

Power : UL listed 110/220V power pack

Warranty : One year

Options :

- Hand-held control module with function keys and display for local control
- IEEE-488 interface
- Interface cables
- Gold optics

See options and accessories

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| CM112 | Dual Grating Turret, 1/8 meter Double Monochromator Specify additive or subtractive mode. |
| CMSP112 | Dual Grating Turret, 1/8 meter Double Spectrograph Specify additive or subtractive mode. |

# Standard Ruled Gratings

## for installation in Digikrom™, CM110/CM112 Monochromators/Spectrographs

### CM Standard Ruled Gratings Size = 30 x 30 mm

| SP Part # | Ruling (g/mm) | Peak (nm) | Range(nm) @ > 30%T | Peak %T |
|---|---|---|---|---|
| AG2400-00240-303 | 2400 | 240 | 180-680 | 70 |
| AG1200-00200-303 | 1200 | 200 | 180-450 | 65 |
| AG1200-00300-303 | 1200 | 300 | 200-750 | 72 |
| AG1200-00500-303 | 1200 | 500 | 330-1000 | 83 |
| AG1200-00600-303 | 1200 | 600 | 400-1500 | 80 |
| AG1200-00750-303 | 1200 | 750 | 480-1500 | 85 |
| AG0600-00500-303 | 600 | 500 | 350-1300 | 80 |
| AG0600-01200-303 | 600 | 1200 | 800-3000 | 85 |

| SP Part # | Ruling (g/mm) | Peak (nm) | Range(nm) @ > 30%T | Peak %T |
|---|---|---|---|---|
| AG0300-00500-303 | 300 | 500 | 310-1100 | 80 |
| AG0300-02500-303 | 300 | 2500 | 1500-6000 | 88 |
| AG0150-00500-303 | 150 | 500 | 320-980 | 72 |
| AG0150-04000-303 | 150 | 4000 | 2500-9000 | 93 |
| AG0075-01700-303 | 75 | 1700 | 1100-2800 | 85 |
| AG0075-08000-303 | 75 | 8000 | 5000-15000 | 82 |
| AG0045-01750-303 | 45 | 1750 | 1100-3000 | 78 |
| | | | | |

See Appendix A for grating efficiency curves

NOTE: Ruled gratings blazed at different wavelengths and Holographic gratings are available on request - call for prices and availability. Response curves also available upon request.

### AG-303-KIT

Backplate mounting kit, required for user installation of CM gratings.

# CM series Options and Accessories

### DK1201

Hand-held control module, 2 line x 20 character LCD display. Allows local operation of CM110/112 monochromators and CMSP110/112 spectrographs.

### CMGPIB

IEEE-488/GPIB option for parallel interface operation of CM110/112 monochromators and AB300 Series automatic filter wheels.

### CMGPIB- 220V (220Vac input)

IEEE-488/GPIB option for parallel interface operation of CM110/112 monochromators and AB300 Series automatic filter wheels.

### CMSP-TO-CM

Attachment to allow CMSP Spectrograph to operate as a monochrometor.

### AB200

Single filter carrier that mounts directly between CM unit and accessories

### IR110

For use with CM110. Infrared(gold) coatings on CM110 mirrors. Enhances transmission by up to 40% between 600 and 1100 nm. Not suitable for work below 600nm

### IR110SP

Same as above, for use with CMSP110.

### IR112

For use with CM112. Infrared(gold) coatings on CM112 mirrors. Enhances transmission by up to 80% between 600 and 1100 nm.

### IR112SP

Same as above, for use with CMSP112.

### DK12PS

RS232 Cable for PS2 style computer

### DK12MA

RS232 Cable for PS2 style computer

### Special Slit Sizes

| | |
|---|---|
| DKFS010 | Pair, 10 µm slits |
| DKFS020 | Pair, 20 µm slits |
| DKFS025 | Pair, 25 µm slits |
| DKFS050 | Pair, 50 µm slits |

DK1201 controller

# Digikröm DK240

## 1/4 Meter Computer-Controlled Monochromator/Spectrograph

- Connects to any computer via RS232 or IEEE-488.
- Motorized slits.
- Triple-grating turret allows high efficiency scanning across a broad spectral range.
- May be factory configured as a monochromator or spectrograph.
- Scans in both directions and with Constant Spectral Resolution (CSR).
- Integrates with AB300 for automatic filter switching. AB300 is controlled by monochromator
- Suitable for fluorescence and absorption studies, detector characterization, thin film measurements, etc.




## The Workhorse: Direct Digital Drive/Constant Spectral Resolution

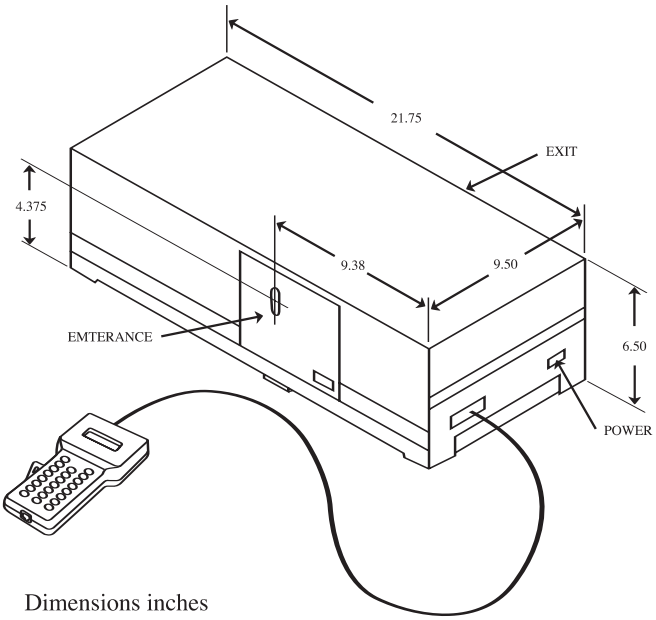
The Digikrom DK240 is a complete computer integrated solution. Easy to use commands control the tripple grating turret, motorized slits, and optional motorized filter wheel for quick and easy sorting. Instrument mode can be set for constant spectral resolution (CSR), where the slit width is automatically modified to compensate in the change in dispersion with wavelength to maintain constant spectral bandpass.

Rugged cast construction, a thermal design, and SP direct grating drive make this unit the most repaetable and reliable in its class. Each instrument is calibrated and certified prior to delivery.

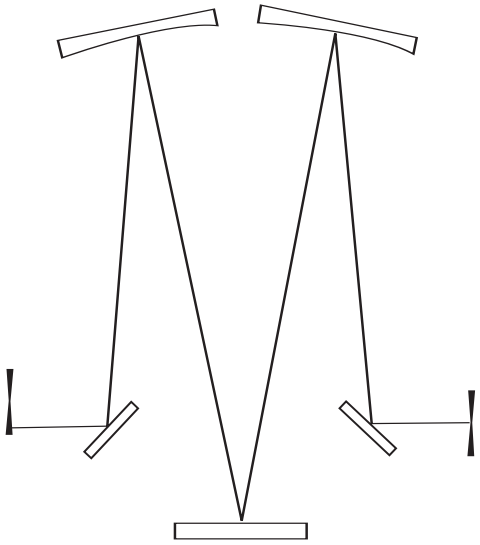
For DK240 models, for list of gratins see Appendix A

| Grating groove/mm | wavelength (nm) | Dispersion nm/mm | Resolution* (nm)/slit 0.01mm | 0.125mm |
|---|---|---|---|---|
| 1200 | 200 | 3.5 | 0.1 | 0.5 |
| | 800 | 3.3 | 0.1 | 0.4 |
| | 1500 | 1.9 | <0.1 | 0.2 |
| 600 | 200 | 6.9 | 0.2 | 0.9 |
| | 1500 | 6.6 | 0.2 | 0.9 |
| | 3000 | 3.8 | 0.1 | 0.5 |
| 150 | 200 | 27.5 | 0.8 | 4 |
| | 5000 | 27.1 | 0.7 | 4 |
| | 10000 | 21.2 | 0.6 | 3 |

※ approximately equivalent to bandpass




Dimensions inches



Optical Path

## Specifications :

Design : Czerny-Turner. Triple-grating turret standard.
Focal Length : 240mm
f/# : 3.9
Wavelength Drive : Worm and wheel with computer control. Bidirectional.
Wavelength Precision and Reproducibility : 0.007nm (with 1200 g/mm grating)
Wavelength Accuracy : ± 0.30nm standard (with 1200 g/mm grating)
Scan Speed : 1 to 1200nm/minute (with 1200 g/mm grating)
Stray Light : <0.01% at 220nm (NaI)
Slits : Unilateral, computer controlled, straight entrance and straight exit standard.
Width - 10mm to 3000mm Height - 2mm to 20mm
Reciprocal Dispersion : 3.2nm/mm (with 1200 g/mm grating)
Max Resolution : 0.06nm (with 1200 g/mm grating)
Gratings : One to three gratings (68 x 68mm standard, 68 x 84mm optional) must be purchased. See Appendix A for options.
Software : Demonstration control program and LabView driver included.
Power : 100 - 240V, 50/60Hz, 60W
Interface : RS232 standard
Weight : 35 lbs.
Warranty : One year
Options :

- DKBS - Bi-lateral slits
- DKGPIB - IEEE-488 communication interface (internal)
- DK2401 - Hand-held controllers for local control
- IR240 - Gold optics
- DKPURGE - Purge port

See options and accessories

Ordering Information: Please indicate product number plus description when ordering.

DK240 1/4 meter Monochromator
DKSP240 1/4 meter Spectrograph w/flat field and fine focus adjustment
DKSP240I Imaging 1/4 meter Spectrograph

# Digikröm DK242

## 1/4 Meter Computer-Controlled Double Monochromator/Spectrograph

- Internal controller connects to any computer via RS232 or IEEE-488. Hands-off control of three slit assemblies and two grating turrets.
- Scans in both directions and with Constant Spectral Resolution (CSR).
- Triple-grating turrets allows high efficiency scanning across a broad spectral range.
- Additive dispersion increases resolution and reduces stray light for Raman and fluorescence studies, subtractive dispersion minimizes broadening of pulse sources.
- Integrates with AB300 for automatic filter switching. AB300 is controlled by monochromator
- May be factory configured as a monochromator or spectrograph.

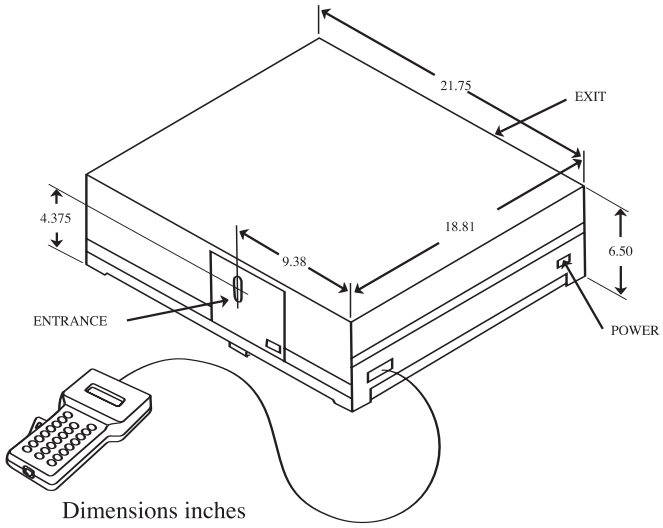


## The Pioneer : Better Resolution, Stray Light Control

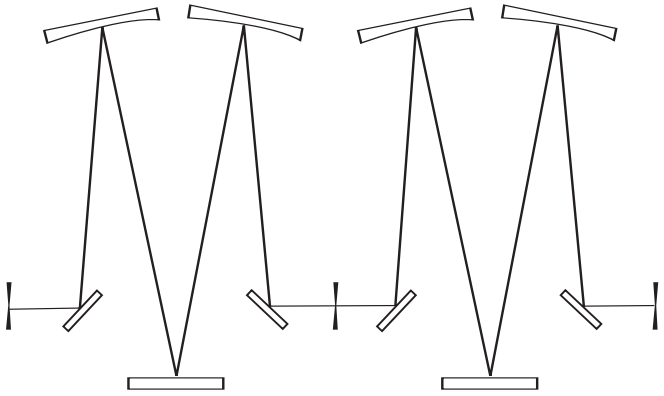
The DK242 is two cascaded monochromators, with the exit slit of the first monochromator functioning as the entrance slit of the second. This instrument may be factory configured to operate as either an additive or subtractive dispersion double monochromator. In both modes, the two monochromators act as a double filter with the rejection of stray light being nearly the square of the single monochromator value. In the additive dispersion mode, the DK242 is the equivalent of a half-meter monochromator, but permits greater reduction of stray light. The first grating spreads the spectrum over an angular range; the second grating then doubles this dispersion. The result is twice the resolution of a single 1/4-meter monochromator. In subtractive dispersion mode the first monochromator selects a bandpass. The second monochromator then removes the temporal and angular aberrations introduced by the angular spectral dispersion in the first monochromator.

The DK242 offers a unique solution to practical problems in the spectroscopy of pulsed sources. For example, an ordinary monochromator will introduce up to 250 pico second broadening in light pulses that are passed through the monochromator. Operated in the subtractive dispersion mode, the DK242 reduces this broadening to almost zero because the second monochromator equalizes the optical path length of the first.

The DK242 is also a unique solution to the practical problems of Raman spectroscopy because the high stray light rejection of the two monochromators allows observation close to the laser line. SP's unique CSR scanning technology also improves efficiency in the red and near IR while maintaining resolution. (In the CSR mode, the monochromator's change in dispersion with wavelength is compensated by a change in slit widths while bandpass remains constant.
Intensity improvement up to 4x can occur).




Dimensions inches



Optical Path



## Specifications :

Design : Double cascaded Czerny-Turner.
Triple-grating turrets standard in each section.
Double-grating turret optional.

Focal Length : 240mm each section

f/# : 3.9 overall

Wavelength Drive : Dual worm and wheel with electronic synchronization and computer control. Programmable in either additive or subtractive dispersion.

Scan Speed : >1 to 1200nm/minute (with 1200 g/mm grating)

Stray Light : <0.01% at 220nm(Nal)

Slits : Unilateral, computer controlled, Width - 10mm to 3000mm
Height - 2mm to 20mm

Gratings : Two to six gratings (68 x 68mm standard, 68 x 84mm optional)must be purchased. See Appendix A for options.

| | Additive | Subtractive |
|---|---|---|
| Wavelength Precision : | 0.01nm | 0.01nm |
| Wavelength Accuracy : | ± 0.3nm | ± 0.3nm |
| Reciprocal Dispersion : | 1.60nm/mm (with 1200 g/mm grating) | |
| Max Resolution : | 0.04nm | 0.06nm |
| Pulse Broadening : | 200 ps max | 10 fs max |

Interface : RS232 standard

Software : Demonstration control program and LabView driver included.

Power : 110 / 120V, 50/60Hz @ 1A standard.
220/230/240V,50/60Hz@0.5Aoptional.

Warranty : One year

Options :

- DKBS - Bi-lateral slits
- DKGPIB - IEEE-488 communication interface (internal)
- DK2401 - Hand-held controllers for local control
- IR240 - Gold optics
- DK2PORT - Bifurcated fiber bundle for attaching 2 device to 1 port
- AB300 - Automated 6 position filter wheel

See options and accessories

Ordering Information: Please indicate product number plus description when ordering.

DK242 Triple Grating Turret, Double 1/4 meter Monochromator Specify additive or subtractive

DKSP242 TripleGrating Turret, Double 1/4 meter Spectrograph Specify additive or subtractive

DKSP242I Triple Grating Turret, Imaging Double 1/4 meter Spectrograph Specify additive or subtractive

# Digikröm DK480

## 1/2 Meter Computer-Controlled Monochromator/Spectrograph

- Connects to any computer via RS232 or IEEE-488.
- Motorized slits.
- Triple-grating turret allows high efficiency scanning across a broad spectral range.
- May be factory configured as a monochromator or spectrograph.
- Scans in both directions and with Constant Spectral Resolution (CSR)
- Integrates with AB300 for automatic filter switching. AB300 is controlled by monochromator
- Suitable for fluorescence and absorption studies, detector characterization, thin film measurements, etc.




## Wavelength Selection is No Longer Expensive

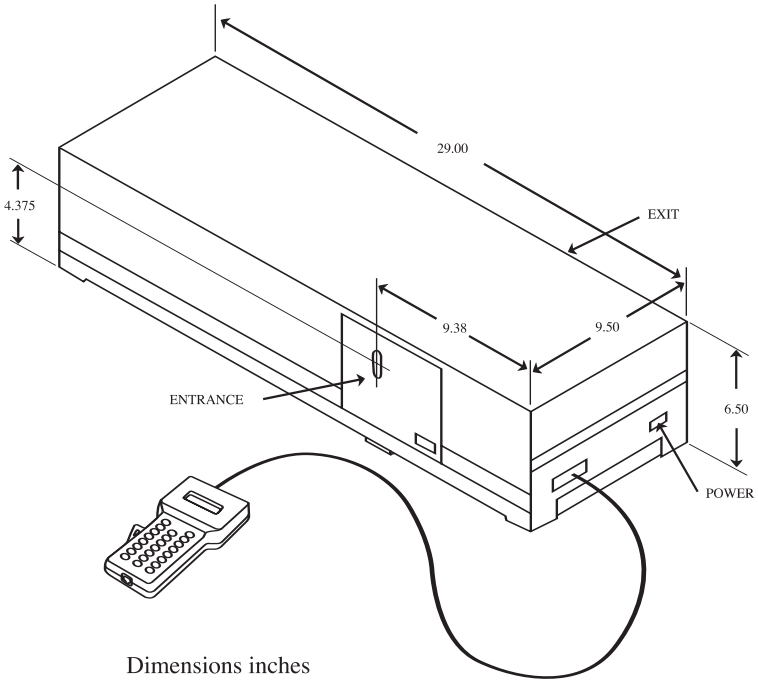
The Digikrom DK480 is a complete computer integrated solution. Easy to use commands control the tripple grating turret, motorized slits, and optional motorized filter wheel for quick and easy sorting. Instrument mode can be set for constant spectral resolution (CSR), where the slit width is automatically modified to compensate in the change in dispersion with wavelength to maintain constant spectral bandpass.

Rugged cast construction, a thermal design, and SP direct grating drive make this unit the most repaetable and reliable in its class. Each instrument is calibrated and certified prior to delivery.

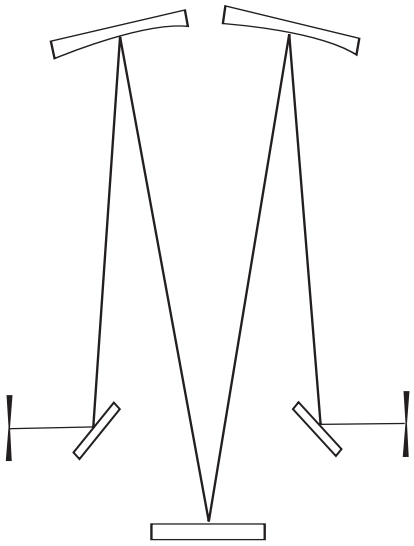
For DK480 models, for a ful list of gratins see Appendix A

| Grating groove/mm | wavelength (nm) | Dispersion nm/mm | Resolution* (nm)/slit 0.01mm | 0.125mm |
|---|---|---|---|---|
| 1200 | 200 | 3.5 | 0.05 | 0.2 |
| | 800 | 3.3 | 0.05 | 0.2 |
| | 1500 | 1.9 | <0.05 | 0.1 |
| 600 | 200 | 6.9 | 0.1 | 0.5 |
| | 1500 | 6.6 | 0.1 | 0.4 |
| | 3000 | 3.8 | 0.05 | 0.2 |
| 150 | 200 | 27.5 | 0.4 | 2 |
| | 5000 | 27.1 | 0.3 | 2 |
| | 10000 | 21.2 | 0.3 | 1 |

※ approximately equivalent to bandpass




Dimensions inches



Optical Path

## Specifications :

Design : Czerny-Turner
Triple-grating turret standard
Focal Length : 480mm
f/# : 7.8
Wavelength Drive : Worm and wheel with computer control. Bidirectional.
Wavelength Precision and Reproducibility : 0.007nm standard (with 1200 g/mm grating)
Wavelength Accuracy : ±0.3nm standard (with 1200 g/mm grating)
Scan Speed : 1 to 1200nm/minute (with 1200 g/mm grating)
Stray Light : < 0.01% at 220nm (NaI)
Slits : Unilateral, computer controlled, straight entrance and straight exit standard.
Width - 10 µm to 3000 µm, Height - 2 µm to 20 µm
Reciprocal Dispersion : 1.60nm/mm (with 1200 g/mm grating)
Max Resolution : 0.03nm (with 1200 g/mm grating)
Gratings : One to three gratings (68 x 68mm standard, 68 x 84mm optional) must be purchased.
See Appendix A for options.
Software : Demonstration control program and LabView driver included.

Power : 100 - 240V, 50/60Hz, 60W
Interface : RS232 standard
Weight : 45 lbs.
Warranty : One year
Options :

- DKBS - Bi-lateral slits
- DKGPIB - IEEE-488 communication interface (internal)
- DK2401 - Hand-held controllers for local control
- IR480 - Gold optics
- DK2PORT - Bifurcated fiber bundle for attaching 2 devices to 1 port.
- AB300 - Automated 6 position filter wheel

See options and accessories

Ordering Information: Please indicate product number plus description when ordering.

DK480 1/2 meter Monochromator
DKSP480 1/2 meter Spectrograph w/flat field and fine focus adjustment
DKSP480I Imaging 1/2 meter Spectrograph

# Standard Ruled Gratings for installation in Digikröm DK series Monochromators/Spectrographs

## DK Standard Ruled Gratings Size = 68 x 68 mm

| Part # | Ruling (g/mm) | Peak (nm) | Range(nm) | Peak %T |
|---|---|---|---|---|
| AG2400-00240-686 | 2400 | 240 | 180 - 680 | 70 |
| AG1200-00200-686 | 1200 | 200 | 180 - 450 | 65 |
| AG1200-00250-686 | 1200 | 250 | 180 - 460 | 70 |
| AG1200-00300-686 | 1200 | 300 | 200 - 750 | 72 |
| AG1200-00500-686 | 1200 | 500 | 330 - 1000 | 83 |
| AG1200-00600-686 | 1200 | 600 | 400 - 1500 | 80 |
| AG1200-00750-686 | 1200 | 750 | 480 - 1500 | 85 |
| AG1200-01000-686 | 1200 | 1000 | 550 - 1500 | 75 |
| AG0600-00500-686 | 600 | 500 | 350 - 1300 | 80 |
| AG0600-01200-686 | 600 | 1200 | 800 - 3000 | 85 |
| AG0600-01600-686 | 600 | 1600 | 950 - 3000 | 93 |
| AG0300-00500-686 | 300 | 500 | 310 - 1100 | 80 |
| AG0300-02000-686 | 300 | 2000 | 1200 - 4000 | 88 |
| AG0300-02500-686 | 300 | 2500 | 1500 - 6000 | 88 |
| AG0300-03000-686 | 300 | 3000 | 1800 - 6000 | 80 |
| AG0150-00500-686 | 150 | 500 | 320 - 980 | 72 |
| AG0150-04000-686 | 150 | 4000 | 2500 - 9000 | 93 |
| AG0075-08000-686 | 75 | 8000 | 5000 - 15000 | 82 |
| AG0050-00600-686 | 50 | 600 | 400 - 1200 | 78 |
| AG0050-12000-686 | 50 | 12000 | 7500 - 20000 | 82 |

See Appendix A for grating efficiency curves

NOTE: Ruled gratings blazed at different wavelengths and Holographic gratings are available on request - call for prices and availability.

Wide gratings (68 x 84mm) are available at 40% above list price, add “W”at the end of the part number.

Response curves also available on request.

## AG-686-KIT

Backplate mounting kit, required for user installation of DK gratings.

# DK Series Options and Accessories

## DKBS

Bi-lateral slit option for DK240/ 242/480. Both sides of slits are automatically controlled for maintaining image centering when wider slits are necessary (tolerance ± 10 µm)

## DKGPIB

Internal IEEE-488/GPIB communication interface option for DK240/242/480. Separate output connector from Monochromator.

## IR240

For use with DK240. Infrared (gold) coatings on optics for DK240. Enhances transmission by up to 40% between 600 - 1100nm. Not suitable for work below 600nm.

## IR240SP

Same as above, for use with DKSP240.

## IR242

For use with DK242. Infrared (gold) coatings on optics for DK242. Enhances transmission by up to 80% between 600 - 1100nm.

## IR242SP

Same as above, for use with DKSP242.

## IR480

For use with DK480. Infrared (gold) coatings on optics for DK480. Enhances transmission by up to 40% between 600 - 1100nm.

## IR480SP

Same as above, for use with DKSP480.

## DKPURGE

Purge port provided with standard MPT socket fitting for easy connect/disconnect.

## DK2401

Hand-held monochromator controller for DK240/242/480. Allows local control of monochromator when computer is not available or in series with a computer.

## DK24PS

RS232 Cable assembly for PS/2 style computer.

## DK24IC

IEEE-488/GPIB universal cable assembly.

## AB300

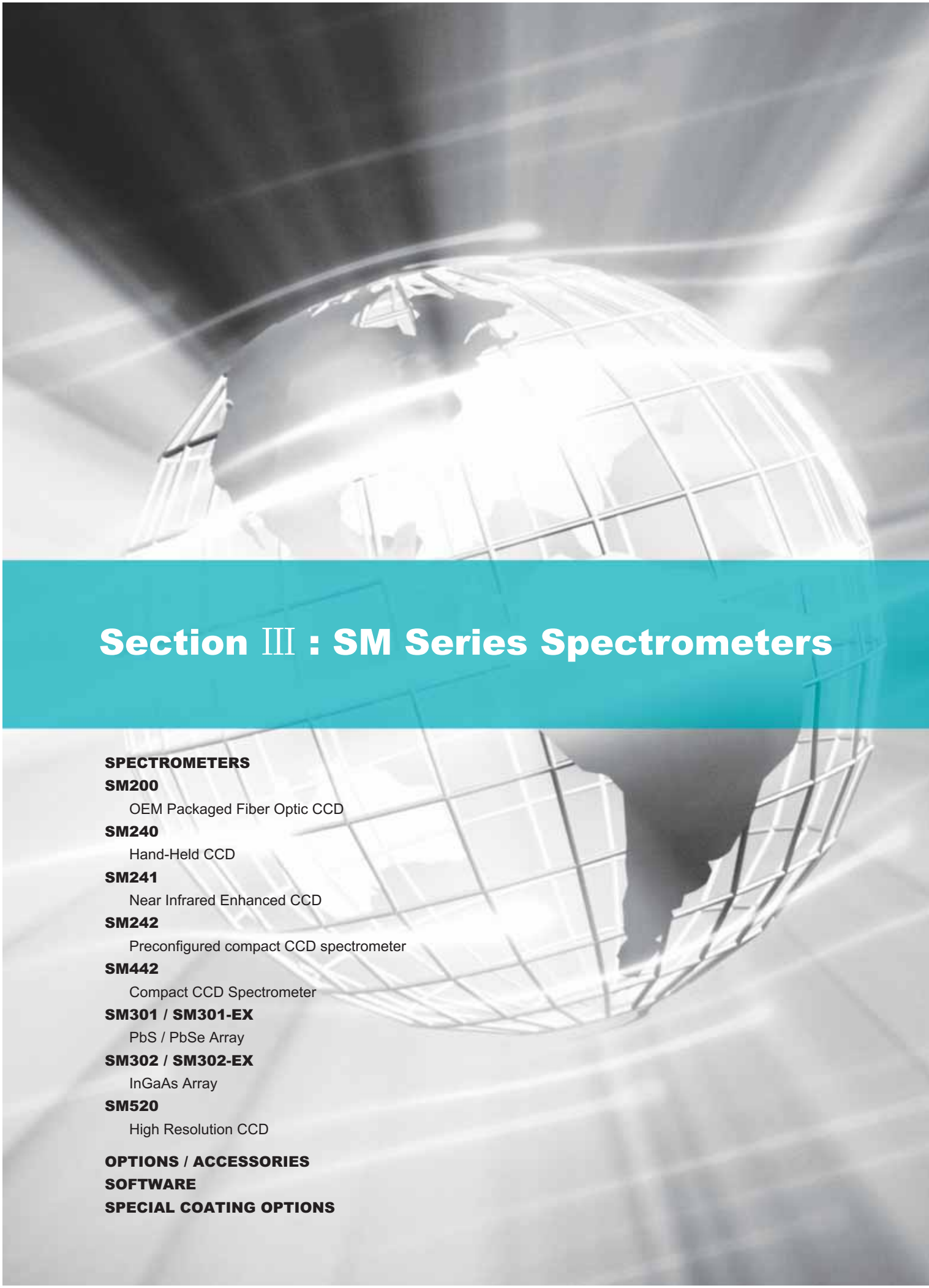
Six position, 1 ” diameter automatic filter wheel assembly that bolts directly to DK entrance. Recieves power and commands directly through DK unit. See page 92 for more information.

## DKSP-TO-DK

Attachment to allow DKSP Spectrograph to operate as a monochrometor. It includes CM standard 6-fixed slit set (page 17).

## AB200

Single filter carrier that mounts directly between DK unit and accessories.



# Section III : SM Series Spectrometers

# SM200

## OEM packaged Fiber Optic CCD Spectrometer

- Best performance cost ratio in the industry.
- Designed from the ground up for OEM integration.
- Small impact resistant optical bench
- Flexible light input direct to slit or via fiber.
- Fully customizable.
- ILX 511 allows up to a 700 nm measurement window between 200nm and 1050nm (800 nm measurement window size possible for some applications).
- USB 2.0 interface with 16-bit dynamic range available!

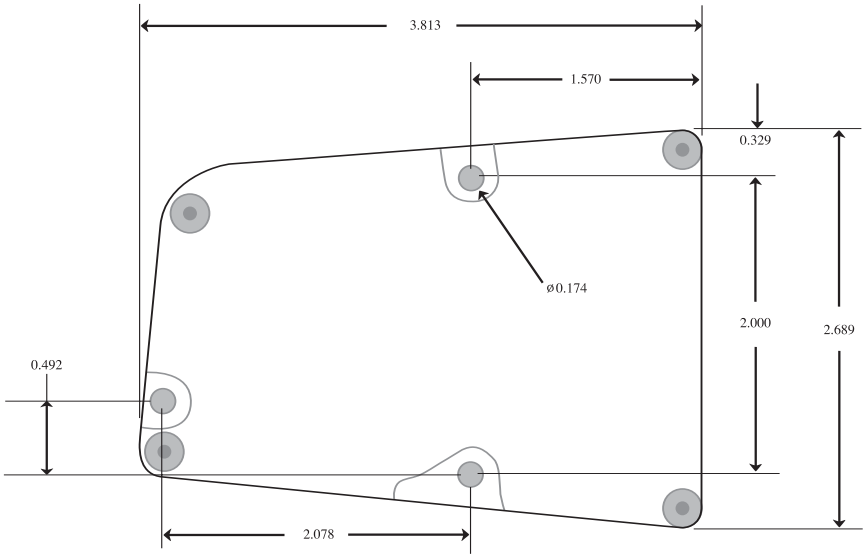
## The Choice for OEM Spectral Applications

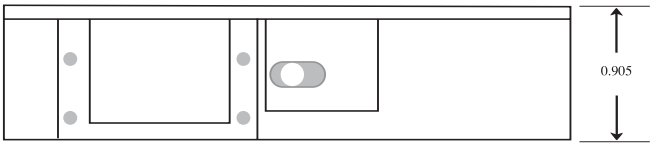
The SM200 is a miniature spectrometer designed for custom OEM applications. It offers a high performance to cost ratio for new systems designs. The SM200 can accept light directly through its built-in slit or via optical fiber. A removable fiber coupler faceplate allows use of standard SMA 905, FC and custom fiber connectors. This faceplate also allows direct attachment to dedicated systems and a number of SMX Accessories. A durable aluminum housing encloses the SM200 optical bench; through careful design this housing provides stable device operation over a wide range of temperatures.

The spectrometer sensor array and array driver electronics are mounted inside the SM200 housing, from there a flex cable connects to exterior support electronics. The standard sensor array used is the Sony ILX 511. The driver electronics have been designed for highly sensitive yet stable operation. The design of the SM200 also allows the use of custom arrays for special applications, including photodiode assemblies and alternative CCD arrays.

Standard interfaces to the SM200 include a USB 2.0 interface with 16-bit extended dynamic range and a PCI card interface with 12-bit dynamic range sampling. Custom interfaces and legacy ISA and PCMCIA interfaces are available.

Software support includes custom DLLs for dedicated applications development and our SM32Pro windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced
acquisition programming and external triggering.




## Specifications :

Detectors : Sony CCD Linear Array
Number of Pixels : 2048
Sensing Pixel Size : 14 µm x 200 µm
Sensitivity : 1800 V/(lx •s) @ 660nm
Customer array installation available

Computer Interface :

| | |
|---|---|
| USB 2.0 | 16 bit 500KHz |
| PCI bus | NI-PCI 12 bit 200 KHz PCI interface board |

Call SP for other interface options, including PCMCIA and ISA

Temperature Induced Shift : 0.01 nm / ˚C
Spectrograph f# : 2.7
Available Gratings : See Appendix A
Slit Options : 10, 25, 50 or 100 µm
Fiber Options : 50 to 600 µm core diameter
Fiber Coupler : SMA 905 or FC standard, custom coupler available
Fiber Numerical Aperture : 0.2
Effective Spectral Range : 200 to 1050nm
Order Sorting Filter : Longpass filter installed per wavelength coverage
Spectral Resolution : 0.3 to 10nm depending on the slit and grating choices
Stray Light : <0.01% at 600nm
Software : SM32Pro (free with spectrometer) Includes SDK and DLLs for easy custom application development.

Ordering Information: Please indicate product number plus description when ordering.

SM200 OEM Fiber Optic Spectrometer

# SM240

## Hand-held CCD Spectrometer

- Compact system, can be handheld or securely mounted.
- Flexible optical input direct to slit or via fiber.
- Designed from the ground up for applications.
- Impact resistant housing.
- High performance electronics.
- Standard design allows up to a 700nm measurement window between 200nm and 1050nm (800 nm window possible for some applications).
- USB 2.0 interface with 16-bit dynamic range available!


## The Choice for Spectral Applications

The SM240 is a compact CCD Spectrometer for use with a PC. Based on the SM200 optical bench design, it supports many different applications where spectral or color measurements are required, including high dynamic range applications.

The SM240 can accept light directly through its built-in slit or via optical fiber. A removable faceplate allows the use of standard SMA 905, FC and custom fiber connectors. This faceplate also allows direct attachment to dedicated systems and a number of SMX Accessories. The durable aluminum housing that encloses the SM240 provides stable optical bench operation over a wide range of temperatures.

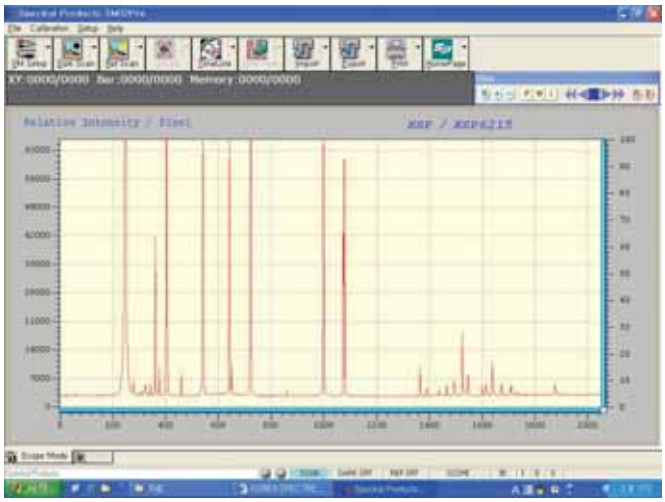
The standard sensor array used is the Sony ILX 511. The array driver electronics have been designed for highly sensitive yet stable operation. This array (in conjunction with our special UV coating process and custom order sorting filters) allows up to a 700nm measurement window located from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity, some laser applications may support a window size of up to 800nm). The design of the SM240 also allows use of custom arrays for special applications, including photodiode assemblies and alternative CCD arrays.

Standard interfaces to the SM240 include a USB 2.0 interface with 16-bit extended dynamic range and a PCI card interface with 12-bit dynamic range. Custom interfaces and legacy ISA and PCMCIA interfaces are available.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

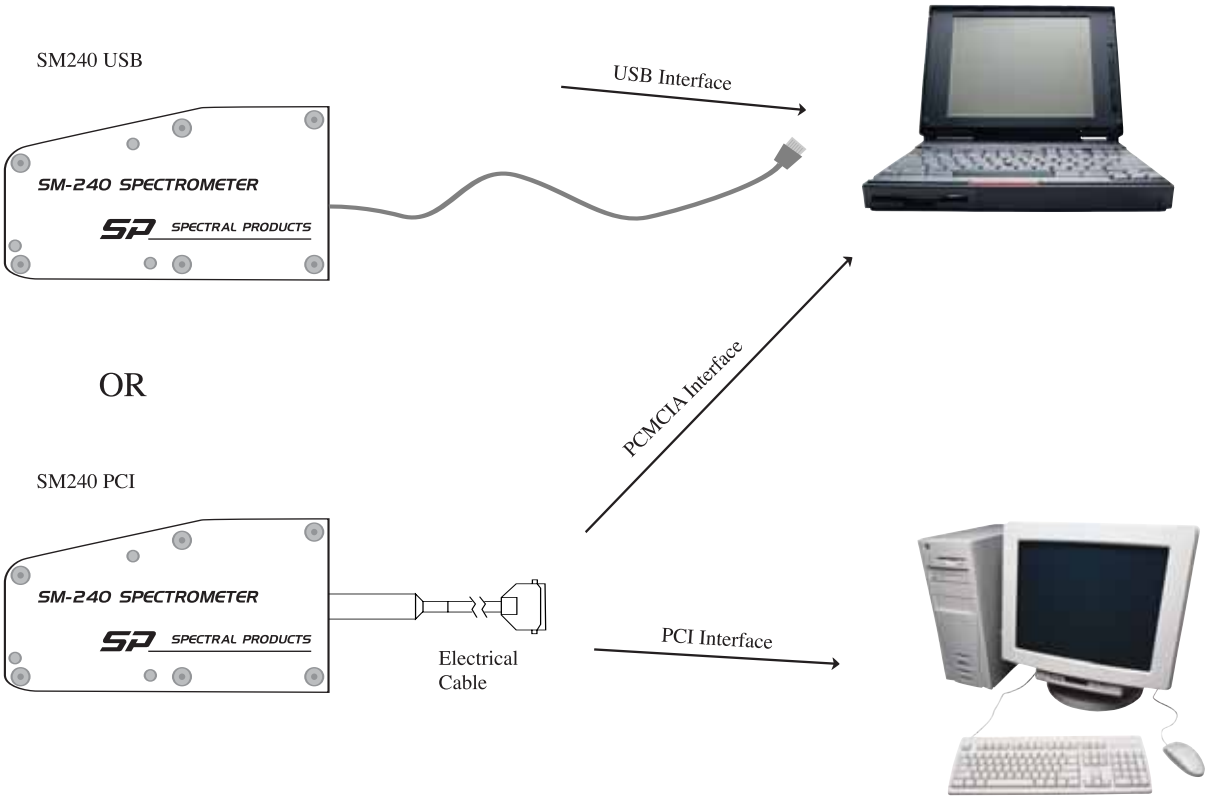
## Software

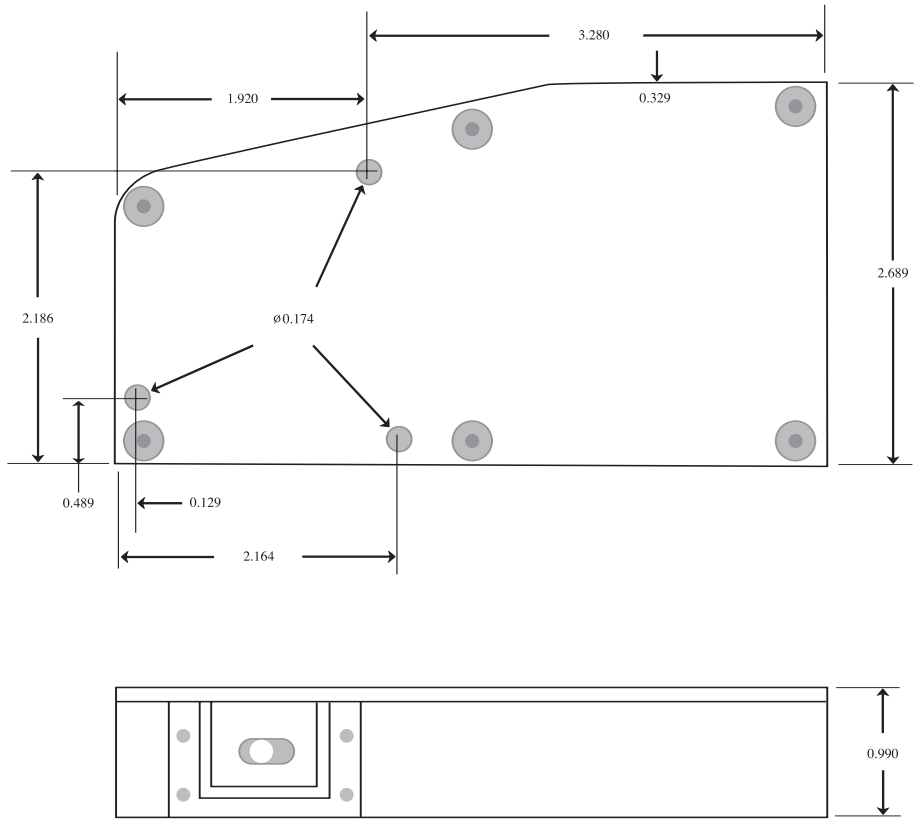
- SM32Pro - Windows® 98,2000, XP based software for data acquisition and analysis.
- Transmission, reflectance, and absorbance measurements.
- Data export, zoom in and out, spectrum overlays, and many more features.
- Color analysis tools included.
- Signal average and integration time control.
- Double beam version available.
- SDK and DLLs available for easy custom software development.



