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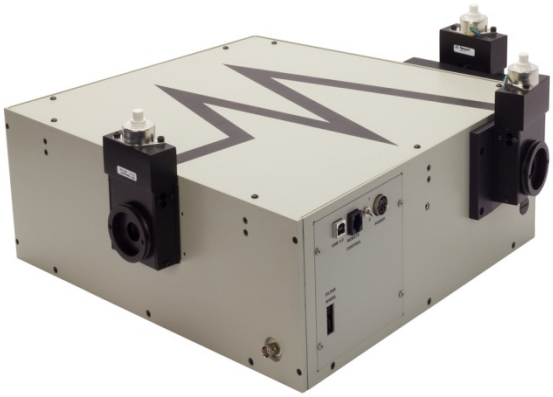
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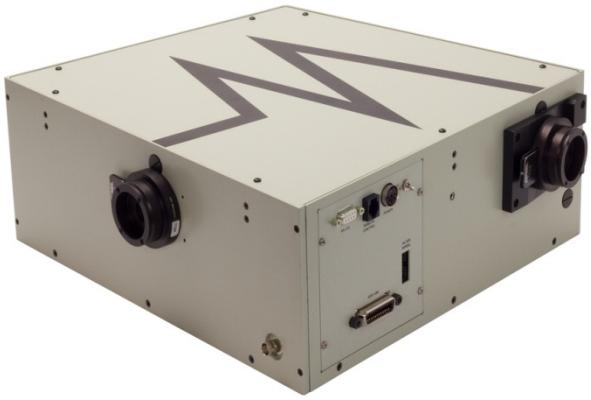
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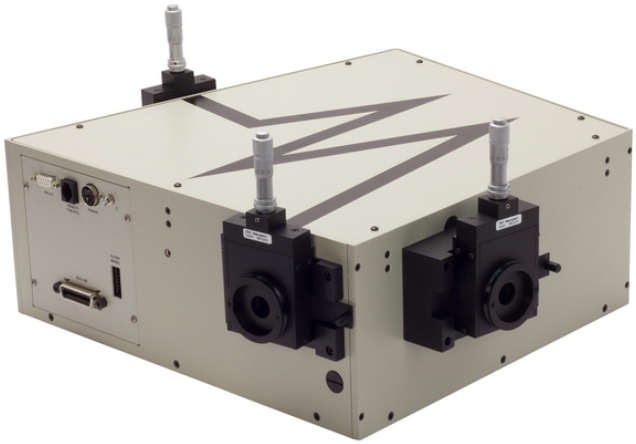
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Cornerstone™ 260

1/4m Monochromator Family







User's Manual

ORIEL INSTRUMENTS
A Newport Corporation Brand

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1 GENERAL INFORMATION

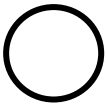
Thank you for your purchase of this Cornerstone™ 260 Monochromator from Oriel Instruments®.

Please carefully read the following important safety precautions prior to unpacking and operating this equipment. In addition, please refer to the complete User's Manual and all other documentation provided for additional important notes and cautionary statements regarding the use and operation of the system.

Do not attempt to operate any system without reading all the information provided with each of the components.

Please read <u>all</u> instructions that were provided prior to operation of the system. If there are any questions, please contact Oriel Instruments or the representative through whom the system was purchased.

1.1 SYMBOLS AND DEFINITIONS

	**WARNING** Situation has the potential to cause bodily harm or death.
	**CAUTION** Situation has the potential to cause damage to property or equipment.
	**ELECTRICAL SHOCK** Hazard arising from dangerous voltage. Any mishandling could result in irreparable damage to the equipment, and personal injury or death.
	**EUROPEAN UNION CE MARK** The presence of the CE Mark on Newport Corporation equipment means that it has been designed, tested and certified as complying with all applicable European Union (CE) regulations and recommendations.
	**WEEE** This symbol on the product or on its packaging indicates that this product must not be disposed of with regular waste. Instead, it is the user's responsibility to dispose of waste equipment according to the local laws. The separate collection and recycling of the waste equipment at the time of disposal will help to conserve natural resources and ensure that the materials are recycled in a manner that protects human health and the environment.
	ON The ON symbol in the above figure indicates the ON position of the power switch.
	**OFF** The OFF symbol in the above figure indicates the OFF position of the power switch.

1.2 GENERAL WARNINGS

- Read all warnings and operating instructions for this system prior to setup and use.
- Do not use this equipment in or near water.
- To prevent damage to the equipment, read the instructions in the equipment manual for proper input voltage and check the requirement on the power supply.
- This equipment is grounded through the grounding conductor of the power cord.
- Route power cords and other cables so they are not likely to be damaged.
- Disconnect power before cleaning the equipment
- Do not use liquid or aerosol cleaners; use only a damp lint-free cloth.
- Lock out all electrical power sources before servicing the equipment.
- To avoid explosion, do not operate this equipment in an explosive atmosphere.
- Qualified service personnel should perform safety checks after any service.
- If this equipment is used in a manner not specified in this manual, the protection provided by this equipment may be impaired.
- Do not position this product in such a manner that would make it difficult to disconnect the power cords.
- Use only the specified replacement parts.
- Follow precautions for static sensitive devices when handling this equipment.
- This product should only be powered as described in the manual.
- Do not remove the cover for normal usage.