Software








## Specifications :

Detectors : Sony CCD Linear Array
Number of Pixels: 2048
Sensing Pixel Size : 14 µm x 200 µm
Sensitivity : 1800 V/(lx • s) @ 660nm
Customer array installation available
Dimensions (inches) : 5.6 h x 2.75 w x 0.87 d
Weight : 0.5 lbs.
Spectral Range : UV - 200nm to 450nm, VIS - 380nm to 760nm
NIR - 550nm to 1050nm
other ranges are configurable from 200nm to 1050nm
Spectral Resolution : 0.25 - 10nm dependent on spectral range, slit width, and fiber diameter
Available Gratings : See Appendix A
Entrance :
Fiber SMA 905 or FC fiber coupler.
50-600 µm core Ø fiber
NA = 0.2
Slit 10, 25, 50 or 100 µm
Dynamic Range : 12 bit (4096:1) or 16 bit (65536:1)
Computer Interface :
USB 2.0 16 bit 500KHz
PCI bus NI-PCI 12 bit 100 KHz
PCI interface board
Call SP for other interface options, including PCMCIA and ISA
Temperature Range : 15°C to 40°C
Software : SM32Pro

Ordering Information: Please indicate product number plus description when ordering.

SM240 - USB USB interface, Spectrometer
SM240 - PCI PCI interface, Spectrometer

# SM241

## NIR Laser Spectrometer

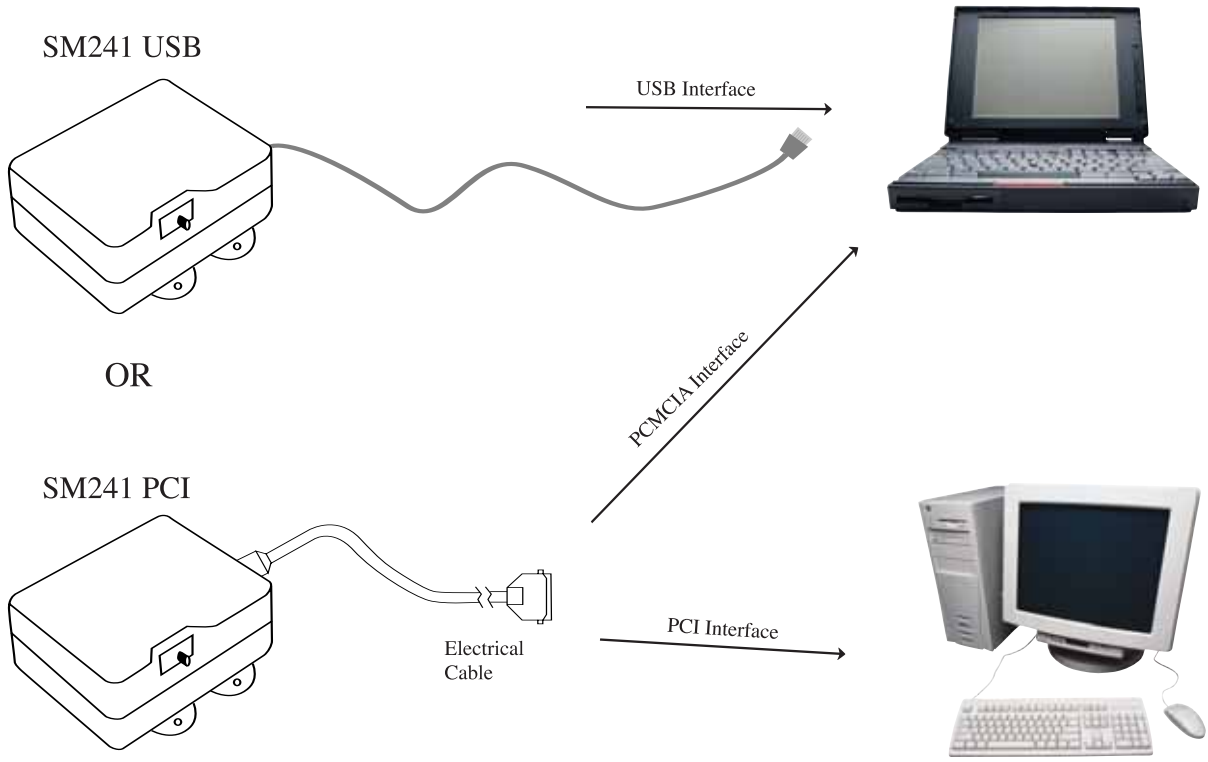
- Less expensive alternative to Germanium or InGaAs systems.
- Compact system, can be handheld or securely mounted.
- Flexible optical input direct to slit or via fiber.
- High performance electronics.
- Allows spectral measurements between 900nm and 1700nm.
- USB 2.0 interface with 16-bit dynamic range available!




## The Choice for Spectral NIR Laser Applications

The SM241 is a compact CCD based Spectrometer designed for NIR laser applications. Spectral Product's IR up-conversion phosphor CCD coating breaks the standard Silicon-based CCD detectors array sensitivity barrier of 1100nm to allow spectral measurements up to 1700nm. This technology makes the SM241 a lower cost alternative to Germanium or InGaAs systems. The SM241 optical bench includes oversized gold plated mirrors and gratings to accommodate NIR light collection and analysis. Maximum spectral coverage with this spectrometer is 900 nm to 1700 nm (reduced coverage window size within 900-1700nm will increase spectral resolution and light sensitivity).

Standard interfaces include a USB 2.0 interface with a 16-bit extended dynamic range and a PCI card interface with a 12-bit dynamic range. Custom interfaces and legacy ISA and PCMCIA interfaces are also available. Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.




## Specifications :

# of CCD Pixels : 2048
CCD Pixel Size : 14 µm by 200 µm
CCD Sensitivity : 30 V/mJ/cm$^2$
Grating : 300 to 1800 grooves per mm
Spectral Response : 900nm to 1700nm
Spectral Resolution : 5nm with standard slit configuration
Available Gratings : See Appendix A
Entrance :
Slit 10 µm - 100 µm
Fiber SMA fiber coupler, NA = 0.2
Stray Light Rejection : better than $10^{-3}$
Analog to Digital : USB 16 bit standard, PCI optional.
Digitizer Resolution : 12-bit, 4096 to 1 or 16 bit, 65536 to 1
Computer Interface:
USB Bus 16 bit 500KHz
PCI bus NI-PCI 12 bit 100 KHz
PCI interface board
Call SP for other interface options

Dimensions (inches) : 5.5 x 2.9 x 0.99
Weight : 0.5 lbs.
Software : SM32Pro

Ordering Information: Please indicate product number plus description when ordering.

SM241 - USB Near Infrared Enhanced Hand-held Spectrometer, USB interface
SM241 - PCI Near Infrared Enhanced Hand-held Spectrometer, PCI interface

# SM242

## Preconfigured Compact CCD Spectrometer

- New compact, pre-configured model
- Can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- Impact resistant housing
- High performance electronics
- Standard design allows up to 200-1050nm range
- USB 1.1/2.0 interface with 16-bit dynamic range available!


## The Choice for Spectral Applications

The SM242 is a new compact, pre-configured design CCD Spectrometer for use with a PC. Based on SP's special optical bench design, it supports many different applications where spectral or color measurements are required, including high dynamic range applications.

The SM242 can accept light directly through its built-in slit or via optical fiber. A removable faceplate allows the use of standard SMA 905, FC, and custom fiber connectors. This faceplate also allows direct attachment to dedicated systems and a number of SMX Accessories. The durable aluminum housing that encloses the SM242 provides stable optical bench operation over a wide range of temperatures.

The standard sensor array used is the Sony ILX 511. The array driver electronics have been designed for highly sensitive yet stable operation. This array (in conjunction with our special UV coating process and customized order sorting filters) allows up to a 850nm measurement window from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity). The design of the SM242 also allows use of custom arrays for special applications, including photodiode assemblies and alternative CCD arrays.

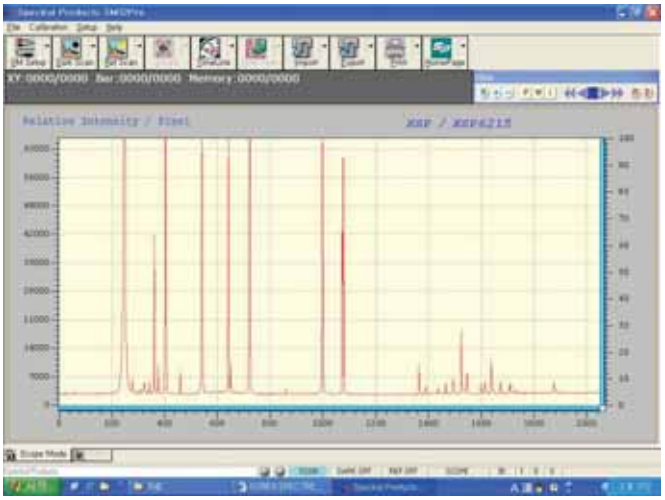
Standard interface to the SM242 is a USB 1.1/2.0 compatible interface with 16-bit extended dynamic range.

The SM242 is a pre-configured model, so if the desired wavelength range matches one of the standard wavelength ranges, SP can ship the unit within a couple of days.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

- SM32Pro - Windows® 95/98/2000/NT/XP-based software for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available



Software

## Specifications :

Detectors : Sony CCD Linear Array
Number of Pixels: 2048
Sensing Pixel Size : 14 µm x 200 µm
Sensitivity : 1800 V/(lx • s) @ 660nm
Customer array installation available
Dimensions (inches) : 3.82 (h) x 2.60 (w) x 1.85 (d)
Weight : 0.5 lbs ARO.
Standard Spectral Ranges:
UV: 200-400nm / 200-450nm / 200-600nm
VIS: 350-700nm / 380-760nm / 400-800nm
VIS/NIR: 650-1050nm / 550-1050nm / 350-1050nm
UV/VIS: 200-700nm / 300-800nm / 200-850nm
UV/VIS/NIR: 200-950nm / 300-1050nm / 200-1050nm
other ranges are also configurable from 200nm to 1050nm
Spectral Resolution : 0.25 - 10nm dependent on spectral range, slit width, and fiber diameter
Available Gratings : See Appendix A
Entrance :
Fiber SMA 905 or FC fiber coupler.
50-600 µm core Ø fiber
NA = 0.2
Slit 10, 25, 50, 100, 200 or 400 µm
Dynamic Range : 16 bit or 65536:1
Signal to Noise Ratio :
>1000:1 (Root-Mean-Square), >300:1 (Peak-to-Valley)
Integration Time : 1 millisecond to 65 seconds
Computer Interface : USB 1.1/2.0 compatible, 16 bit A/D
Temperature Range : 15°C to 40°C
Stray light : <0.1% (typical)
Software : SM32Pro

Ordering Information: Please indicate product number plus description when ordering.

SM242 - USB Preconfigured Compuct CCD Spectrometer

# SM442

## Compact CCD Spectrometer

- New compact model with new CCD
- Can be handheld or securely mounted
- Flexible optical input direct to slit or via fiber
- Designed from the ground up for a wide range of applications
- Impact resistant housing
- High performance electronics
- Standard design allows up to 200-1050nm range
- USB 1.1/2.0 interface with 16-bit dynamic range available!




## The Choice for Spectral Applications

The SM442 is a new compact design CCD Spectrometer for use with a PC. Based on SP's special optical bench design, it supports many different applications where spectral or color measurements are required, including high dynamic range applications.

The SM442 can accept light directly through its built-in slit or via optical fiber. A removable faceplate allows the use of standard SMA 905, FC, and custom fiber connectors. This faceplate also allows direct attachment to dedicated systems and a number of SMX Accessories. The durable aluminum housing that encloses the SM442 provides stable optical bench operation over a wide range of temperatures.

The standard sensor array used is the Toshiba TCD 1304. The array driver electronics have been designed for highly sensitive yet stable operation. This array (in conjunction with our special UV coating process and customized order sorting filters) allows up to a 850nm measurement window from 200nm to 1050nm (smaller measurement window sizes increase spectral resolution and light sensitivity). Thanks to increased pixel numbers from 2048 of old Sony CCD to 3648, the SM442 allows almost twice better resolution with narrower slit than the SM242.

Standard interface to the SM442 is a USB 1.1/2.0 compatible interface with 16-bit extended dynamic range.

The SM442 is a custom configuration model at the moment but will be a pre-configured model soon so that if the desired wavelength range matches one of the standard wavelength ranges, SP can ship the unit within a couple of days.

Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro Windows-based spectral acquisition and analysis software.

## Software

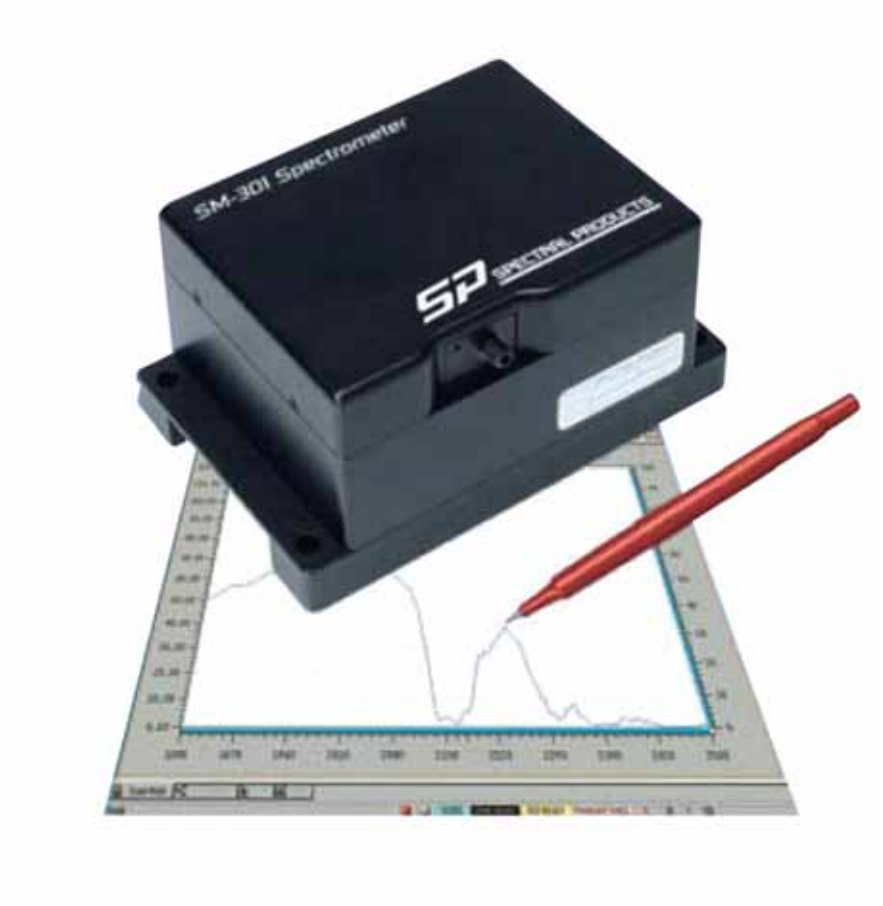
- SM32Pro - Windows® 95/98/2000/NT/XP-based software for data acquisition and analysis
- Transmission, reflectance, and absorbance measurements
- Data export, zoom in and out, spectrum overlays, and many more features
- Color analysis tools included
- Signal average and integration time control
- DLL libraries available for easy user software development in DOS and Windows®
- VC++/VB/Labview examples available

| Feature | Value |
|---|---|
| Detectors | Toshiba CCD Linear Array<br>Number of Pixels: 3648<br>Sensing Pixel Size: 8 µm x 200 µm<br>Sensitivity: 160 V/(lx s) @ 660nm |
| Dimensions (inches) | 3.82 (h) x 2.60 (w) x 1.85 (d) |
| Weight | 0.5 lbs ARO. |
| Standard Spectral Ranges | UV: 200-400nm / 200-450nm / 200-600nm<br>VIS: 350-700nm / 380-760nm / 400-800nm<br>VIS/NIR: 650-1050nm / 550-1050nm / 350-1050nm<br>UV/VIS: 200-700nm / 300-800nm / 200-850nm<br>UV/VIS/NIR: 200-950nm / 300-1050nm / 200-1050nm<br>other ranges are also configurable from 200nm to 1050nm |
| Spectral Resolution | 0.10 - 10nm dependent on<br>spectral range, slit width, and fiber diameter |
| Available Gratings | See Appendix A |
| Entrance | Fiber :<br>SMA 905 or FC fiber coupler<br>50-600 µm core ®™ fiber<br>NA = 0.2<br>Slit :<br>5, 10, 25, 50, 100, 200 or 400 µm |
| Dynamic Range | 16 bit or 65536:1 |
| Signal to Noise Ratio | >1300:1 (Root-Mean-Square), >400:1 (Peak-to-Valley) |
| Integration Time | 0.01 millisecond to 65 seconds |
| Computer Interface | USB 1.1/2.0 compatible, 16 bit A/D |
| Temperature Range | 15°C to 40°C |
| Stray light | <0.1% (typical) |
| Software | SM32Pro |

# SM301 and SM301-EX

## PbS / PbSe Array Spectrometer

- Low Noise
- Cooled, Stable Operation
- 256 Detection Elements
- Accommodates spectral measurements in the 1.0 to 3.0 micron(PbS) or 1.5 to 5.0 micron(PbSe)range.
- Optical input direct to slit or via fiber.




## The Choice for IR Spectral Applications

The SM301 / SM301-EX is a versatile, high performance PbS / PbSe array spectrometer. Its active components include a TE cooler and a 256-element PbS / PbSe detector element array. Operation of the unit for research applications is easy with the included Windows based SM32Pro-based analysis software. The system is ideal for spectroscopic applications in the 1.0 to 3.0 micron (PbS) or 1.5 to 5.0 mocron(PbSe) region.

Available system options include a built-in high-speed shutter and optical blank pixels for setting dark current offsets. The SM301 / SM301-EX includes thermoelectric cooling to guarantee long-term operational stability.

## General Description

The SM301 / SM301-EX is a complete compact PbS / PbSe array Spectrometer for use with a PC to perform spectral measurements in the region of 1.0 to 3.0 micron (PbS) or 1.5 to 5.0 mocron(PbSe).

It consists of four parts: 1. an entrance mechanism with a built-in slit, a fiber coupling adapter, and an order sorting filter; 2. a spectrograph of a crossed Czerny-Turner arrangement using high quality optics; 3. a linear PbS / PbSe sensor array and driving circuitry; 4. a computer interface for data acquisition.

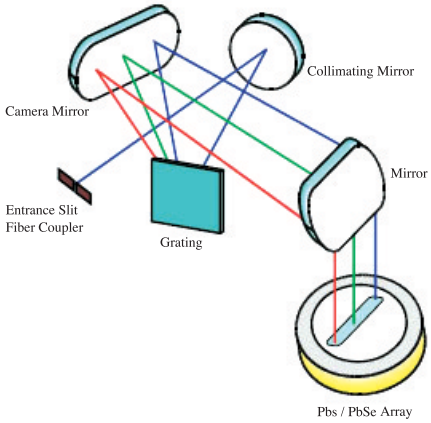
All the optical components and driving electronics are enclosed in an aluminum housing for stable operation. A thermal electric (TE) cooler is also included.

## Application

The SM301 / SM301-EX employs a multiplexed PbS / PbSe array as its NIR detection element. The array is cooled and temperature stabilized at -10℃ which ensures a long-term operation stability. A built-in mechanical shutter mechanism is controlled by the system clock and is synchronized with the array readout operation. Dark signal can thus be automatically measured by the built-in electronics periodically and subtracted automatically. Compared with conventional scanning NIR spectrometers the SM301 / SM301-EX provides the multichannel detection advantage, both in reducing the measurement time and enhancing measurement signal-to-noise ratio. The SM301 / SM301-EX can operate at a readout rate of 100 kHz or faster allowing fast measurement and averaging operation to be performed in a short period of time.

A variety of accessories makes the SM301 / SM301-EX versatile for process control, spectroscopy, environmental monitoring, and other applications. It can easily be configured for transmission, reflectance, absorbance, and other measurements. The wavelength range from 1.0 to 3.0 micron (PbS) or 1.5 to 5.0 mocron(PbSe) can be covered by one grating optimized for the wavelength range. The spectral range can also be factory configured to meet application needs.

The SM301 / SM301-EX can accept light directly coupled through a built-in slit, from a fiber through an SMA coupler or both. The fiber coupling ability makes the unit flexible for remote and process control applications. Where high mobility is required, the SM301 / SM301-EX can be used with just a slit to eliminate the light transfer variations caused by the changes in fiber bending curvatures. As a result, attenuation resulting from the use of optical fibers can also be avoided.




SM301 Optical Path

## Specifications :

Number of pixels : 256
Pixel size : 45 by 450 μm
Peak responsivity : $1x10^6$ V/watt
Spectral response range : 1000 to 3000nm(PbS)
1500 to 5000nm(PbSe)
Spectral Resolution : ~20nm with standard module and slit option.
Light entrance :
Slit : 50 μm to 400 μm
Fiber : SMA 905 fiber coupler
50 μm to 600 μm core diameter
NA = 0.2
Grating : 75 to 1200 grooves per mm
Stray light rejection : better than $10^{-3}$
Analog to digital : 12-bit resolution, PCMCIA standard
Dynamic range : > 1000:1 for single scan
Dimensions : 5”x 4”x 2.5” (LxWxH)
Shutter : Built-in
Detector cooling : -10°C
Weight : 2 lbs
Software : SM32Pro

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| SM301 | PbS Array Spectrometer |
| SM301 - EX | PbSe Array Spectrometer |

# SM302 and SM302-EX

## InGaAs Array Spectrometer

- 0.9 to 1.7 µm or 0.9 to 2.6 µm Extended
- Cooled Stable Operation
- Large Dynamic Range
- 16 bit Data Acquisition
- Low Noise
- Fiber Coupling Capability

## Compact, Tunable, NIR Spectrometer

The SM302 is a versatile, high performance, compact InGaAs array spectrometer that consists of a low noise, 256-element, InGaAs array detection module, a high precision tunable spectrograph optimized for the spectral range of 0.9 to 1.7•Ïm (0.9 to 2.6•Ïm extended), a 16-bit data acquisition board, and Windows¢Á based operating software.

The dual grating capacity spectrometer comes preloaded with one grating and slit tailored for high-resolution work throughout the usable range of the detector. An optional second grating may be loaded to add wide coverage capability, or both gratings may be user specified to achieve desired coverage and resolution. Integrated filters allow the user to selectively block out unwanted higher orders, and the standard dual function entrance can accept light directly coupled through the built-in slit or from a standard NIR fiber.

The SM302 detector is a multiplexed InGaAs array that is thermoelectrically cooled and temperature stabilized to ensure long-term operation stability. The multichannel detection with a readout rate of 333 kHz or faster both reduces measurement time and enhances signal-to-noise ratio.

## Specifications :

Resolution : <2nm with standard configuration
Light entrance : Dual SMA/ 50 µm slit standard
Other slit or fiber connections options available
Available slit sizes : 50 µm standard
10 µm, 25 µm available
f# : 3.9
Grating : One 600 groove grating included
Additional gratings available upon request
Grating control : RS232
Filtering : Permanent 0.9 µm low blocking filter included
1.3 µm low blocking flip-filter included in extended model

Dimensions (inches) : 10.5 h x 5 w x 4 d
Weight : 6.5 lbs
Software : Windows control program and
LabVIEW. drivers included

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| SM302 | InGaAs Array Spectrometer |
| SM302 - EX | Extended InGaAs Array Spectrometer |

# SM520

## Extreme Resolution CCD Spectrometer

- Optical input direct to slit or via fiber.
- Allows higher resolution spectral measurements in up to a 700nm measurement window between 200nm and 1050nm - double the resolution of the SM200 and SM240.
- USB 2.0 interface with 16-bit dynamic range available!



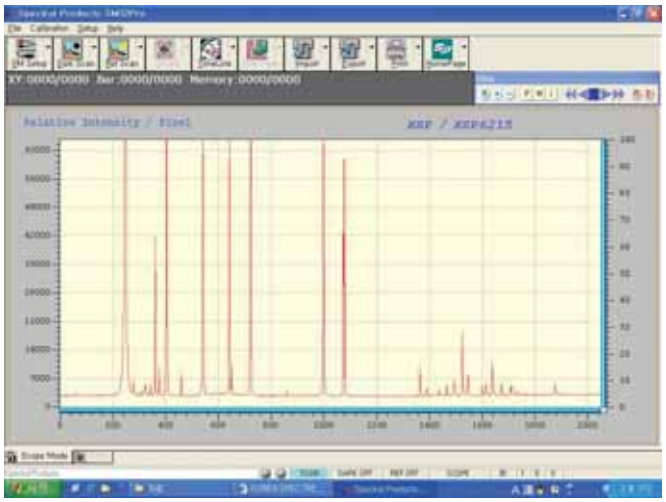
## The Choice for Spectral Applications

The SM520 is a CCD based spectrometer that offers more than double the resolution of the SM240. This resolution is achieved using oversized (30mm x 30mm) optical-bench components. These components offer approximately 4 times the effective collimation, grating and focusing area than what is used in the SM200 and SM240. As with all spectrometers, effective resolution increases as window size decreases. A 100nm window will have approximately .09nm resolution (as opposed to .3nm for the SM200 and SM240). A 700 nm window will have approximately .56nm resolution (as opposed to 1.12 nm for the SM200 and SM240).

Standard interfaces include a USB 2.0 interface with 16-bit extended dynamic range and a PCI card interface with 12-bit dynamic range. Custom interfaces and legacy ISA and PCMCIA interfaces are also available. Software support includes a SDK and DLLs for dedicated applications development and our SM32Pro windows based spectral acquisition and analysis software. Both standard and legacy interface designs provide support for advanced acquisition programming and external triggering.

## Software

- SM32Pro - Windows® 98,2000, XP based software for data acquisition and analysis.
- Transmission, reflectance, and absorbance measurements.
- Data export, zoom in and out, spectrum overlays, and many more features.
- Color analysis tools included.
- Signal average and integration time control.
- Double beam version available.
- SDK and DLLs available for easy custom software development.



Software

# Specifications :

Detectors : Sony CCD Linear Array
Number of Pixels: 2048
Sensing Pixel Size : 14 µm x 200 µm
Sensitivity : 1800 V/(lx • s) @ 660nm
Customer array installation available

Dimensions (inches) : 7.0 h x 6.75 w x 3.0 d

Weight : 4.0 lbs.

Spectral Range : UV - 200nm to 450nm, VIS - 380nm to 760nm
NIR - 550nm to 1050nm
other ranges are configurable from 200nm to 1050nm

Spectral Resolution : ~0.1nm, dependent on spectral range, slit width, and fiber diameter.

Entrance :
Fiber SMA 905 or FC fiber coupler.
50-600 µm core Ø fiber
NA = 0.2
Slit 10, 25, 50 or 100 µm

Dynamic Range : 12 bit (4096:1) or 16 bit (65536:1)

Computer Interface :
USB 2.0 16 bit 500KHz
PCI bus NI-PCI 12 bit 200 KHz
PCI interface board
Call SP for other interface options, including PCMCIA and ISA

Temperature Range : 15°C to 40°C

Software : SM32Pro

Ordering Information: Please indicate product number plus description when ordering.
SM520 - USB USB interface, Spectrometer
SM520 - PCI PCI interface, Spectrometer

# Spectrometer Options/Accessories

Spectral Products provides a wide selection of various options/accessories for SP's spectrometers. Some useful accessories for various applications are available on "Sampling Accessories" section in catagories.

## 1. A/D Cards, USB2.0 Converters and Cables

### NI PCI-6023E/NI DAQCard-6024E (PCMCIA)

16 analog inputs at 200 kS/s, 12-bit resolution
Up to 2 analog outputs, 12-bit resolution
8 digital I/O lines (5 V/TTL/CMOS); two 24-bit counter/timers
Digital triggering
4 analog input signal ranges
NI-DAQ driver simplifies configuration and measurements

### USB2.0 PCI/PCMCIA Cards

Hi-Speed USB 2.0 Adapter support for Mac OS X v10.1, Windows 98SE/Me/2000/XP.
Up to 480 Mbps of data transfer rate; 40 time faster than USB 1.1 (11Mbps) device.
Fully backward compatible with older 12 Mbps USB devices.

### USB External Trigger Cable

BNC type connector

## 2. Inside Options

SM-QZWIN : Quartz (Fused Silica) CCD Window, The detector's standard window (BK7) is replaced with a quartz (fusted silica) window for UV (200nm ~ 350nm) applications.

SM-ARWIN : Anti-Reflection coated CCD Window, AR coating will reduce the reflectance and enhance the tranmittance efficiency of the CCD window in given wavelength range. To view the reflectance curve of each AR coating, Click Here.

DU : Deep UV range (200nm ~ 250nm)
UV : UV range(250nm ~ 400nm)
VS : Visible range, Shorter(320nm ~ 600nm)
VL : Visible range, Longer(400nm ~ 700nm)
IS : NIR range, Shorter(650nm ~ 1100nm)
IL : NIR range, Longer(1050nm ~ 1700nm)

SM-CCD-UV/SM-CCD-NIR : UV/NIR enhancing coating on CCD, SP's UV/IR up-conversion phosphor CCD coating breaks the standard Silicon-based CCD detectors array sensitivity barrier of 400~1100nm to allow spectral measurements down to 200nm (UV application) or up to 1700nm (NIR application, SM241).

### UV/NIR coated CCDs and cylidrical focusing lens

SM-AT-F1 : CCD Decter Array Focusing Lens, SP's cylindrical UV grade fused silia (quartz) lens increases light-collection efficiency.

SM-SLT : Entrance Slits, SP provides various widths and 1mm tall slits. The standard widths are 10um, 25um, 50um, 100um, 200um and 400um.

SM-OSF : Order Sorting Filter, SP's order sorting filter consists of various combinations of 250nm/300nm/440nm/590nm/780nm long pass filters. The broadband spectrum showed a strange dip or peak at the junction part of each filter before. But with the use of SP's unique technique, the induced dip or peak at the junction part was removed (except the junction part of the deep UV of below 250nm & UV/VIS range). Considering the lower sensitivity of the CCD (Sony ILX511) in UV and NIR range, SP also offers varius partially anti-reflection coated substrates.

SM-OSF2 : 2 position order sorting filter. Ex, 350nm ~ 800nm

SM-OSF2-UV : 2 position order sorting filter, UV quartz substrates. Ex, 300nm ~ 700nm

SM-OSF2-AUV : 2 position order sorting filter, UV AR coated quartz substrates. Ex, 250nm ~ 850nm

SM-OSF2-ADU : 2 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 600nm

SM-OSF2-AIR : 2 position order sorting filter, NIR AR coated quartz substrates. Ex, 450nm ~ 1000nm

SM-OSF3 : 3 position order sorting filter. Ex, 350nm ~ 1050nm

SM-OSF3-UV : 3 position order sorting filter, UV quartz substrates. Ex, 300nm ~ 1000nm

SM-OSF3-AUV : 3 position order sorting filter, UV AR coated quartz substrates. Ex, 250nm ~ 1050nm

SM-OSF3-ADU : 3 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 850nm

SM-OSF3-AIR : 3 position order sorting filter, NIR AR coated quartz substrates. Ex, 400nm ~ 1050nm

SM-OSF3-AUN : 3 position order sorting filter, UV & NIR partial AR coated quartz substrates. Ex, 200nm ~ 850nm, 250nm ~ 950nm

SM-OSF4-UV : 4 position order sorting filter, UV quartz substrates. Ex, 200nm ~ 950nm

SM-OSF4-ADU : 4 position order sorting filter, Deep UV AR coated quartz substrates. Ex, 200nm ~ 950nm

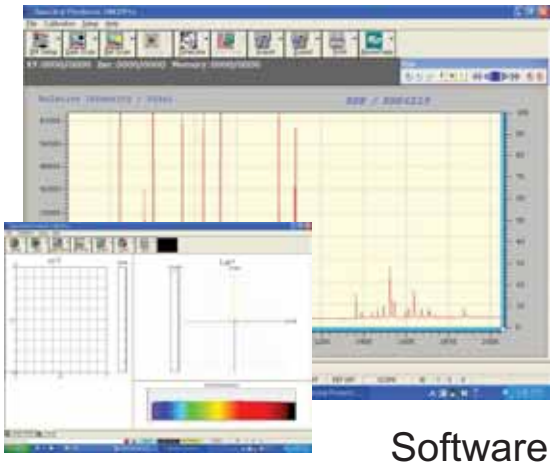
SM-OSF4-AUN : 4 position order sorting filter, UV & NIR partial AR coated quartz substrates. Ex, 200nm ~ 1050nm

SM-LPF : Long Pass Filters, SP's long pass filter is installed permanently in the SMA 905/FC connector (face plate) of SM series spectrometers. Various long pass filters are available from 280nm to 1000nm .

SM-EQF : CCD System Equalizer Filter, SP's equalizer filter flattens the general intensity distribution of CCD detector.

# SM32Pro Software

- Displays percent of reflectance.
- Calculates XYZ, Yxy, L*a*b*, L*C*h$_{o}$, △L*a*b*, △L*C*h*, △ELab and △ ECMC
- Illuminant conditions A and D65.
- CIE 2$_{o}$ and 10$_{o}$ standard observers.
- View up to 6 reflectance traces on a single graph, with multiple graphs tiled on a single screen.
- Prints in color or black & white.
- Offers easy custom wavelength calibration function.
- Control signal averages and integration time
- Save color files, export color files, and print color matching files.
- Exports graph or data to other Windows™, software and to most DOS software.
- Has rubber-band zoom and auto-peak find.
- Features intuitive menu system and tool bars.
- Includes comprehensive documentation
- 32-bit Windows? SDK software and LabView developer libraries are available.



Software

## SM32Pro

General-purpose data acquisition and processing software for SM200, SM240, SM241, SM520, and SM301 units. SM32Pro allows Reflectance,Transmission and Absorbance measurements. Additionally CIE color values such as X Y Z, and Lab, may be obtained-using A and D 65 illuminant conditions with the software package. Data may be saved as a graph, or exported to ASCII text files for import to spreadsheet applications for further analysis. Graphing functions include zooming, basic text annotation, and plot overlays on a single graph. Color values may be compared to a user selectable standard in order to obtain Delta values. Spectrometer calibration can be handled easily through use of the software combined with a traceable light source.

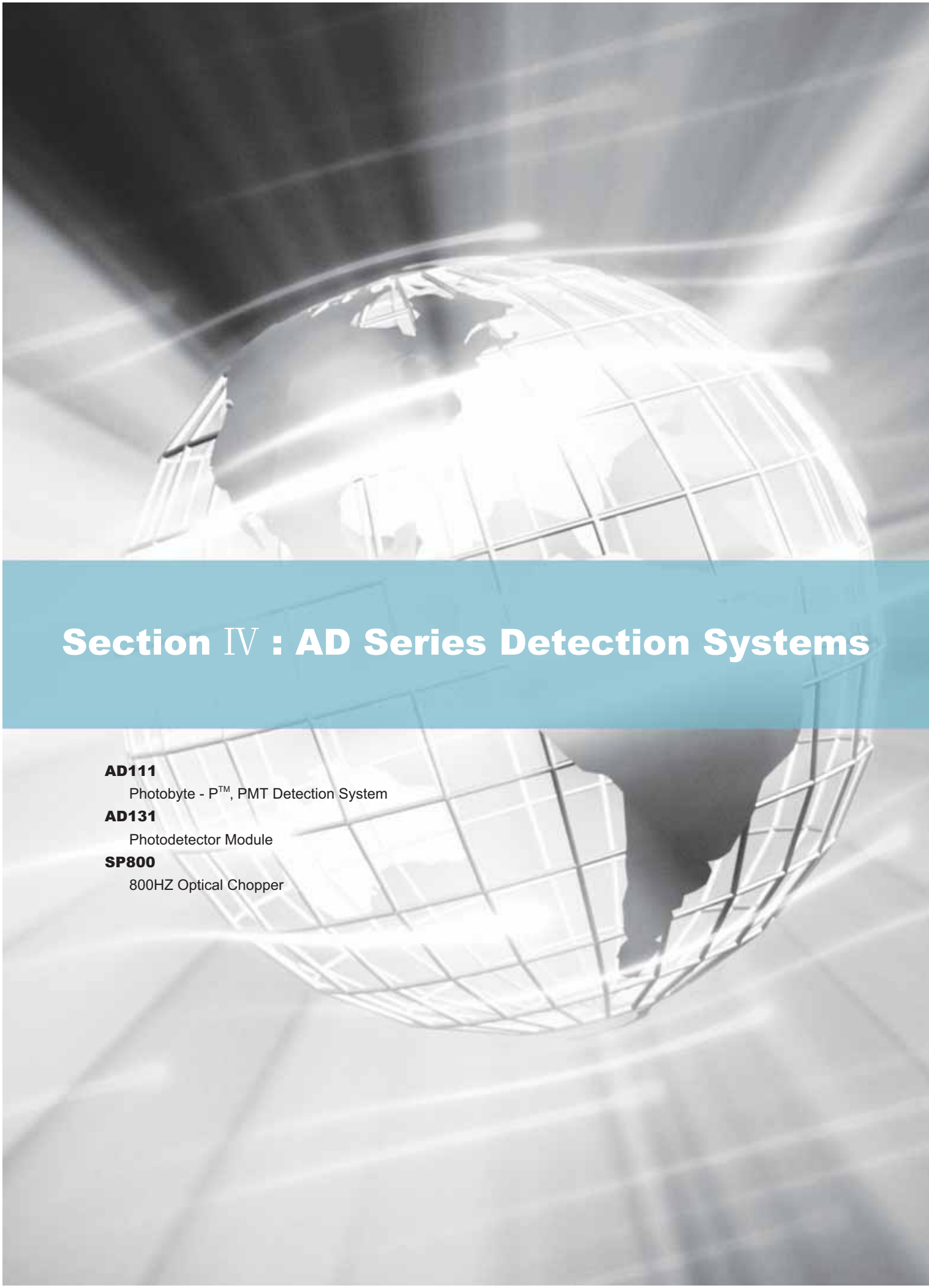
## SM32Pro SDK, 32 Bit

Available for customers who wish to use SM hardware with custom designed software. The SDKs are available in 32-bit formats, and include our dynamic linked libraries in addition to several various code samples (VC++, VB and LabView) on how to use the functions the DLLs contain. A manual that details the functions available is also included.

# Special Coating Options

SP's pioneering coating technologies also allow us to take another step further to reduce energy lost between optical surfaces. For customers' special applications, SP provides special coating options.

SM-PG600 : Special Gold Coating on mirror optics installed in spectrometer to enhance the reflectance (R>95%) in 600nm ~ range.
SM-PS400 : Special Silver Coating on mirror optics installed in spectrometer to enhance the reflectance (R>95%) in 380nm ~ range.
SM-BBDS3501100 : Special BBDS Coating on mirror optics installed in spectrometer to enhance the reflectance (R>98.5%) in 350nm ~ 1100nm.
Anti-Reflection Coating Options : SP provides various Anti-Reflection coating options. This coating helps to enhace the transmittance efficiency of focusing lens or CCD window. Typical reflectance of optics is ~4% per each interfacing surface but this AR coating will reduce the reflectance less than 0.5% (at normal incidence).
DU : Deep UV range (200nm ~ 250nm), UV : UV range(250nm ~ 400nm), VS : Visible range, Shorter(320nm ~ 600nm),
VL : Visible range, Longer(400nm ~ 700nm), IS : NIR range, Shorter(650nm ~ 1100nm), IL : NIR range, Longer(1050nm ~ 1700nm)



# Section Ⅳ : AD Series Detection Systems

**AD111**

Photobyte - P™, PMT Detection System

**AD131**

Photodetector Module

**SP800**

800HZ Optical Chopper

# AD111

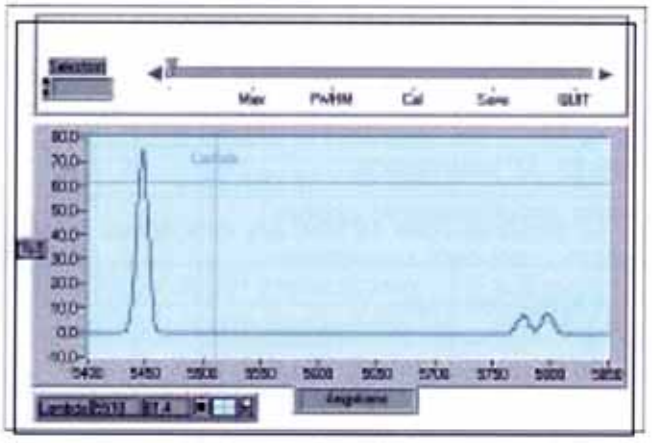
## Photobyte - P™ Photomultiplier Detection System

- Provides a complete detection system for SP ṡ Digikrom monochromators.
- Easy RS232 interface.
- Wide selection of PMT's.


The AD111 is a convenient computer controlled photomultiplier detection system for use with Spectral Products Digikrom line of monochromators. It features a detector housing that has a dynode divider chain and direct anode connection, mounts directly to exit-slit ports of Digikrom monochromators, and accommodates side-on photomultiplier tubes. (PMT ṡ must be ordered separately.) It also features the Photomultiplier Amplifier, a compact electronic unit containing the preamplifier and high voltage power supply for the PMT. Coaxial cables for the high voltage and PMT output current signals connect between the detector housing and the amplifier unit. The entire operation, including wavelength and bandpass selection, is controlled with a customer-supplied PC. (The Digikrom monochromator and the AD111 utilize one serial for monochromator and one USB port for AD111) An easy to use program is also included that allows full control of both PMT and monochromator. It graphically displays wavelength versus intensity, intensity versus time and allows ASCII data storage for importing to other user interfaces as desired.