1.3 ELECTRICAL HAZARDS

Make all connections to or from the instrument with the power off.

The Cornerstone requires DC voltage for operation, which is provided by an external power supply. This power supply has no user serviceable parts. Do not attempt to open the external power supply. Do not attempt to work in the Cornerstone compartment without first disconnecting the power cord, since electrical hazards are present inside the compartment even with the power switch in the “off” position.

The Cornerstone monochromator contains a microprocessor and should be installed with appropriate surge/EMI/RFI protection on the power line. A dedicated power line or line isolation may be required for some extremely noisy sites. The electronic circuits within the monochromator are extremely sensitive to static electricity and radiated electromagnetic fields. Operation of this instrument close to intense pulsed sources (lasers, xenon strobes, arc lamps, etc.) may compromise performance if shielding is inadequate, and may cause permanent damage to the microprocessor.

Note: This instrument conforms to CE standards for both safety and EMC. During normal use, this equipment will not pose any electrical hazards to the user. Read all warnings before installing or operating this system. If there are any questions or concerns, contact Oriel Instruments or the regional sales representative for Newport.

1.4 MECHANICAL HANDLING

Avoid dropping, sudden shocks, or rough handling of the monochromator since this may cause the system to lose its calibration and may destroy the high precision drive components or optics.

1.5 OPTICS CARE AND HANDLING

Do not touch any optical surfaces since this is likely to cause irreparable damage. Always wear powder-free gloves to cover the entire hand, not finger cots. Never touch the surface of a diffraction grating, even when wearing gloves.

Dust or debris on the grating surface may negatively impact performance, so it should be prevented from entering the instrument by keeping the protective grating covers in place when it is not in use. If the gratings do require cleaning, do not attempt to clean any optical surface except by blowing off dust or lint particles with a stream of dry clean air or nitrogen. Wiping the grating surface will cause permanent damage.

Avoid getting any moisture or condensation onto the grating. Do not breathe on or talk directly in front of a grating, as the moisture from one's breath should never be allowed to condense on the grating surface.

This instrument comes with gratings pre-installed, aligned and the calibration parameters set. An experienced user may choose to install a different grating in the field, although it is strongly encouraged to send the instrument back to the factory instead.

If a grating is installed in the field, the grating cover must never touch the grating's front surface. The specially designed grating cover contacts only the edges of the grating. When removing this cover, a grating can be scratched easily, so use extreme caution when handling.

Hand tighten the grating mount screws. Do not use tools, since this may cause damage to the drive assembly. Never touch the surface of the grating, even while wearing gloves. Handle the grating assembly only by its mount.

2 INTRODUCTION

The Oriel Cornerstone 260 is a high performance, economical and user-friendly monochromator – an ideal instrument for research and OEM applications.

Each of these instruments includes up to three diffraction gratings, filter wheel control circuitry and an integrated electronic shutter. Communication may be established using USB, RS232, GPIB (IEEE-488) or an optional hand controller designed specifically for use with the Cornerstone family of monochromators.

The Cornerstone 260 includes a utility program designed to run on a computer using the Microsoft Windows operating system. The simple, intuitive interface means that users can get up and running within minutes of opening the box. Instrument control examples using National Instruments LabVIEW are provided, along with a command set and API for those wishing to develop their own programs. An optional hand controller may be used for quick access to all common commands and queries, without requiring a computer. This is especially beneficial in universities and secure facilities.

A wide selection of preconfigured grating selections are available for the Cornerstone 260, as well as special order options. Throughput and resolution can be adjusted by selecting the appropriate slit size. Fixed slits are available for high accuracy and repeatability, and micrometer adjustable slits may be used for maximum flexibility. Automatic bandpass control is available with the use of motorized slits.

2.1 OPTICAL CONFIGURATION

The optical design of the Cornerstone 260 is based upon an asymmetrical in-plane version of a Czerny-Turner monochromator. The optical configuration is designed to ensure high resolution and maximum throughput. This F/3.9 monochromator is optimized to provide excellent stray light rejection while minimizing aberrations. A high precision motor is used to select the desired wavelength and switch between diffraction gratings quickly, without sacrificing performance.