## Specifications :

Wavelength Range : Per PMT detector (see below)
High Voltage Range : 0-1000 VDC
A/D Resolution : 16 bit (Successive Approximation)
Response Rate : USB2.0
High Voltage Resolution : 244mV
Input Voltage : ± 5 VDC
Data Resolution : 76.3 µV, (data range = 0-5V)
Time Constant per step : Selectable from 1 µS to 10 sec
Conversion time : 2 µS (Maximum)
USB 2.0 Transfer Rate : 480 Mbits/sec
Amplification Gains : x1 to x10 (programmable)
Supply Voltage : 100-240 VAC
Current Input Range : 0 to -5 µA



Data Acquisition ScreenShot

## SP offers the following PMTs for use with the AD110

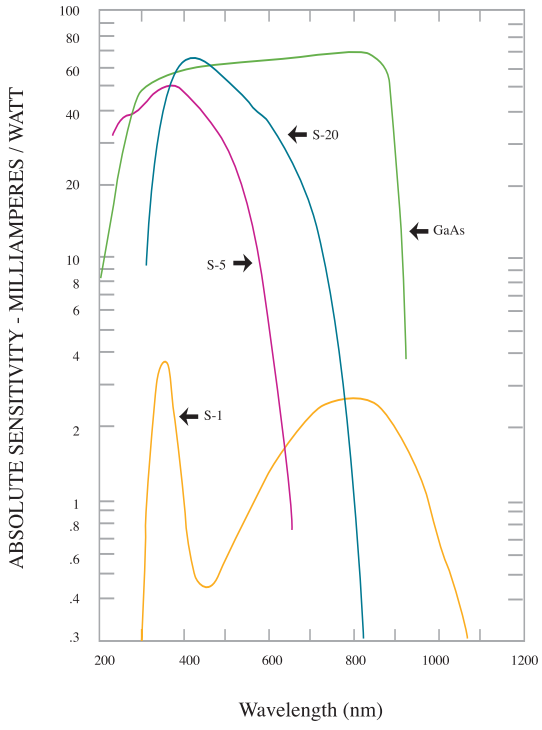
| AP Part# Code | PMT Type | Wavelength Range and Spectral Response |
|---|---|---|
| AD311 | 鞭R928P | 185-900nm; S-20 (extended) |
| AD321 | R 212 | 185-650nm; S -5 |
| AD322 | R 406 | 400-1100nm; S -1 |
| AD323 | R 777 | 185-850nm; S -20 |
| AD324 | R 636 | 185-930nm; GaAs (extended) |

* selected for low noise

Other PMTs are available from SP by request

Ordering Information: Please indicate product number plus description when ordering.

AD111 Photobyte - P™, Photomultiplier Detection System
AD100 PMT Housing, for 1-1/8 ” side on PMTs from AD3xx series
AD311 PMT Type - R 928
AD321 PMT Type - R 212
AD322 PMT Type - R 406
AD323 PMT Type - R 777
AD324 PMT Type - R 636




Typical Photocathode Spectral Response Characteristics

# AD131

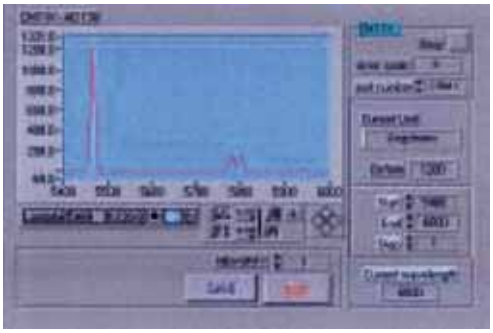
## Photodetector Module 190nm to 4.8 µm

- Combines SP photodiode detector, programmable charge integrator, and data conversion in a compact package.
- Expandible with add-on modules for cooled sensor capability.
- Null function for background noise subtraction.
- Programmable gain ranges.
- Windows® based data acquisition software included.
- Easy to install and use on any SP Monochromator
- Internal data averaging.


## Compact, Convenient, Affordable

The AD131 is a computer controlled data acquisition device for photodiode detectors, covering a wide wavelength range with Si, InGaAs, PbS, and PbSe photocells from the AD4x series. The unit contains an internal programmable charge integration amplifier, a 20-bit A/D converter, and a microprocessor with a RS232 interface. Signal processing functions take place internal to the AD131 to greatly reduce the noise level of the measured signal, including Correlated Double Sampling (CDS) and signal oversampling for digital filtering. Windows® based software allows for stand-alone operation or integrated control and data acquisition with any of the Digikrom line of monochromators.

Adding the AD131-TC Thermoelectric Controller module to the AD131 enables the use of AD4x series heads with cooling capability (designated by a -C on the model name). AD4x heads are easily exchanged on the same AD131 unit.



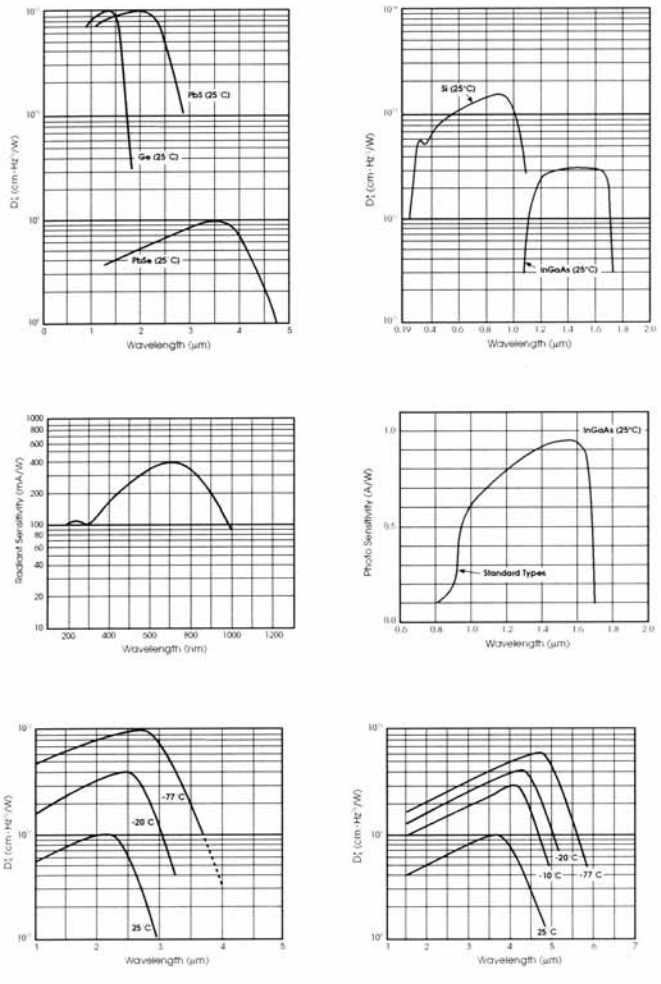
Data Acquisition Screen Shot

| SP Part # | Detector Type | Size | Range | Temp | Sensitivity | Dark resistance or current |
|---|---|---|---|---|---|---|
| AD421 | Si | 5.8x5.8 | 190-1000 | 25°C | 0.4 A/W at 1550 nm | 20 pA |
| AD427* | PbS | 3x3 | 1000-2900 | 25°C | 5x10⁴ V/W at 2200 nm | 0.5 to 2.5 MΩ |
| AD429* | PbSe | 3x3 | 1500-4800 | 25°C | 5x10² at 4 μm | 0.3 to 1.5 MΩ |
| AD430 | InGaAs | 3 dia | 800-1700 | 25°C | 0.95 A/W at 1.55 μm | 15 nA |
| AD431 | Si/InGaAs | 2.4x2.4 | 300-1700 | 25°C | 0.45 A/W at 0.94 μm | 30 pA |
| | | 1 dia | | 25°C | 0.55 A/W at 1.55 μm | 1 nA |
| The following require the AD131-TC Thermoelectric Controller module in addition to the AD131 Photodetector module. | | | | | | |
| AD427-C* | Cooled PbS | 4x5 | 1000-2900 | -10°C | 8x10⁴ V/W at 2.2μm | 0.5 tp 10 MΩ |
| AD429-C* | Cooled PbSe | 3x3 | 1500-4800 | -10°C | 1x10³ V/W at 4 μm | 1.7 to 7 MΩ |
| AD430-C | Cooled InGaAs | 3 dia | 800-1700 | -10°C | 0.95 A/W at 1.55 μm | 1 nA |
| AD431-C | Cooled Si/InGaAs | 2.4x2.4 | 300-1700 | 25°C | 0.45 (25°C) at 0.94 μm | 30 pA |
| | | 1 dia | | -10°C | 0.55 at 1.55 μm | 0.07 nA |

* Requires 450 Hz chopped optical signal



## Typical Spectral Response Characteristics




## Specifications :

Wavelength Range : Per detector (see above)
A/D Resolution : 20 bit
Sample Rate : Variable; integration period dependent.
Max. Samples Averaged per Measurement : 128
Input Current Ranges : 7.8 μA max.
Internal Test Current : 100nA ±20nA
Communications : RS232
Software : Windows® control program for stand-alone use or integrated with SP Monochromators.

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| AD131 | Photodetector Module |
| AD131-220V | Photodetector Module (220VAC input) |
| AD131-TC | Thermoelectric Controller Module |

(order detector heads separately)

| | |
|---|---|
| AD421 | Detector Head Type - Si |
| AD427 | Detector Head Type - PbS |
| AD429 | Detector Head Type - PbSe |
| AD430 | Detector Head Type - InGaAs |
| AD431 | Detector Head Type - Si/InGaAs |

The following detector heads are for use with the AD131-TC Thermoelectric Controller Module

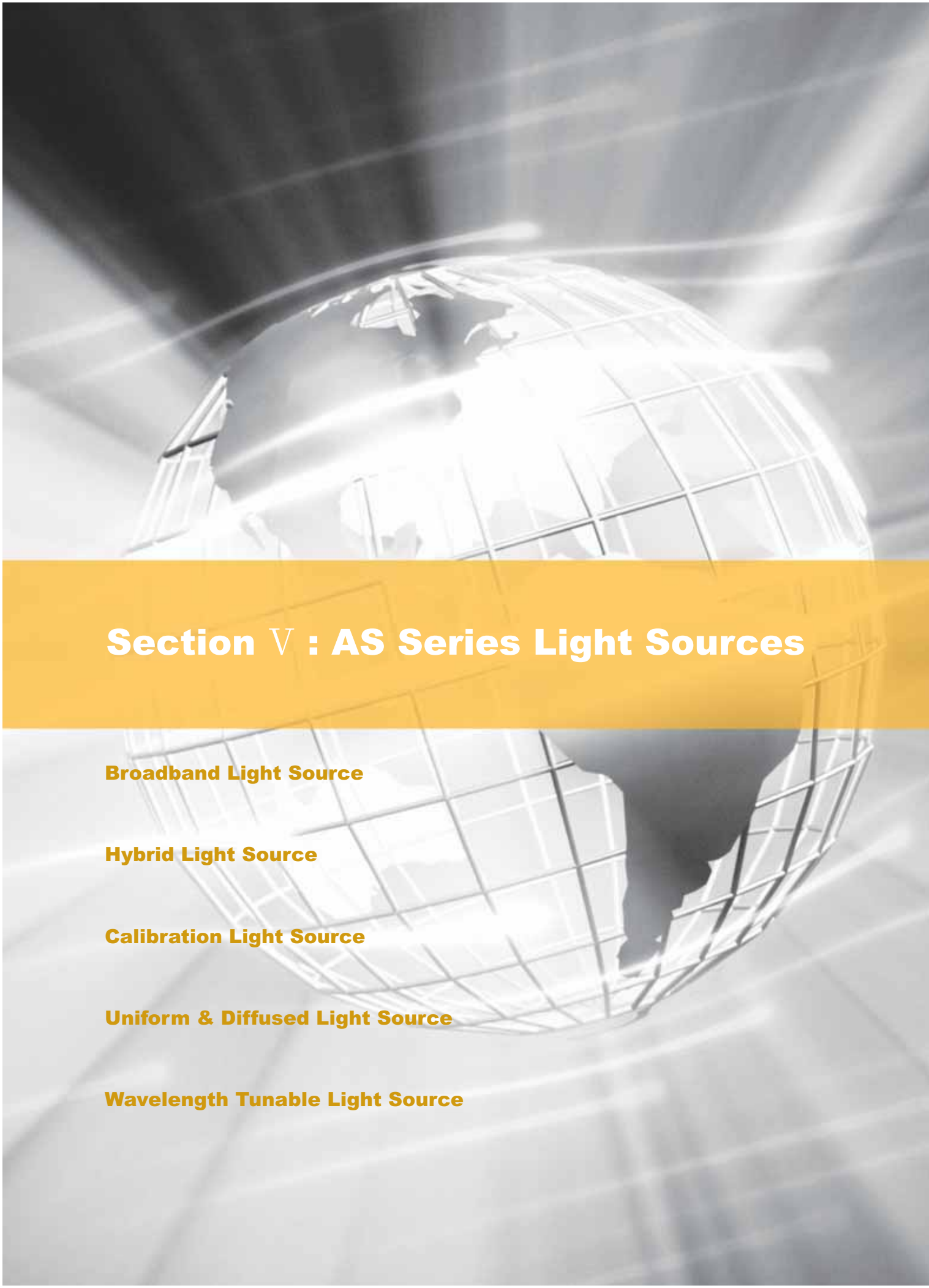
| | |
|---|---|
| AD427-C | Detector Head Type - PbS, TE Cooled |
| AD429-C | Detector Head Type - PbSe, TE Cooled |
| AD430-C | Detector Head Type - InGaAs, TE Cooled |
| AD431-C | Detector Head Type - Si/InGaAs, TECooled |

# SP800
## 800Hz Optical Chopper

- Provides 800Hz chopped optical signal for use with PbS and PbSe Infrared Detectors.
- Mounts directly to all Spectral Products monochromators, detectors, light sources, filter wheels and filter carriers.
- High Reliability
- Light Spectrum Purity
- Low Profile
- Small Footprint when integrated with light source or detector
- Low Power
- High Shock Resistance
- High Temperature Resistance


The Spectral Products 800 Hz optical chopper provides many unique advantages over a motorized chopper wheel or reciprocating blade. In an industrial product, the compact size, frequency stability and reliability permit many tough applications to become possible. The aperture motion or chopper window is produced by a high-Q resonating tuning fork that is highly resistant to vibration and shock. There is basically no moving part to jam or to wear down.

Spectral Products choppers will quickly reach stability after " power-on " in less than 2 seconds. Power consumption is typically around 20mW. Due to the compact size and special alloys, Spectral Products choppers can be mounted in close proximity to many hot filament sources.



# Section Ⅴ : AS Series Light Sources

**Broadband Light Source**

**Hybrid Light Source**

**Calibration Light Source**

**Uniform & Diffused Light Source**

**Wavelength Tunable Light Source**

## Broadband Light Source

Tungsten - Halogen (TH)
**ASB-W-003 / 005**
**ASB-W-020**
**ASBN-W-005 / 020**
**ASB-W-030**
**ASBN-W**

Deuterium (D2)
**ASBN-D130 / 230**
Xenon (Xe)
**ASB-XE 175**
IR Emitter (CFIR)
**ASB-IR**

# ASB-W-003 and ASB-W-005

## High Stability Visible Lamp Assembly

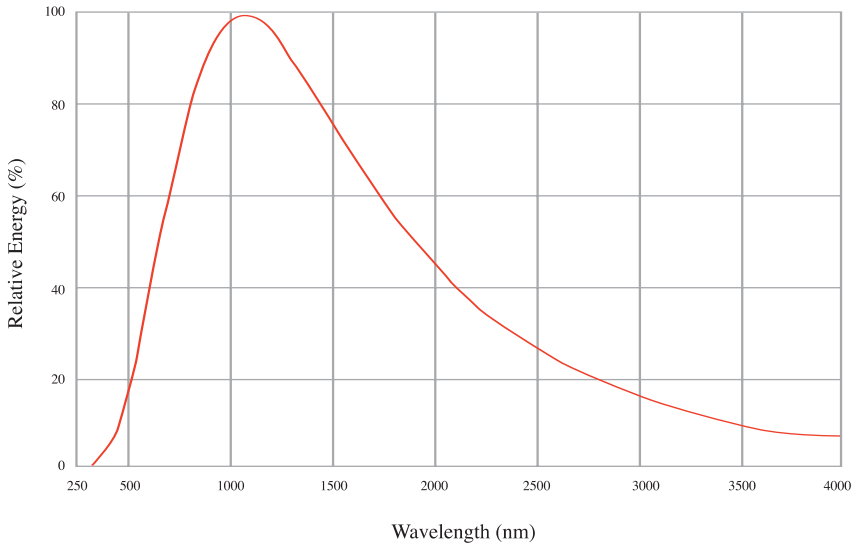
- Provides optimal illumination to fiber optics for remote applications
- Offers excellent color temperature stability
- Use with SP's SM Series spectrometers
- Contains internal current regulation

## Optimum Illumination for SP's SM Series Spectrometers

This lamp is a near Black Body source of light in the visible to near IR spectral region. It has been designed to produce the maximum illumination from a Black Body source into a fiber bundle.

The lamp assembly comes in a 3 watt (ASB-W-003) or a 5 watt (ASB-W-005) tungsten/halogen lamp configuration, an aluminum housing, and a wall transformer as a power supply. The power input is regulated inside the lamp housing to assure a ±0.4% stability over the current range. Current regulation ensures color temperature stability.

The tungsten/halogen lamp used inside the lamp has a nominal color temperature of 2800°K and an average life of 10,000 hours at this color temperature.




Spectral Distrbution of Light Emmitted by Blackbody at 2800°K.

## Specifications :

Lamp : Tungsten-halogen
Powe : Wall transformer, 115 VAC, 50/60 Hz to 12 VDC at 0.8 amps 220 VAC version available
Current Regulation : ± 0.4%
Mean Spherical Candlepower : 3.3
Color Temperature : 2800°K
Bulb Life : 10,000 hrs. average
Housing : Aluminum, convection cooled, 1/4 "-20T in base for post mounting.
Connector : SMA Fiber connector Type 905
Size :
Long 3.8 inches (9.8cm)
High 2.3 inches (5.9cm)
Wide 2.1 inches (5.7cm)
Weight : 11 ozs. (0.3 kgs.)
Options : Specify SM, FC, ST, CL, or CS for specific fiber couplers.

Ordering Information: Please indicate product number plus description when ordering.

ASB-W-003 3 watt Tungsten-halogen Visible Light Assembly
ASB-W-005 5 watt Tungsten-halogen Visible Light Assembly
ASB-W-003B Spare Bulb, 3 watt
ASB-W-005B Spare Bulb, 5 watt

# ASB-W-020

## High Stability Tungsten-Halogen Fiber Light Source

- Offers excellent color temperature stability
- Provides illumination for applications through optical fiber
- Focus adjustable light source SMA and fiber bundle adaptor
- Features built in current regulation

## Optimum Illumination for Your Fiber Optic Needs

The ASB-W-020 is a complete light source assembly with a tungsten-halogen lamp that emits in the 300 to 2500 nanometer (nm) wavelength region. It has been designed to transfer the maximum possible illumination to a variety of fibers. The tungsten-halogen lamp of the ASB-W-020 is a near blackbody source of light with a built-in fused silica lens that focuses the light to the fiber. Figure 1 shows blackbody spectral distributions at various color temperatures in Kelvin (K). The ASB-W-020 spectral distributions resemble those of Figure 1 out to about 2500nm, beyond which the transmission of the fused silica lens limits the output.

In addition to the 20 Watt tungsten-halogen lamp (SP # ASB-W-020B), the ASB-W-020 features a lamp housing and a current regulator to assure a stable output. The housing contains an adjustable lamp mount. A variety of flanges allow the mounting of different fiber terminations, from a single fiber to bundles.

The 20 Watt tungsten-halogen lamp used in the ASB-W-020 has a nominal color temperature of 3100 K and the regulated power input assures an average life of 2000 hours.

The power supply provided with the ASB-W-020 is a wall plug-in type.

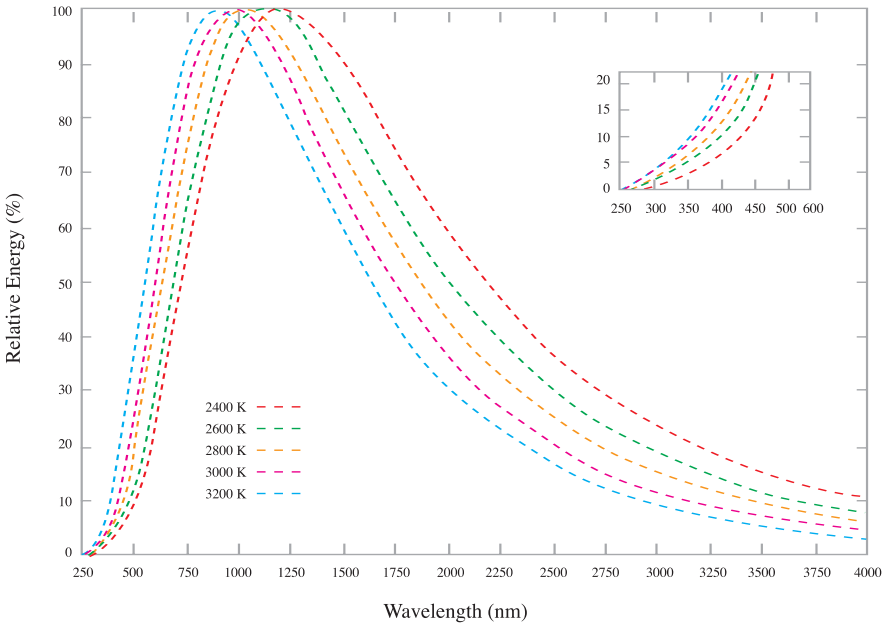



Figure 1. Spectral distribution of light emitted by blackbodies at various color temperatures indicated in Kelvin (K)

## Specifications :

Lamp : Tungsten-halogen
Powe : Wall transformer, 120 VAC, 50/60 Hz to 24 VDC at 2.0 amps.
220 VAC version available
Current Regulation : Built-in, ± 0.4%
Color Temperature : 3100°K
Bulb Life : 2,000 hrs. average (nominal)
Spectral Distribution : Near blackbody (see Figure 1)
Housing : Aluminum, forced air cooled, Limited focus adjustment
Connector : SMA Fiber connector
Options : Spare lamp ASB-W-020B
Mounting flange for 10mm fiber bundle
Optical bench mounts
Specify FC, ST or CS for specific fiber couplers.
Warranty : One year

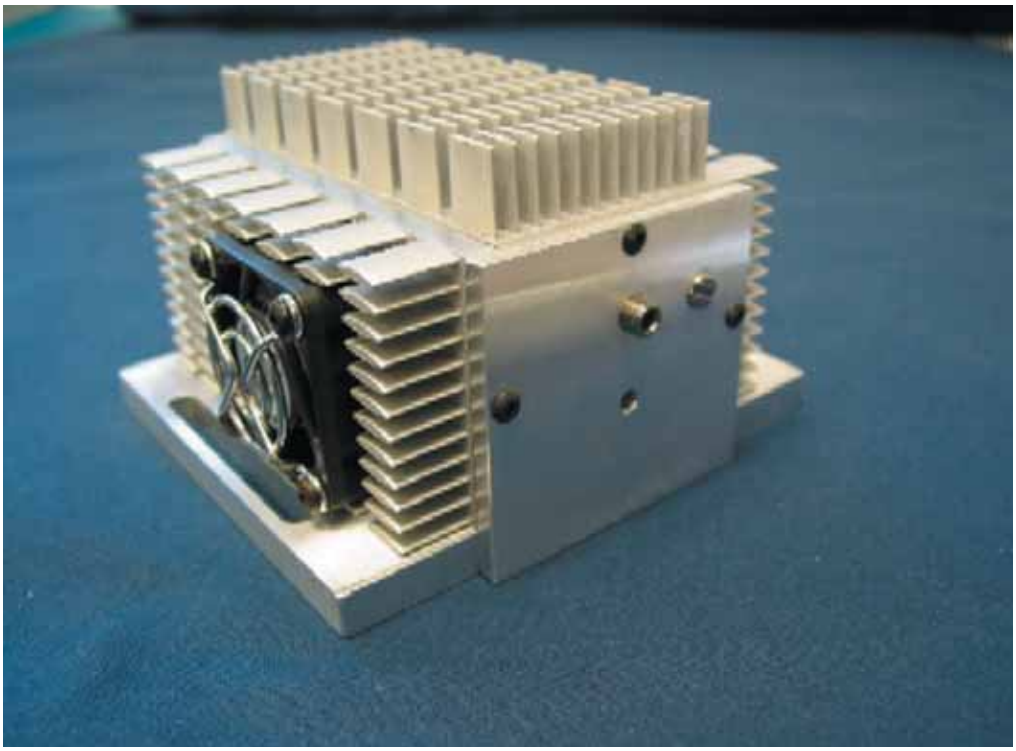
Ordering Information: Please indicate product number plus description when ordering.

ASB-W-020 Visible Source Assembly
ASB-W-020B Spare Lamp, 20 Watt Tungsten-halogen

# ASBN-W-005 and ASB-W-020

## Tungsten-Halogen Source

- Rectangular type heat-sink version of our popular ASB-W line! The ASBN-W-005 has the same characteristics as the ASB-W-005.
- Provides optimal illumination to fiber optics for remote applications
- Offers excellent color temperature stability
- Use with SP's SM Series spectrometers
- Contains internal current regulation



## Optimum Illumination for SP's SM Series Spectrometers

This lamp is a near Black Body source of light in the visible to near IR spectral region. It has been designed to produce the maximum illumination from a Black Body source into a fiber bundle. This light source is ideal for use with SM Series spectrometers.

The lamp assembly comes in a 5 watt (ASBN-W-005) or a 20 watt (ASBN-W-020) tungsten/halogen lamp configuration, an aluminum housing, and a wall transformer as a power supply. The power input is regulated inside the lamp housing to assure a ±0.4% stability over the current range. Current regulation ensures color temperature stability.

The tungsten/halogen lamp used inside the lamp has a nominal color temperature of 2800°K (5W) / 3100°K (20W) and an average life of 10,000 hours (5W) / 2,000 hours (20W) at this color temperature.

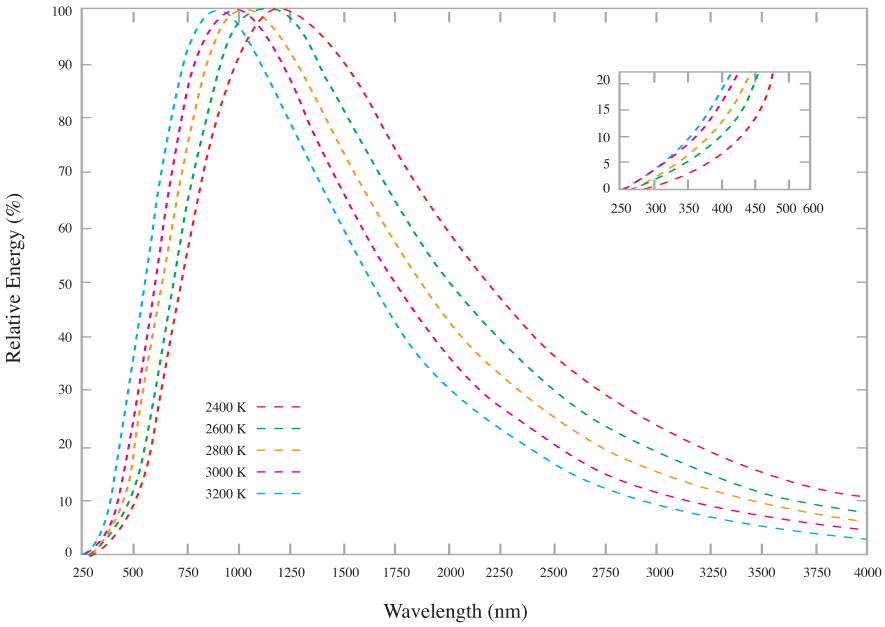



Figure 1. Spectral distribution of light emitted by blackbodies at various color temperatures indicated in Kelvin (K)

## Specifications :

Lamp : Tungsten-halogen
Powe : Wall transformer, 115 VAC, 50/60 Hz to 12 VDC at 0.8 amps
220 VAC version available
Current Regulation : ± 0.4%
Light output : 53 lumens (5W) / 250 lumens (20W)
Color Temperature : 2800°K (5W) / 3100°K (20W)
Bulb Life : 10,000 hrs (5W) / 2,000 hours (20W). average
Housing : Aluminum, convection cooled, 1/4"-20 screw slots on base for surface mounting.
Connector : SMA Fiber connector Type 905
Size : Length 4.25"
Height 2.75"
Width 4.50"
Weight : 11 ozs. (0.3 kgs.)
Options : Specify SM, FC, ST, CL, or CS for specific fiber couplers.

Ordering Information: Please indicate product number plus description when ordering.

| | | |
|---|---|---|
| ASB-W-005 | 5W | Tungsten - halogen Visible Light Assembly |
| ASB-W-020 | 20W | Tungsten - halogen Visible Light Assembly |

# ASB-W-030

## High Stability Tungsten-Halogen Light Source

- Provides optimal illumination to monochromators
- Offers excellent color temperature stability
- Features adjustable constant current power supply
- Contains focusable fused silica lens assembly
- Uses AF Series for remote fiber optic illumination

## Optimum Illumination for Your Monochromator

The ASB-W-030 is a complete light source assembly with a tungsten-halogen lamp that emits in the 300 to 2600 nanometer (nm) wavelength region. It has been designed to transfer the maximum possible illumination from a tungsten-halogen lamp to Digikrom monochromators. The tungsten-halogen lamps of the ASB-W-030 are near blackbody sources of light with fused silica envelopes around the lamp filaments. Figure 1 shows blackbody spectral distributions at various color temperatures in Kelvin (K). The ASB-W-030 spectral distributions resemble those of Figure 1 out to about 2600nm, beyond which the transmission of the fused silica lamp envelope limits the output.

In addition to the 30 Watt tungsten-halogen lamp (SP type ASB-W-030B), the ASB-W-030 features a housing for the lamp and an adjustable constant current power supply. The housing contains a focusable fused silica lens assembly selected for optimum coupling to the monochromator. The focus adjustment also allows for flexible mounting configurations for the ASB-W-030, with output focusing adjustable over a wide range of focal lengths. This also makes the ASB-W-030 an excellent light source for illumination of samples.

The 30 Watt tungsten-halogen lamp used in the ASB-W-030 has a nominal color temperature of 3100 K and an average life of 400 hours at this temperature. The color temperature of the lamp is directly proportional to the lamp current which may be varied ±25% with a control knob on the power supply. Over this range, both illumination and average life will change by approximately ±50%.

The optics of the ASB-W-030, in combination with the 30 Watt lamp, provide maximum illumination for monochromators. Higher power lamps have larger filaments, but no greater brightness per unit area. A filament larger than the 30 Watt size would simply overfill the entrance slit.

The power supply provided with the ASB-W-030 is a DC current regulated power supply. Current regulation optimizes color temperature stability.

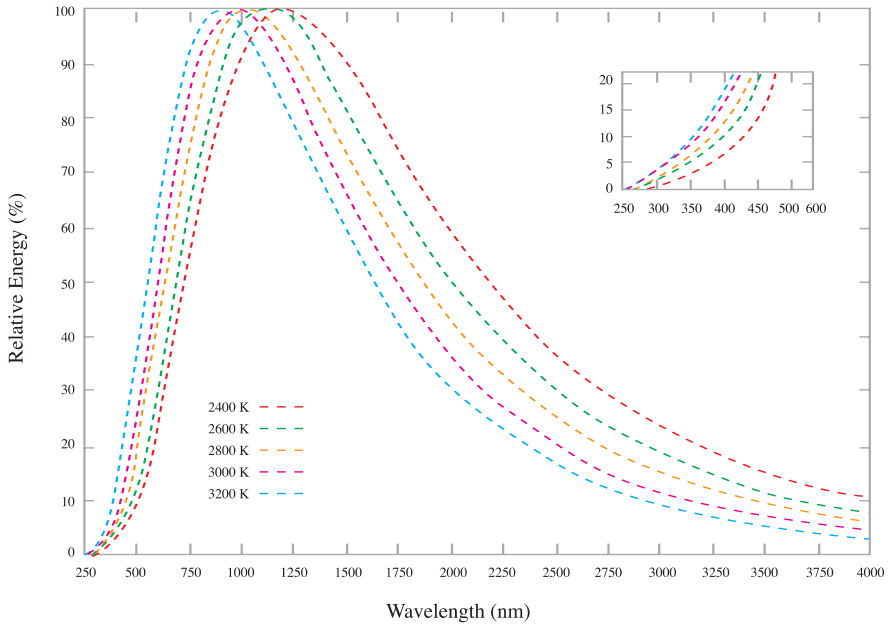



Figure 1. Spectral distribution of light emitted by blackbodies at various color temperatures indicated in Kelvin (K)

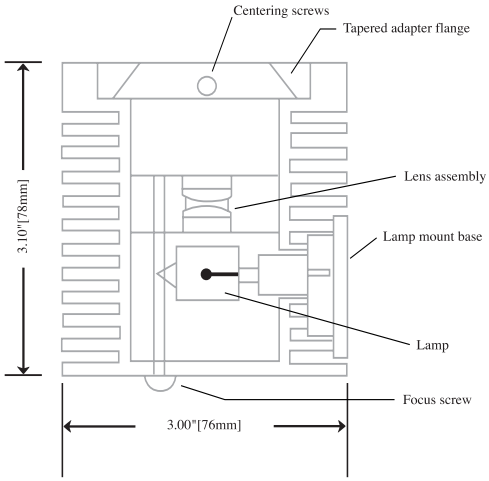



Figure 2. Lamp cross section

## Specifications :

Lamp : Type : Tungsten-halogen
Filament size : 1mm x 4mm
Power input : 30 Watts (nominal)
Light Output : 800 lumens (nominal)
Current : 2.75 amp (nominal)
Color Temperature : 3100°K
Average Life : 400 hours (nominal)

Spectral distribution : near blackbody
Mount : Tapered flange, adjustable, Post mounting for standalone operation
Housing : Air cooled with focusable fused silica doublet collection lens, f/1.9 collection and f/3.9 output. (lamp cross section)
Power Input : 115 VAC, 50/60 Hz, 1 amp (standard)
220 VAC, 50/60 Hz, 0.5 amp (optional)
Power Output :
Type : constant current DC
Range : 2.0 amp to 3.5 amp
Regulation : 0.05%
Warrant : One year
Options : Spare lamp ASB-W-030B
AF Series for remote fiber optic illumination.

An infrasil lens assembly is available by request for better lamp emission at wavelengths beyond 2600nm. Contact the SP sales team if you have special requirements.

Ordering Information: Please indicate product number plus description when ordering.

ASB-W-030 Visible Source Assembl
ASB-W-030B Spare Lamp, 30 Watt Tungsten-halogen

# ASBN-W

## High power Tungsten-Halogen Light Source Series

- Provides optimal illumination to monochromators
- Offers excellent color temperature stability
- Features adjustable constant current power supply
- Contains focusable fused silica lens and UV protected Al coated mirror assembly


## Optimum Illumination for Your Monochromator

The ASBN-W high power tungsten-halogen series are complete light source assemblies with 50W/75W/100W/150W tungsten-halogen lamps that emit in the 300 to 2600 nanometer (nm) wavelength region. They have been designed to transfer the maximum possible illumination from a tungsten-halogen lamp to Digikrom monochromators. The tungsten-halogen lamps of the ASBN-W high power series are near blackbody sources of light with fused silica envelopes around the lamp filaments.

The housing contains a 1" UV grade fused silica lens (f#/1.2) and UV protected Al coated mirror (f = 12.5mm) assembly selected for optimum coupling to the monochromator or the fiber, a regulated power supply and a cooling fan. The power supply provided with the ASB-W-030 is a DC current regulated power supply. Current regulation optimizes color temperature stability.

# Specifications :

Lamp :

| Power input | Light output | Color Temp. | Life Time | Filament size |
|---|---|---|---|---|
| 50W | 900 lumens | 3,000°K | 2,000 hours | 4.2mm X 2.5mm |
| 75W | 1,400 lumens | 3,000°K | 2,000 hours | 5.0mm X 1.6mm |
| 100W-H | 3,000 lumens | 3,400°K | 50 hours | 5.3mm X 3.0mm |
| 100W-L | 2,000 lumens | 3,000°K | 2,000 hours | 5.2mm X 2.3mm |
| 150W | 4,700 lumens | 3,400°K | 50 hours | 6.2mm X 3.1mm |

Housing : Air cooling fan with a regulated power supply, 1" UV grade focusable fused silica collection lens (f#/1.2), 1" UV protected Al coated mirror (f = 12.5mm)

Dimension : 8" X 10" X 5"

Power Input : Input Voltage: 85-264 VAC (110V/220V compatible)

Input Frequency : 47-63Hz

Inrush Current : 30A/100V, 40A/200V

Over-voltage Protection : Clamp, 115-135%

Current Limit : 105-150% typ, Self-reset Fold back

Safety : UL / TUV / CE

Oper. Temp. : 0 to 50°C

Power Output : Type: constant current DC

VDC : 12V (24V for 150W)

Max. Current : 12.5A (8.4A for 150W)

Ripple/Noise (20MHz BW) : 100mV Pk-Pk, typ.

Regulation : ±0.5%, typ.

Warranty : One year

Options :

Spare lamp : ASBN-WB-050/075/100-H/100-L/150

Input power controller : ASBN-W-PT (including voltage indicator)

Needed to be specify the fiber coupling or collimated output

Focusing lens set for monochromator: ASBN-W-FL (1" UV fused silica lens)

Ordering Information: Please indicate product number plus description when ordering.

| | | |
|---|---|---|
| ASBN-W050(F/C) | 50W | High Power Tungsten-halogen |
| ASBN-W075(F/C) | 75W | High Power Tungsten-halogen |
| ASBN-W100(F/C) - (H/L) | 100W | High Power Tungsten-halogen |
| ASBN-W150(F/C) - (H/L) | 150W | High Power Tungsten-halogen |

F : Fiber Coupling C : Collimated

H : High Color Temp. L : Low Color Temp.

# ASBN-D130 / ASBN-230

## deep UV Deuterium Light Source Assembly

- Provides maximum possible illumination
- Contains 1" quartz doublet assembly for optimum coupling
- Assures maximum stability and lifetime of lamp




## Optimum UV Illumination for Fiber Optics

The ASBN-D130/230 is a deep UV ultraviolet deuterium light source for the 180-400nm (max. 160-400nm) region. It has been designed to provide the maximum possible illumination either directly or through an optical fiber.

The ASBN-D130 consists of one 30 watt deep UV deuterium lamp, a housing and a regulated power supply. The housing contains a 1" quartz doublet (f#/1.0, 1X) assembly for maximum possible illumination to the optical fiber.

The ASBN-D230 consists of two 30 watt deep UV deuterium lamps, a housing and two regulated power supplies. The housing contains two 1" quartz doublet (f#/1.0, 1X) assemblies. One is for focusing the second deuterium lamp on the first lamp and the other is for maximum possible illumination to the optical fiber. The first deuterium lamp has a "see-through" hole to allow the light from a secondary source to pass through the same light path as the first one.

The 30 watt deuterium lamp used in the ASBN-D130/230 has an average lifetime of 1,000 hours under regulated conditions. The life end is defined as the time when the UV region radiant intensity falls below 50% of its initial value or when output fluctuation exceeds 0.03%.

The power supply provided with the ASBN-D130/230 is a dc current regulated one. This assures maximum stability and lifetime of the lamp.

# Specifications :

Lamp

Type : Deuterium with fused silica jacket, mounted and pre-aligned.

Power input : 30 Watt (nominal)

Lamp current : 300 ± 30 mA DC

Average Life : 1000 hours (nominal)

Lamp Housing : 1" quartz doublet (f#/1, 1X) collection lens. Convection cooled.

Dimension : 6" X 5" X 10"

Power Supply : Power input:115 vac, 50/60 Hz, 3 amps. 230 vac, 50/60 Hz, 1 amp, optional

Power output : Constant current dc, 60-120vdc selectable, 300 mA DC

Regulation : + 10 mA

Stability : 100 ppm/°C

Operating Temperature : 5-35°C

Warranty : One year

Options : Spare lamp (mounted and pre-aligned), Specify SM, FC, ST, CL, or CS for specific fiber couplers.

Ordering Information: Please indicate product number plus description when ordering.

ASBN-D130-(F/M) Single deep UV Deuterium
ASBN-D230-(F/M) Double deep UV Deuterium

F : Fiber Coupling
M : Monochromator f/# matching

# ASB-XE-175

## Xenon Fiber Optic Light Source

- Provides optimum illumination to fiber optics for remote applications
- High intensity (5600°K) Xenon output
- Contains CERMAX® high intensity xenon lamp

### FEATURES :

- High Color Temperature (5600°K)
- CERMAX® Collimated
- Xenon Lamp
- Brightness Control (0 - 100%)
- Portable and Light Weight

### APPLICATIONS:

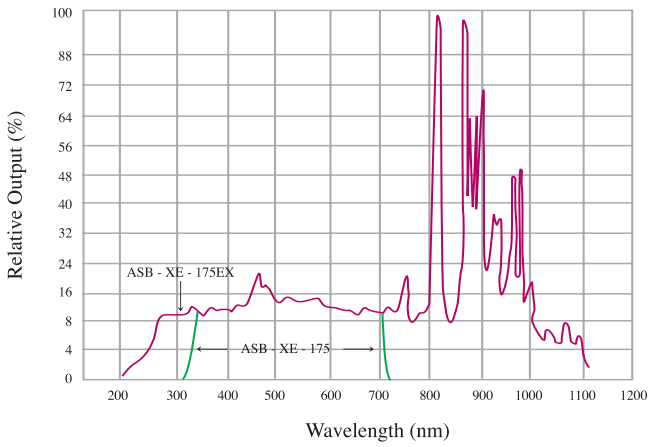
- Endoscopy
- Spectroscopy
- Microscopy
- Visual Inspection
- Boroscopes
- Machine Vision
- Optical Scanning
- Data and Video Projection

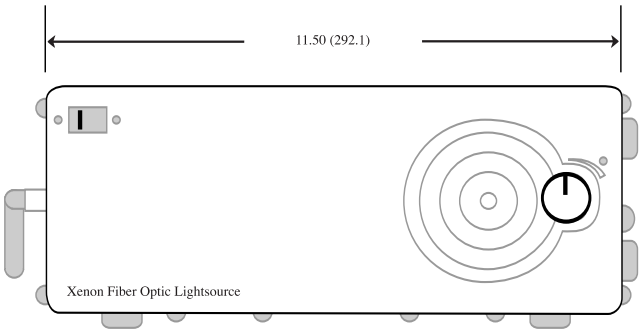

## Optimum Remote or Direct Illumination

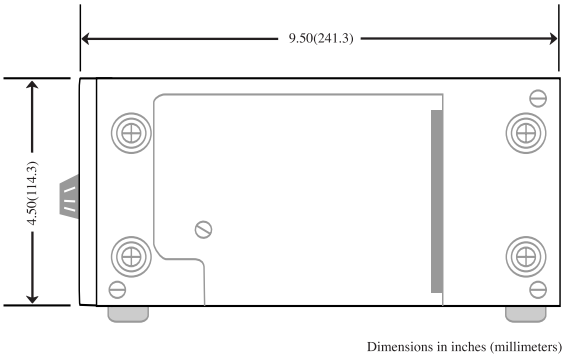
The ASB-XE-175 is a compact and light weight high intensity fiber optic light source. It is especially suitable as a light source for spectroscopy, microscopy, optical scanning, medical and industrial uses, as well as for use with SP's popular Digikrom monochromators and spectrographs.