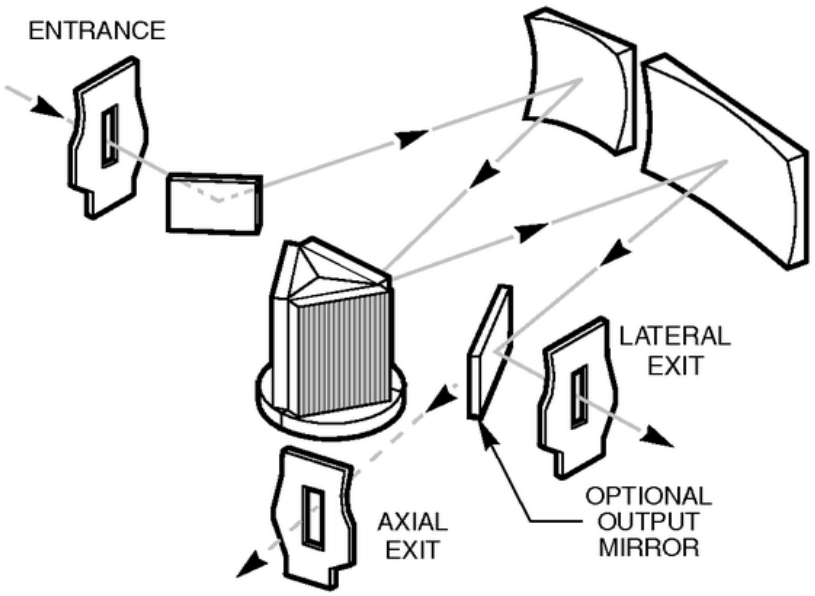


Figure 1: Optical Configuration of the Cornerstone 260

2.2 STRAY LIGHT REJECTION

Stray light may have a variety of origins. Its presence may be caused by a wide variety of design and manufacturing factors. The level of stray light due to the dispersed radiation inside the monochromator is affected by the design of the instrument, its baffles and interior finish. The Cornerstone 260 incorporates a sophisticated design, proven materials, and a quality manufacturing system to ensure high stray light rejection.

The amount of stray light measured on top of true signal will depend on many experimental factors as well as the performance of the instrument. When comparing stray light specifications, it is important to compare values that were measured under identical circumstances. The spectral distribution of the source and the response of the detection system are often the dominant factors when determining a stray light value.

2.3 AVAILABLE MODELS

The model number of each Cornerstone monochromator reflects its features. Refer to the part number code to determine the features present in the instrument. If the model number differs from the code, it is a Special Order configuration. In that case, refer to the Sales Order for the instrument for more information.

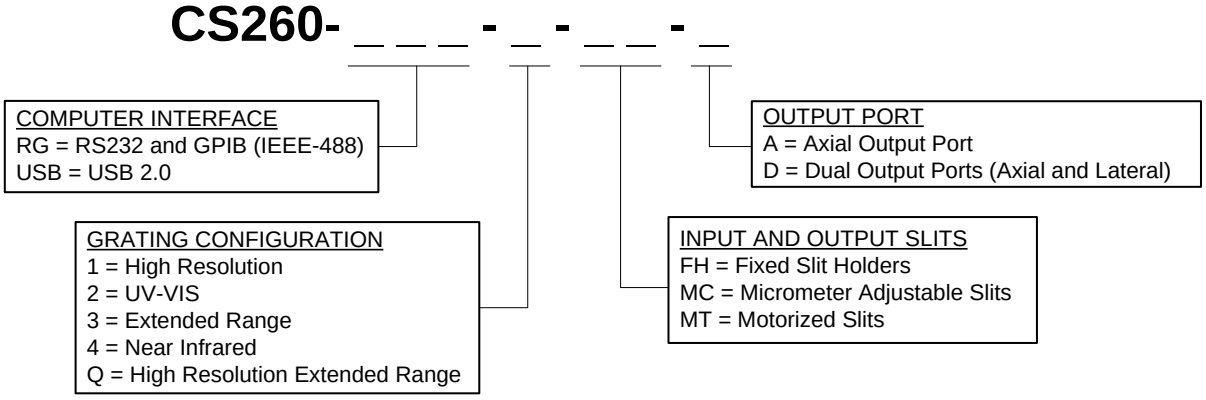


Figure 2: Model Number Codes

2.4 TYPICAL APPLICATIONS

The applications for the Cornerstone 260 monochromator are practically limitless. Here we present one example: a quantum efficiency measurement system using an optically chopped light source used with a lock-in digital amplifier to extract small signal levels from background radiation. All components shown are available from Oriel Instruments.