The ASB-XE-175 uses a CERMAX® compact high intensity xenon lamp, state of the art optics and a high efficiency lightweight switching power supply in one compact package.

The 175W short-arc xenon lamp provides broadband output from 200 to 2200nm (dominantly, from 250 to 1100nm). This lamp is compact, rugged, and easily focused to a liquid light guide (sold separately). The lamp efficiency is enhanced by the integral parabolic reflector which provides precision system alignment and maximum transition of light energy. Beam stability is achieved instantly following lamp ignition and the ASB-XE-175 provides instant re-ignition without an imposed time delay.




Dimensions in inches (millimeters)

# Specifications :

Lamp
- Type : CERMAX® LX175F
- Powe : 200 Watts (maximum)
- Power Range : 150-200 W
- Color Temperature : 5600°K
- Current : 14 amps DC (nominal)
- Average Life : Typically 1000 hours (500 hours minimum)
- Voltage : 12-17V (14V nominal)
- Trigger Voltage : 25 Kilovolts
- Boost Voltage : 140-200 Volts
- Current Leakage : < 300mA
- ASB-XE-175-EX : UV extended, 200nm ~ 2200nm (dominant, 250nm ~ 1100nm)
- ASB-XE-175 : Ozone blocking, 320nm ~ 700nm
- ASB-XE-175-BFEX : NIR extended, Ozone blocking, 320nm ~ 2200nm (dominant, 320nm ~ 1100nm)

Weight : 7.5 lbs. (3.4 kg)

Input Line : 95-136 VAC, 50/60 Hz (only)

Input Current : 3.5 amp.

Environment
- Operating : +6 to +45°C
- Storage : -40 to +70°C

Front Panel : Brightness Control (0-100%) Output Aperture

Side Panel : Main Power (On/Off)
Line Cord Jack (IEC 320)
(US to IEC Line Cord included)
Fuse Holder - MDL-5

Caution : Damage to glass or fused silica fiber optic lightguides can occur due to high temperatures associated with Xenon lamps. Use our liquid light guides (order separately).

Ordering Information: Please indicate product number plus description when ordering.

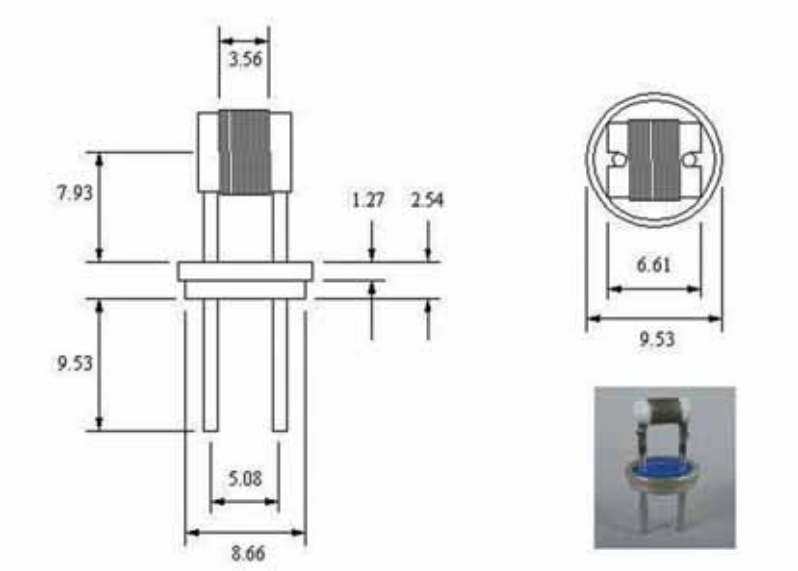
| | |
|---|---|
| ASB-XE-175EX | Extended Xenon Source (200-2200nm) |
| ASB-XE-175 | Ozone Blocking Xenon Source (320-700nm) |
| ASB-XE-175-BFEX | NIR extended, Ozen Blocking Xenon Sourie (320-2200nm) |
| ASB-XE-175BUV | Replacement Extended bulb |
| ASB-XE-175BF | Replacement Ozone Blocking bulb |
| AF5000-50001111-S10S | Liquid Light Guide (270-720nm) S Type |
| AF5000-50001111-V10S | Liquid Light Guide (340-750nm) V Type |

Please see the AF series section in this catalog for more details about Liquid Light Guides and other Fiber Assemblies.

# ASB-IR-12R/K

## Coiled filament IR Emitter

- Supported, Coil-Wound
- Rugged and Reliable
- ASB-IR-12R operates at 800°C when powered with 8 watts
- ASB-IR-12K operates at 975°C when powered with 11 watts




The coiled filament operates at approximately 800°C when powered with 8 watts for the ASB-IR-12R and 975°C when powered with 11 watts for the ASB-IR-12K. The radiating element is a coil of resistance wire which has a high emissivity in the Infrared spectral region. The coil is supported on a grooved cylindrical substrate of alumina, resulting in the windings being electrically insulated from each other. This contributes to a more uniform radiating source. The unit does not require operation in a sealed atmosphere. The header is fabricated from cold-rolled steel. The support pins are hermetically sealed in glass. Please click the right picture to view the detail dimension of the ASB-IR-12 series.

| Part Number | ASB-IR-12R | ASB-IR-12K |
|---|---|---|
| Voltage | 4.5 V (AC or DC) | 6.0 V (AC or DC) |
| Temperature | 800°C | 975°C |
| Current | 1.8 A | 1.8 A |
| Power | 8.0 W | 11.0 W |
| Life Time | 3+ years at 825°C typical | 3+ years at 975°C typical |
| Emissivity | 0.80 | 0.80 |
| Active area | 3.5mm X 3.5mm | 3.5mm X 3.5mm |

Ordering Information: Please indicate product number plus description when ordering.

ASB-IR-12R 8W Coiled filament IR emitter
ASB-IR-12K 11W Coiled filament IR emitter

## Hybrid Light Source

Miniature Deuterium & Tungsten - Halogen
**ASB-DW-MINI**

Dual Deuterium & Tungsten - Halogen
**ASB-D2**

Single Deuterium & Tungsten - Halogen
**ASB-D1-W**

# Miniature hybrid light source

- Small size
- Low power consumption (6W)
- Low heat generation
- Easy coupling to optical fibers, measuring cells and capillaries
- Long life time
- Robust mode of operation


## Optimum Illumination for SP's SM Series Spectrometers

The ASBN-DW-MINI is a miniature UV-VIS light source a continuous spectrum covering the whole range from deep UV to near Infrared ( spectrum curve ). This light source was developed in response to customer requests for a small UV-Light source with negligible heat generation. The features of this light source open the way for new solutions in small spectroscopy equipment and UV optics. Features are small size low power consumption (6 W) low heat generation easy coupling to optical fibers, measuring cells and capillaries lifetime up to 3 years robust mode of operation.

The ASBN-DW-MINI incorporates a miniature Deuterium Lamp ? an electrode-less high frequency excited gas discharge lamp. The Deuterium Lamp features small size, 3Watt power consumption, and negligible heat generation. It is a complete UV-VIS light source with a shine-through design deuterium lamp, a 0.25 Watt tungsten lamp, shutter, optical system and SMA 905 connector or collimating output les set. All elements are mounted on a printed circuit board driven by an external 12 Vdc/600 mA power supply. Both lamps and the shutter can be controlled by a TTL signal.

## Specifications :

Lamp : 3W Deuterium, 185-400nm
0.25W Tungsten-halogen, 400-1100nm
Power : Approx. 6W.
12Vdc/0.6Adc
Relative Humidity : Max. 90%, non-condensing
Ambient Temperature : 5 - 35°C
Shutter : Lamp off/dark current measurement, TTL controlled
Functions : Deuterium and tungsten-halogen lamp can be triggered separately by a TTL signal
Bulb Lifetime : Deuterium: >1,000 hours (50% intensity loss)
Tungsten : >2,000 hours
Connector : SMA 905 Fiber connector or collimated output

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| ASB-DW-MINI | Miniature Deuterium & Tungsten - Halogen Light Source |

# Single deuterium and tungsten-halogen hybrid light source

ASBN-D1-W series, single deuterium and Tungsten-halogen hybrid light source consists of one 30W deep UV deuterium lampand a high power tungsten-halogen lamp. The specially designed "see-through" deuterium lamp can allow the light from a secondary source to pass through the same light path as the deuterium lamp. SP uses a proper focusing/collimating doublet lens set to obtain maximum optical power of the secondary light source (Tungsten-halogen) through the small "see-thgough" hole.

| | |
|---|---|
| ASBN-D1-W050F | 30W deep UV Deuterium lamp and 50W Tungsten-Halogen (3000°K /2000hours / 900 lumens) light source, 180nm ~ 2.6 μm. |
| ASBN-D1-W050M | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W075F | 30W deep UV Deuterium lamp and 75W Tungsten-Halogen (3000°K / 2000hours / 1400 lumens) light source, 180nm ~ 2.6 μm. |
| ASBN-D1-W075M | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W100F-H<br>ASBN-D1-W100M-L | 30W deep UV Deuterium lamp and 100W Tungsten-Halogen light source, 180nm ~ 2.6 μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH. |
| ASBN-D1-W100M-H<br>ASBN-D1-W100M-L | w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 3000 lumens)<br>L: Low color temperature (3000°K / 2000 hours / 2000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D1-W150F | 30W deep UV Deuterium lamp and 150W Tungsten-Halogen (3400°K / 50 hours / 4700 lumens) light source, 180nm ~ 2.6 μm. |
| ASBN-D1-W150M | w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |

# Dual deuterium and tungsten-halogen hybrid light source

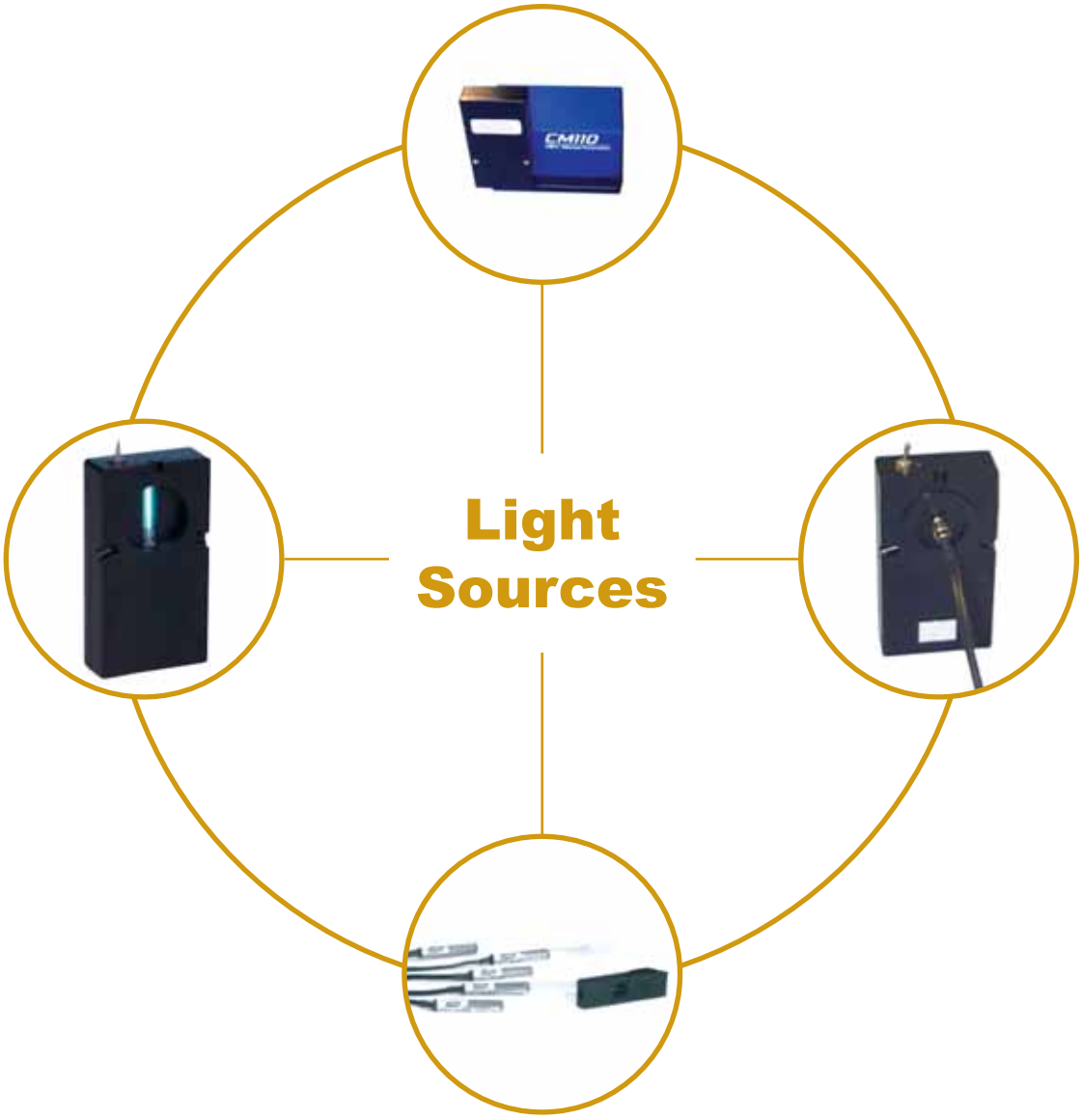
ASBN-D2-W series, dual deuteriums and Tungsten-halogen hybrid light source consists of two 30W deep UV deuterium lamps and a high power tungsten-halogen lamp. The specially designed "see-through" deuterium lamp can allow the light from secondary sources to pass through the same light path as the deuterium lamp. SP uses proper focusing/collimating doublet lens sets to obtain maximum optical power of the secondary light sources through the small "see-thgough" holes.
Generally, the optical power of deuterium is lower than that of tungsten-halogen. In some special applications that need high power UV light, these light sources will be useful.

| | |
|---|---|
| ASBN-D2-W050F<br><br>ASBN-D2-W050M | Two 30W deep UV Deuterium lamps and 50W Tungsten-Halogen (3000°K / 2000 hours / 900 lumens) light source, 180nm ~ 2.6 μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W075F<br><br>ASBN-D2-W075M | Two 30W deep UV Deuterium lamps and 75W Tungsten-Halogen (3000°K / 2000 hours / 1400 lumens) light source, 180nm ~ 2.6 μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W100F-H<br>ASBN-D2-W100F-L<br>ASBN-D2-W100M-H<br>ASBN-D2-W100M-L | Two 30W deep UV Deuterium lamps and 100W Tungsten-Halogen lightsource, 180nm ~ 2.6 μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>H: High color temperature (3400°K / 50 hours / 3000 lumens)<br>L: Low color temperature (3000°K / 2000 hours / 2000 lumens)<br>F: fiber coupling,<br>M: monochromator f# matching. |
| ASBN-D2-W150F<br><br>ASBN-D2-W150M | Two 30W deep UV Deuterium lamps and 150W Tungsten-Halogen (3400°K / 50 hours / 4700 lumens) light source, 180nm ~ 2.6 μm.<br>w/ 1" UV fused silica doublet & UV protected mirror for focusing TH.<br>w/ 1" UV fused silica doublet for focusing the 2nd deuterium lamp.<br>w/ 1" UV fused silica doublet for optimal fiber coupling/monochromator f# matching<br>w/ regulated power supplies.<br>F: fiber coupling,<br>M: monochromator f# matching. |

## Calibration Light Source

Portable Wavelength Calibration Source
**ASC-DC**

Spectral Calibration Lamps and Assemblies
**ASC Series**



# ASC-DC

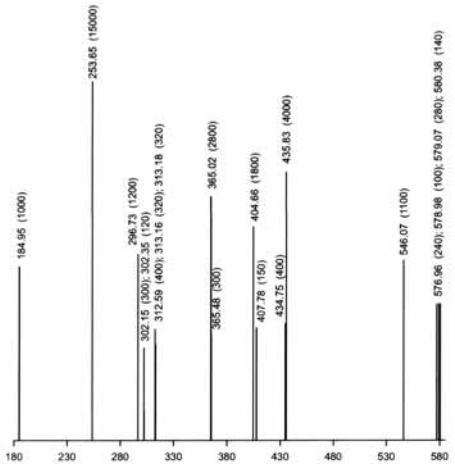
## Portable Wavelength Calibration Source

- Argon enhanced Mercury portable calibration lamp
- Highly repeatable wavelength, linewidth, and intensity calibration standard
- Easily mounts to SP monochromaters and spectrographs
- Couples to SP AF Series coupler for fiber optic output
- Convenient Battery with AC adapter for use in the field


The atomic emission of the ASC Series lamps consists of discrete spectral lines of defined wavelength, spectral width, and relative intensity. Their stability makes them extremely useful for calibration, alignment, and resolution testing of spectrophotometric instrumentation, including monochromators, spectrographs, spectrophotometers, and detectors. Portable battery operation for field use. Rechargable.

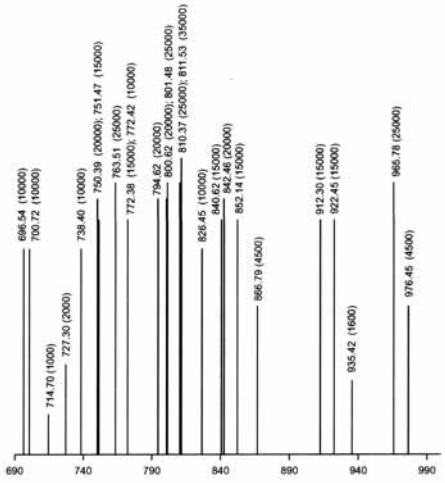
| Lamp | Application |
|---|---|
| Mercury | Strong lines throughout UV-VIS |
| Argon | Lines between 700-1000nm; lines with 1nm spacing for resolution testing |

Hg Spectral Calibration Data




Wavelength (nm)

Ar Spectral Calibration Data




Wavelength (nm)

## Specifications :

Lamp : Atomic emmission lamps with double bore fused silica tubing
Housing : Black anodized Aluminum
Dimensions : 4.125" x 1.25" x 0.875" (HxWxD)
AC Power : Wall transformer, 120 VAC, 50/60 Hz to 9 VDC
Battery : 9 V
Battery Life : 25-45 minutes On-time
Options : AF Series fiber optic couplers

Ordering Information: Please indicate product number plus description when ordering.

| | |
|---|---|
| ASC-HGAR-DC | Argon enhanced Mercury Spectral Calibration Lamp |

# ASC Series

## Spectral Calibration Lamps and Assemblies

- Accommodates compact pencil-style calibration lamps. Offering various lamp selections.
- Provides highly repeatable wavelength, linewidth, and intensity calibration standards.
- Allows quick-on/quick-off instrument mounting. Features post mount for optical bench.
- Five elemental emitters - Hg, Ne, Xe, Ar, and Kr.

## A Complete Spectral-Line Source

The ASC Series spectral calibration lamp and lamp assembly constitute a complete spectral-line source. The AS260 lamp assembly consists of a power supply and lamp housing for the AS Series calibration line-source lamps.

As a reference standard, the atomic emission of the AS Series lamps consists of discrete spectral lines of defined wavelength, spectral width and relative intensity. The stability makes them extremely useful for calibration, alignment, and resolution testing of spectrophotometric instrumentation, including monochromators, spectrographs, spectrophotometers and detectors.

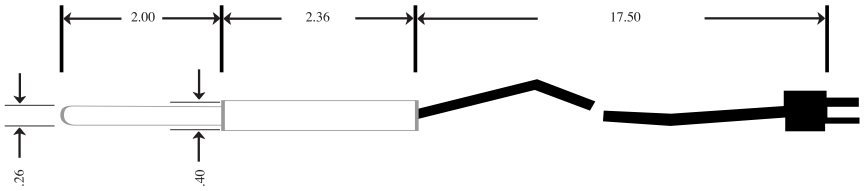
Five different calibration lamps are available: Mercury (Hg); Neon (Ne); Argon (Ar); Krypton (Kr); and Xenon (Xe). The Mercury lamp has strong spectral lines throughout the UV-VIS region.

The Neon lamp has a large number of lines of mid to high intensity in the 800nm to 3400nm range, which makes it useful for resolution testing in the NIR region . There are also a number of closely spaced lines of similiar intensity over this wavelength range.

The Xenon lamp's distribution of lines of moderate intensity between 800nm and 3500nm is useful for calibration in the IR. These emission lines are relatively close to wavelengths used by fiber optic communication systems for data transfer. Testing of fibers and detectors for these systems can be performed without the inherent high cost of lasers for light sources.

The Argon line spectrum features a number of lines of consistent high intensity between 700nm and 1000nm. These lines at such a high intensity are excellent for calibration in that region. There are also several lines spaced less than 1 nm apart that can be used for resolution testing.

AS Series Lamps

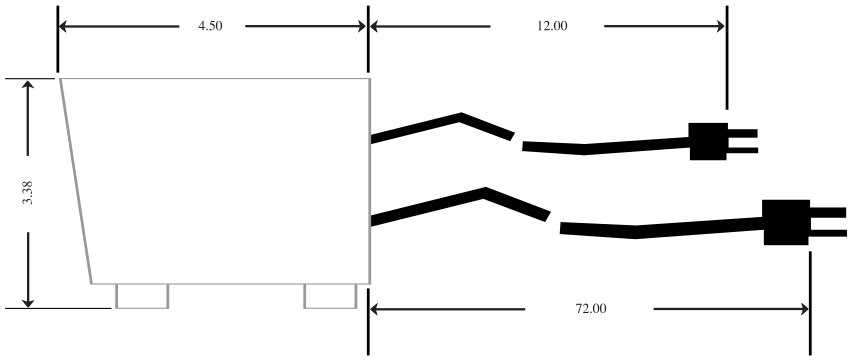



Dimensions in inches

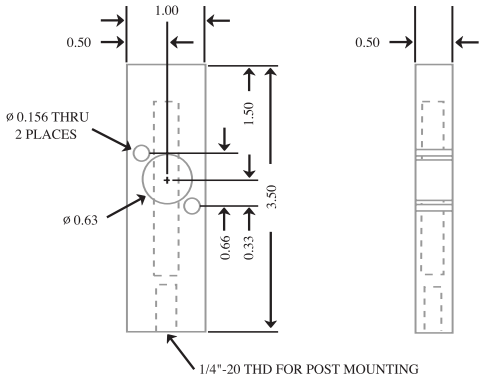
Note : These lamps produce intense ultra-violet radiation and require that appropriate precautions be taken when used. Avoid prolonged exposure of eyes or skin to the lamps' rays.

AS Series Power Supply

Width - 6.13




AS Series Lamp Holder




Note: Output cord has a polarized cap, the large pin receptacle is ground. DO NOT use power supply from unground mains. The transformer used in the AS260 Power Supply is manufactured to NEMA standards for Class A transformer operation.

## Specifications :

Package : Sealed double bore fused silica tubing. tubing
Warmup : 2-4 minutes
Lamp Lifetime : 5000 hours (500 hours for Neon)
Power Supply : 110 to 230 VAC, 50/60 Hz
Line Cord : 6 ft. (1.83m), 3-wire ground type SJ
Output Connection : 16 ”(40.6 cm) cord with polarized female connectors
Output Voltage : 1600V rms, +10%, -0%
Output Current : 0.018 Amp, +10%, -0%
Max Ambient Temperture : 35°C
Min Ambient Temperature : 15°C
Options : AF2 Series Fiber Optic Couplers.

Ordering Information : Please indicate product number plus description when ordering.

| | |
|---|---|
| ASC-AC | Spectral Calibration Lamp Assembly Includes power supply and lamp housing |
| ASC-HG | Mercury (Hg) Spectral Calibration Lamp |
| ASC-NE | Neon (Ne) Spectral Calibration Lamp |
| ASC-XE | Xenon (Xe) Spectral Calibration Lamp |
| ASC-AR | Argon (Ar) Spectral Calibration Lamp |
| ASC-KR | Krypton (Kr) Spectral Calibration Lamp |

# ASC Series

## Calibration Lamp Spectral Data

### Mercury (Hg) - ASC-HG

| Wavelength Å | Relative Intensity |
|---|---|
| 1849.50 | 1000 |
| 2536.52 | 15000 |
| 2967.28 | 1200 |
| 3650.15 | 2800 |
| 3654.84 | 300 |
| 4046.56 | 1800 |
| 4347.49 | 400 |
| 4358.33 | 4000 |
| 5460.74 | 1100 |
| 10139.75 | 2000 |

### Neon (Ne) - ASC-NE

| Wavelength Å | Relative Intensity |
|---|---|
| 7936.996 | 700 |
| 7943.181 | 2000 |
| 8082.458 | 2000 |
| 8118.549 | 1000 |
| 8128.911 | 600 |
| 8136.406 | 3000 |
| 8259.379 | 2500 |
| 8266.077 | 2500 |
| 8267.117 | 800 |
| 8300.326 | 6000 |
| 8365.749 | 1500 |
| 8377.606 | 8000 |
| 8417.159 | 1000 |
| 8418.427 | 4000 |
| 8463.358 | 1500 |
| 8495.360 | 5000 |
| 8571.352 | 1000 |
| 8591.259 | 4000 |
| 8634.647 | 6000 |
| 8647.041 | 3000 |
| 8654.383 | 15000 |

### Neon (Ne) - ASC-NE *continued*

| Wavelength Å | Relative Intensity |
|---|---|
| 8655.522 | 4000 |
| 8679.492 | 5000 |
| 8681.921 | 5000 |
| 8704.112 | 2000 |
| 8771.656 | 4000 |
| 8780.621 | 12000 |
| 8783.753 | 10000 |
| 8853.867 | 7000 |
| 8865.306 | 1000 |
| 8865.755 | 1000 |
| 8919.501 | 3000 |
| 8988.57 | 2000 |
| 9148.67 | 6000 |
| 9201.76 | 6000 |
| 9220.06 | 4000 |
| 9221.58 | 2000 |
| 9226.69 | 2000 |
| 9275.52 | 1000 |
| 9300.85 | 6000 |
| 9310.58 | 1500 |
| 9313.97 | 3000 |
| 9326.51 | 6000 |
| 9373.31 | 2000 |
| 9425.38 | 5000 |
| 9459.21 | 3000 |
| 9486.68 | 5000 |
| 9534.16 | 5000 |
| 9547.40 | 3000 |
| 9665.42 | 1000 |
| 10562.41 | 2000 |
| 10798.07 | 1500 |
| 10844.48 | 2000 |
| 11143.020 | 3000 |
| 11177.528 | 3500 |
| 11390.434 | 1600 |
| 11409.134 | 1100 |

### Neon (Ne) - ASC-NE *continued*

| Wavelength Å | Relative Intensity |
|---|---|
| 11522.746 | 3000 |
| 11525.020 | 1500 |
| 11536.344 | 950 |
| 11614.081 | 1200 |
| 11766.792 | 2000 |
| 11789.044 | 1500 |
| 11789.889 | 500 |
| 11984.912 | 1000 |
| 12066.334 | 3000 |
| 12689.201 | 1000 |
| 12912.014 | 1100 |
| 18083.21 | 1000 |
| 18276.68 | 2500 |
| 18282.62 | 2000 |
| 18303.97 | 1200 |
| 18384.85 | 1200 |
| 18389.95 | 2000 |
| 18402.84 | 1000 |
| 18422.39 | 1200 |
| 18591.55 | 900 |
| 18597.70 | 1600 |
| 21041.295 | 1200 |
| 22530.40 | 2250 |
| 23260.30 | 1000 |
| 23373.00 | 1050 |
| 23636.52 | 3500 |
| 23709.2 | 1100 |
| 23951.42 | 1800 |
| 23956.46 | 600 |
| 23978.12 | 1000 |
| 24365.05 | 1500 |
| 24371.60 | 800 |
| 33901.00 | 1300 |
| 33912.10 | 2200 |

# ASC Series

## Calibration Lamp Spectral Data

| Xenon (Xe) — ASC-XE | | Argon (Ar) — ASC-AR | | Krypton (Kr) — ASC-KR | |
|---|---|---|---|---|---|
| Wavelength Å | Relative Intensity | Wavelength Å | Relative Intensity | Wavelength Å | Relative Intensity |
| 8231.635 | 10000 | 6965.431 | 10000 | 4273.969 | 1000 |
| 8266.52 | 500 | 7067.218 | 10000 | 4318.551 | 400 |
| 8280.116 | 7000 | 7068.736 | 100 | 4319.579 | 1000 |
| 8346.82 | 2000 | 7147.042 | 1000 | 5570.288 | 2000 |
| 8409.19 | 2000 | 7272.936 | 2000 | 5870.914 | 3000 |
| 8819.41 | 5000 | 7383.980 | 10000 | 7587.411 | 1000 |
| 8952.25 | 1000 | 7503.869 | 20000 | 7601.544 | 2000 |
| 9799.70 | 2000 | 7514.652 | 15000 | 7685.244 | 1000 |
| 9923.19 | 3000 | 7635.106 | 25000 | 7694.538 | 1200 |
| 12623.391 | 2500 | 7723.761 | 15000 | 8059.503 | 1500 |
| 13657.055 | 2000 | 7724.207 | 10000 | 8104.364 | 4000 |
| 14142.444 | 1250 | 7948.176 | 20000 | 8112.899 | 6000 |
| 14732.806 | 3000 | 8006.157 | 20000 | 8190.054 | 3000 |
| 15418.394 | 2500 | 8014.786 | 25000 | 8263.240 | 3000 |
| 16053.28 | 1000 | 8103.693 | 20000 | 8281.050 | 1500 |
| 16728.15 | 1500 | 8115.311 | 35000 | 8298.107 | 5000 |
| 17325.77 | 1500 | 8264.522 | 10000 | 8508.870 | 3000 |
| 20262.242 | 3000 | 8408.210 | 15000 | 8776.748 | 6000 |
| 23193.33 | 1250 | 8424.648 | 20000 | 8928.692 | 2000 |
| 24824.71 | 1800 | 8521.442 | 15000 | 9751.758 | 2000 |
| 30475.46 | 1500 | 8667.944 | 4500 | 11819.377 | 1500 |
| 31069.23 | 6000 | 9122.967 | 35000 | 13177.412 | 1100 |
| 32739.26 | 1800 | 9224.499 | 15000 | 13622.415 | 1000 |
| 33666.69 | 3500 | 9354.220 | 1600 | 13634.220 | 2400 |
| 35070.25 | 5000 | 9657.786 | 25000 | 14426.793 | 2000 |
| | | 9784.503 | 4500 | 14734.436 | 1600 |
| | | 10470.054 | 1600 | 14762.672 | 550 |
| | | 13313.210 | 1000 | 14765.472 | 450 |
| | | 13367.111 | 1000 | 15239.615 | 1700 |
| | | 13504.191 | 1000 | 15334.958 | 1500 |
| | | 13718.577 | 1000 | 15372.037 | 700 |
| | | | | 16785.128 | 2000 |
| | | | | 16853.488 | 1000 |
| | | | | 16890.441 | 2400 |
| | | | | 16896.753 | 1600 |
| | | | | 16935.806 | 1800 |
| | | | | 18167.315 | 2600 |
| | | | | 21902.513 | 1800 |

## Uniform & Diffused Light Source

Integrating Sphere with TH
**AT-IS-1.5**

Diffused Light Source
**ASD-X**

# AT-IS-1.5

## Integrating Sphere w/Built-in Tungsten Light Source

- 1.5" Integrating Sphere combined with an 5W regulated Tungsten Halogen Light Source
- Detector Port with SMA interface
- 1/2" Full Size Port

Designed for color applications, this compact 1.5" integration sphere and light source can also be used as a low cost diffuse (uniform) light source. Standard unit includes SMA detector port connection and detector collection optic. 1/2" Full Size Port can be place aganist surface to be analyzed; small objects can also be inserted for analysis.

Detector port can also be directly interfaced to Spectral Products SM200 and SM241 spectrometers

Ordering Information: Please indicate product number plus description when ordering.

AT-IS-1.5 1.5”Uniform Light Source

# ASD-X

## Diffused Light Sources

New for 2003, diffused (uniform) light sources from monochromatic LED sources and traditional sources (Tungsten-Halogen, Halide, Xe). Please call the design engineer for this product at (877)928-5834x13 with your requirements!

Currently available configurations:

- Monochrmatic 1mW to 5mW output from 370nm to 1000nm (~30 different wavelengths available); bandwidth of 25nm to 35nm. Narrow bandwidths 10, 5, 1, and .5nm available.
- 5, 20, 30 and 150 Watt Tungsten-Halogen
- 100 Watt Halide
- 175 Watt Xenon

Ordering Information: Please indicate product number plus description when ordering.

ASD-X Diffused Light Source

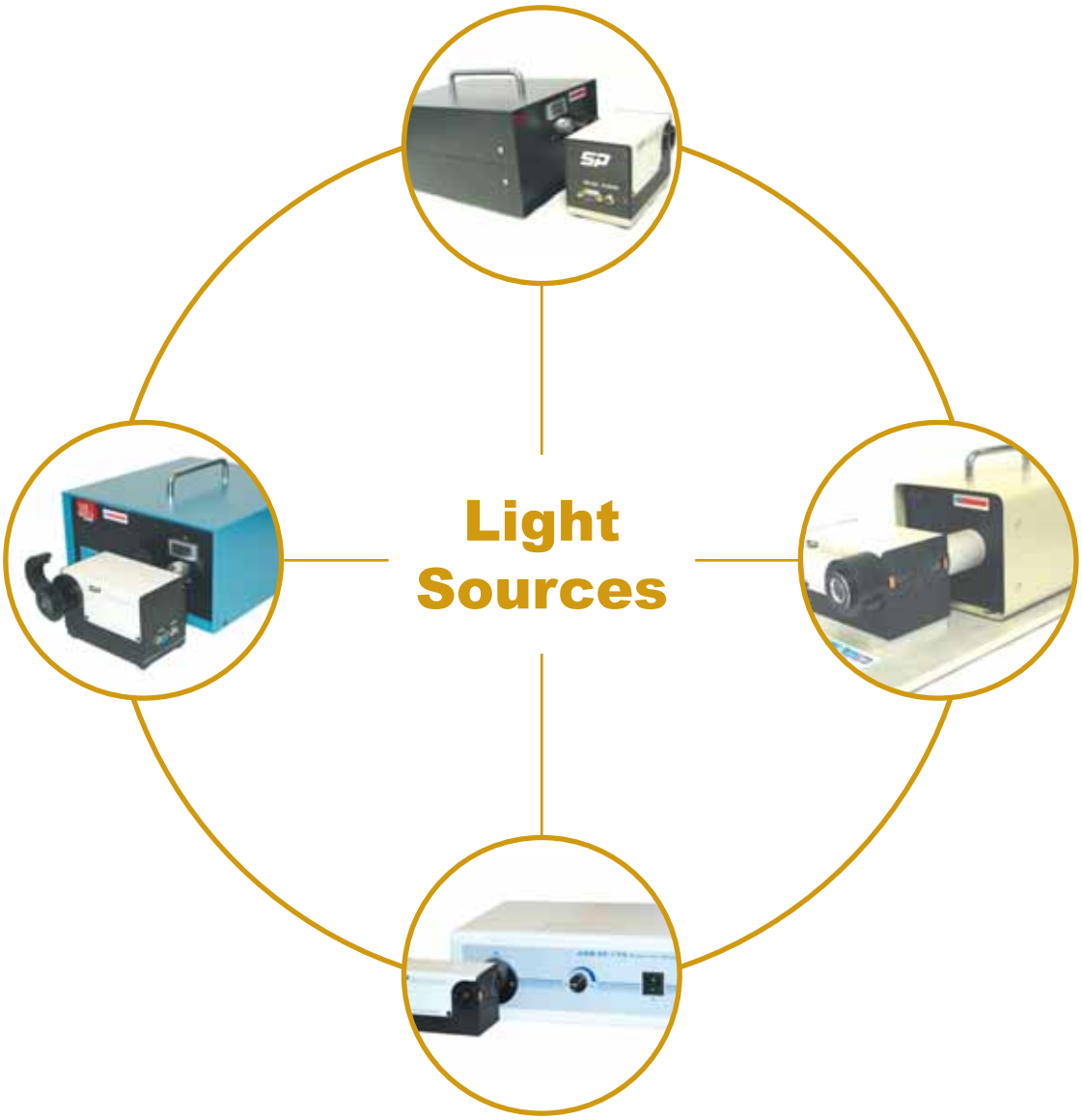
## Wavelength Light Source

Tungsten - Halogen Based
**AST-W**

Deuterium Based
**AST-D**

175W Xenon Based
**AST-XE**

Deuterium & Tungsten - Halogen Hybrid Based
**ASTN-D1 / D2**



# Wavelength Tunable Light Sources

- Computer controlled via standard RS232 interface.
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV.
- May be configured for optimal fiber optic illumination.
- 4 models for UV, VIS, and IR. Modular design allows for reconfiguring.
- Couples to SP Spectral Products equipment.

## 1.Tungsten-Halogen Based

- Variable narrowband light output selection from Near UV (300nm) to Near IR (2.6 μm)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment


## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' high power tungsten-halogen light sources.

## Models

AST-W-030 : 30W tungsten-halogen model.
ASTN-W-050 : 50W tungsten-halogen model.
ASTN-W-075 : 75W tungsten-halogen model.
ASTN-W-100-L : 100W low color temperature tungsten-halogen model.
ASTN-W-100-H : 100W high color temperature tungsten-halogen model.
ASTN-W-150 : 150W tungsten-halogen model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings )<br>Interface : RS232 standard |
| Light Source | Model : ASB-W-030/ASBN-W050/075/100-L/100-H/150<br>Power : 30/50/75/100/150 Watts<br>Bulb Light Power : 800 ~ 4,700 lumens<br>Bulb Life : 50 ~ 2,000 hours.<br>Bulb Color Temp. : 3,000°K ~ 3,400°K |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 2.Deuterium Based

- Variable narrowband light output selection in UV range (180nm - 400m)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment

## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' deep UV 30W deuterium light sources.

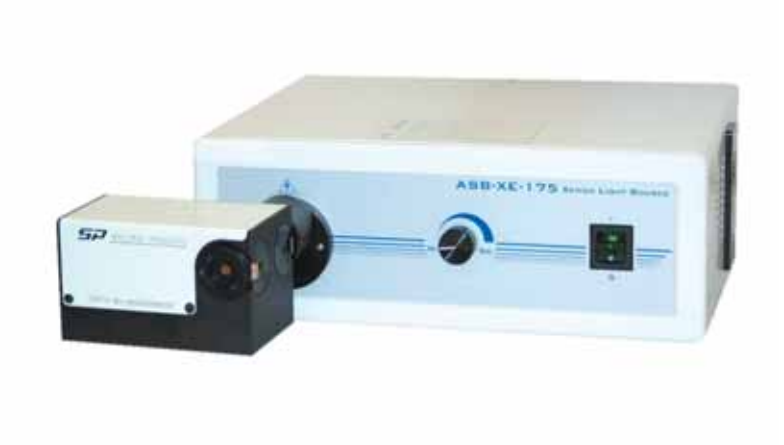
## Models

AST-D-030 : 30W deep UV deuterium model (conventional).
ASTN-D130 : One 30W deep UV deuterium model.
ASTN-D230 : Two 30W deep UV deuterium model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings )<br>Interface : RS232 standard |
| Light Source | Model : ASBN-D130/230<br>Power input : 30 Watts (nominal)<br>Lamp current : 300 ±30 mA DC<br>Average Life : 1000 hours (nominal) |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 3.175W Xenon Based

- Variable narrowband light output selection from UV (200nm) to Near IR (2.2 μm)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Attenuation control
- Couples to Spectral Products equipment






## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' 175W Xenon light sources.

## Models

AST-XE-175EX : 175W UV/NIR Extended Xenon based model, 200nm ~ 2,200nm range.
AST-XE-175BFEX : 175W NIR Extended Xenon based model, 320nm ~ 2,200nm range. Ozone free.
AST-XE-175BF : 175W Ozone blocking Xenon based model, 320nm ~ 750nm range.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings)<br>Interface : RS232 standard |
| Light Source | Model : ASB-XE-175EX, ASB-XE-175BF, ASB-XE-175BFEX<br>Power : 175 Watts<br>Bulb Light Power : 800 ~ 4,700 lumens<br>Bulb Life : 1000 hours typical, 500 hours minimum |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |

# 4. Deuterium & Tungsten-Halogen Hybrid Based

- Variable narrowband light output selection from deep UV (180nm) to Near IR (2.6 μm)
- Computer controlled via standard RS232 interface
- Scans in both directions and in nanometers, Angstroms, microns, wave-numbers, or eV
- May be configured for optimal fiber optic illumination
- Modular design allows for reconfiguring
- Couples to Spectral Products equipment

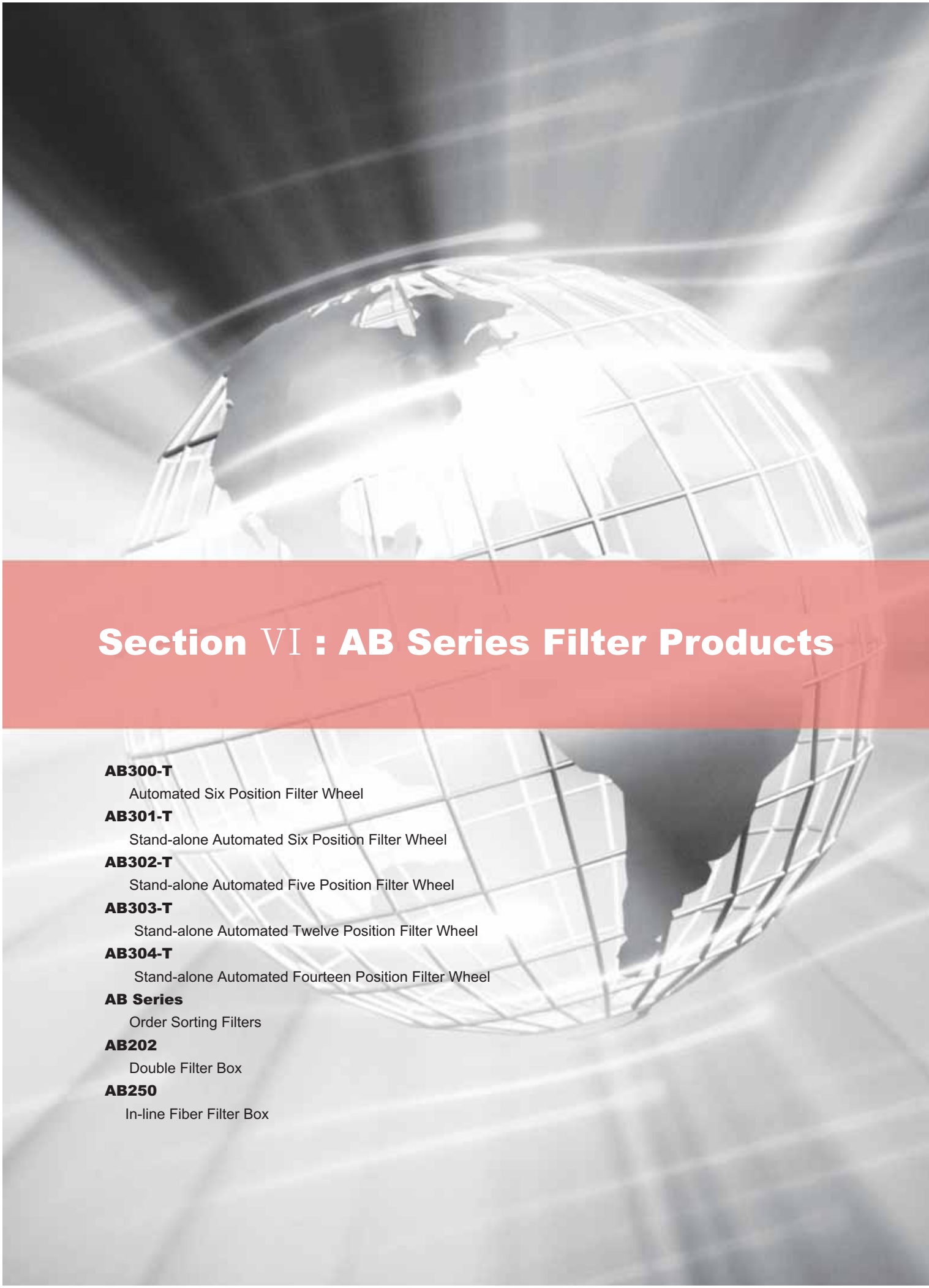
## Simple, Flexible

Spectral Products has a tunable light source to meet your needs. Each model is based on our popular CM110 dual grating, 1/8-meter monochromator, paired with one of Spectral Products' Deuterium & Tungsten-Halogen hybrid light sources.

## Models

ASTN-D1-W050 : One 30W deep UV Deuterium & 50W Tungsten-Halogen model.
ASTN-D1-W075 : One 30W deep UV Deuterium & 75W Tungsten-Halogen model.
ASTN-D1-W100-L : One 30W deep UV Deuterium & 100W low color temperature Tungsten-Halogen model.
ASTN-D1-W100-H : One 30W deep UV Deuterium & 100W high color temperature Tungsten-Halogen model.
ASTN-D1-W150 : Two 30W deep UV Deuterium & 150W Tungsten-Halogen model.
ASTN-D2-W050 : Two 30W deep UV Deuterium & 50W Tungsten-Halogen model.
ASTN-D2-W075 : Two 30W deep UV Deuterium & 75W Tungsten-Halogen model.
ASTN-D2-W100-L : Two 30W deep UV Deuterium & 100W low color temperature Tungsten-Halogen model.
ASTN-D2-W100-H : Two 30W deep UV Deuterium & 100W high color temperature Tungsten-Halogen model.
ASTN-D2-W150 : Two 30W deep UV Deuterium & 150W Tungsten-Halogen model.

| | |
|---|---|
| Monochromator | Model : CM110<br>f/# : 3.9<br>Grating : Two gratings can be installed (ref, CM Gratings)<br>Interface : RS232 standard |
| Light Source | Model : ASBN-D1-W series, ASBN-D2-W series<br>Power : Deuterium: 30 Watts, Tungsten-Halogen: 50 ~ 150 Watts<br>Bulb Life : Deuterium: 1000 hours typical, 500 hours minimum,<br>Tungsten-Halogen: 50 ~ 2,000 hours |
| Accessories & Options | Order sorting filter holder : AB202 included.<br>Order sorting filter : AB3XXX series (sold separately).<br>Fiber coupling output : AFCM-L-XX, XX: SM-SMA, FC-FC, CS-Ferrule. Sold separately. |



# Section VI : AB Series Filter Products

**AB300-T**
Automated Six Position Filter Wheel

**AB301-T**
Stand-alone Automated Six Position Filter Wheel

**AB302-T**
Stand-alone Automated Five Position Filter Wheel

**AB303-T**
Stand-alone Automated Twelve Position Filter Wheel

**AB304-T**
Stand-alone Automated Fourteen Position Filter Wheel

**AB Series**
Order Sorting Filters

**AB202**
Double Filter Box

**AB250**
In-line Fiber Filter Box

# AB Series

## Automated Filter Wheels

- Low cost!
- High performance!
- RS232 controlled (GPIB optional).
- Multiple Filter Wheel systems available.
- Threaded capture rings allow easy change of filters.


① AB300-T Plug-in and Go with Digikrom DK240/242/480. 6 positions - 1”filters.


③ AB302-T Stand - alone , 2”filters. 5 positions

② AB301-T Stand - alone , 1”filters. 6 positions

④ AB303-T Stand - alone , 1/2”filters. 12 positions

⑤ AB304-T Stand - alone , 1”filters. 14 positions

## Versatile Computer Controlled Filter Wheels

**AB300-T** A six position wheel that integrates with SP ṡ popular Digikrom1/4 and 1/2 meter monochromators. Plugging directly into the Digikrom, resident software commands allow easy manipulation to filter higher order energy. It can also be controlled by your hand-held controller. The AB300 uses 1 ”diameter filters.

**AB301-T** stand-alone, six position 1 ”filter wheel that is stepper motor controlled via RS232 and can be used with SP ṡ 1/8 meter compact monochromators for order sorting purposes.

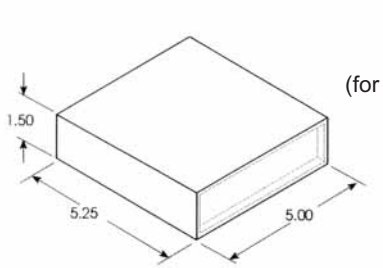
**AB302-T** A stand-alone, five position 2 ”filter wheel that is ideal for LIDAR applications. Stepper motor controlled, it can be combined with AB301-T's, AB302-T's, or AB303-T's in multiple filter wheel systems.

**AB303-T** A stand-alone, twelve position 1/2" filter wheel that is stepper motor controlled. Ideal for multiple monochromatic illumination applications.

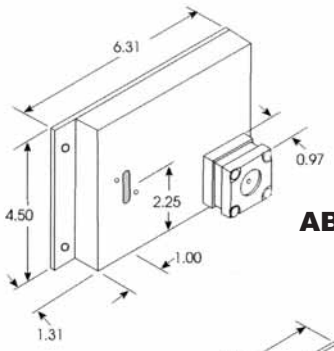
**AB304-T** A stand-alone, fourteen position 1 ”filter wheel that is stepper motor controlled. Ideal for multiple monochromatic illumination applications.

**Inexpensive Monochromators** When used with narrowband interference filters, you can select up to twelve specific bandpasses for monochromatic illumination. This provides maximum throughput with excellent stray light rejection.

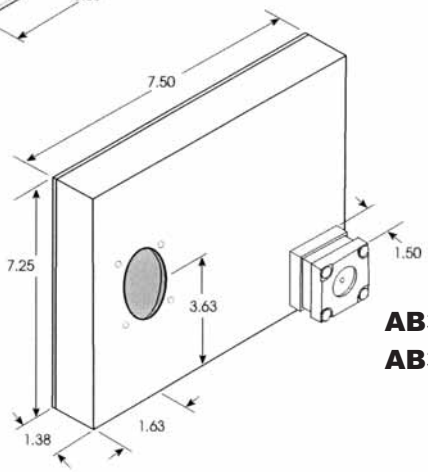
**Applications** Not only are these filter wheels ideal for use with monochromators, spectrographs and spectrophotometers, but they can be easily integrated with microscopes, flow cytometers, fluorimeters, and fluorescence photometers. Neutral density filters will allow for photometric linearity and dynamic range studies. Modern communication multiplexing capabilities provide the capability of combining any number of these filter wheels together in an integrated system. Call with your custom or OEM requirements.



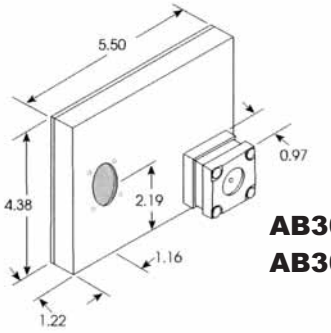

**Controller Box**
(for use with AB301-T, AB302-T, AB303-T, AB304-T)




**AB300-T**




**AB302-T**
**AB304-T**




**AB301-T**
**AB303-T**

Dimensions in Inches
Drawings Not to Scale

## Specifications :

Accuracy :
AB300-T/AB301-T/AB303-T/AB304-T
± 0.004 ”from center of optical axis
AB302-T
± 0.030" from center of optical axis

Filter Change Speed :
AB300-T 0.5 second per position
AB301-T 0.5 second per position
AB302-T 1.1 second per position
AB303-T 0.25 second per position
AB304-T 0.50 second per position

Drive : Stepper Motor

Capacit :
AB300-T Six 1.0 ”diameter filters
AB301-T Six 1.0 ”diameter filters
AB302-T Five 2.0 ”diameter filters
AB303-T Twelve 0.5 ”diameter filters
AB304-T Twelve 1.0 ”diameter filters

Clear Aperture/Maximum Filter Thickness :
AB300-T Slot 1.0 ”x 0.44 ”/ 0.25 ”thick
AB301-T 0.875 ”Ø / 0.25 ”thick
AB302-T 1.825 ”Ø / 0.50 ”thick
AB303-T 0.400 ”Ø / 0.25 ”thick
AB304-T 0.875 ”Ø / 0.25 ”thick

Control : DCE, 8 bits protocol, no parity, 1 stop bit, RS232 (GPIB optional), baud rates programmable.

Software : Demo program and LabView® driver provided.

Manual Control : Pushbutton switch with 1 position advance

Ordering Information: Please indicate product number plus description when ordering.

AB300-T Six position, 1" diameter Automatic Filter Wheel Assembly, for use with Digkrom DK240/242/480 monochromators. Power and Control supplied through monochromator.

AB301-T Six position, 1" diameter Automatic Filter Wheel Assembly, for use with Digikrom CM110/112 monochromators, stand-alone, or in multiple systems.

AB302-T Five position, 2" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

AB303-T Twelve position, 1/2" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

AB304-T Twelve position, 1" diameter Automatic Filter Wheel Assembly, for use as stand-alone or in multiple Filter Wheel systems.

(All Filter Wheels come with appropriate cabling, power supply, and mounting flanges for turn-key operation. Cable to computer supplied by customer or selected separately from Price List.)

Options AB Series Filters
Blocking plugs - Call for Quote.
Multiple Systems - Call with Requirements.

# AB Series

## Order Sorting Filters

- Provides blocking of light radiation below filter specific transition or cut-on wavelength.
- Made from semi-conductor material.
- Allows for various mounting options.
- Offers several filter choices.

## Select Light Radiation Easily

The AB30XX Series of Long Pass Order Sorting Filters provide blocking of light radiation below the filter specific transition or cut-on wavelength.

They can be mounted in the AB202 Filter Carrier or in the AB300 Automated Six Position Filter Wheel. The AB202 Filter Carrier is inserted into the AB200 Filter Mount Assembly. The AB3032, AB3058, AB3066. AB3072, and AB3085 are long-wave pass, color glass filters and are available in 25.4 mm diameter.

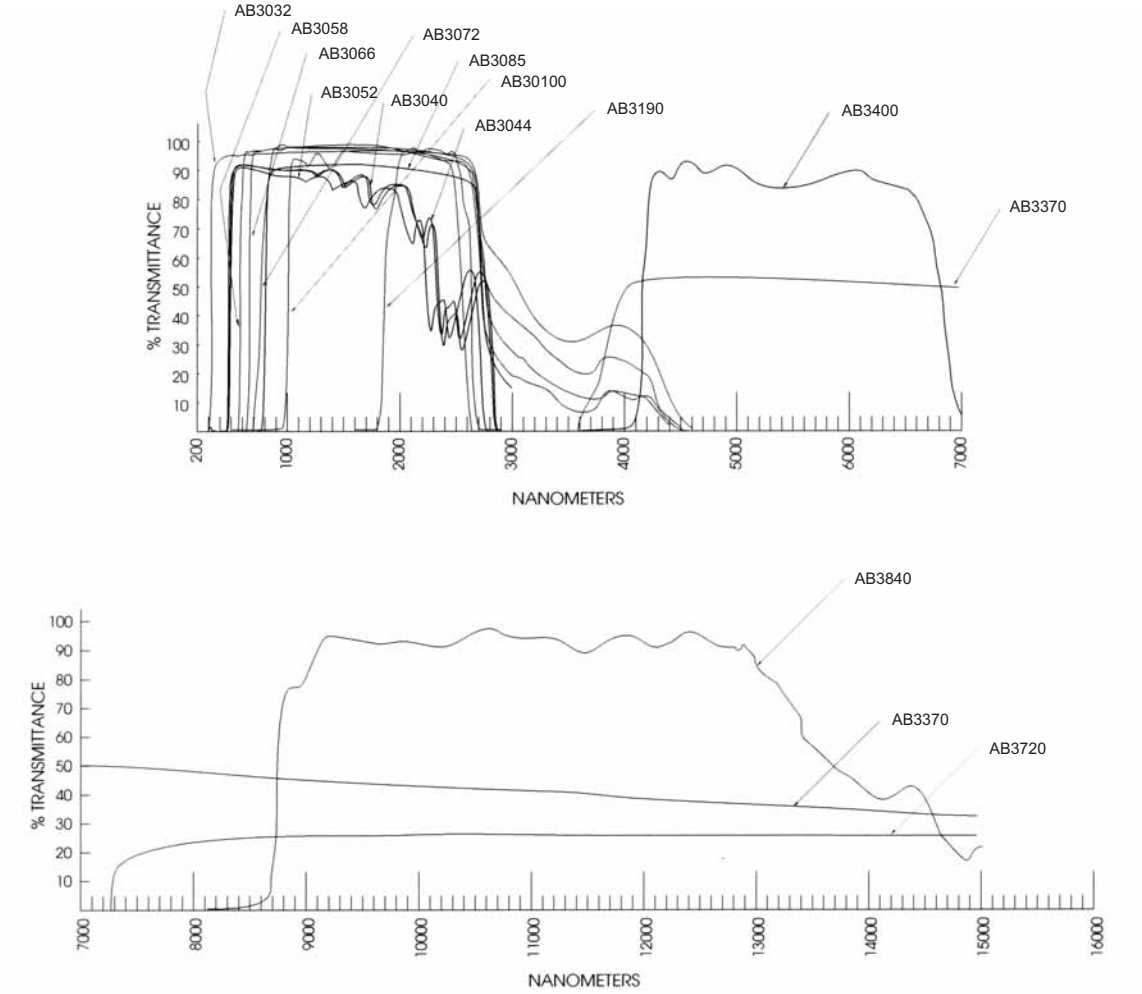
The average high transmittance (TH) of the color glass filters is greater than 90%. The average high transmittance value is the average transmittance of the filter between the first peak after the cut-on wavelength to the peak before the cut-off wavelength. The transition interval of the AB30XX Series Filters is listed in the following table. The transition interval is the distance (nm) from the cut-on wavelength to the cut-on peak.

The AB3100, AB3190, AB3300, AB3370, AB3720, AB3400, and the AB3840 Order Sorting Filters are made of semiconductor materials. These long-wave pass filters are anti-reflection coated for operation from the longpass wavelength to at least twice that wavelength.

The average high transmittance for the AB3100, AB3190, AB3400, and AB3840 filters is greater than 75%.

These long-pass semiconductor filters are 1 inch (25.4mm) diameter with a thickness of 0.083" or less (2.1mm). These filters can also be mounted in the AB201 Filter Carrier or in the AB300 Automated Six Position Filter Wheel.

The blocking average for all of the filters is 0.1% below the passband through the UV wavelengths.




Transmittance curves of Order Sorting Filters

## Specifications :

Size : 25.4mm Ø
Thickness : 2.1mm typical
Material : Schott optical glass or equivalent
Surface Quality : Commercial polish
Mounting Options : AB201 Filter Carrier AB300 Series Automated Filter Wheels

Check out our Filter catalog for Many More Filter option.

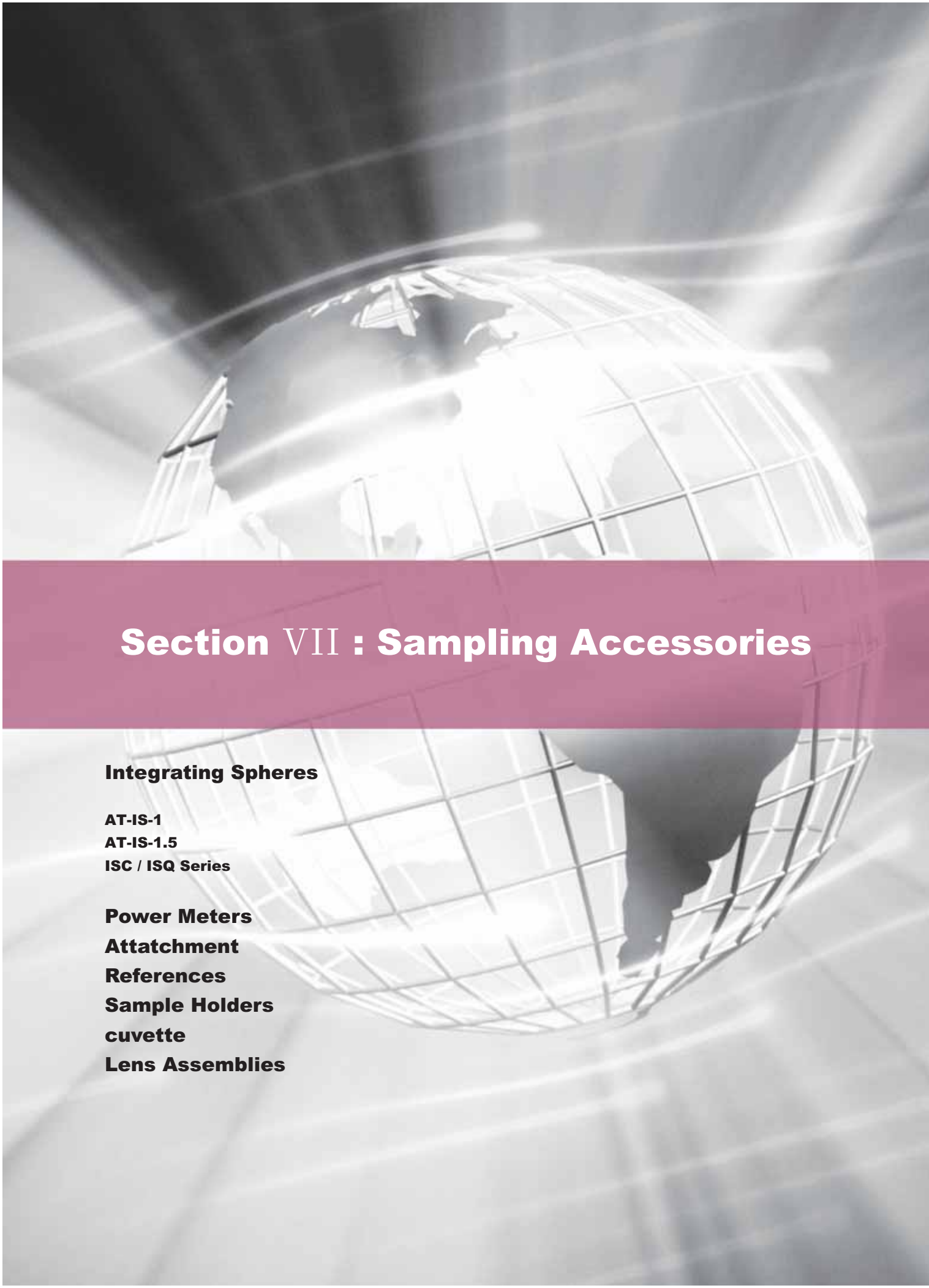
Ordering Information: Please indicate product number plus description when ordering.

| Part Number | Transition λ $\lambda_T$ (nm) | Transition Tolerance (± nm) $\triangle\lambda_T$ |
|---|---|---|
| AB3032 | 320 | 7 |
| AB3040 | 400 | 7 |
| AB3044 | 440 | 7 |
| AB3052 | 520 | 10 |
| AB3058 | 580 | 5 |
| AB3066 | 660 | 5 |
| AB3072 | 720 | 10 |
| AB3085 | 850 | 10 |
| AB3100 | 1000 | 25 |
| AB3190 | 1900 | 35 |
| AB3300 | 3000 | 50 |
| AB3370 | 3700 | 80 |
| AB3400 | 4000 | 150 |
| AB3580 | 5800 | 100 |
| AB3720 | 7200 | 185 |
| AB3840 | 8400 | 300 |

# AB202

## Double Filter Box

- Connects to SP Spectral Products instruments including monochromators, lightsources, and detectors.
- Cost effective method for order sorting.
- Holds one 2.5mm thick filter and one 0.25" thick filter.
- Includes 1” UV fused silica collimating lens
- Fast and Easy filter changing.



# Section VII : Sampling Accessories

## Integrating Spheres

**AT-IS-1**
**AT-IS-1.5**
**ISC / ISQ Series**

## Power Meters
## Attatchment
## References
## Sample Holders
## cuvette
## Lens Assemblies

# Sampling Accessories

AB250 Fiber Coupled In-Line Attenuator
AT-IS-1 Integrating sphere (1 ”sphere)
AT-IS-1.5 Stand alone or directly attachable Integrating sphere (1.5 ”sphere) with internal source.
AT-IS-4 Stand alone Integrating sphere (4 ”sphere)
AT-SHC 1/2 ”x 1/2 ”cuvette holder with Fiber optic attachment.
AT-SHC-4 1/2 ”x 1/2 ”cuvette holder with four ports.
AT-SHL-9 Collimator assembly with lens.
AT-WRS White reflectance standard for reflectance measurement use.

## Attachments

AT-450 : Reflectance attachment
5W tungsten-halogen light source built-in
45° illuminating and 0° viewing geometry
Diffused reflectance/Color measurement
AT-CRT : CRT attachment for SM Spectrometers.
AT-COS : Cosine Corrector for measurement of filtered off-angle light The fused silica dome shaped diffuser gives excellent transmission in the visible region and adequate transmission in the UV region
AT-DIF : Diffuser mounts directly to the SM Series spectrometers. Offered with a ground quartz diffuser as standard Up to 3 - 0.5" size by 1.5mm thick ND filters can be added to the assembly.

## References

AT-WRS/AT-BRS : White/Black reflectance standards for diffused reflectance measurement use.

## Sample Holders

AT-SHC : Two Port Cuvette Holder.
Supports 1/2" x 1/2" cuvettes
Supports SMA or FC fiber connection

The AT-SHC Two Port Cuvette Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies. Included cover excludes ambient light. Holder also allows insertion of a reference filter (1.5"x1.25"x.075" max. dimensions) for system calibration.

AT-SHC-4 : Four Port Cuvette Holder.
Supports 1/2" x 1/2" cuvettes
Supports SMA or FC fiber connection

The AT-SHC-4 Four Port Cuvette Holder allows FC or SMA fiber connection for sample transmission, absorbtion and especially fluorescence studies. Included cover excludes ambient light. Holder also allows insertion of a reference filter (1.5"x1.25"x.075" max. dimensions) for system calibration.

## Cuvettes :

AT-2-Q-10 : UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm, 170nm ~ 2200nm, 2 polished window, 10mm path length, For Absorption and Transmittance Application
AT-4-Q-10 : UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm, 170nm ~ 2200nm, 4 polished window, 10mm path length, For Absorption, Transmittance and Fluorescence Application
AT-SHF : Two Port Filter Holder.
Reconfigurable design fits almost any 1.00" filter up to 6mm thick filter

The AT-SHF Two Port Filter Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies. Included cover excludes ambient light.

## Collimating/Focusing assembly with lens for sample holders :

AT-SHL-C : 1/2" Collimating/Focusing assembly with one lens. UV grade Fused Silica (200nm ~ 2000nm)
AT-SHL-F : 1/2" Focusing assembly with two lenses. UV grade Fused Silica (200nm ~ 2000nm). For Fluorescence application. Anti-Reflection Coatings available.
DU : Deep UV range (200nm ~ 250nm)
UV : UV range(250nm ~ 400nm)
VS : Visible range, Shorter(320nm ~ 600nm)
VL : Visible range, Longer(400nm ~ 700nm)
IS : NIR range, Shorter(650nm ~ 1100nm)
IL : NIR range, Longer(1050nm ~ 1700nm)


AT-SHC-4 Four port curvette holder


AT-IS-1.5 Integrating Sphere


AT-IS-4 Integrating Sphere


AT-SHC Fiber Optic Sample Holder
(shown with ASB-W-003 light source)

# AT-IS-1

## Integrating Sphere, 1"

1" Spectralon Integrating Sphere
SMA Detector Port
SMA Illumination Port
1/4" Full Size Port
Ultra compact, low cost integrating sphere. Milled Spectralon interior provides excellent diffuse reflectance from 300nm to 2.5 µm.

# AT-IS-1.5

## Integrating Sphere w/Built-in Tungsten Light Source

1.5" Integrating Sphere combined with an 5W regulated Tungsten Halogen Light Source
Detector Port with SMA interface
1/2" Full Size Port
Designed for color applications, this compact 1.5" integration sphere and light source can also be used as a low cost diffuse (uniform) light source. Standard unit includes SMA detector port connection and detector collection optic. 1/2" Full Size Port can be place aganist surface to be analyzed; small objects can also be inserted for analysis.

Detector port can also be directly interfaced to Spectral Products SM200 and SM241 spectrometers.

# ISC Integrating Spheres

- Classical Integrating Sphere
- Four Ports
- Post Mount

ISC integrating spheres come standard with ReflectraSpec coating (effective from 400nm-2500nm, four orthogonal ports (please specify orthogonal, 8 degree or custom configuration). Wall construction is cast aluminum (allows use of set screws).

| Model | Diameter | Port Size |
|---|---|---|
| ISC-020 | 2" | .5" |
| ISC-040 | 4" | 1.0" |
| ISC-060 | 6" | 1.5" |
| ISC-080 | 8" | 2.0" |
| ISC-100 | 10" | 2.5" |
| ISC-200 | 20" | 5.0" |

How to Select and Size an Integrating Sphere
In order to select the Spectral Products Integrating Sphere that is best suited for your application, several factors must be taken into consideration. The most important factors include the following:

Diameter/Source Ratio The diameter of the sphere should be at least 1.5 times the largest dimension of any device mounted within the sphere.

Surface-to-Port Area If ports cover more than 5% of the Integrating Sphere?s surface, the Integrating Sphere may not integrate properly. If port requirements are greater than 5% of the sphere, a larger sphere should be purchased.

The following formulas can determine port area and sphere surface area:

r = Port radius, D = Sphere Diameter
Port Area = pr^2
Sphere Surface Area = 4pD^2

Integrating Sphere Coatings The coating of a Spectral Products Integrating Sphere is a high efficiency diffuse reflector that delivers reliable integration and low throughput loss. The reflectance is high in order to minimize absorption loss from multiple reflections, yet it must not reflect light specularly.

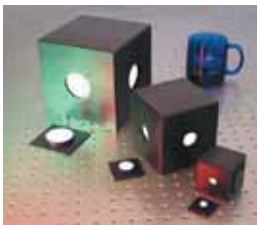
Spectral Products Integrating Sphere Coatings offer reflectance efficiencies between 95 and 99%. A Lambertian Source is a perfect diffuse source. When a perfect diffuse reflector is illuminated with uniform intensity, it acts as a Lambertian Source. Spectral Products uses a proprietary ReflectraSpec coating, effective from 400 up to 2500 nm, to provide these state-of-the-art Lambertian properties. AuSpec (for IR applications) and UVSpec (for UV applications) coatings are also available.

# ISQ Integrating Q Spheres

New Product!
Integrating sphere with cubical exterior.
Machined port plugs match interior sphere curvature.
Sits flat or can be used with optical post.

Heavy duty construction (each sphere is composed of two halves, each machined from solid aluminum stock). Standard Q spheres come with ReflectraSpec coating, four orthogonal ports. Sphere can sit flat on work surface or be mounted on an optical mount post.

| Model | Diameter | Port Size |
|---|---|---|
| ISQ-020 | 2" | .5" |
| ISQ-040 | 4" | 1.0" |
| ISQ-060 | 6" | 1.5" |
| ISQ-080 | 8" | 2.0" |
| ISQ-100 | 10" | 2.5" |
| ISQ-200 | 20" | 5.0" |



# Power Meters

## Nova - Laser Power Meter and Laser Energy Meter

- compatible with all Ophir heads, thermopile , pyroelectric & photodiode single shot energy measurement with thermal heads
- optional RS232 computer interface with Windows software
- power and energy logging with graphical display and statistics
- power averaging
- easy to use soft keys, menu driven
- screen graphics
- backlight & rechargeable battery
- analog output
- EMI rejection

## Nova II-Laser Power Meter and Laser Energy Meter

- compatible with all Ophir thermopile, pyroelectric and photodiode detectors
  large, high definition LCD display
- Both digital and analog needle display
- USB and RS232 output to PC with Statistics package
- analog output
- Soft keys and menu driven functions with on line help
- log every data point at >1000Hz with pyroelectric heads
- non-volatile data storage up to 50,000 points
- laser tuning screen and power log
- 2 position kickstand

## Orion - Laser Power Meter and Laser Energy Meter

**Orion PD for photodiode heads**

- Supports all Ophir photodiode heads - 200-1800 nm.
- Wavelength corrected at 1 nm increments with user selected favorite wavelength for ease to use.
- nW to 3W dynamic range
- Patented dynamic background subtraction
- Displays Watts or dBM
- Auto or manual range
- Laser tuning screen to maximize laser power

**Orion TH for thermopile heads**

- Supports over 50 Ophir thermal heads - uW to 20kW
- Fast response power measurement with auto or manual ranging
- Corrected for major laser wavelengths
- Laser tuning screen to maximize laser power
- Offset background at the push of a button

**Photodiode Detector Heads**

Model PD-300 series heads offer spectral coverage from 200nm-1800nm. The power range is from 1 picoWatt to 3 Watts.
The PD-300 offers automatic background subtraction so the measurement is not sensitive to room light.
All models have wavelength calibration built into the system.

**Photodiode Heads for low power 1nW - 3W**

| Head | Features | Aperture | Spectral Range | Power Range |
|---|---|---|---|---|
| PD-300-IR | Germanium photodiode | Ø5mm | 800 - 1800nm | 5nW -300mW |
| PD-300-UV | wide spectral range | 10x10mm | 200 - 1100nm | 10pW -300mW |
| PD-300-IRG | InGaAs photodiode | Ø5mm | 800 - 1700nm | 1pW -300mW |
| F.O. PD300 | fiber optic adapters for models PD300 | | | |
| PD-300-BB | Flat spectral response from 400 to 1000nm | 10x10mm | 400 - 1000nm | 50pW - 8mW |
| PD-300-CIE | Measurements in units of 2.4x2.8mm Lux | | 400 - 700nm | 20m Lux-200K Lux |

**Integrating Spheres for Divergent Beams 1 µW-100W**

| Head | Features | Aperture | Spectral Range | Power Range |
|---|---|---|---|---|
| 3A-IS | integrating sphere fordivergent beams to 3W. | Ø12mm | 420 - 1100nm | 1 µW - 3W |
| 3A-IS-IRG | as above for near IR.. | Ø12mm | 800-1700nm | 1 µW - 3W |
| F.O.Adapters | fiber optic adapters for integrating sphere power meters | | | |

# Thermopile Surface Absorber Head

Ophir thermopile surface absorber heads are spectrally flat from .19um-20um.

They have a damage threshold of up to 20 KW/cm2. They offer a wide dynamic range from uW to kW and a fast response time as short as 1 second.

The detector head information is stored in the EEROM of the detector head and is downloaded when the display is turned on so all heads are plug and play.

**Thermal Surface Absorber Heads for CW and Long Pulse Lasers**
**15uJ-200J, 60 µW-30KW**

| Head | Features | Aperture | Spectral Range | Power Range | Energy Range |
|---|---|---|---|---|---|
| 3A | very low powers | Ø10mm | 0.19 -20 µm | 60uW - 3W | 15uJ - 2J |
| 10A | general purpose to 10W | Ø16mm | 0.19 -20 µm | 6mW - 10W | 1mJ - 20J |

# Attachments

**AT-450**

Reflectance attachment

5W tungsten-halogen light source built-in

45° illuminating and 0° viewing geometry

Diffused reflectance/Color measurement

**AT-CRT**

CRT attachment for SM Spectrometers.

**AT-COS**

Cosine Corrector for measurement of filtered off-angle light

The fused silica dome shaped diffuser gives excellent transmission in the visible region and adequate transmission in the UV region

**AT-DIF**

Diffuser mounts directly to the SM Series spectrometers.

Offered with a ground quartz diffuser as standard

Up to 3 - 0.5" size by 1.5mm thick ND filters can be added to the assembly.

# References

**AT-WRS/AT-BRS**

White/Black reflectance standards for diffused reflectance measurement use.

# Sample Holders

**AT-SHC**

Two Port Cuvette Holder.

Supports 1/2" x 1/2" cuvettes

Supports SMA or FC fiber connection

The AT-SHC Two Port Cuvette Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies. Included cover excludes ambient light. Holder also allows insertion of a reference filter (1.5"x1.25"x.075" max. dimensions) for system calibration.

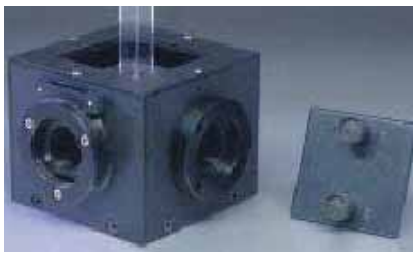
**AT-SHC-4**

Four Port Cuvette Holder.

Supports 1/2" x 1/2" cuvettes

Supports SMA or FC fiber connection

The AT-SHC-4 Four Port Cuvette Holder allows FC or SMA fiber connection for sample transmission, absorbtion and especially fluorescence studies. Included cover excludes ambient light. Holder also allows insertion of a reference filter (1.5"x1.25"x.075" max. dimensions) for system calibration.



# Cuvette

**AT-2-Q-10**

UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm, 170nm ~ 2200nm, 2 polished window, 10mm path length, For Absorption and Transmittance Application

**AT-4-Q-10**

UV Quartz Cuvette, 12.5mm X 12.5mm X 45.0mm, 170nm ~ 2200nm, 4 polished window, 10mm path length, For Absorption, Transmittance and Fluorescence Application

**AT-SHF**

Two Port Filter Holder.
Reconfigurable design fits almost any 1.00" filter up to 6mm thick filter

The AT-SHF Two Port Filter Holder allows FC or SMA fiber connection for sample transmission and absorbtion studies. Included cover excludes ambient light.

# Collimating/Focusing assembly with lens for sample holders

**AT-SHL-C**

1/2" Collimating/Focusing assembly with one lens. UV grade Fused Silica (200nm ~ 2000nm)

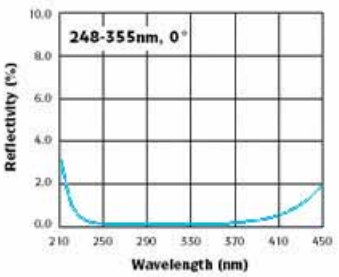
**AT-SHL-F**

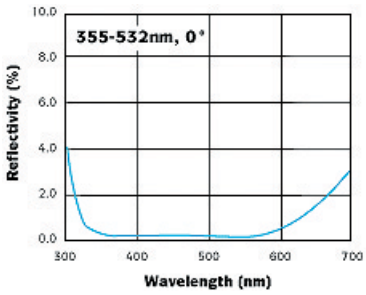
1/2" Focusing assembly with two lenses. UV grade Fused Silica (200nm ~ 2000nm). For Fluorescence application.

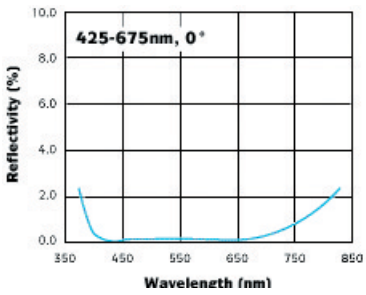
**Anti-Reflection Coatings**

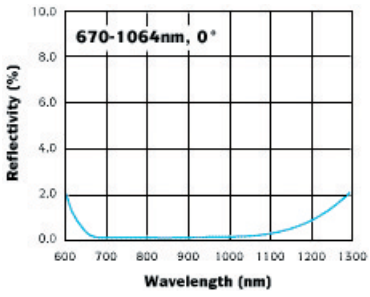
available.

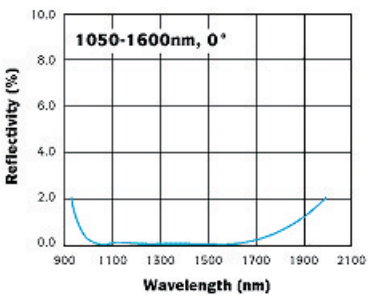
**DU** : Deep UV range (200nm ~ 250nm),
**UV** : UV range(250nm ~ 400nm),
**VS** : Visible range, Shorter(320nm ~ 600nm),
**VL** : Visible range, Longer(400nm ~ 700nm),
**IS** : NIR range, Shorter(650nm ~ 1100nm),
**IL** : NIR range, Longer(1050nm ~ 1700nm)

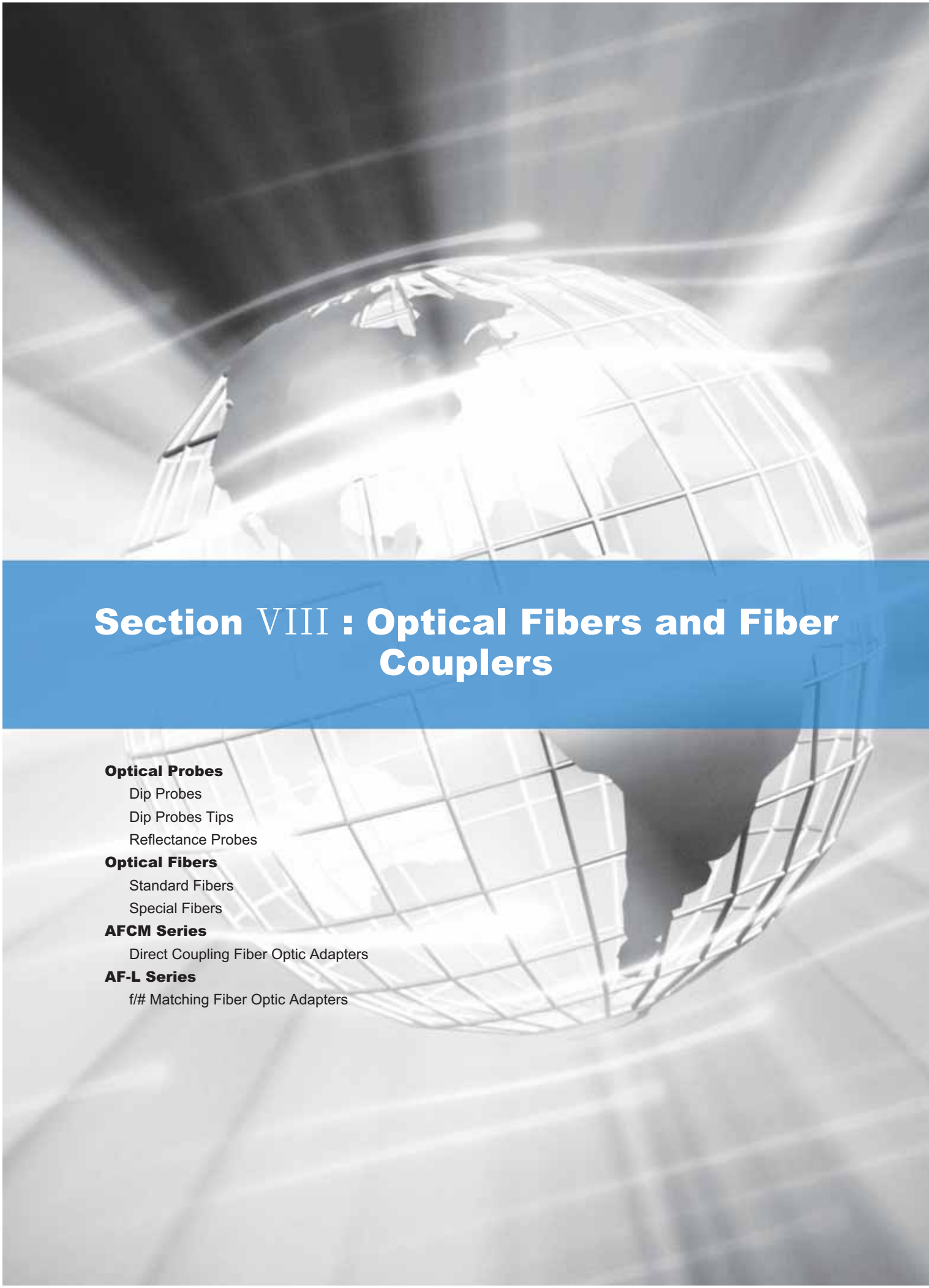




# Section VIII : Optical Fibers and Fiber Couplers

**Optical Probes**
- Dip Probes
- Dip Probes Tips
- Reflectance Probes

**Optical Fibers**
- Standard Fibers
- Special Fibers

**AFCM Series**
- Direct Coupling Fiber Optic Adapters

**AF-L Series**
- f/# Matching Fiber Optic Adapters

# Optical Probes

Spectral Products offers fiberoptic probes for use in absorbtion and transflectance applications.