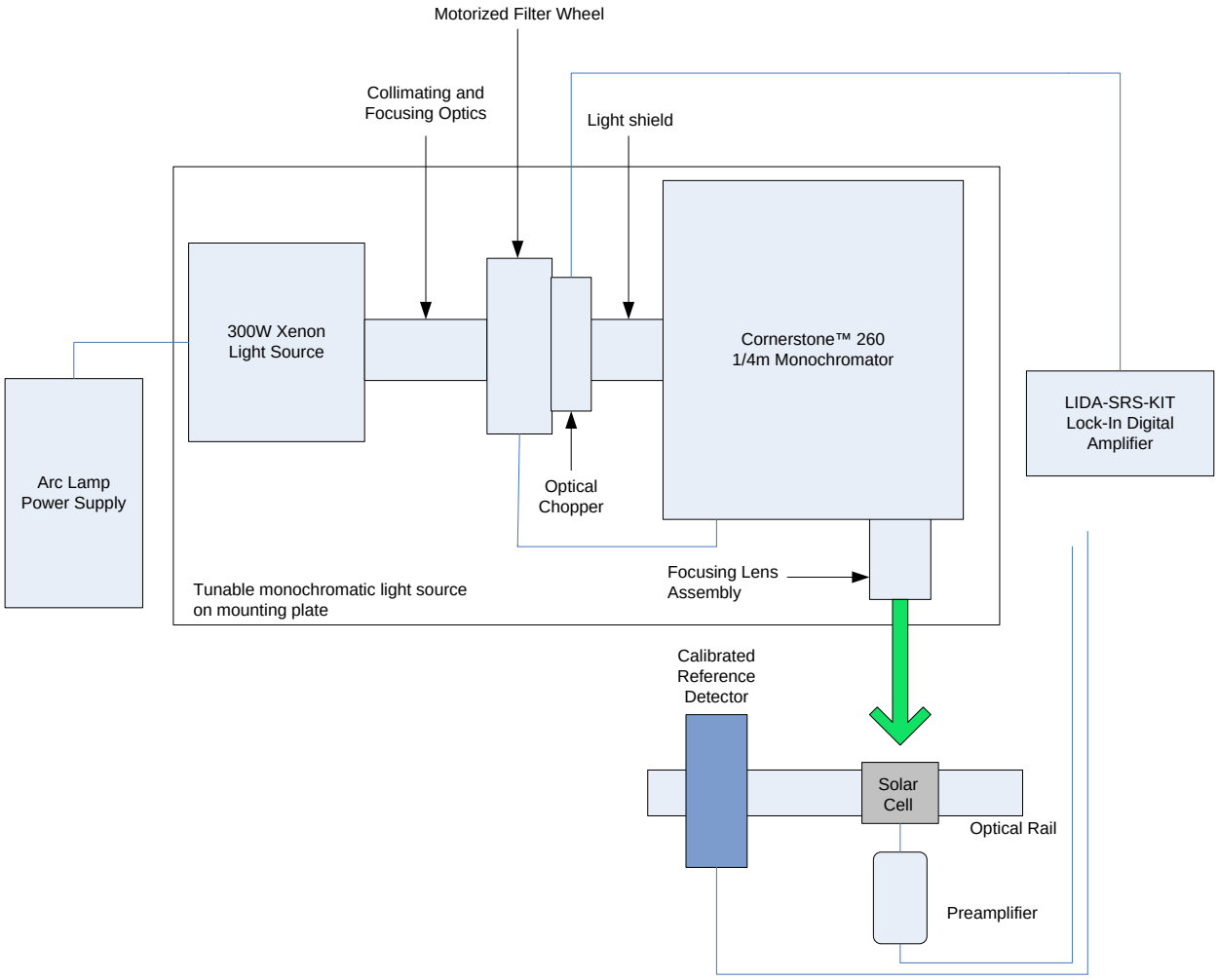


Figure 3: Application Example: Quantum Efficiency Measurements

3 INITIAL SETUP

3.1 WHAT'S INCLUDED

- Preselected diffraction gratings, installed and aligned
- Electronic shutter at input port
- A choice of single or dual output ports
- A choice of micrometer adjustable slits, motorized or fixed slit holders at the input port and output port(s)
- A choice of electronics interface for GPIB/RS232 or USB communication
- LabVIEW™ based utility software
- Application Programming Interface (API) for LabVIEW with examples
- MonoTerm low-level command software
- Certificate of Calibration
- Monochromator Power Supply
- Line cords (U.S. and Europe)
- User's manual

3.2 UNPACKING

Remove all items from the shipping containers and verify each item is accounted for. The instrument is carefully packaged to minimize the possibility of damage during shipment. Inspect the shipping box for external signs of damage or mishandling. Inspect the contents for damage.

If any item is missing or damaged, immediately contact Oriel Instruments or the Newport representative from whom the system was purchased.

It is suggested to save the packaging material and shipping container, in case the equipment needs to be relocated at a future date.



WARNING

Do not attempt to operate this equipment if there is evidence of shipping damage or there is suspicion that the equipment will not operate correctly. Damaged equipment may present hazards.

3.3 CHOOSING A LOCATION

Choose an installation location where the power requirements can be met for the monochromator, as well as the rest of the optical system. Be sure power is not applied to the system until the setup has been completed and all electrical connections made.

Ensure that there is easy access to the monochromator's power switch and the electrical outlet.

3.4 MOUNTING OPTIONS

The ability to mount the monochromator simplifies setup and alignment of the optical system. The mounting plate or kits also helps ensure consistent results over time, as the monochromator cannot be accidentally moved out of position. The following options are available for securing the Cornerstone 260:

- Mounting plate
- Mounting kit to couple with Oriel's Research Lamp Housings
- Optical rods

The 74105 Mounting Plate is used to secure a Cornerstone 260 Monochromator to an inch or metric optical table. The plate adds 0.25 inch [6.35 mm] to the optical height. If the Cornerstone 260 will be used with Oriel's research lamp housing, consider using the 74104 mounting kit.

The 74104 Mounting Kit connects the Cornerstone 260 monochromator to an arc lamp or quartz tungsten halogen light source. This kit is compatible with Oriel's Research Lamp Housings that hold 50 to 250 watt lamps. It includes a base plate, a flexible light shield, a 1.5-inch diameter focusing lens and lens holder. All the hardware required to mount the lamp housing and monochromator to the base plate is provided. The mounting kit's base plate uses four adjustable leveling feet. The feet may be removed to secure the base plate to an inch or metric optical table.