These dip probes offer the highest throughput in the industry.

Throughput data (transmission efficiency) sent with every probe.
Superior design minimizes bubbles & trapped liquid
Available in all industry standard terminations
Custom instrument / process interfaces or configurations.
Fixed pathlength or removable tip
UV, UV/VIS and VIS/NIR versions
200 µ 400 µand 600 µcore fibers are standard and other single fiber or bundles of fibers are also available

## Part number Notation

## (R or D)P(OOOO)-(XX)(YY)-(U or I)(oo)(-NS)

| Keyword | Description |
|---|---|
| Probe Type (R or D) | Reflectance Probe: RP |
| | Dip Probe: DP |
| Core Size (OOOO) | OOOO micron, ex) 0600: 600um |
| Connector Type (XX)(YY) | SMA-905: SM |
| | SMA-906: SA |
| | FC: FC |
| | Ferrule: FR |
| | ex) SMFC: SMA-905 and FC connection types "XX" is for the bifurcated ends and "YY" is for the joint end. |
| Wavelength range (U or I) | U: UV / VIS (250-1150nm), I: VIS / NIR (500-2250nm) |
| Fiber length (oo) | oo: oo/10 meter, ex) 20: 2.0m, 15: 1.5m |
| Non-solarizing option (-NS) | NS: Non-solarizing for deep UV (190-1150nm) |

## 1. Dip Probes

| Part Numbers | Description |
|---|---|
| DP0200-SMFR-U20 | Std Transflection Dip Probe for 200 µm 2m length, UV / VIS (Requires a Tip) |
| DP0200-SMFR-U20-NS | Std Transflection Dip Probe for 200 µm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0200-SMFR-I20 | Std Transflection Dip Probe for 200 µm 2m length, VIS / NIR (Requires a Tip) |
| DP0300-SMFR-U20 | Std Transflection Dip Probe for 300 µm 2m length, UV / VIS (Requires a Tip) |
| DP0300-SMFR-U20-NS | Std Transflection Dip Probe for 300 µm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0300-SMFR-I20 | Std Transflection Dip Probe for 300 µm 2m length, VIS / NIR (Requires a Tip) |
| DP0400-SMFR-U20 | Std Transflection Dip Probe for 400 µm 2m length, UV / VIS (Requires a Tip) |
| DP0400-SMFR-U20-NS | Std Transflection Dip Probe for 400 µm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0400-SMFR-I20 | Std Transflection Dip Probe for 400 µm 2m length, VIS / NIR (Requires a Tip) |
| DP0600-SMFR-U20 | Std Transflection Dip Probe for 600 µm 2m length, UV / VIS (Requires a Tip) |
| DP0600-SMFR-U20-NS | Std Transflection Dip Probe for 600 µm 2m length, UV / VIS NonSola rizing (Requires a Tip) |
| DP0600-SMFR-I20 | Std Transflection Dip Probe for 600 µm 2m length, VIS / NIR (Requires a Tip) |

## 2. Dip Probe Tips

| Part Numbers | Description |
|---|---|
| DPT-002 | Transflection Dip Probe Tip Path Length 2 µm |
| DPT-005 | Transflection Dip Probe Tip Path Length 5 µm |
| DPT-010 | Transflection Dip Probe Tip Path Length 10 µm |
| DPT-020 | Transflection Dip Probe Tip Path Length 20 µm |

## 3. Reflectance Probes

| Part Numbers | Description |
|---|---|
| RP0100-SMFR-U20 | 100 µm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0100-SMFR-I20 | 100 µm 6 around 1 Stainless Steel Probe Body VIS/IR |
| RP0200-SMFR-U20 | 200 µm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0200-SMFR-I20 | 200 µm 6 around 1 Stainless Steel Probe Body VIS/NIR |
| RP0400-SMFR-U20 | 400 µm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0400-SMFR-I20 | 400 µm 6 around 1 Stainless Steel Probe Body VIS/NIR |
| RP0600-SMFR-U20 | 600 µm 6 around 1 Stainless Steel Probe Body UV/VIS |
| RP0600-SMFR-I20 | 600 µm 6 around 1 Stainless Steel Probe Body VIS/NIR |

# Optical Fibers

Spectral Products offers a complete line of silica core optical fibers and patch cord assemblies. Standard assemblies are listed below. Please call if you don't see what your looking for, have questions, or have a custom requirement!

Standard assemblies are sheathed in crush resistant black PVC covered flexible galvanized steel monocoil.

**Fiber core sizes :** Single Fibers: 50um, 100um, 200um, 400um, 600um and 1000um. Other core sizes (up to 1000nm) are possible Bifurcated Fibers: 100um, 200um and 400um.

**Sheathing options :** PVC with Kevlar reinforcement , PVC Monocoil (Standard) , Flexible stainless steel interlock , Polyimide Tefzel , Acrylate , Nylon

**Connector options :** SMA-905 (Standard) , SMA-906 , ST , FC (Standard) , Custom ferrules available

**Part number Notation :**

## 1. Standard Fibers

## (S or B)F(OOOO)-(XX)(YY)-(U or I)(oo)(-NS)

| Keyword | Description |
|---|---|
| Fiber Type (S or B) | Single Fiber: SF<br>Bifurcated Fiber: BF |
| Core Size (OOOO)<br>Connector Type (XX)(YY) | OOOO micron, ex) 0600: 600um<br>SMA-905: SM<br>SMA-906: SA<br>FC: FC<br>Ferrule: FR<br>ex) SMFC: SMA-905 and FC connection types<br>In case of the bifurcated fibers, "XX" is for the bifurcated ends and "YY" is for the joint end. |
| Wavelength range (U or I)<br>Fiber length (oo)<br>Non-solarizing option (-NS) | U : UV / VIS (250-1150nm), I: VIS / NIR (500-2250nm)<br>oo : oo/10 meter, ex) 20: 2.0m, 15: 1.5m<br>NS : Non-solarizing for deep UV (190-1150nm) |

Ex)

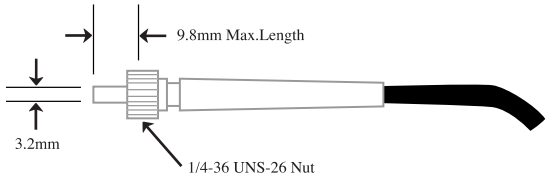
SF0100-SMFC-U20 : single fiber, 100um core size, SMA (905) to FC fiber connection type, UV / VIS range, 2.0m length

BF0200-FCFC-I10 : bifurcated fiber, 200um core size, FC to FC fiber connection type, VIS / IR range, 1.0m length

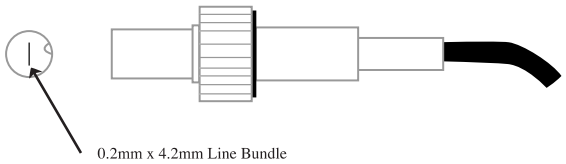
## 2. Special Fibers

| Part Number | Description |
|---|---|
| AF0400-1500SMRP-U20B | Fiber, Bifurcated, SMA, six & one, 2m length, UV/VIS |
| AF0200-0400CSSM-U20B | Fiber, Bifurcated, Line, SMA/SMA, 2m length, UV/VIS |
| AF0200-2180SMSM-U20 | Fiber, Bundle, 2.18mm, 200um core size, 0.22NA, 2m length, UV/VIS |
| AF0100-0625SMCL-U20 | Fiber, Bundle, Round-Line, 0.22NA, 2m length, UV/VIS |
| AF0100-0625SMCS-U20 | 2.275um tall line, best for CM Series |
| AF0200-1300SMCS-U20B | Fiber, Bundle, Round-Line, 4.5um tall line, best for DK Series |
| AF0100-0625SMCS-U20-NS | 2.275um tall line, best for CM Series |
| AF0200-1300SMCS-U20B-NS | Fiber, Bundle, Round-Line, 4.5um tall line, best for DK Series |
| AF0100-0625SMCS-I20 | 2.275um tall line, best for CM Series |
| AF0200-1300SMCS-I20B | Fiber, Bundle, Round-Line, 4.5um tall line, best for DK Series |
| AF0035-3500CSCS-G20S | Fiber, Bundle, 0.55 NA, 3.5um, Ferrule, 2m length, VIS |
| AF5000-50001111-S10S | Liquid, Round-Round, 0.59 NA, Ferrule, 1m, S Type (270nm ~ 720nm) |
| AF5000-50001111-V10S | Liquid, Round-Round, 0.60 NA, Ferrule, 1m, V Type (340nm ~ 750nm) |
| AF5000-50001111-I10S | Liquid, Round-Round, 0.60 NA, Ferrule, 1m, I Type (350nm ~ 2200nm) |
| AF0300-6100SMSM-U20 | Fiber, Bifurcated, SMA, six for UV & one for VIS, 2m length, UV/VIS, Steel jacket, 300um core size |
| AF0400-6100SMSM-U20S | Fiber, Bifurcated, SMA, six for UV & one for VIS, 2m length, UV/VIS, Steel jacket, 400um core size |
| AF0200-0200-FGF-10IR | Mid IR fiber (600nm ~ 4.0um), 200um core size. 1m length, FC connection type only. |
| AF0450-0450-FGF-10IR | Mid IR fiber (600nm ~ 4.0um), 450um core size. 1m length, FC connection type only. |

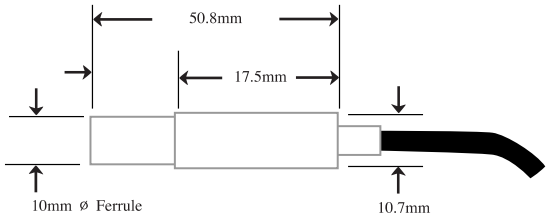
SMA



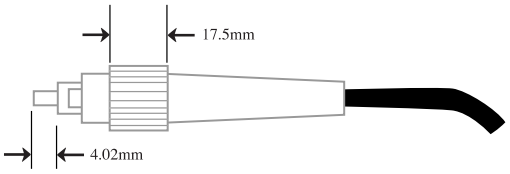

SP Locking Ferrule (Line)

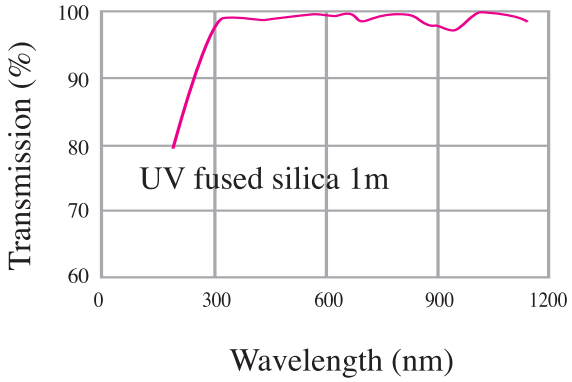


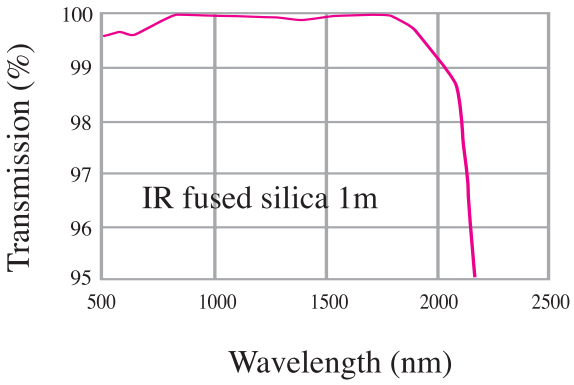

10mm Ferrule




FC



# AF-L Series

## f/# Matching Fiber Optic Adapters

- High efficiency.
- Enables precise alignment.
- Provides a broad spectral range with UV grade lenses.
- Allows quick connect/disconnect while maintaining alignment.
- Use on input or output ports.
- Connects SMA, FC/PC, ST, or 10mm diameter Fiber Connectors.

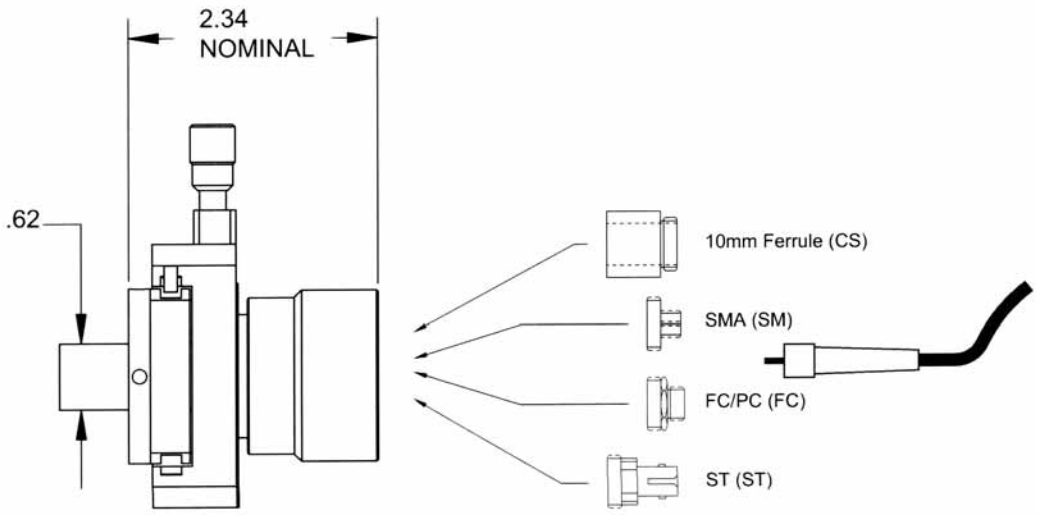

The AF-L Series of Fiber Optic Adapters will optically match the Numerical Aperture of a SP fiber (NA=0.22) to the f/# of a SP Monochromator or spectrograph while mechanically joining the two.

As an input adapter, the AF-L Series focuses the light from the fiber onto the entrance slit. The magnified fiber image fills more of the slit. All of the light entering the slit strikes the grating. The efficiency of this coupling is 4 to 20 times better than a direct non-matched coupling.

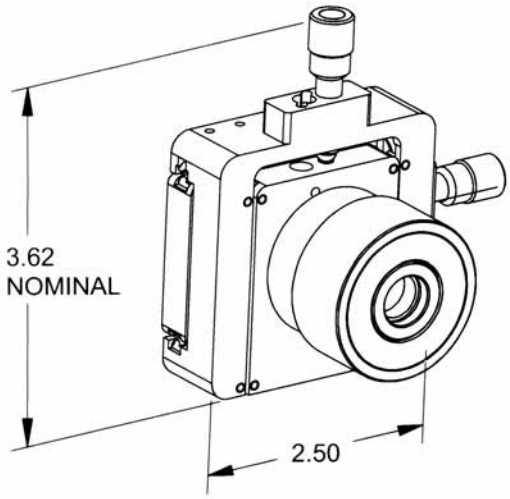
As an output adapter, the AF-L Series focuses the light from the exit slit onto the fiber. The demagnified slit image concentrates light onto the fiber's face and takes advantage of the fiber's " faster " collection angle. The efficiency of this coupling is 2 to 4 times better than direct non-matched coupling.

These dramatic increases in efficiency support applications where low light levels make direct fiber coupling impractical. Fluorescence analysis, spectral analysis of LEDs and laser diodes, and detector characterization all benefit from this efficiency. Fibers used as detection probes with the AF-L Series can take full advantage of their inherent wide acceptance angle for increased light collection. Fibers used as illumination probes with the AF-L Series can deliver up to 4 times more intensity than with direct coupling. In addition, the fiber will illuminate over its full Numerical Aperture.

The AF-L Series **allow three axes of precise fiber translation translation**. Precision of better than 0.001 " in linear movement is typical. Because UV lenses are standard, the AF-L Series provides better than 90% transmission from 200nm to 1900nm.




*Dimensions in inches*




## Specifications :

Adjustment :

X and Y Axes : 80-pitch adjustment screws, 0.0002 ” linear movement for 5° of adjustment screw rotation; 10mm range

Z-Axis : 0.0005 ” linear movement for 5° of collar rotation; 5mm range

Wavelength Range : 200-1900nm @ >90% transmission

Warranty : One year

Ordering Information: Please indicate product number plus description when ordering.

f/# matching Fiber Optic Adapter for CMSeries monochromators/spectrographs

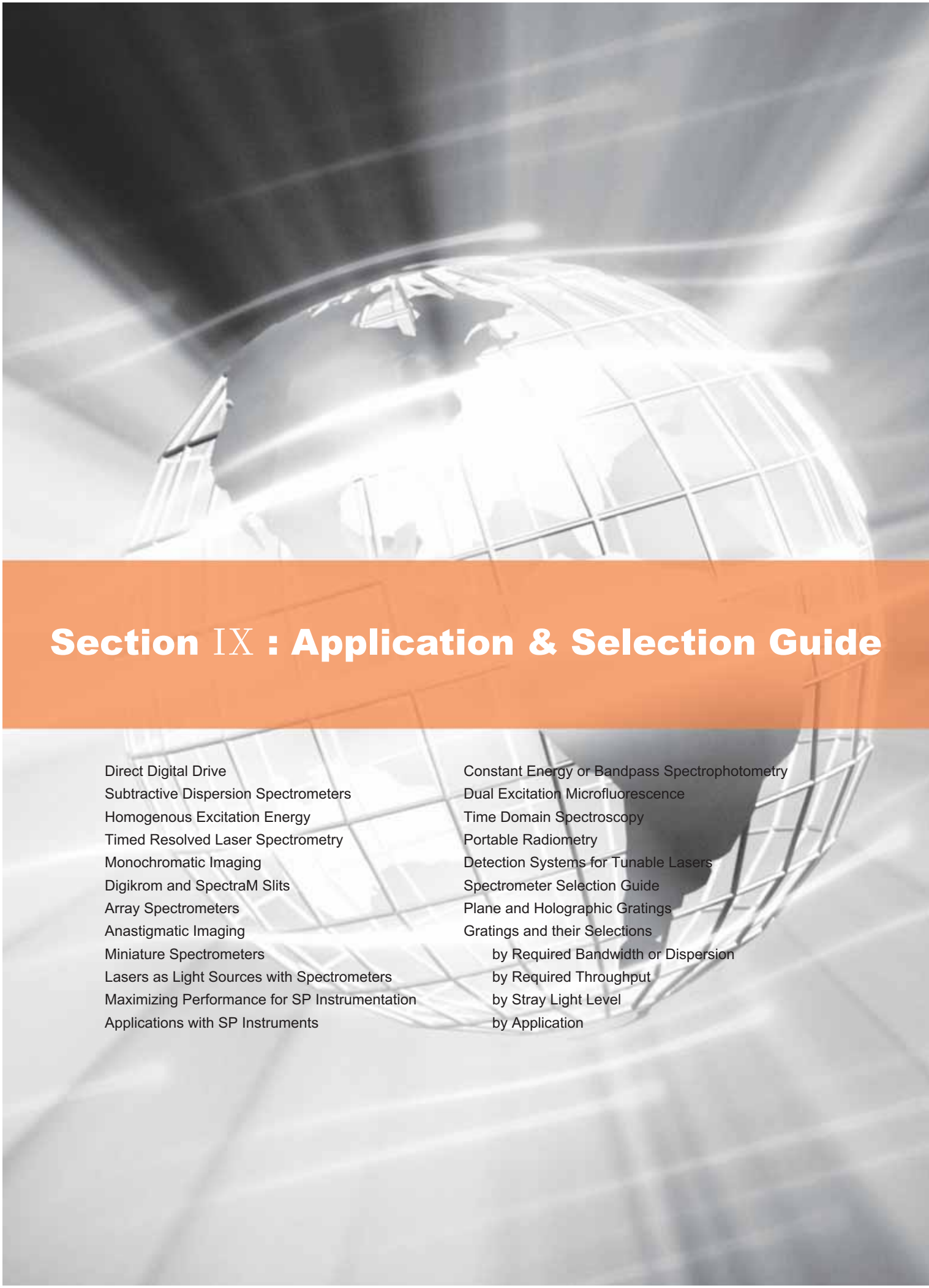
AFCM-L-SM with SMA end plate
AFCM-L-FC with FC/PC end plate
AFCM-L-ST with ST end plate
AFCM-L-CS with 10mm ferrule end plate

f/# matching Fiber Optic Adapter for DK240/DK242 monochromators/spectrographs

AFDK240-L-SM with SMA end plate
AFDK240-L-FC with FC/PC end plate
AFDK240-L-ST with ST end plate
AFDK240-L-CS with 10mm ferrule end plate

f/# matching Fiber Optic Adapter for DK480 monochromators/spectrographs

AFDK480-L-SM with SMA end plate
AFDK480-L-FC with FC/PC end plate
AFDK480-L-ST with ST end plate
AFDK480-L-CS with 10mm ferrule end plate



# Section IX : Application & Selection Guide

# Direct Digital Drive for Digikrom Products - Simple, Rugged, Reliable

In 1987 We introduced the first change in grating drives in more than 50 years. Using digital electronics, We replaced the unreliable mechanical linkages that were used to translate the rotary motion of the drive motor into the sine motion needed for wavelength linearity. Photo 1 shows a typical direct drive grating table that SP manufactures. SP named this method Direct Digital Drive and incorporated it into a new line of Digikrom monochromators and spectrographs.

The equation relating grating angle ( $\theta$) and wavelength ( $\lambda$) is the well known non-linear equation,

$$m\lambda = 2d \sin\theta \cos\varnothing/2$$

where $\varnothing$ is the angle between the central incident ray and the central exiting ray that reaches the exit slit, and $\theta$ is the grating rotation from zero order.

In a spectrometer the rotary motion of the drive motor and associated reduction gears linearly determines theta. In sine-drive instruments a second mechanism, a cam or a sine arm, creates the sine function.

SP Laser replaced the mechanical sine mechanism with digital electronic calculation of sine (theta). When a wavelength is input to a Digikrom monochromator, the internal microprocessor calculates the required sine (theta) and the corresponding angle theta. In about 500 microseconds this calculation finds the number of stepping motor steps required to reach the angle corresponding to the wavelength. This would not have been possible without the microprocessor revolution that permits inclusion of a micro-controller within each instrument at a reasonable cost.

The advantages of Direct Digital Drive are significant. The mechanical mechanism is simpler and more reliable. Calibration is easier and more accurate. A multi-grating turret with automatic grating change becomes a simple, inexpensive option. Finally, inclusion of a micro-controller with each spectrometer makes computer control of the spectrometer easy. These advantages come with a price reduction because of the replacement of expensive mechanical parts with inexpensive, reliable electronics.

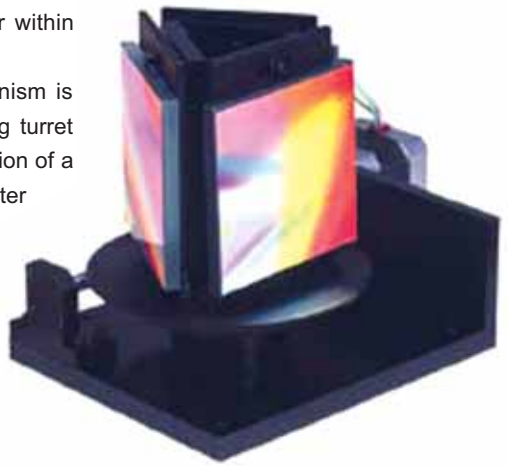


Photo 1. A direct dirve grating assembly

Both Direct Digital Drives and conventional sine drives use a stepping motor, which typically rotates 0.9 degrees per step. The stepper motor rotation is reduced via gear reduction. But, at this point the traditional sine-drive becomes complex.

In the traditional sine-drive, the gear reduction is typically a 5:1 worm and wheel. This output then rotates a lead screw that moves a nut along the opposite side of a right triangle. A precision slide is needed to prevent the nut from rotating as it translates. A hypotenuse arm pivots around the axis of rotation of the grating to follow the nut. As the arm pivots, it rotates the grating proportional to the sine of the angle.

In Direct Digital Drive, a 120:1 worm and wheel gear reduction connects the stepping motor directly to the rotational shaft of the grating. No other mechanism is necessary. Only a single precision worm and wheel is used. There are fewer parts to wear or break and no tolerance errors accumulate as in cascaded mechanisms.

Calibration is easier with the Direct Digital Drive. Only two points - the slope and intercept - need to be specified to calibrate the grating equation. The intercept is optical zero; at optical zero, theta is zero, m is zero, the grating acts like a mirror, and the spectrometer transmits white light. The slope, $2d\cos\varnothing/2$ is found from the angle $\theta$ at a known wavelength.

In the traditional sine drive it is quite difficult to make the mechanical zero of the sine function mechanism equal to the optical zero. While optical ero can be determined precisely as the point of specular reflection, the mechanical zero can only be determined with mechanical gauges or complicated calculations derived from the errors at multiple calibration wavelengths. In fact, a separate rotational adjustment is needed on each grating in a sine-drive system to make the mechanical and optical zeros coincide.

In Direct Digital Drive, the sine function is electronic, and the electronic sine function is reset to begin at the optical zero. The correspondence between the optical zero and the zero of the sine function is then exact. When power is applied to a SP Spectrometer, a predetermined position in the mechanical rotation - the home position - is detected. The grating then rotates to optical zero. The offset angle between home and optical

zero has been previously stored in the microprocessor memory. If the optical zero is incorrect - for example, if gratings were changed - the user commands further grating rotation until optical zero is identified. The micro-controller remembers the new offset angle. Calibration is thus simple and exact.

Direct Digital Drive also allows the option of a multiple grating turret with automatic grating change, see Photo 1. This is a tremendous advantage when a wide spectral range needs to be covered because the entire range can be studied without disassembling, realigning and recalibrating the spectrometer to replace gratings.

The worm and wheel mechanism allows 360° rotation of the grating turret, so it is possible to have two or more gratings on the same turret. This is not possible with the traditional sine-drive, which is limited to about 70 degrees of total rotation. Direct Digital Drive makes the multiple grating turret simple and inexpensive.

In addition, with proper design of the dual or triple grating turret, no vignetting results from the translation on the front face of the grating as it rotates around the central axis. The final enhancement of the Direct Digital Drive is the additional capacity inherent in including a micro-controller in the spectrometer. The included micro-controller allows a simple interface, motorized slit control and automatic grating change at little additional cost. The simple interface is the biggest advantage. It is now unnecessary for the user to build a stepper motor interface or to buy additional motor drive boxes. The micro-controllers in Digikrom spectrometers accept simple commands over an RS232C serial interface from any computer.

The advantages of Direct Digital Drive are clear. The mechanics are simple and more reliable. Calibration is easier and more accurate. A multi-grating turret with automatic grating change is a simple, inexpensive option. Inclusion of a micro-controller with each spectrometer makes computer control easy. Finally, with expensive mechanics replaced by low cost electronics, the price is less.



## Subtractive Dispersion Spectrometers

When we think of a spectrometer we envision white light entering and being dispersed by a prism or grating and exiting in a dispersed spectrum across an arc.This is the archetype of spectral dispersion. If we reverse this process, an arc of color enters the prism or grating and a homogenous white light exits. This reversal is called spectral recombination. When we couple this spectral dispersion followed by spectral recombination we have created an optical curiosity called subtractive dispersion.Today, time-resolved spectroscopy and imaging applications are reviving interest in this technique. (Figure 1) Two Digikrom models, the DK242 and the CM112, employ it.

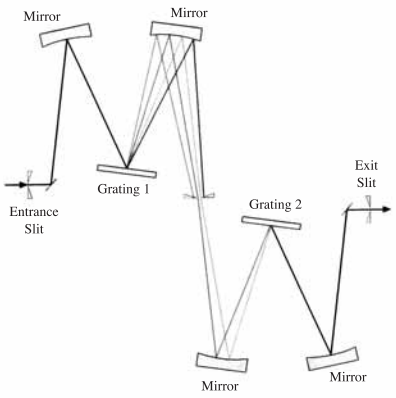



Figure 1. Diagram of a subtractive monochromator.

A simple subtractive dispersion monochromator appears in the figure at right. The instrument consists of coupled grating monochromators. White light enters the entrance of the first monochromator and is dispersed across the shared intermediate slit. The intermediate slit, for example, blocks red and blue but passes yellow and green. The second monochromator is designed for spectral recombination. The yellow and green rays that enter the intermediate slit at different positions and angles are recombined into a beam that is spectrally homogenous across the exit. The second monochromator has no influence on the spectral transmission. The entrance and intermediate slits determine the bandpass. The exit slit is almost superfluous; yet the light emerging from the exit has a very useful uniformity.

## Homogenous Excitation Energy

One of the earliest applications of subtractive dispersion was in the excitation side of spectrofluorometers. In a typical spectrofluorometer, light from an arc lamp is filtered by a monochromator and directed to a sample cuvette (Figure 2). This narrow bandwidth energy induces fluorescence at different wavelengths. A monochromator/detector combination looks at this emitted fluorescence. If the excitation section of the fluorometer uses an ordinary monochromator, then the illumination of the cuvette will vary spectrally with the position of the cuvette.

Subtractive dispersion homogenizes the beam so that each area in the cuvette sees the same spectral excitation, resulting in increased accuracy. Similar considerations apply to both the detection half of fluorometers and to spectrophotometers. In both, subtractive dispersion has been used to make spectral transmission independent of physical position.

A bonus in the use of subtractive dispersion in fluorometry is reduction of stray light. Stray light in a monochromator originates primarily in scattering at the surface of the grating. Not only is the diffracted light of the desired wavelength directed to the exit slit, but also light that is scattered from scratches, pits, dust and imperfections from the ruling process. The second monochromator acts as a filter for this scattered light reducing it by almost the square of the ratio for a single instrument.

## Timed Resolved Laser Spectrometry

The advent of time-resolved laser spectroscopy in the sub-nanosecond regime has created a new application for subtractive dispersive instruments. A conventional single monochromator introduces not only spectral dispersion, but temporal dispersion as well. The temporal dispersion originates in the unequal optical path lengths in the diffraction from the grating.

In Figure 3, the plane wave AB strikes the grating and the diffracted wave is CD. The path of the light that is diffracted from the left edge of the grating, ALC, is longer than the path of the light that strikes the right edge of the grating, BRD. The path difference, W * sin θ gives a temporal dispersion of W * sin θc. With a typical 68mm wide grating used near 30 degrees, a temporal broadening of l00 picoseconds is the result. A subtractive dispersion instrument removes this instrumentally induced temporal dispersion. The second monochromator introduces an equal and opposite delay across the face of its grating. The degree of cancellation is only limited by the optical aberrations of the systems. In the DK242 and CM112, sub-picosecond residual broadening results.

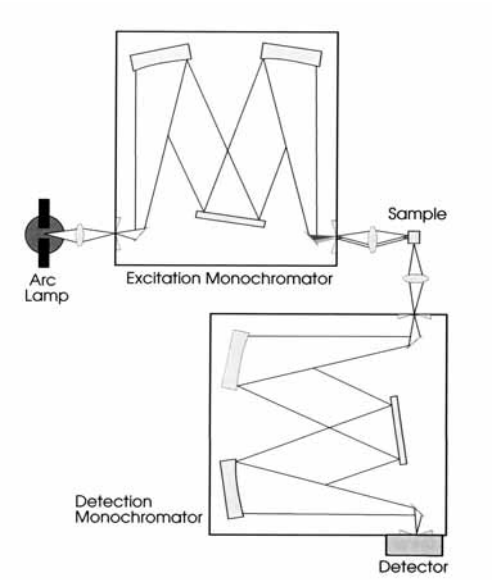



Figure 2. Diagram of a typical fluorometer.

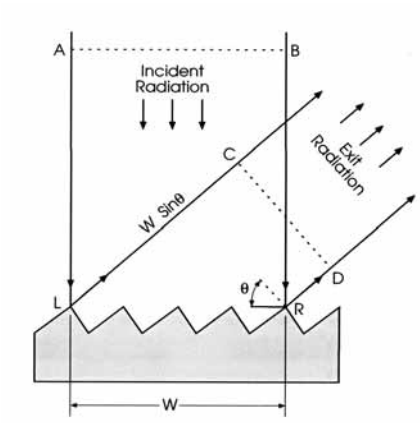



Figure 3. Temporal broadening caused by a grating

## Monochromatic Imaging

Monochromatic imaging can also benefit from subtractive dispersion. Imaging objects at monochromatic wavelengths has grown from its roots in the Lyman-alpha mappings of the sun. Fluorescent imaging of biological materials now permits direct measurements of positively charged ion concentrations in living cells. Combustion analysis also relies upon optical mapping. In many cases this mapping is being done with filters because of the image smear introduced by a conventional monochromator. Imaging through monochromators uses one of two methods: the object is imaged near the entrance slit, or the object is imaged on the grating (at infinity). In the first method, different wavelength images overlap at the exit slit. In the second method, the monochromatic images that are passed by the monochromator exit at wavelength dependent angles.

The subtractive dispersion instrument cancels both effects, making either form of monochromatic imaging possible. Unlike the conventional monochromator, the subtractive dispersion instrument offers a one-to-one wavelength-independent correspondence between the positions and angles of rays at the exit and entrance.

The Digikrom double monochromators employ a single intermediate slit, housing the two optical paths in one integral unit. This maintains the integrity of the stray light and imaging capabilities while offering ease of use and compactness. As you can see, subtractive dispersion is becoming a more commonly used technique today. Keep it in mind, whether your application is fluorescence, spectrophotometry, time- resolved spectroscopy or monochromatic imaging.

## Digikrom and SpectraM Slits - Adjustable and Fixed

Fixed-interchangeable slits are available on all SP eighth-meter monochromators and spectrometers. Computer controlled variable slits are standard on quarter-meter and larger monochromators and spectrographs. In both cases the slit jaws are thin, typically 25 microns, to reduce tunneling. The materials selected are durable, typically stainless steel, molybdenum, or berylliumcopper. The fixed slits are precisely manufactured so that the width and jaw parallelism is exact to within 5 microns for wide slits and 2 microns for slits with a width of less than 50 microns. The adjustable slits are interferometrically adjusted at SP to better than 2 micron parallelism and width accuracy.

Separation of the slit jaws must be precisely known so that the bandwidth will be exactly known. The slit jaws must be parallel so that the bandwidth for light will be the same at the top and bottom of the slit. The entrance and exit slits must be parallel because the entrance slit is imaged onto the exit slit as the grating is rotated. The slit jaws should be thin compared to their separation, so that tunneling does not reduce the acceptance angle of incident light.

The adjustable slits are computer controlled. A stepping motor and precision lead screws are used to change the separation of the slit jaws thereby adjusting the slit width and the monochromator bandpass. When power is first applied to the instrument, the slit jaws automatically self-calibrate then assume a 50 micron separation. The user from a controller or computer may then program slit width and therefore bandwidth.

## Array Spectrometers - Multi-channel Detection with Impr Improved Signal to noise

In recent years the combination of array detector and spectrograph has become the system of choice for spectroscopy. The major advantage of the array detector is improvement in detection signal-to-noise (S/N) ratio.

An array of N elements has the capability of collecting N times the signal of a single detector. Observation of N units of time with a spectrograph allows a potential improvement in S/N to $N^{1/2}$ opposed to a single detector sampling for one unit of time. Alternatively, N wavelength bands can be sampled in just 1/N the time required for a single detector to do sequentially for identical S/N. This is termed the Fellgate advantage.

In practice the improvement in S/N may be reduced due to the following reasons:

1) Currently available array elements have limited heights, for example 1 to 2 millimeters at most as opposed to 10 to 20 millimeters for a non-array detector.
2) Frequently, only 20% of the array elements have an interesting signal.
3) The switching noise associated with the multiplexed readout of some arrays will frequently double the noise level.
4) When the array element width is smaller than the desired bandwidth, several elements must be combined.

Combining the above effects implies a reduction in the estimated improvement by a factor of 10 to 300. Therefore, for an array with small number of elements, this improvement becomes insignificant.

Array detection has some other advantages. Very rapid multiple wavelength sampling is possible. Moving parts as in a scanning monochromator are eliminated.

SP provides the Digikrom line of high performance spectrographs and a wide selection of CCD and InGaAs cameras covering spectral ranges from UV to NIR.

Our SpectraM product line suits your need for a compact, low cost and high performance CCD spectrometer.

(a) (b)

Figure 4. Entrance slit images at the exit with
(a) regular optics and, (b) anastigmatic optics

## Anastigmatic Imaging - Keeping the Images Sharp

Spectrometers, like other optical instruments, exhibit aberrations. Coma, spherical aberration and astigmatism are usually the worst offenders to a spectrometer performance. A spectrometer such as a Czerny-Turner spectrometer employs a diffraction grating together with collimating and focusing mirrors. Any aberration introduced by the mirrors will be transformed by diffraction to the exit focal plane. Using appropriate design parameters can compensate coma in a Czerny-Turner spectrometer. Astigmatism causes a point at the entrance slit to extend tangentially at the exit after image transfer, see Figure 4(a). This extension is primarily attributed to the higher order aberrations associated with the use of spherical mirrors. In a spectrograph application a two-dimensional detector array is usually employed at the exit focal plane of a spectrometer. The astigmatism can thus cause a serious energy spread. limiting the multi-channel spectrometer to a device for virtually single input at the entrance. SP Digikrom series spectrographs offer astigmatism corrected options. The use of specially designed aspherical optics corrects for astigmatism in the wavefront produced by spherical mirrors, Figure 4(b). The anastigmatic optics in turn result in highly energy concentrated images at the exit and tightly focused spots. Multiple inputs along the entrance slit are thus made possible with SP anastigmatic spectrographs.

Figure 5(a) demonstrates a multiple spectral input Raman application by use of a SP spectrograph equipped with a two-dimensional CCD camera. Four fiber inputs are presented at the entrance as shown in Figure 5(b). SP anastigmatic spectrographs allow for inexpensive versatile and multi- functional spectro scopic applications.

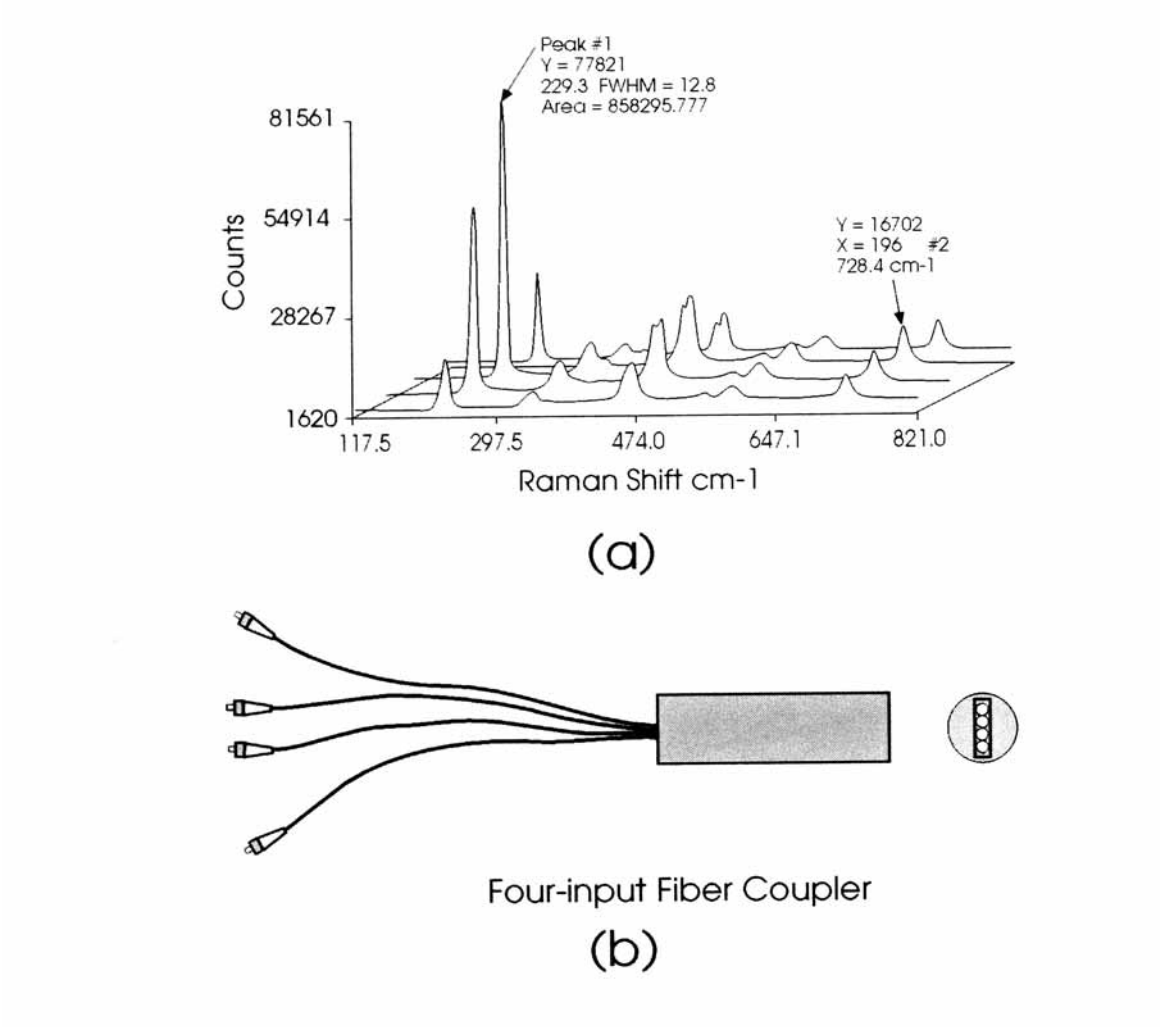



Figure 5. Raman spectrometer with anastigmatic imaging and a multiple input fiber.

## Miniature Spectrometers - Compact, Stable, Sensitive, Unique and Low Cost

SP SpectraM miniature spectrometers are packed with great features and performance in a small footprint. The SM series spectrometers are based on a crossed Czerny-Turner configuration as shown in Figure 6. A light input through the slit, either fiber coupled or direct coupling is collimated by the first mirror and directed to a diffraction grating. The diffracted ligh is collected by the camera mirror and focused onto a detector array for detection. The spectrograph is enclosed in a rugged aluminum housing for stability. Connections between the spectrometer and the computer interface are made via a shielded electrical cable. Detector arrays are also included in the same housing in hand held versions. SM spectrometers can be interfaced to computers via ISA, PCI, PCMCIA, etcetera. By use of a PCMCIA interface with a notebook computer, Figure 7, the SM spectrometers place a powerful portable spectrometer system at your fingertips.

It is known that all detectors exhibit“ dark signals ”originated from thermally agitated electrons. A temperature increase of 7°C can result in a doubled dark signal in a silicon-based detector. SP offers cooled SM spectrometers for greater temperature stability for demanding applications. Uncooled SM spectrometers are also available for low cost detection use. The separation of the spectrometer module from a heat source such as a computer ensures reasonable temperature stability.

SM spectrometers employ detector arrays with high sensitivity. A sensing element height of 200mm to 2.5mm maximizes the detector light collection capability. A cylindrical focusing lens in front of the detector array further enhances the effective pixel size. In addition, for UV and near IR regions where silicon detector response is inherently weak, we provide a variety of sensitivity enhancement coatings for detector arrays. Our pioneering optics and coating technologies also allow us to take another step further to reduce energy lost between optical surfaces.

As discussed before, all gratings generate higher orders. By use of SP°Øs unique variable filters in SM spectrometers, a wide simultaneous wavelength coverage is achieved free of higher order interferences. Our continuous product development effort is adding to the uniqueness of our spectrometer line everyday. For example the compact double Czerny-Turner spectrometer from SP, which needs only one detector array, is the first in the world.

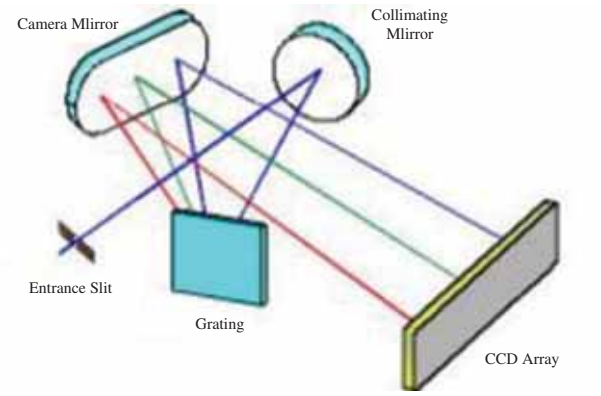



Figure 6. Diagram for a crossed Czerny-Turner spectrograph as employed in SM spectrometers.

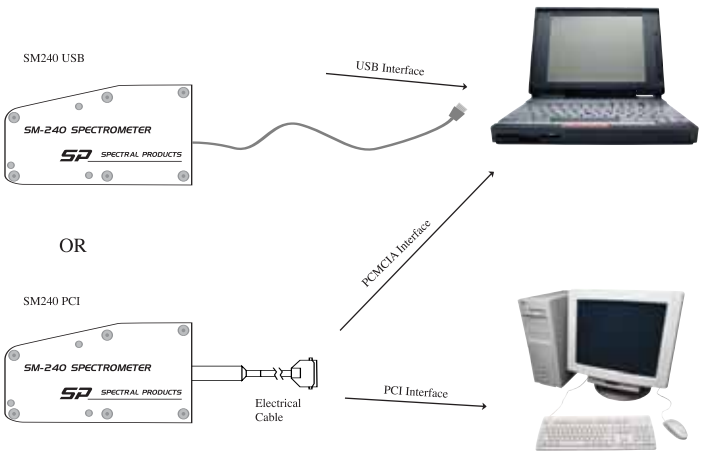



Figure 7. Diagram for SM computer-based miniature spectrometers.

## Issues with Using Lasers as Light Sources with Spectrometers

1. Underfilling the grating. The resolution of a monochromator is limited by the number of grating grooves that are illuminated. Written mathematically:

$$R = mN$$

As an example, an unexpanded HeNe laser with a beam diameter of about 0.3mm used directly on a 1200 groove-per-millimeter grating in a monochromator will have a best resolution of:

$$633.2\ [nm]/(1200 * 0.3) = 0.8[nanometer]$$

Expanding a 0.3mm laser beam to fill a 68mm grating can be difficult. One of the simplest ways is to place a diffuser near the slit or use an integrating sphere, and illuminate that diffuser with a moderately expanded beam. For an f/4 monochromator with a diffuser 4 millimeters from the slit, the beam spot on the diffuser needs to be only a 1 millimeter diameter.

2. Melting the slits. The slits of monochromators are typically stainless steel that tapers to a 0.001 ”thickness at the tip. Experience with pinholes has shown that even a few hundred milliwatts (CW) or a fraction of a Joule (Pulsed) will melt 0.001 ”thick stainless steel. The best solution is to use a beamsplitter to send only a small fraction of the beam to the monochromator. The 0.3% reflection from an antireflection coated plate is usually more than sufficient for measurement. Another solution is to not use the slit. The laser beam, focussed at the slit plane, will act as its own slit. Be warned, however, that the laser beam will be refocussed by the monochromator at the exit slit. That exit slit then is in danger of melting.

3. Melting the grating. Grating surfaces are typically micron thick aluminum that is bonded to the glass substrate by a thin epoxy resin; the aluminum will have about 6% absorption. At high CW powers (about 20kW/cm$^2$) the thermal heating due to the absorption will cause the epoxy to melt. At high pulsed power (about 2 MW/cm$^2$) the aluminum will ablate. In either case the grating is destroyed.

The solutions are the same as given in cases One and Two above. The power input into the monochromator can be attenuated. The beam can be expanded to use the whole grating area. Note that the area of a 68mm grating, 46 cm$^2$, is sufficient for pulse powers of about 0.1 GW.

## Maximizing performance for SP Instrumentation

SP spectrometers are designed to meet the highest performance standards. To ensure the designed performance is achieved, it is also important that the instruments are set up and optimized.

1. When coupling light into and out of a spectrometer, f# matching is helpful for efficient coupling. f# matching helps to minimize stray light introduced by overfilling the spectrometer optics. In many instances, a simple aperture behind the coupling optics works efficiently for this purpose. Figure 8 depicts a spectrometer light coupling system which uses f# matching optics together with a mechanical aperture.

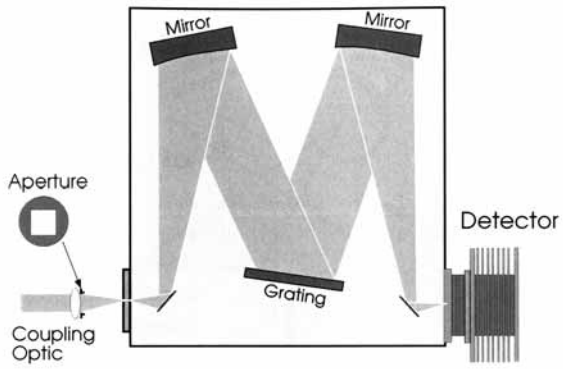



Figure 8. Diagram illustrating the use of f# matching optics and mask for coupling light into spectrometers

2. Incident radiation into a spectrometer with a band broader than necessary may have a negative impact on the instrument°Øs stray light performance. A tungsten halogen lamp, for example, emits radiation from about 320nm to over 2000nm. In applications where only the visible spectrum, 400 to 700nm, is concerned the use of a band pass filter can minimize the stray light arising from dumping the entire band into a spectrometer. Measurement signal to noise ratio can thus be improved.

3. All grating instruments exhibit higher diffraction orders originating from the use of diffraction gratings (see also Spectrometer Basics section). Ignoring the higher orders, especially the second order contribution may result in serious errors. Use of SP filters or filter wheels may remove the second order. The optimum position for the placement of such a filter is in front of the instrument entrance whenever possible.

4. Filter wheels are not limited to order sorting purposes. SP ṡ automatic filter wheels are ideal for usein variable ratio beam splitting, variable beam attenuation and other applications when mounted with appropriate optics.

5. Fibers operate based on total internal reflections, Figure 9. Light transmitting characteristics for fibers may change with bending curvature and positioning of coupling. When fiber input is selected for SP spectrometers it is a good practice to minimize the change in fiber bending curvature during operation. Fibers with precision positioning couplers, such as offered by SP, are highly recommended for repeatability and maximum light coupling.

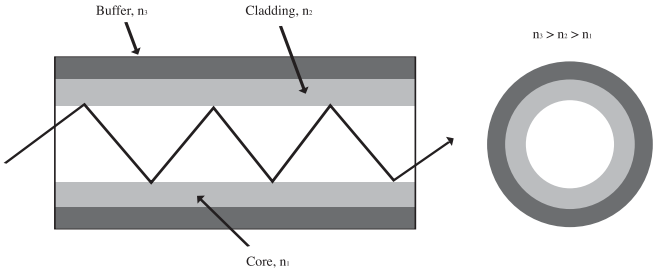



Figure 9. Fiber operate based on total internal reflections

6. When using scanning monochromators be aware that resolution will be lost if data is not collected at sufficiently fine wavelength increments. In a continuous scan mode the maximum scan rate at which the instrument resolution will be maintained is also dictated by the Nyquist theorem. Instrument resolution will degrade with an increase in scan speed exceeding the Nyquist limit.

7. Gratings and other optical components are delicate and precise optics. Any attempt to clean them with inappropriate methods may cause scratches and other damage, leading to performance degradation.

8. The relationship between the slit widths and bandpasses can be calculated by multiplication of reciprocal dispersion with the slit width. For example, a monochromator configured with 0.25 millimeter slits and a grating displaying a reciprocal dispersion of 8 nm/mm has a bandpass of 8 * 0.25 = 2nm.

9. In array detection on a spectrograph such as a CCD camera mounted onto the DKSP240 spectrograph or a SM240 spectrometer, the minimum resolution element is three array elements (pixels). As pixels are typically 14 microns wide, the effective slit width is 42 microns in this case. This would equate to 0.3 nanometers on a 1/8 meter spectrograph utilizing a 1200 g/mm grating.

## Applications with SP Instruments

SP instrument products have found wide applications in many areas for light illumination, light detection and other usage. It is beyond the scope of this catalog to attempt to cover all these aspects. However for the benefit to our customers, we demonstrate here some general application configurations.

Figure 10 illustrates a tunable light source, which consists of a wide band light source and a SP scanning monochromator. The output wavelength can be programmed for continuous scan or a selected narrow band.

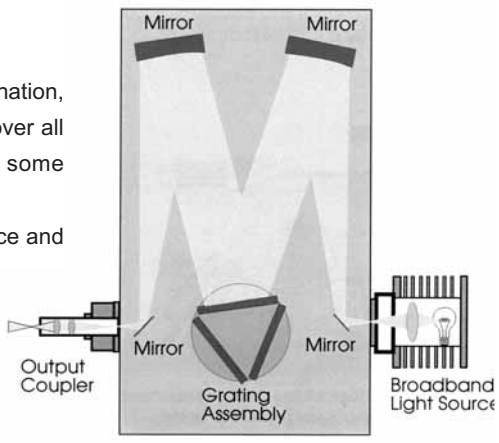



Figure 10. Tunable light source with a SP monochromator

Figure 11 (next page) shows the above tunable light source equipped with a bifurcated fiber for a dual beam type of arrangement. One of the fibers can be used to couple the narrow band light to a sample channel for transmittance, reflectance, absorption or other measurement use. The second fiber directly introduces a portion of the narrow band output from the monochromator into a reference detection channel. Using the reference channel can compensate any possible fluctuation in the output light intensity in the measurement channel, since they are all derived from the same source. In this sense a so-called“ dual beam ”or “ double beam ”system can be established. With SP fiber couplers, light can be introduced in and out of SP spectrometers for flexibility and remote capability.

On the next pages, Figures 12 through Figures 18 review some typical application arrangements with SP SM spectrometers for transmittance, reflectance, and emission measurements.

SP's monochromators and spectrographs have features that are unduplicated in any other spectrometers. For this reason, they have been applied in unique applications. The following are a few examples.

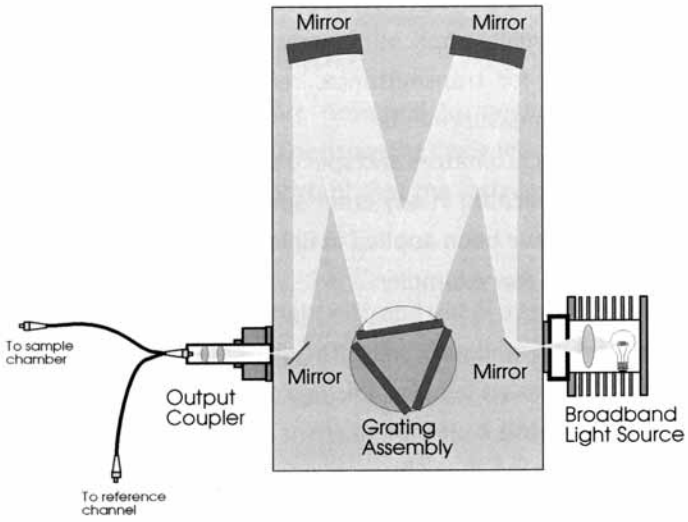



Figure 11. Diagram for a dual-beam illumination source by use of a SP monochromator.

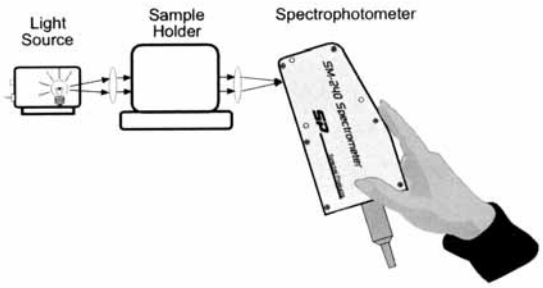



Figure 12. Diagram transmittance / absorbance measurement with SM spectrometers

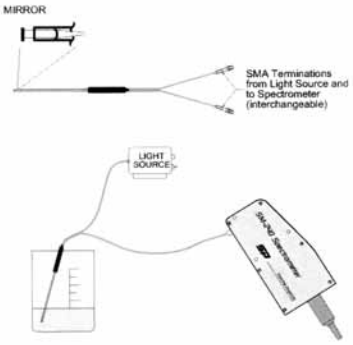



Figure 13. Transmittance / absorbance measurement by use of a fiber optic immersive probe

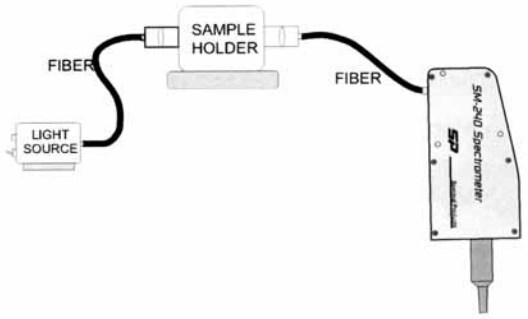



Figure 14. Transmittance / absorbance measurement with SM spectrometers via optical fibers.

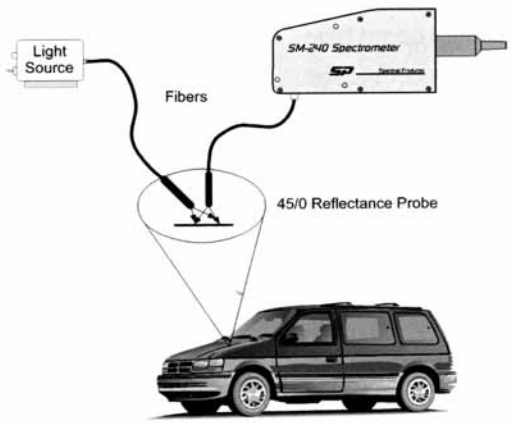



Figure 15. Refiectance measurement with SM spectrometers by use of 45° configuration via optical fibers.

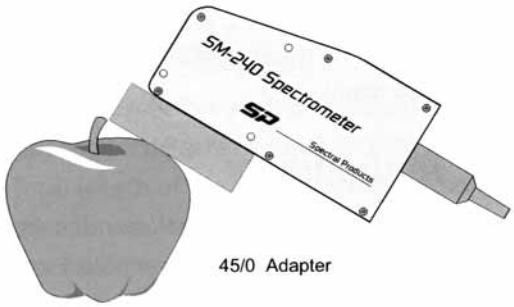



Figure 16. Direct reflectance measurement performed with a 45° attachment and an SM 240 spectrometer

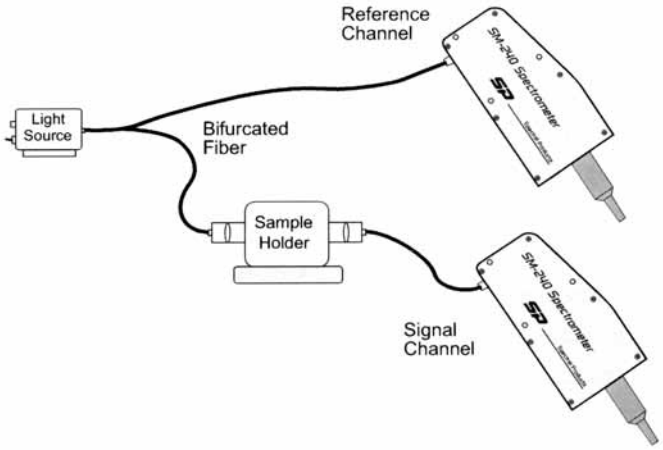



Figure 17. Dual-beam transmittance / absorbance setup involving two SM240 spectrometers connected via fibers.

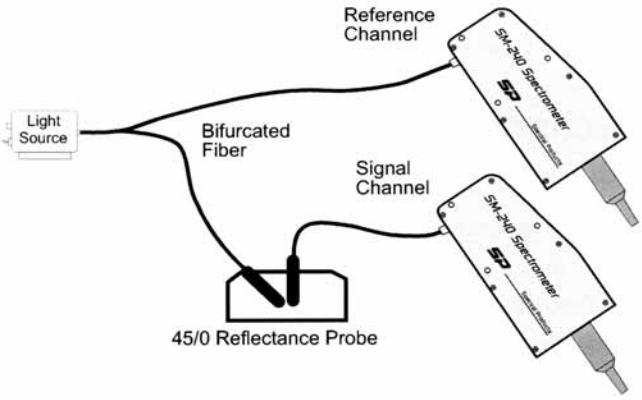



Figure 18. Dual-beam 45° reflectance measurement by use of two SM240 spectrometers via fiber connection.

## Constant Energy or Bandpass Spectrophotometry

The slits in SP's larger monochromators are computer controlled. Usually, the slits are set for a particular width. However, when the monochromator is used in a spectrophotometer it is possible to adjust the slits to maintain constant energy or constant bandpass.

The spectrophotometer consists of a lamp, the monochromator, a sample, and a detector. The overall system response is not flat over the entire spectral range. By adjusting the slit width at each wavelength increment during a scan, constant signal size can be maintained. The same settings can then be used for reference or sample measurements.

In the above adjustment fashion the actual spectrometer bandpass is varied with the slit width since the grating dispersion changes with the wavelength. In applications where constant bandpass is necessary, the slit width on SP monochromators can be adjusted via computer control.

## Dual Excitation Microfluorescence

The compact size and low price of SP ṡ 1/8 meter monochromators enables them to be used in place of filters. The simple, internal computer interface allows these monochromators to be much more than a fixed filter replacement.

For example, in a dual-excitation micro-fluorescence system, two xenon arc lamps direct light into two SP 1/8 meter monochromators. The exits are coupled through fast shutters into two halves of a bifurcated fiber bundle. The exit of the bundle provides fast, tunable, dual-wavelength, epifluorescent illumination for a Zeiss microscope. By using SP's 1/8 meter monochromator, the system has been made compact and computer controlled.

## Time Domain Spectroscopy

Pulsed laser fluorescence spectroscopy is increasingly interesting because of the extra information that the time domain provides. However, if a conventional monochromator is used to clean up the excitation beam or analyze the emission, the monochromator will broaden the pulse by several hundred picoseconds.

Single monochromators introduce temporal dispersion in pulses. The optical paths using the left and right sides of the grating are unequal. SP's double monochromators eliminate the temporal dispersion when used in their subtractive dispersion mode. The optical path differences in the second monochromator entirely compensate for the path differences in the first. Zero temporal dispersion results.

## Portable Radiometry

Field measurements of lamps, reflection and transmission frequently require more range, accuracy and computer compatibility than a commercial colorimeter will provide. With SP ṡ 1/8 meter monochromator and AD130 smart detector, or an SM spectrometer and a notebook computer, a research grade radiometer can be slipped into a briefcase. The briefcase would still have room for standards, notes, and perhaps an AF series fiber optic probe and interface to make sampling easy. Both approaches make a complete computer compatible system in a very small package.

## Detection Systems for Tunable Lasers

Tunable lasers such as Ti:sapphire and optical parametric lasers are finding more applications as excitation sources in laser spectroscopy. SP scanning monochromators and array spectrometers are capable of synchronized detection in such experiments. In one application a Digikrom monochromator was programmed to follow the wavelength scan of an OPO laser for detecting fluorescence. In another setup with a Ti:sapphire laser tuning through a spectral range, an SM spectrometer was used to monitor the laser radiation wavelength in a real time mode.

## A Guide to Spectrometer Selection

The choice of a spectrometer must be guided by the application requirements. The parameters that delineate most applications are listed below:

1. Is the needed output a single wavelength or a dispersed spectrum? Monochromators select single wavelengths, spectrographs have dispersed spectral outputs.
2. Is high resolution (high dispersion) or low resolution (low dispersion) needed? The greater the resolution that is needed, the longer the focal length of the monochromator should be. A spectrograph with greater resolution will necessarily have a smaller bandpass. High resolution also dictates a narrow slit width in array spectrometers.
3. Does the spectrometer need to select a weak signal in a strong light background? If stray light rejection is important, then a double monochromator may be necessary.

## Table 1. Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Fluorescence | | |
| Fluorescence in liquids (emission or excitation) | 1-20nm bandwidth Good stray light rejection | CM110 1/8 meter monochromator or SM spectrometer for emission detection |
| Fluorescence in biological materials (emission or excitation) | 1-20nm bandwidth Excellent scattered light rejection | CM112 1/8 meter monochromator or SM spectrometer with special filter |
| Fluorescence in solids (emission or excitation) | 0.2-3.0nm bandwidth Good stray light rejection | DK240 1/4 meter monochromator or SM GT2 spectrometer for detection |
| Weak fluorescence in solids, liquids (emission) | Array detection for high sensitivity 0.2-3.0nm bandwidth | DKSP240 1/4 meter spectrogrsph with array detection system |
| Weak fluorescence in scattering biomaterials (emission or excitation) | High stray light rejection High sensitivity | DKSP240 1/4 meter monochromator |
| Phosphorescence, fluorescence kinetics (emission) | Array detection for time resolution | DKSP240 1/4 meter spectrograph with array detection system |

## Table 1. (continued) Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Spectrophotometry | | |
| Spectrophotometry of clear liquids, optics | 1-20nm bandwidths 0.1% transmission | Cm110 1/8 meter monochromator or SM spectrometers |
| Spectrophotometry of gases, traces in clear solids | To 0.01% transmission, 0.05-1.0nm bandwidth | DK240 1/4 meter monochromator |
| Spectrophotometry of dense objects | To 0.01% transmission, 1-20nm bandwidth | DK240 1/4 meter monochromator |
| Time varying spectrophotometry (thin film monitoring) | Array detection | DKSP240 1/4 meter spectrogrsph with array detection system or SM spectrometers |

| Application | Requirements | Recommended |
|---|---|---|
| Laser Spectrometry | | |
| Picosecond studies liquids, biological materials | Preserving pulse width 1-20nm bandwidths | CM110, CM112 monochromator |
| Picosecond studies solids, gases | Preserving pulse width 0.2-20nm bandwidths | DK240 1/4 meter monochromator |
| Tuning, wavelength checking, diode lasers | Resolution, accuracy to 1.0nm | CM110 1/8 meter monochromator |
| Tuning, wavelength checking, gas and dye lasers | Resolution, accuracy to 0.1nm | CM140 1/4 meter monochromator |
| Diode laser mode structure | Resolution to 1.0nm | CM110 1/8 meter monochromator |

## Table 1.(countinued) Selsction Chart by Applications

| Application | Requirements | Recommended |
|---|---|---|
| Emission Spectrometry, Radiometry | | |
| Arc, spark, or plasma spectroscopy | Resolution to 0.03nm | DK480 1/2 meter monochromator |
| Arc, spark, or plasma spectroscopy of small traces | Resolution to 0.03nm array capability | DK480 1/2 meter monochromator and spectrograph |
| LEDs, incandescent lamps, fluorescent lamps, phosphors | 1-20nm bandwidth | CM110 1/8 meter monochromator or SM spectrometer |
| Raman spectrometry | 0.3-10cm$^{-1}$ bandwidth Excellent stray light rejection | CM110 1/8 meter monochromator with special filter, CM112 double monochromator |

| Application | Requirements | Recommended |
|---|---|---|
| Infrared Spectrometry | | |
| Fiber analysis, LED analysis source or detector | 1-20nm bandwidths 200-2500nm tunability | CM110, DK240 monochromators or multiple SM spectrometers |
| NIR spectrophotometry | 1-20nm bandwidths 700-1100nm tunability | CM110, DK240 monochromators or SM spectrometers |

| Application | Requirements | Recommended |
|---|---|---|
| General purpose | | |
| Teaching, general lab use | Array capability 200-20000nm tunability 0.3-30nm bandwidth | CM110, DK240 monochromators and spectrographs or SM spectrometers |

## Notes

Biological samples frequently scatter almost 100% of the incident light. To detect a weak fluorescence signal in this environment requires a double monochromator, frequently on both the excitation and emission sides.

Array detection can potentially multiply the signal collected by the number of detector elements, N. The signal to noise ratio potentially improves by the square root of N.

## Plane and Holographic Gratings

In recent years spectrometers using corrected concave holographic gratings have been heavily promoted. The advantages of these instruments are compactness, few optical elements and aberration correction that improve resolution.

Why has the plane-grating spectrometer survived? For the UV, for the IR, for wide spectral ranges, and for radiometry in which absolute intensity of a signal is important, the plane-grating spectrometer is superior.

Corrected concave-gratings offer good resolution over a wavelength octave, typically 350nm to 700nm. Outside of this region, the aberrations are much worse than those in a plane-grating instrument are. A typical Czerny-Turner monochromator with a 1200 groove-per-millimeter plane grating will have a good resolution from 250nm to 1500nm, over three times the wavelength range of itsconcave grating counterpart. The plane-grating spectrometer offers superior resolution in the UV and IR.

Concave-grating instrument designs are generally good for one spectral region only. Changing gratings is not possible. Plane-grating spectrometers can change their spectral region by changing gratings. A Czerny-Turner spectrometer with a triple grating turret can span 200 to 2000nm with good resolution and good efficiency.

Concave-grating spectrometers have transmission efficiencies that vary greatly with the input angle. This makes them poor choices for radiometric studies in which the intensity at each wavelength is critical and uniform illumination of the grating cannot be guaranteed. Because the groove profiles of corrected concave gratings vary greatly across the grating surface, the diffraction efficiency also varies greatly across the surface.

This contrasts with the plane-grating which has the same efficiency at all points on the surface. Unless the light enters a concavegrating instrument in exactly the same distribution each time, the instrument will have varying transmission efficiency. Fifty-percent changes from central illumination to edge illumination have been measured.

Corrected concave-gratings average half the diffraction efficiencies of plane-gratings.The groove profile of a ruled-plane grating is designed for high efficiency within narrow limits. Ion etching has been used to sharpen the groove profiles of corrected concave-gratings, but this is akin to making a lens from a glass plate by sandblasting. The profile improves, but the surface and scatter are horrible.

While corrected-concave-grating spectrometers occupy an important niche in spectroscopy, plane-grating instruments remain the workhorses.

## Gratings and Their Selections

From the foregoing discussion on grating equation it is clear that the longest wavelength that will be diffracted by a grating is 2*d. This places a long wavelength limit on the spectral range of a grating. The table below illustrates this limit. Loss of light as the grating is rotated to a steep angle usually limits the actual range to about 90% of the long wavelength limit listed.

The wavelength dependence of grating efficiency also constrains the spectral range. SP has a complete set of diffraction efficiency curves for all of its standard and custom gratings, and the appropriate curves should be reviewed if spectral range is important.

## Table 2. Grating Density and Long Wavelength Limit

| Grating Density (g/mm) | Groove spacing (nm) | Long-wavelength Limit (nm) |
|---|---|---|
| 3600 | 277.78 | 555.56 |
| 2400 | 416.67 | 833.33 |
| 1800 | 555.56 | 1,111.11 |
| 1200 | 833.33 | 1,666.67 |
| 600 | 1,666.67 | 3,333.33 |
| 300 | 3,333.33 | 6,666.67 |
| 150 | 6,666.67 | 13,333.33 |
| 75 | 13,333.33 | 26,666.66 |
| 50 | 20,000.00 | 40,000.00 |

## Selection by Required Bandwidth or Dispersion

A table giving typical reciprocal linear dispersions near the center of the spectral range is given below.

The bandwidth transmitted by a monochromator will be the dispersion times the slit width. Given two of the three variables-bandpass, slit width and dispersion-the third can be calculated.

Most applications are light starved, and it is useful to open the slits to the greatest width that is compatible with the desired bandwidth. To increase the slit width while retaining the bandwidth, one can select a higher groove density. For example, at 340nm and a 10nm bandwidth in a 1/8 meter monochromator, a 1200 g/mm grating will allow a 1.4nm slit width, but a 2400 g/mm grating will allow a 2.8 millimeter slit width at the same bandpass.

Occasionally, the bandwidth may be constrained by the maximum slit width. A typical 1/4 meter monochromator might have a maximum slit width of four millimeters; a 14 nanometer bandpass would result with a 1200 g/mm grating. If a 28nm bandwidth was desired, a 600 g/mm grating would give the required bandpass.

For spectrographs, a particular dispersion is frequently desired. To cover 400 to 700 nanometers on a 25mm array detector would require a dispersion of 12nm/mm. The grating suitable for this dispersion for an SM2XX spectrometer would be a 1200 g/mm.

A particular resolution might also be required in a spectrograph. To resolve 0.3 angstroms in three pixels (75 microns) would require a dispersion of:

(.03/. 075) = 1.3nm/mm.

This dispersion would be typical of an 1800 g/mm grating in a 1/2 meter spectrograph.

## Selection by Required Throughput

One frequently needs to obtain the maximum grating efficiency for a particular wavelength band. It would be useful to be able to design a groove profile to provide that efficiency profile. Unfortunately, this problem has not yet been solved. In practice, the efficiencies of many gratings have been measured; one selects from the grating with the desired efficiency curve.

For ruled gratings and blazed holographic grating the efficiencyprofile is generally triangular. The grating is most efficient

at a blaze wavelength, λb While a number of blaze wavelengths are generally available, the most common is 1/3 of the long wavelength limit. (For a 1200g/mm grating, this would be at 500 nanometers.) The peak at λb usually 90%, and the efficiency falls to about 20% at 67 * λb and at 1.5 * λb

Holographic gratings generally have flat efficiency profiles. The mean efficiency is about 30% over a range of .33 * λb to 1.5 * λb. In both cases, real efficiencies show complicated polarization dependence. The ratio of efficiency for polarization parallel to the groove to that perpendicular to the grooves may be 3:1 over a large spectral range.

In Figure 19, typical efficiency curves for a standard SP grating are presented. These curves span a wide range of wavelengths from UV to IR. These curves do not account for loss of solid angle of the grating as it is rotated. In addition to the curves included here, SP has measured efficiencies for both polarized and unpolarized light on a wide variety of other gratings; this data is available upon request.

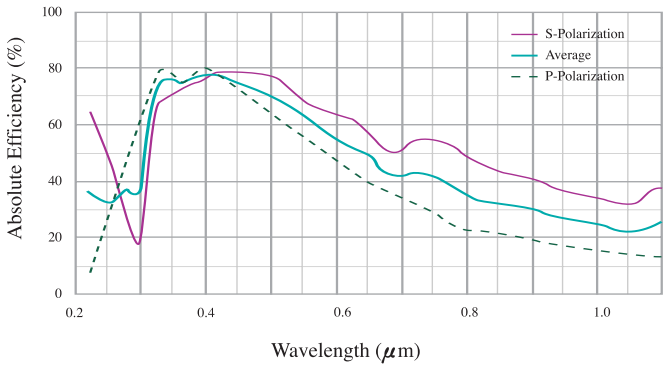



Figure 19. Typical grating efficency curves.

## Selection by Stray Light Level

Both scatter and extraneous spectral features (ghosts) may result from grating imperfections (see Stray Light discussion in Spectrometer Basics section). These imperfections result from the grating manufacturing processes. In general there are five types of gratings available; interferometrically ruled, ruled, holographic, sheridan blazed holographic and ion-etched holographic.

Interferometrically ruled gratings, holographic gratings and sheridan blazed gratings have comparable levels of stray light. All three are generally free of ghosts.

Exposing photoresist with a laser generated interference pattern makes the holographic gratings. The interference sinusoidaSheridan blazed gratings are produced by exposing the photoresist from both sides. A triangular profile results; these gratings have good efficiency. However, the technique will only produce UV blazed gratings. In ruling gratings, a pointed diamond is used to burnish the groove profile into a gold film on a quartz substrate. The position of the diamond is controlled by an interferometer as each groove is cut.

Classical ruled gratings are ruled without interferometric control. These gratings tend to have small, periodic errors in their groove profile.

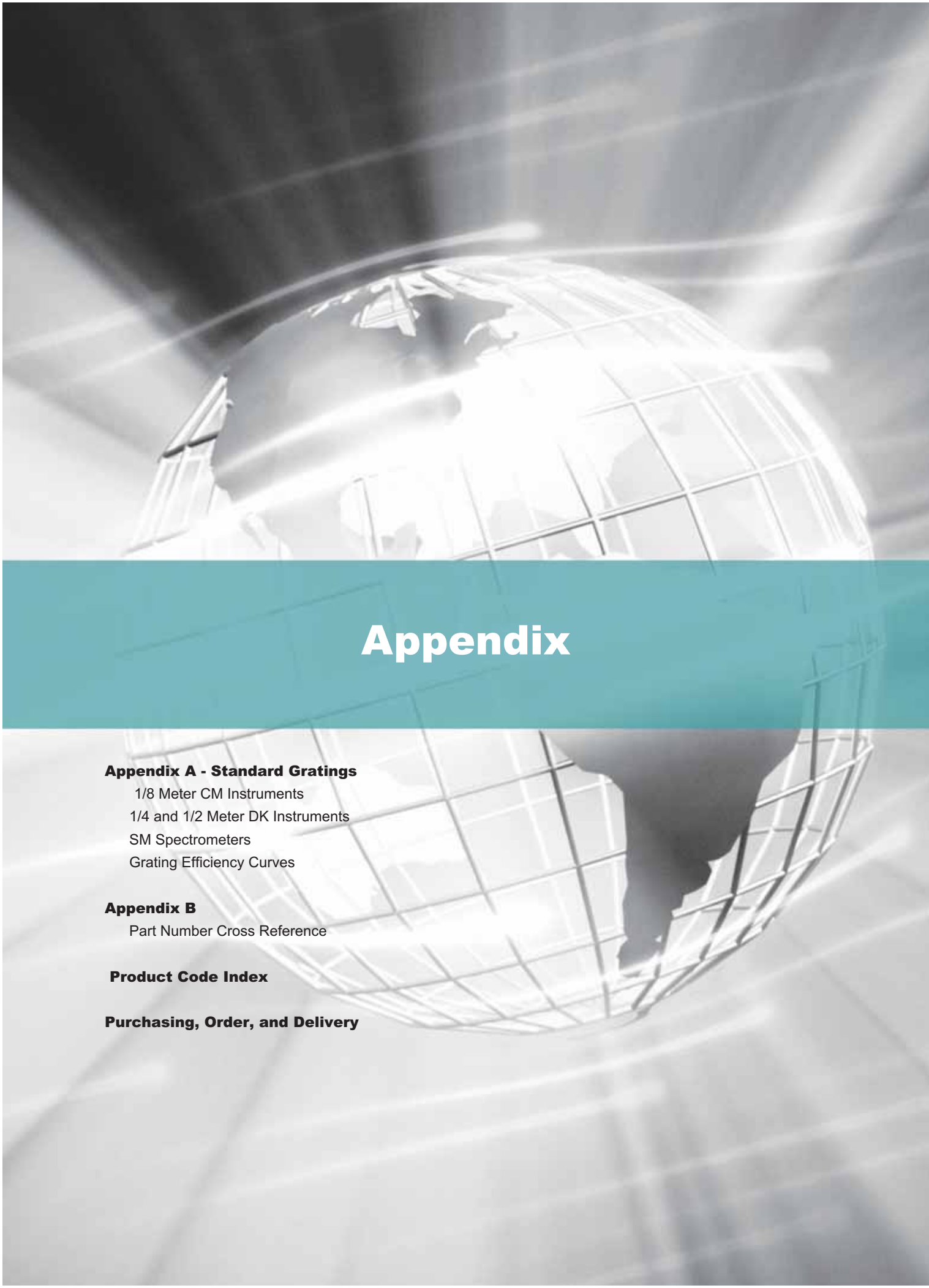
SP's standard gratings are listed in Appendix A. Standard DK24 series gratings are 68mm x 68mm. Wide gratings (64mm x 84mm) are available. SP's standard DK12 series gratings are 30mm x 30mm. For gratings not listed consultSP.