The most economical option is to use optical rods and rod holders to mount the Cornerstone 260 to an optical table or breadboard. On the monochromator's mounting surface, four #1/4-20 threaded holes may be used to install standard optical rods. Care should be taken to ensure the instrument is level and secured well enough that its location remains consistent over time, even if the instrument is bumped or components coupled to the ports.

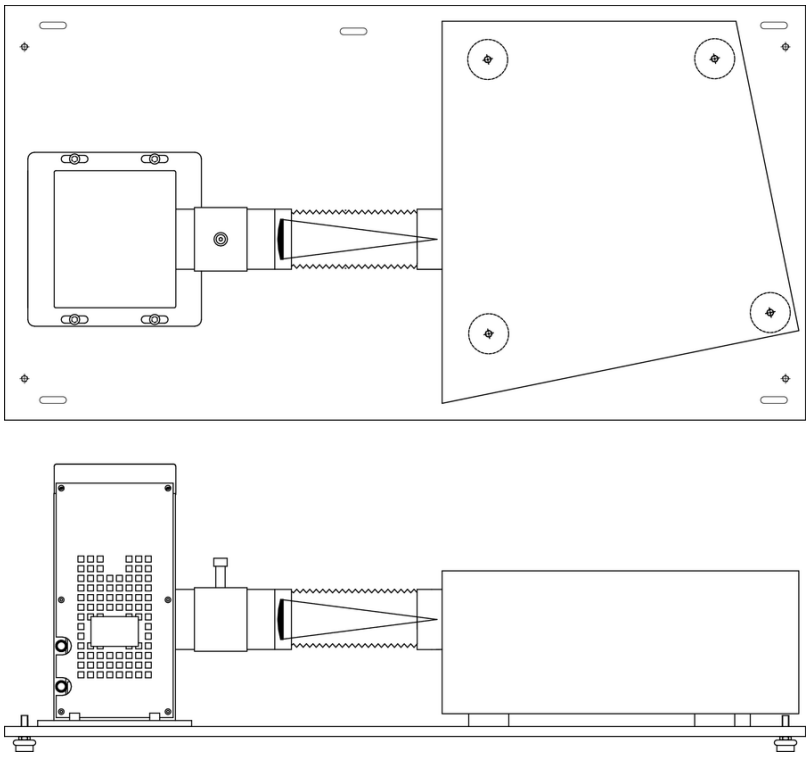


Figure 4: Model 74104 Mounting Kit

3.5 ELECTRICAL AND COMPUTER CONNECTIONS

Before powering up the system for the first time, it is suggested to have a qualified electrician verify the wall socket to be used with the instrument meets the requirements for operation as noted.

Before making any electrical connections, verify the front panel power switch is in the off position for the monochromator.



WARNING

To avoid electric shock, connect the instrument to properly earth-grounded, 3-prong receptacles only. Failure to observe this precaution can result in severe injury or death.

The line voltage requirement is as follows:

Monochromator Power Adapter 100 to 240 VAC, 47-63 Hz

The monochromator conforms to CE standards for both safety and EMC. During normal use, this equipment will not pose any electrical hazards to the user. Read all warnings before installing or operating this system. If there are any questions or concerns, contact Oriel Instruments or the regional sales representative for Newport.



ELECTRICAL SHOCK

Never attempt to open the lamp power supply or monochromator power adapter. These items do not contain any user serviceable parts. Failure to follow this warning can result in severe injury or death.

The monochromator's power adapter connects to an AC wall socket and supplies DC voltage to the instrument. Do not open the monochromator cover and attempt to work inside without first turning the instrument off and disconnecting the power cord from the AC mains.

The ribbon cable connecting the monochromator to the optional model 74010 filter wheel is installed before the system ships out. The monochromator provides power to the filter wheel and allows the user to select which filter is placed in the optical path.

Ensure the monochromator power switch is in the off position (marked as O). Then connect the power adapter to the monochromator, as shown. Insert the power cord provided into the power adapter and connect to the AC mains.

Connect the USB, RS232 or GPIB cable to the monochromator. Plug the other end of the USB cable into the computer only after the TracQ Basic software is installed.

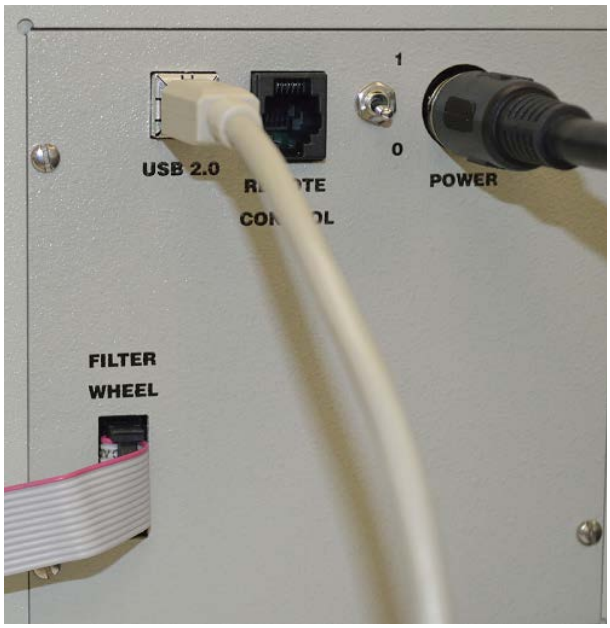


Figure 5: Monochromator Connections

The USB models of the Cornerstone 260 each include a USB 2.0 cable. A GPIB cable (model 70038) and RS232 cable (model 70040) are available from Oriel, and are sold separately.

If using a commercially available USB/GPIB or USB/RS232 converter cable, the driver for this cable must be installed before communication to the monochromator can be established.

Follow the instructions provided in the Quick Start Guide to install the utility software onto a computer.

4 SHUTTER

An electronic shutter is integrated into the Cornerstone monochromator's design. It is mounted inside the housing at the input port. This shutter is normally closed.

The shutter is used to close the light path when light is not required. This allows the light source to remain on, and therefore remain warmed up, so that it continues to provide stable performance. Additionally, restarting a lamp results in wear of the filament (with quartz tungsten halogen lamps) or wear of the anode/cathode (with arc lamps). Therefore, when the light is not needed during short periods, closing the shutter is suggested.

Diffraction gratings are mounted on a rotating turret inside the monochromator. When the monochromator switches between diffraction gratings, the changing angle of the grating causes light to be diffracted at various wavelengths. This includes white light, which is output at a higher power than other individual wavelengths. In order to prevent saturation of a detection system, it is suggested to close the shutter temporarily while changing gratings. It is especially important to prevent saturation and possible damage when using a photomultiplier tube.

A scan may be completed while the shutter is closed to perform background subtraction calculations on subsequently scans completed while the shutter is open.

Please note that the shutter is not designed to block high power direct light. When using a 450W or greater light source, heat mitigation strategies should be employed. For example, Oriel offers liquid filters to protect the shutter, filters and other items from potential heat damage.

4.1 REMOTE OPERATION

The BNC female connector located on the outside of the monochromator allows the shutter to be controlled remotely, if desired. A TTL low condition will open the shutter. The shutter may also be opened by completing a connection between the BNC conductor and shield (i.e. shorting out the connector). Control can be overridden by the shutter commands issued from a computer or the optional hand controller.



Figure 6: Remote Shutter Control BNC Connector

5 INPUT AND OUTPUT SLITS

To operate any monochromator, slits are required at the input and output port. The slits offered with the Cornerstone 260 all have 1.5-inch male flanges, allowing them to be easily connected to the wide variety of Oriel accessories and instruments.

Note: The slits need to be the same width and height at the input and output ports. A wider input slit when compared to the output slit results in more stray light inside the instrument. A wider output slit with respect to the input slit will not increase throughput.

5.1 FIXED SLITS

The fixed slits slide into the holders at the input and output port. The width and height cannot be adjusted, but may be individually replaced with other slit sizes. Fixed slits are a low cost alternative to micrometer adjustable or motorized slits, and provide excellent repeatability. They are a good choice when only a few slit sizes are required.

Fixed slits are sold separately to allow customized choices based on the needs of the application. When ordering, be sure to purchase two fixed slits of the same model for single output port instruments – one for the input port, and the other for the output port. When ordering, be sure to purchase three fixed slits of the same model for dual output port instruments – one for the input port, and the others for the output ports. Insert the slit as shown, with the label facing outward. Be sure that it is fully inserted into the holder's slot to ensure the best performance and repeatability.



Figure 7: A Fixed Slit Installed into the Holder

Fixed Slit Model	Width	Height
77222	10 µm	2 mm
77220	25 µm	3 mm
77219	50 µm	6 mm
77218	120 µm	18 mm*
77217	280 µm	18 mm*
77216	600 µm	18 mm*
77215	760 µm	18 mm*
77214	1.24 mm	18 mm*
77213	1.56 mm	18 mm*
77212	3.16 mm	18 mm*

*Actual slit height is 18 mm, usable height is 12 mm.

Figure 8: Available Fixed Slits

5.2 MICROMETER ADJUSTABLE SLITS

Micrometer adjustable slit assemblies are continuously variable from fully closed to 3 mm width. A height adjustment slide allows variation in the height from 2 to 12 mm. Benefits of the micrometer adjustable slits are flexibility and high throughput. This type of slit is designed primarily for versatility and convenience in changing resolution and throughput, which are related to the slit width.