Recommended applications are listed at right for ruled diffraction gratings using spectral range, bandwidth, throughput and stray light selection criteria discussed above,

# Selection by Application

## Table 4. Selection of Gratings by Applications

| Application | Grating g/mm | Grating Blaze Wavelength (nm) | DK | CM | SM | Rearks |
|---|---|---|---|---|---|---|
| Fouorescent illumination | 2400 | 240 | x | x | | Highest UV through-put |
| Fluorescent detection | 1200 | 500 | x | x | | Effcient over emission range |
| NIR laser analysis | 600 | 1000 | x | x | | Effcient over emission range |
| NIR laser analysis | 1200 | 1000 | | | x | Effcient over emission range |
| Raman | 1800 | 500 holographic | x | x | | Fair effciency, good stray light performance |
| NIR Raman | 600 | 1100 | x | x | | Good effciency, good stray light performance |
| UV-VIS-Array | 300 | 300 | x | x | | Good effciency, good UV and part of visible |
| UV-VIS-Array | 1200 | 250 | | | x | Good effciency, good UV and part of visible |
| VIS Array | 300 | 500 | x | x | | Good effciency, covers entire visible region |
| VIS Array | 600-1200 | 550 | | | x | Good effciency, covers entire visible region |



# Appendix

# Standard Gratings

## Standard Ruled Gratings for CM 1/8 Meter Instruments (including SM300, AD300, and SM302)

Table 1. Standard Gratings for CM monochromators / spectrographs

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30%T | Peak T% |
|---|---|---|---|---|
| AG2400-00240-303 | 2400 | 240 | 180-680 | 70 |
| AG1200-00200-303 | 1200 | 200 | 180-450 | 65 |
| AG1200-00300-303 | 1200 | 300 | 200-750 | 72 |
| AG1200-00500-303 | 1200 | 500 | 330-1500 | 82 |
| AG1200-00600-303 | 1200 | 600 | 400-1500 | 80 |
| AG1200-00750-303 | 1200 | 750 | 480-1500 | 85 |
| AG0600-00500-303 | 600 | 500 | 350-1300 | 80 |
| AG0600-01250-303 | 600 | 1250 | 800-3000 | 85 |
| AG0300-00500-303 | 300 | 500 | 310-1100 | 80 |
| AG0300-02500-303 | 300 | 2500 | 1500-6000 | 88 |
| AG0150-00500-303 | 150 | 500 | 320-980 | 72 |
| AG0150-04000-303 | 150 | 4000 | 2500-9000 | 93 |
| AG0075-01700-303 | 75 | 1700 | 1200-2500 | 85 |
| AG0075-08000-303 | 75 | 8000 | 5000-15000 | 82 |
| AG0045-01750-303 | 45 | 1750 | 1200-2500 | 77 |

# Standard Ruled Gratings for DK 1/4 & 1/2 Meter Instruments

Table 2. Standard Gratings for DK monochromators / spectrographs

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30T% | Peak T% |
|---|---|---|---|---|
| AG2400-00240-686 | 2400 | 240 | 180-680 | 70 |
| AG1200-00200-686 | 1200 | 200 | 180-450 | 65 |
| AG1200-00250-686 | 1200 | 250 | 180-460 | 70 |
| AG1200-00300-686 | 1200 | 300 | 200-750 | 70 |
| AG1200-00500-686 | 1200 | 500 | 330-1500 | 82 |
| AG1200-00600-686 | 1200 | 600 | 400-1500 | 80 |
| AG1200-00750-686 | 1200 | 750 | 480-1500 | 85 |
| AG1200-01000-686 | 1200 | 1000 | 550-1500 | 75 |
| AG0600-00500-686 | 600 | 500 | 350-1300 | 80 |
| AG0600-01200-68 | 600 | 1250 | 800-3000 | 85 |
| AG0600-01600-686 | 600 | 1600 | 950-3000 | 93 |
| AG0300-00500-686 | 300 | 500 | 310-1100 | 80 |
| AG0300-02000-686 | 300 | 2000 | 1200-4000 | 88 |
| AG0300-02500-686 | 300 | 2500 | 1500-4500 | 88 |
| AG0300-03000-686 | 300 | 3000 | 1800-6000 | 80 |
| AG0150-00500-686 | 150 | 500 | 320-980 | 72 |
| AG150-04000-686 | 150 | 4000 | 2500-9000 | 93 |
| AG0075-08000-686 | 75 | 8000 | 5000-15000 | 82 |
| AG0050-00600-686 | 50 | 600 | 400-1200 | 78 |
| AG0050-1200-686 | 50 | 12000 | 7500-20000 | 82 |

## Standard Ruled Gratings for SM Spectrometers

Table 3. Standard Gratings for SM spectrometers

| Part Number | Density (g/mm) | Peak I (nm) | Range (nm) @ > 30T% | Peak T% |
|---|---|---|---|---|
| AG0600-00300-163 | 600 | 300 | 200-650 | 71 |
| AG0600-00400-163 | 600 | 400 | 250-1000 | 77 |
| AG0600-00500-163 | 600 | 500 | 300-1100 | 77 |
| AG0600-00750-163 | 600 | 750 | 500-1700 | 72 |
| AG0600-01000-163 | 600 | 1000 | 600-3000 | 74 |
| AG0600-01200-163 | 600 | 1200 | 800-3200 | 76 |
| AG0600-01600-163 | 600 | 1600 | 950-3200 | 87 |
| AG0830-00800-163 | 830 | 800 | 450-2350 | 76 |
| AG0830-01200-163 | 830 | 1200 | 600-2350 | 75 |
| AG1200-00250-163 | 1200 | 250 | 200-650 | 69 |
| AG1200-00300-163 | 1200 | 300 | 200-700 | 70 |
| AG1200-00400-163 | 1200 | 400 | 200-900 | 71 |
| AG1200-00500-163 | 1200 | 500 | 300-1650 | 71 |
| AG1200-00750-163 | 1200 | 750 | 460-1650 | 71 |
| AG1200-01000-163 | 1200 | 1000 | 520-1650 | 69 |
| AG1800-00500-163 | 1800 | 500 | 300-1075 | 67 |

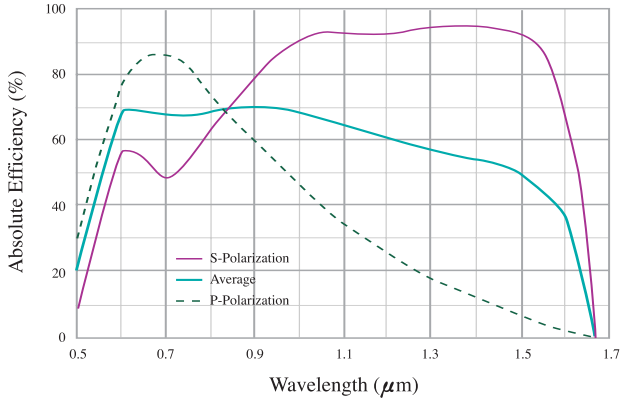
## References

M.V.R.K. Murty, Theory and Principles of Monochromators, Spectrometers, and Spectrographs, Optical Engineering, Vol.13, No.1, Jan 1974

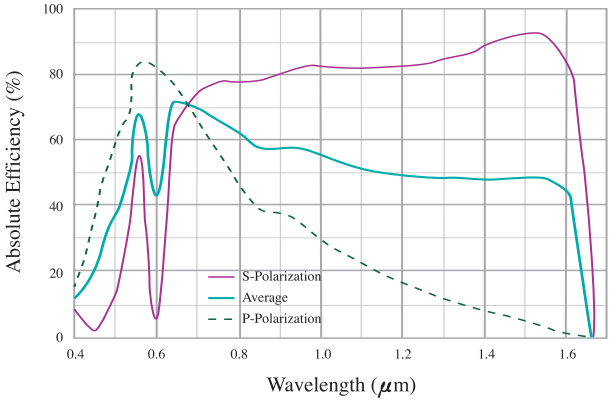
T.M. Niemczyk and G.W. Gobeli, Characteristics of a Direct Grating Drive, Applied Spectroscopy, Vol. 42, No. 5, 1988

## Grating Efficiency Curves

# Grating Efficiency Curves




AG1200-01000

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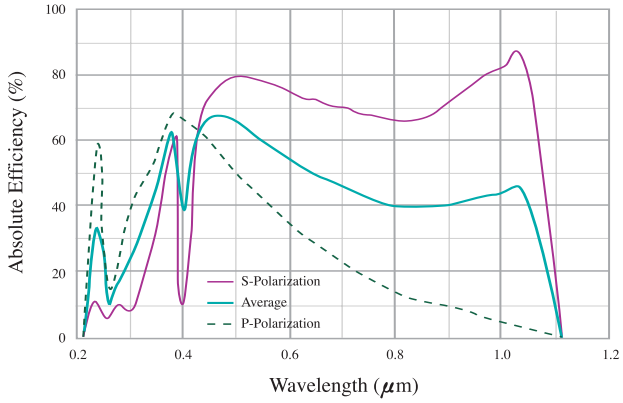


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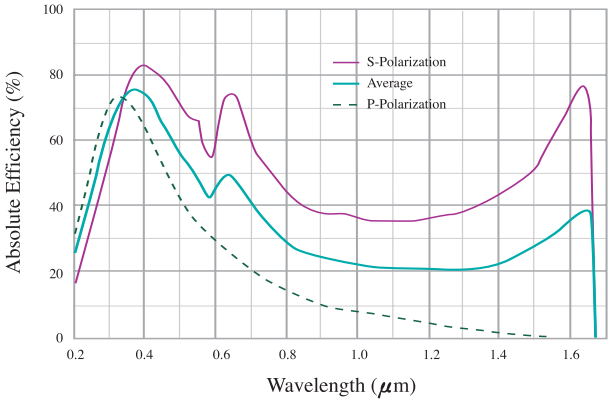


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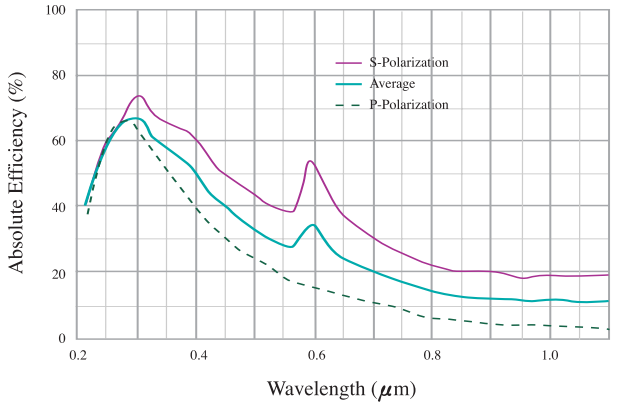


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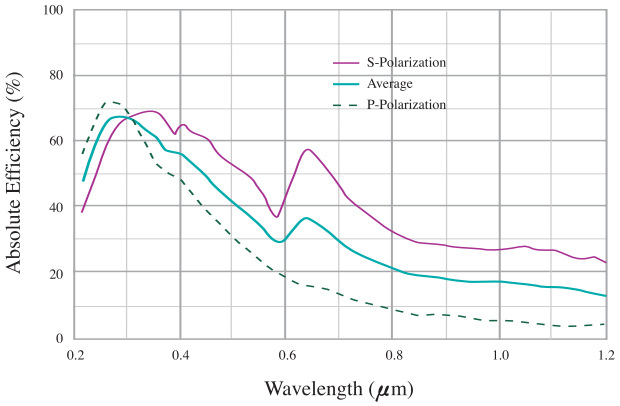


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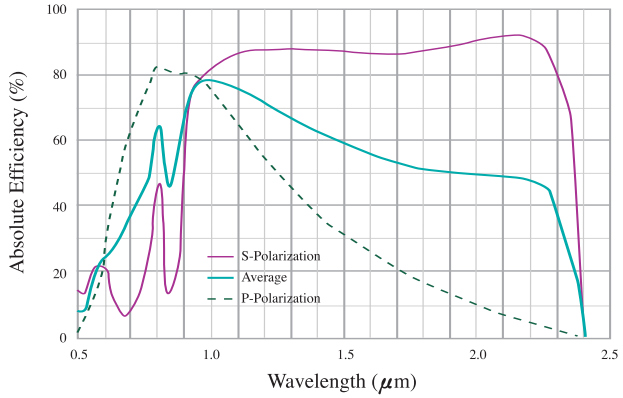


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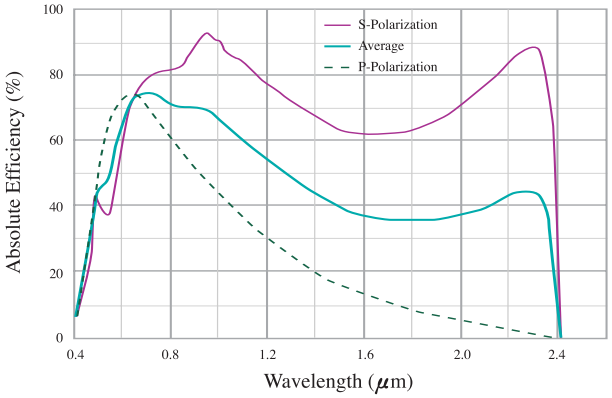


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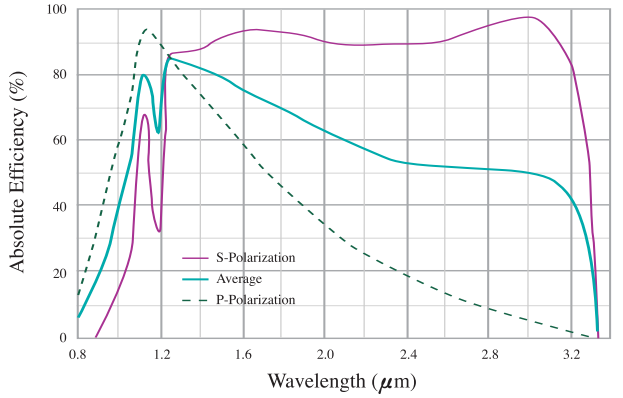


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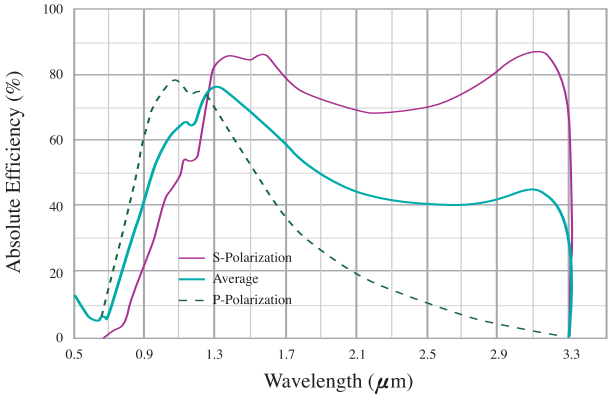


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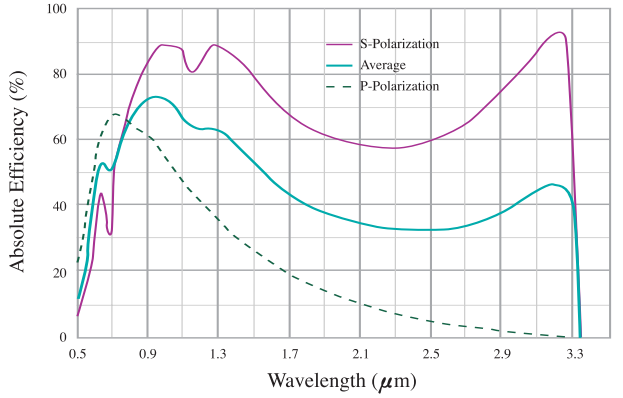


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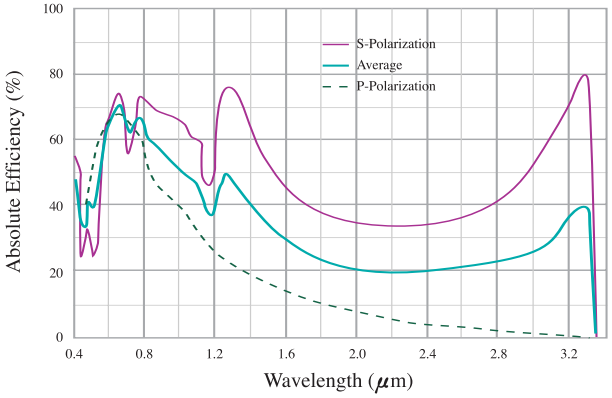


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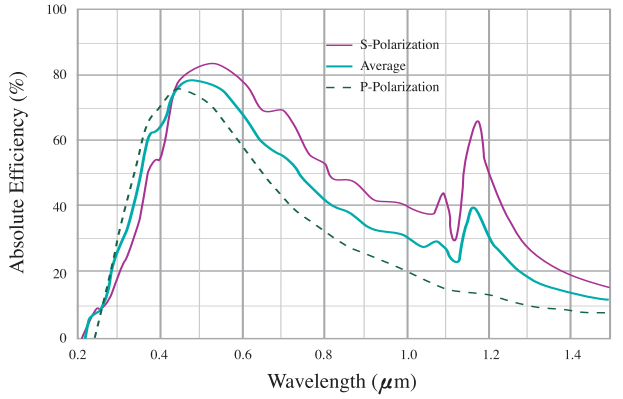


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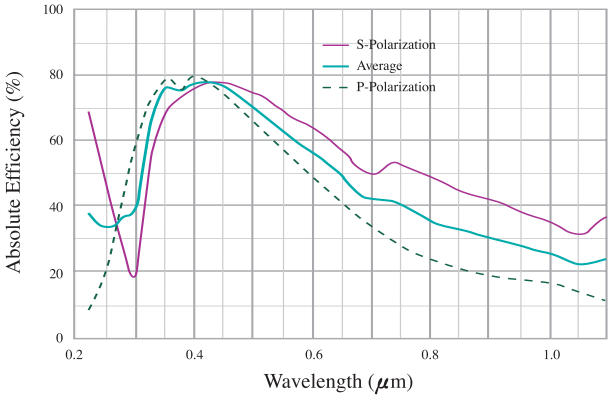


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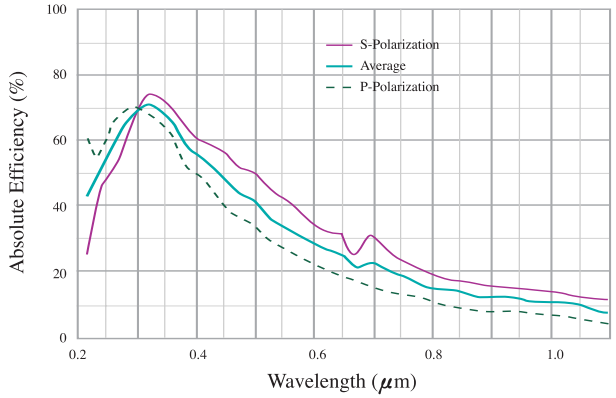


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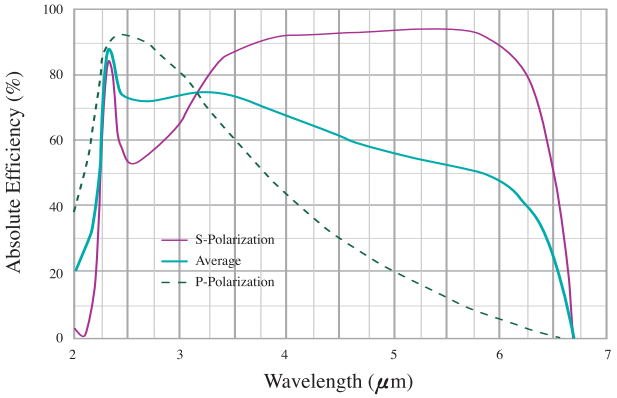


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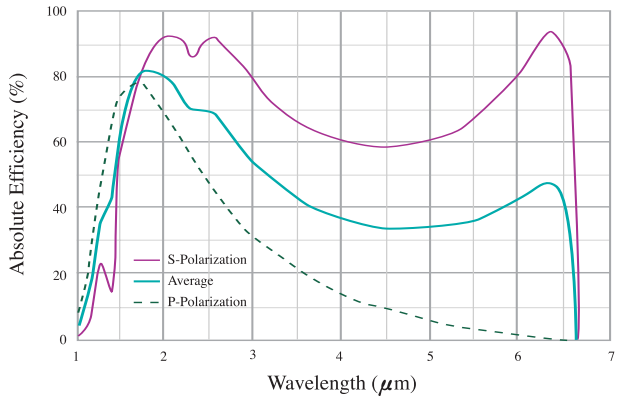


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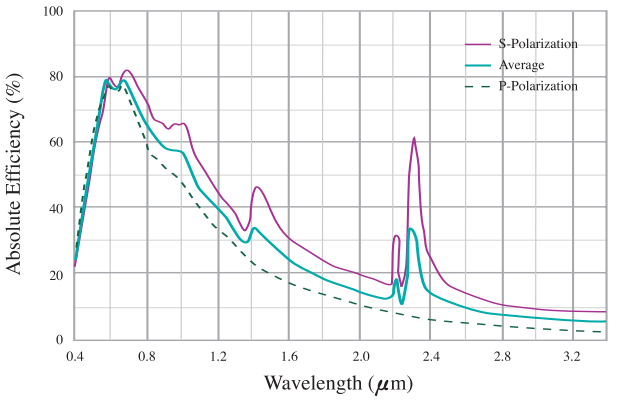


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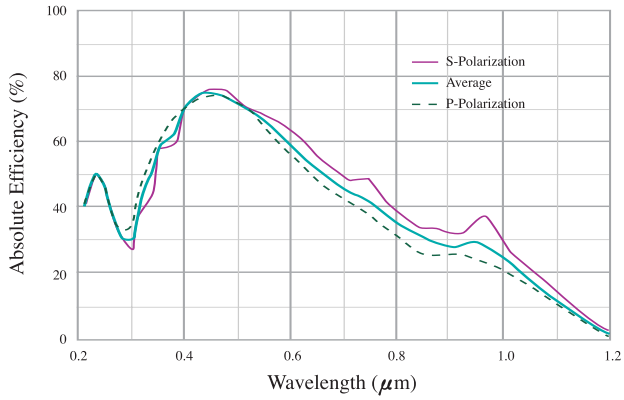


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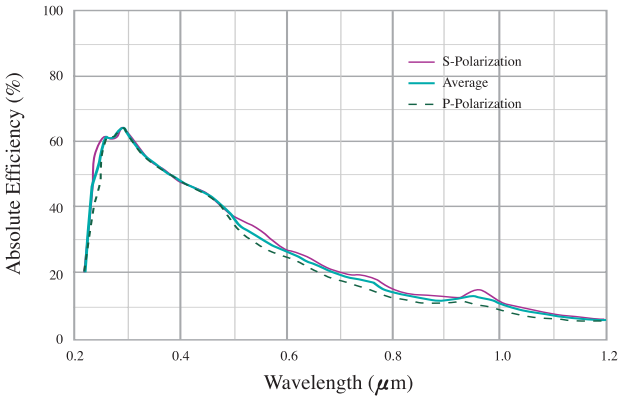


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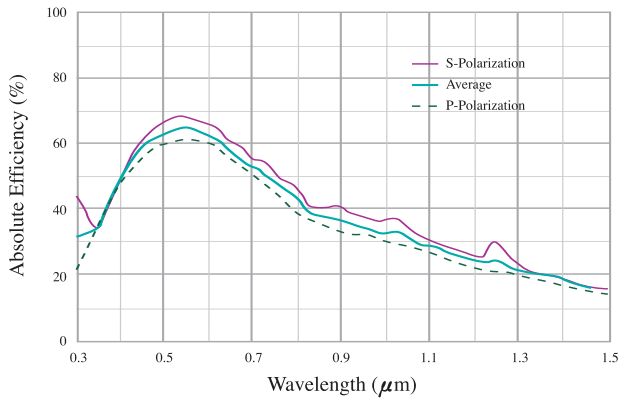


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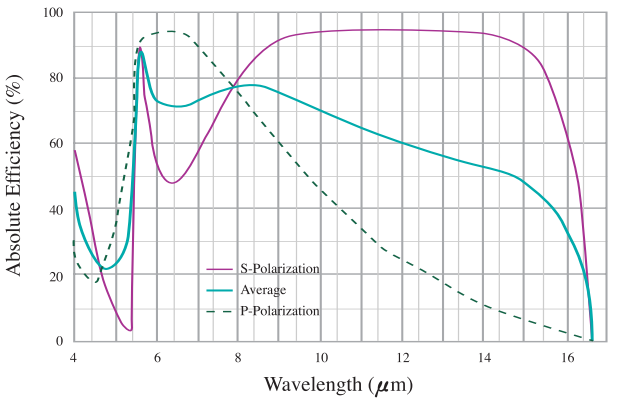


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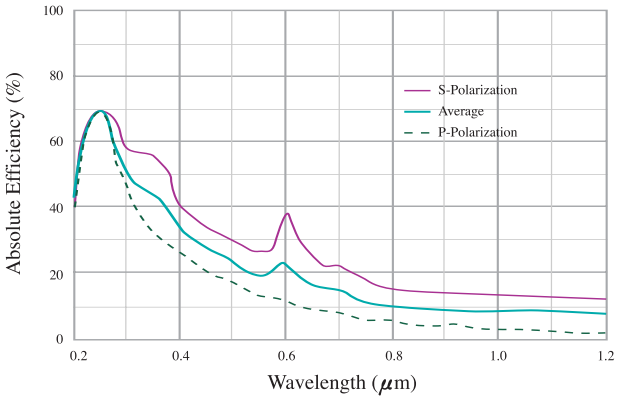
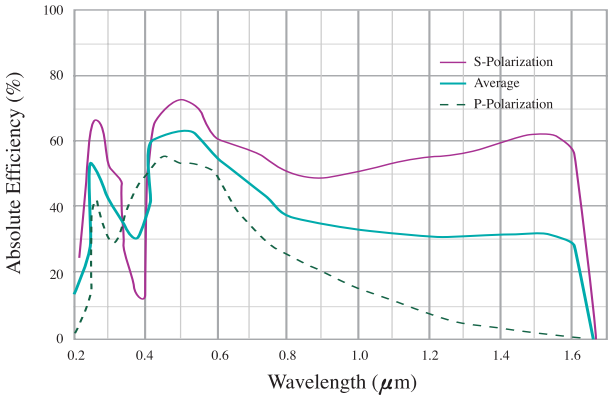



AG1200-U (Holographic)

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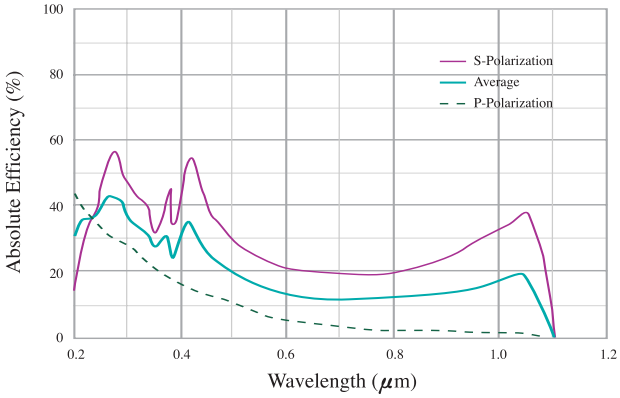


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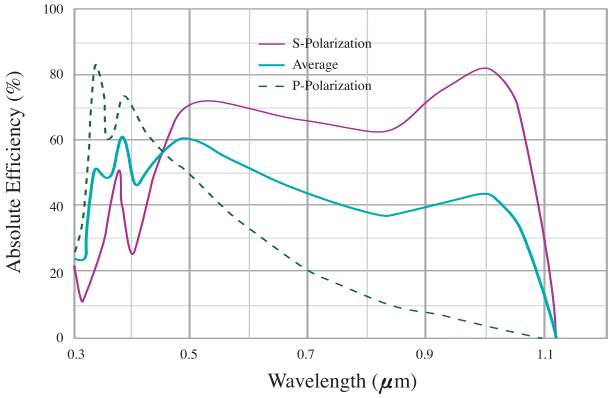


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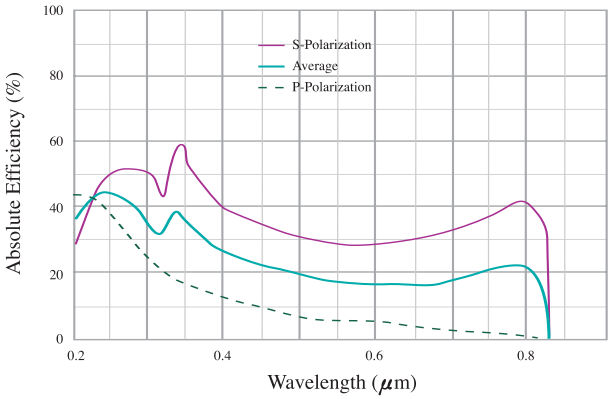


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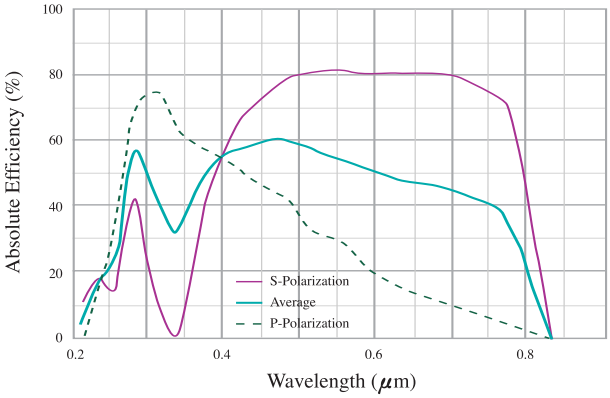


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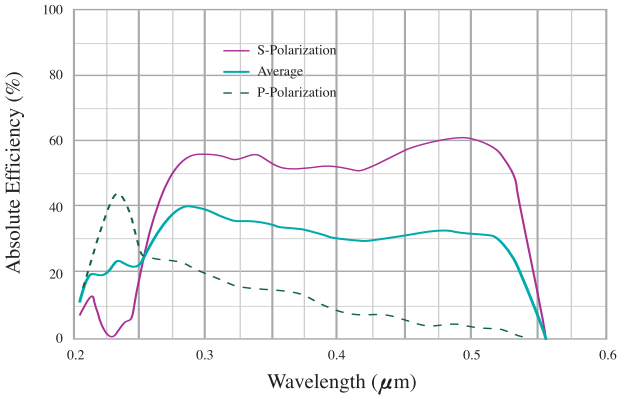


AG3600-U (Holographic)

# Appendix B

## Part # Cross Reference

### Fiber Products

| Past Part Numbers | Current Part identifier | Description |
|---|---|---|
| AF600 | AF0200-0200DPSM-U20B | Immersive fiber probe, 200 µm,2m |
| AF601 | AF0400-1400SMSM-U20B | Fiber, cable, Bifurcated, SMA-SMA/SMA, 2m |
| AF602 | AF0200-2000SMCL-U20B | Fiber, Bifurcated, SMA-SMA/Line, 2m |
| AF603 | AF0400-1500SMSM-U20B | Fiber, Bifurcated, SMA, six & one, 2m |
| AF610 | AF0400-0400SMSM-U20S | Fiber, Single, .22NA, 400 µm, 2m |
| AF611 | AF0200-0200SMSM-U20S | Fiber, Single, .2mm, 200 µm.22NA |
| AF613 | AF0100-0100SMSM-U20S | Fiber, Single, .2mm, 100 µm.22NA |
| AF641 | AF0200-3500CSCS-U20S | Fiber, Bundle, .38 NA, 3.5, 2m Ferrule |
| AF642 | AF0200-1000SMCS-U20S | Fiber, Bundle, Round-line, .22NA, 2m |
| AF643 | AF0200-2180SMSM-U20S | Fiber, Bundle, 2.18mm, .2mm, 200 µm.22NA |
| AF644 | AF0100-0625SMCL-U20S | Fiber, Bundle, Round-line, .22NA, 2m |
| AF651 | AF0035-23500CSCS-G20S | Fiber, Bundle, .55 NA, 3.5, 2m Ferrule |
| AF650 | AF5000-50001111-S10S | Liquid, Round-Round, .59 NA, Ferrule, 1m, S Type |
| AF660 | AF5000-50001111-V10S | Liquid, Round-Round, .60 NA, Ferrule, 1m, V Type |

### Grating Products 30m x 30mm x 3mm

| Past Part Numbers | Current Part identifier | Ruling (g/nm) | Peak (nm) |
|---|---|---|---|
| DK122424 | AG2400-00240-303 | 2400 | 240 |
| DK121220 | AG1200-00200-303 | 1200 | 200 |
| DK121230 | AG1200-00300-303 | 1200 | 300 |
| DK121260 | AG1200-00600-303 | 1200 | 600 |
| DK121275 | AG1200-00750-303 | 1200 | 750 |
| DK120605 | AG0600-00500-303 | 600 | 500 |
| DK120612 | AG0600-01200-303 | 600 | 1200 |
| DK120305 | AG0300-00500-303 | 300 | 500 |
| DK120325 | AG0300-02500-303 | 300 | 2500 |
| DK121505 | AG0150-00500-303 | 150 | 500 |
| DK121540 | AG150-04000-303 | 150 | 4000 |
| DK127580 | AG0075-08000-303 | 75 | 8000 |

### Grating Products 68m x 68mm x 6mm

| Past Part Numbers | Current Part identifier | Ruling (g/nm) | Peak (nm) |
|---|---|---|---|
| DK242424 | AG2400-00240-686 | 2400 | 240 |
| DK241220 | AG1200-00200-686 | 1200 | 200 |
| DK241225 | AG1200-00250-686 | 1200 | 250 |
| DK241230 | AG1200-00300-686 | 1200 | 300 |
| DK241250 | AG1200-00500-686 | 1200 | 500 |
| DK241260 | AG1200-00600-686 | 1200 | 600 |
| DK241275 | AG1200-00750-686 | 1200 | 750 |
| DK241210 | AG1200-01000-686 | 1200 | 1000 |
| DK240605 | AG0600-00500-686 | 600 | 500 |
| DK240612 | AG0600-01200-686 | 600 | 1200 |
| DK240616 | AG0600-01600-686 | 600 | 1600 |
| DK240305 | AG0300-00500-686 | 300 | 500 |
| DK240320 | AG0300-02000-686 | 300 | 2000 |
| DK240325 | AG0300-02500-686 | 300 | 2500 |
| DK240330 | AG0300-03000-686 | 300 | 3000 |
| DK241505 | AG0150-00500-686 | 150 | 500 |
| DK241540 | AG0150-04000-686 | 150 | 4000 |
| DK247580 | AG0075-08000-686 | 75 | 8000 |
| DK245006 | AG0050-00600-686 | 50 | 600 |
| DK245012 | AG0050-12000-686 | 50 | 12000 |

## Light Source Products

| Past Part Numbers | Current Part identifier | Description |
|---|---|---|
| AS201 | ASB-XE-175EX | Light Source, Xenon, 175W, Extended |
| AS201-S | merge w AS201 | Light Source, Xenon, w/Fiber |
| AS202 | ASB-XE-175 | Light Source, Xenon, 175W, Ozone Blocking |
| AS202-V | merge w AS202 | Light Source, Xenon, Type V |
| AS203 | ASB-XE-175B | Replacement Lamp, Xenon 175W |
| AS220 | ASB-W-030 | Light Source, Tungsten-Halogen, 30W |
| AS220-220V | ASB-W-030CE | Light Source, Tungsten-Halogen, 30W, 220V |
| AS20-B | ASB-W-020RB | Replacement Lamp, 20W |
| AS200-F | ASB-W-020R | Light Source, Tungsten-Halogen, 20W, Regulated |
| AS220F | ASB-W-030F | Light Source, Tungsten-Halogen, 30W, Fiber Coupled |
| AS222 | ASB-W-020U | Light Source, Tungsten-Halogen, 20W, Unregulated |
| AS240 | ASB-D-030 | Light Source, Deuterium, 30W, IST |
| AS240-220V | ASB-D-030CE | Light Source, Deuterium, 30W, 220V |
| AS240F | ASB-D-030F | Light Source, Deuterium, 30W, IST, Fiber Coupled |
| AS240-F | ASB-D-030R | Light Source, Deuterium, 30W, Regulated |
| AS250 | ASB-W-150U | Light Source, Tungsten-Halogen, 150W |
| AS260 | ASC-AC | Lamp Assembly, Spectral Calibration, 110V |
| AS260-CE | ASC-ACCE | Lamp Assembly, Spectral Calibration, 220V |
| AS320 | ASB-W-030B | Replacement Lamp, Tungsten-Halogen, 30W |
| AS321 | same as ASB-W-020RB | Replacement Lamp, Tungsten-Halogen, 20W |
| AS322 | ASB-W-150B | Replacement Lamp, Tungsten-Halogen, 150W |
| AS340 | ASB-D-030B | Lamp Assembly, Deuterium, 30W |
| AS240-B | ASB-D-030RB | Lamp Assembly, Deuterium, 30W |
| AS361 | ASC-HG | Lamp , Spectral Calibration, Hg |
| AS362 | ASC-NE | Lamp , Spectral Calibration, Ne |
| AS363 | ASC-XE | Lamp , Spectral Calibration, Xe |
| AS364 | ASC-AR | Lamp , Spectral Calibration, Ar |
| AS365 | ASC-KR | Lamp , Spectral Calibration, Kr |
| AS90 | discontinued | Visible Light Source |
| AS95 | ASB-W-005R | Light Source, Regulated |
| AS95-B | ASB-W-005RB | Replacement Lamp, Tungsten-Halogen, 5W |

## Spectrum Analyzers converersion from Melles Griot model numbers

| Past Part Numbers | Current Part identifier | Description |
|---|---|---|
| 13SAE001 | SA300-04 | Spectrum Analyzer, 450-550nm, 300 MHz FSR |
| 13SAE002 | SA300-08 | Spectrum Analyzer, 550-680nm, 300 MHz FSR |
| 13SAE003 | SA300-12 | Spectrum Analyzer, 700-860nm, 300 MHz FSR |
| 13SAE006 | SA300-14 | Spectrum Analyzer, 860-1100nm, 300 MHz FSR |
| 13SAE007 | SA300-16 | Spectrum Analyzer, 1050-1250nm, 300 MHz FSR |
| 13SAE008 | SA300-18 | Spectrum Analyzer, 1300-1550nm, 300 MHz FSR |
| 13SAE009 | SA300-20 | Spectrum Analyzer, 1500-1650nm, 300 MHz FSR |
| 13SAE104 | SA300-06 | Spectrum Analyzer, 480-640nm, 300 MHz FSR |
| 13SAE105 | SA300-10 | Spectrum Analyzer, 630-860nm, 300 MHz FSR |
| 13SAE106 | SA300-02 | Spectrum Analyzer, 390-425nm, 300 MHz FSR |
| 13SAF001 | SA300-04-F | Spectrum Analyzer, 450-550nm, 300 MHz FSR, Fiber input |
| 13SAF002 | SA300-08-F | Spectrum Analyzer, 550-680nm, 300 MHz FSR, Fiber input |
| 13SAF003 | SA300-12-F | Spectrum Analyzer, 700-860nm, 300 MHz FSR, Fiber input |
| 13SAF006 | SA300-14-F | Spectrum Analyzer, 860-1100nm, 300 MHz FSR, Fiber input |
| 13SAF007 | SA300-16-F | Spectrum Analyzer, 1050-1250nm, 300 MHz FSR, Fiber input |
| 13SAF008 | SA300-18-F | Spectrum Analyzer, 1300-1550nm, 300 MHz FSR, Fiber input |
| 13SAF009 | SA300-20-F | Spectrum Analyzer, 1500-1650nm, 300 MHz FSR, Fiber input |
| 13SAF104 | SA300-06-F | Spectrum Analyzer, 480-640nm, 300 MHz FSR, Fiber input |
| 13SAF105 | SA300-10-F | Spectrum Analyzer, 630-860nm, 300 MHz FSR, Fiber input |
| 13SAF106 | SA300-02-F | Spectrum Analyzer, 390-425nm, 300 MHz FSR, Fiber input |
| 13SAE021 | SA2-04 | Spectrum Analyzer, 450-550nm, 2 GHz FSR |
| 13SAE022 | SA2-08 | Spectrum Analyzer, 550-680nm, 2 GHz FSR |
| 13SAE023 | SA2-12 | Spectrum Analyzer, 700-860nm, 2 GHz FSR |
| 13SAE026 | SA2-14 | Spectrum Analyzer, 860-1100nm, 2 GHz FSR |
| 13SAE027 | SA2-16 | Spectrum Analyzer, 1050-1250nm, 2 GHz FSR |
| 13SAE028 | SA2-18 | Spectrum Analyzer, 1300-1550nm, 2 GHz FSR |
| 13SAE029 | SA2-20 | Spectrum Analyzer, 1500-1650nm, 2 GHz FSR |
| 13SAE124 | SA2-06 | Spectrum Analyzer, 480-640nm, 2 GHz FSR |
| 13SAE125 | SA2-10 | Spectrum Analyzer, 630-860nm, 2 GHz FSR |
| 13SAE126 | SA2-02 | Spectrum Analyzer, 390-425nm, 2 GHz FSR |
| 13SAF021 | SA2-04-F | Spectrum Analyzer, 450-550nm, 2 GHz FSR, Fiber input |
| 13SAF022 | SA2-08-F | Spectrum Analyzer, 550-680nm, 2 GHz FSR, Fiber input |
| 13SAF023 | SA2-12-F | Spectrum Analyzer, 700-860nm, 2 GHz FSR, Fiber input |
| 13SAF026 | SA2-14-F | Spectrum Analyzer, 860-1100nm, 2 GHz FSR, Fiber input |
| 13SAF027 | SA2-16-F | Spectrum Analyzer, 1050-1250nm, 2 GHz FSR, Fiber input |
| 13SAF028 | SA2-18-F | Spectrum Analyzer, 1300-1550nm, 2 GHz FSR, Fiber input |
| 13SAF029 | SA2-20-F | Spectrum Analyzer, 1500-1650nm, 2 GHz FSR, Fiber input |
| 13SAF124 | SA2-06-F | Spectrum Analyzer, 480-640nm, 2 GHz FSR, Fiber input |
| 13SAF125 | SA2-10-F | Spectrum Analyzer, 630-860nm, 2 GHz FSR, Fiber input |
| 13SAF126 | SA2-02-F | Spectrum Analyzer, 390-425nm, 2 GHz FSR, Fiber input |
| 13SAE031 | SA7.5-04 | Spectrum Analyzer, 450-550nm, 7.5 GHz FSR |
| 13SAE032 | SA7.5-08 | Spectrum Analyzer, 550-680nm, 7.5 GHz FSR |
| 13SAE033 | SA7.5-12 | Spectrum Analyzer, 700-860nm, 7.5 GHz FSR |
| 13SAE036 | SA7.5-14 | Spectrum Analyzer, 860-1100nm, 7.5 GHz FSR |
| 13SAE037 | SA7.5-16 | Spectrum Analyzer, 1050-1250nm, 7.5 GHz FSR |
| 13SAE038 | SA7.5-18 | Spectrum Analyzer, 1300-1550nm, 7.5 GHz FSR |
| 13SAE039 | SA7.5-20 | Spectrum Analyzer, 1500-1650nm, 7.5 GHz FSR |
| 13SAE0134 | SA7.5-06 | Spectrum Analyzer, 480-640nm, 7.5 GHz FSR |

## Spectrum Analyzers conversion from Melles Griot model numbers (cont'd.)

| Past Part Numbers | Current Part identifier | Description |
|---|---|---|
| 13SAE 135 | SA 7.5-10 | Spectrum Analyzer, 630-860nm, 7.5 GHz FSR |
| 13SAE 136 | SA 7.5-02 | Spectrum Analyzer, 390-425nm, 7.5 GHz FSR |
| 13SAF 031 | SA 7.5-04-F | Spectrum Analyzer, 450-550nm, 7.5 GHz FSR, Fiber input |
| 13SAF 032 | SA 7.5-08-F | Spectrum Analyzer, 550-680nm, 7.5 GHz FSR, Fiber input |
| 13SAF 033 | SA 7.5-12-F | Spectrum Analyzer, 700-860nm, 7.5 GHz FSR, Fiber input |
| 13SAF 036 | SA 7.5-14-F | Spectrum Analyzer, 860-1100nm, 7.5 GHz FSR, Fiber input |
| 13SAF 037 | SA 7.5-16-F | Spectrum Analyzer, 1050-1250nm, 7.5 GHz FSR, Fiber input |
| 13SAF 038 | SA 7.5-18-F | Spectrum Analyzer, 1300-1550nm, 7.5 GHz FSR, Fiber input |
| 13SAF 039 | SA 7.5-20-F | Spectrum Analyzer, 1500-1650nm, 7.5 GHz FSR, Fiber input |
| 13SAF 134 | SA 7.5-06-F | Spectrum Analyzer, 480-640nm, 7.5 GHz FSR, Fiber input |
| 13SAF 135 | SA 7.5-10-F | Spectrum Analyzer, 630-860nm, 7.5 GHz FSR, Fiber input |
| 13SAF 136 | SA 7.5-02-F | Spectrum Analyzer, 390-425nm, 7.5 GHz FSR, Fiber input |
| 13SAE 041 | SA 10-04 | Spectrum Analyzer, 450-550nm, 10 GHz FSR |
| 13SAE 042 | SA 10-08 | Spectrum Analyzer, 550-680nm, 10 GHz FSR |
| 13SAE 043 | SA 10-12 | Spectrum Analyzer, 700-860nm, 10 GHz FSR |
| 13SAE 046 | SA 10-14 | Spectrum Analyzer, 860-1100nm, 10 GHz FSR |
| 13SAE 047 | SA 10-16 | Spectrum Analyzer, 1050-1250nm, 10 GHz FSR |
| 13SAE 048 | SA 10-18 | Spectrum Analyzer, 1300-1550nm, 10 GHz FSR |
| 13SAE 049 | SA 10-20 | Spectrum Analyzer, 1500-1600nm, 10 GHz FSR |
| 13SAE 144 | SA 10-06 | Spectrum Analyzer, 480-640nm, 10 GHz FSR |
| 13SAE 145 | SA 10-10 | Spectrum Analyzer, 630-860nm, 10 GHz FSR |
| 13SAE 146 | SA 10-02 | Spectrum Analyzer, 395-425nm, 10 GHz FSR |
| 13SAF 041 | SA 10-04-F | Spectrum Analyzer, 450-550nm, 10 GHz FSR, Fiber input |
| 13SAF 042 | SA 10-08-F | Spectrum Analyzer, 550-680nm, 10 GHz FSR, Fiber input |
| 13SAF 043 | SA 10-12-F | Spectrum Analyzer, 700-860nm, 10 GHz FSR, Fiber input |
| 13SAF 046 | SA 10-14-F | Spectrum Analyzer, 860-1100nm, 10 GHz FSR, Fiber input |
| 13SAF 047 | SA 10-16-F | Spectrum Analyzer, 1050-1250nm, 10 GHz FSR, Fiber input |
| 13SAF 048 | SA 10-18-F | Spectrum Analyzer, 1300-1550nm, 10 GHz FSR, Fiber input |
| 13SAF 049 | SA 10-20-F | Spectrum Analyzer, 1500-1600nm, 10 GHz FSR, Fiber input |
| 13SAF 144 | SA 10-06-F | Spectrum Analyzer, 480-640nm, 10 GHz FSR, Fiber input |
| 13SAF 145 | SA 10-10-F | Spectrum Analyzer, 630-860nm, 10 GHz FSR, Fiber input |
| 13SAF 146 | SA 10-02-F | Spectrum Analyzer, 395-425nm, 10 GHz FSR, Fiber input |



# Product Code Inde Index

# Working with SP Spectral Products

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