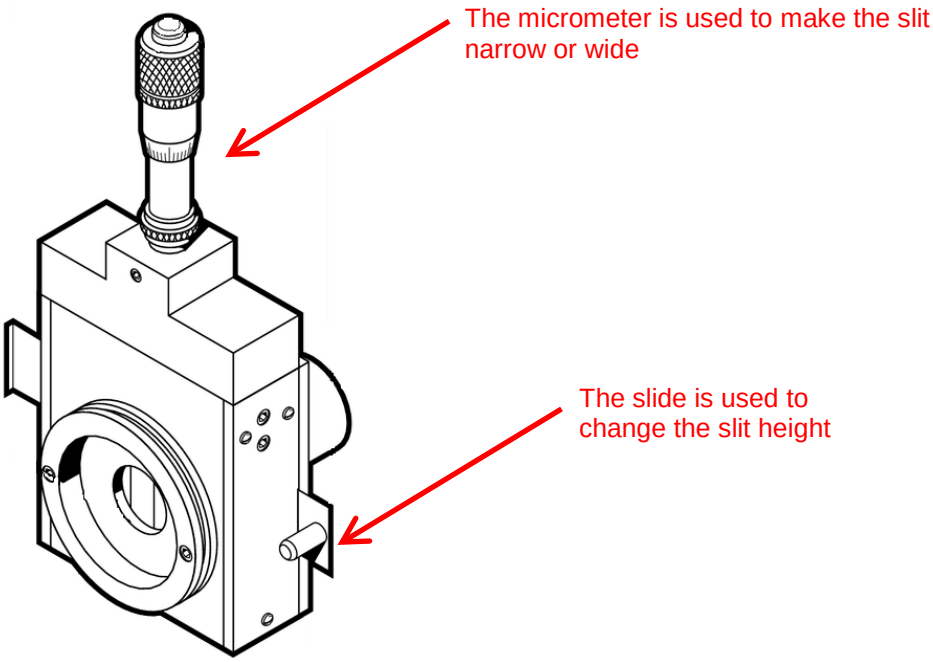


Figure 9: A Micrometer Adjustable Slit

The slit width setting is read on the micrometer. A set of numbers go around the turning dial. Another set of numbers are located on the shaft. When the zeroes in both these locations line up, the slit is fully closed. Turning the dial clockwise advances the dial position further down on the shaft, closer to the body of the micrometer. This opens the slit.

Use a 10x multiplier to convert the micrometer reading to the actual slit opening size. For example, turning the dial one full revolution starting from the fully closed position will give a reading of 50 on the micrometer. Using the multiplier, this indicates the micrometer width is set to 500 um. If unsure of the reading, begin at the fully closed position and add up each full revolution made.

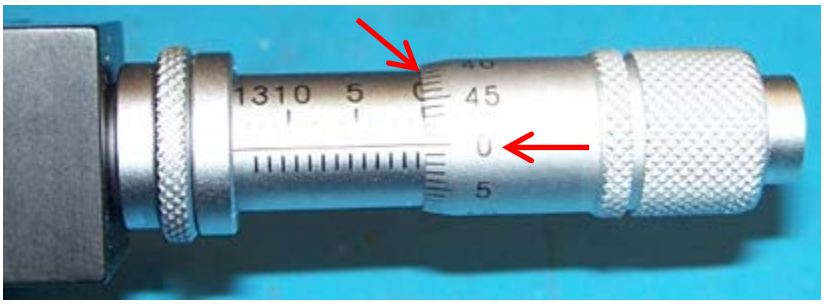


Figure 10: A Fully Closed Micrometer Adjustable Slit

The slit height is continuously adjustable. Pull the lever out for the shortest height. Push the slide in for the tallest height setting.

Use a 10x multiplier to convert the micrometer reading to the actual slit opening size. For example, turning the dial one full revolution starting from the fully closed position will give a reading of 50 on the micrometer. Using the multiplier, this indicates the micrometer width is set to 500 um. If unsure of the reading, begin at the fully closed position and add up each full revolution made.



Figure 11: Shortest Micrometer Adjustable Slit Height



Figure 12: Tallest Micrometer Adjustable Slit Height

5.3 MOTORIZED SLITS

A motorized slit assembly may be adjusted from 6 µm to 2 mm width in 6 µm steps. The slit width is controlled through the utility software, optional hand controller, optional TracQ Basic software or by using low level commands.

An advantage of using motorized slits is that in addition to setting the slit widths individually, the software can be configured to an automatic bandpass setting. The software adjusts the slit widths to maintain the chosen bandpass as scans are performed using multiple gratings and either output port.

The mathematics involved in determining the slit width takes into account the input and output focal lengths of the instrument's design, as well as the angle of the grating at the specified wavelength.



Figure 13: A Motorized Slit

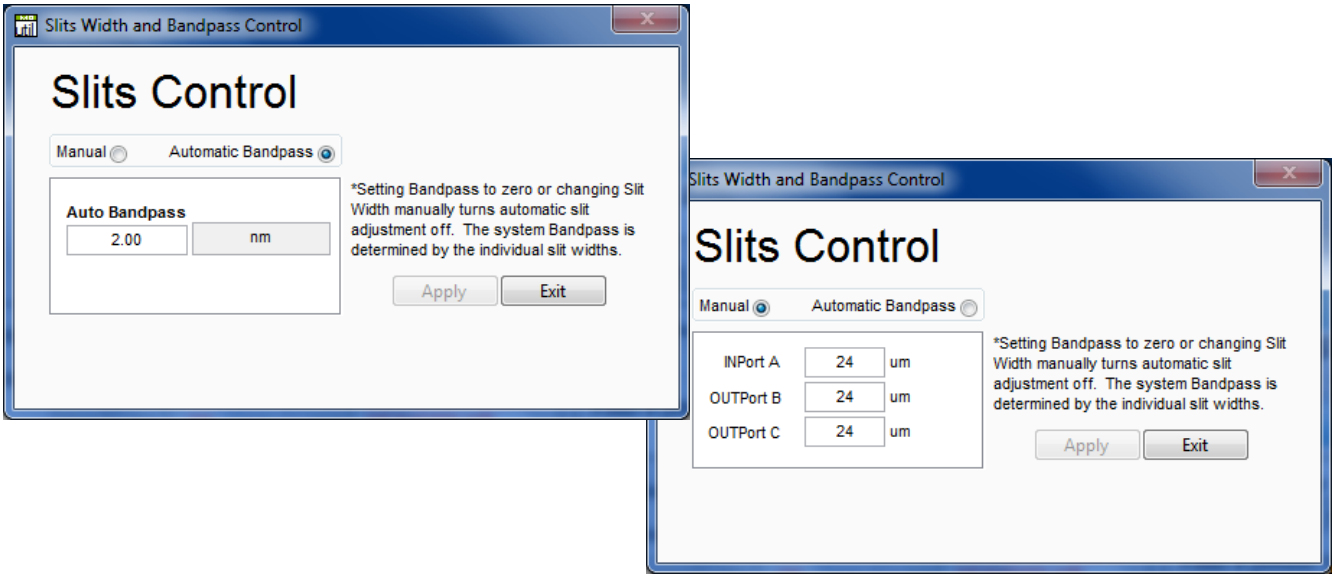


Figure 14: Mono Utility Software Slit Control

6 DIFFRACTION GRATINGS

Diffraction gratings are used to disperse light, i.e. to spatially separate light of different wavelengths. They have replaced prisms in most fields of spectral analysis. Two or three gratings are installed into the Cornerstone 260 monochromator, depending upon the configuration selected. In general, the grating with the highest efficiency is chosen at a particular wavelength. The optional Oriel TracQ™ Basic Data Acquisition and Radiometery Software allows users to set up a specific grating switchover wavelength, so the most appropriate grating will automatically be chosen while performing a scan over a range of wavelengths.

The Cornerstone 260 monochromators feature diffraction gratings produced by Richardson Gratings. Both Oriel Instruments and Richardson Gratings are part of the Newport family of brands, and have a long history of working together to design monochromators that are appropriate for a wide variety of applications.

A tutorial on grating physics may be found in the Appendix of this user's manual.

The photo below illustrates diffraction gratings mounted into holders for installation into the Cornerstone 260 monochromator. The grating is precisely positioned on the mount using a fixture, and then the grating angle is aligned by Oriel, with the screws locked into place using the red adhesive. An unmounted grating cannot be installed by the user in the field; gratings must be installed onto the appropriate mount for the Cornerstone 260 monochromator and aligned at the factory. The mount differs, depending on whether it is a dual-grating or triple-grating instrument configuration.



Figure 15: Gratings Installed onto Mounts

6.1 GRATING TYPES

Ruled grating masters (also called interference gratings) are produced using a ruling engine with an extremely fine cutting tool. Holographic gratings are produced by recording interference fringes in photoresist. The different techniques cause some differences in performance. Holographic gratings are most frequently available at high groove densities due to manufacturing limitations inherent in the technology.

Holographic gratings are generally favored for work in the UV and through the visible to about 600 nm. Holographic gratings produce less scattering, thereby reducing stray light inside the monochromator. The signal-to-noise ratio (SNR) is the ratio of diffracted energy to unwanted light energy. Although it may be assumed that increasing diffraction efficiency will increase SNR, stray light usually plays the limiting role in the achievable SNR for a grating system. Note that the actual signal to noise ratio will depend on the spectral content of the incident light and the detector.

Ruled gratings typically have higher efficiencies. Ruled gratings may have periodic errors in the grating grooves caused by minor defects in the ruling machine, resulting in anomalous readings or “ghosts”. Holographic gratings do not suffer from ghosts, so interpretation of line spectra is simplified.

GRATING PROPERTIES					
Configuration	**Grating Position**	**Type**	**Groove Density (lines/mm)**	**Blaze Wavelength (nm)**	**Reciprocal Dispersion (nm/mm)**
High Resolution	#1	Holographic	1200	250	3.2
	#2	Ruled	1200	350	3.2
	#3	Ruled	1200	1000	3.2
High Resolution Extended Range	#1	Ruled	1200	350	3.2
	#2	Ruled	1200	750	3.1
	#3	Ruled	600	1000	6.4
UV-VIS	#1	Ruled	600	200	6.4
	#2	Ruled	600	400	6.5
Extended Range	#1	Ruled	600	400	6.5
	#2	Ruled	600	1000	6.4
VIS-NIR	#1	Ruled	300	500	12.8
	#2	Ruled	600	1000	6.4
	#3	Ruled	300	2000	12.9

Figure 16: Grating Properties Table

6.2 GRATING EFFICIENCY AND BLAZING

Efficiency and its variation with wavelength and spectral order are important characteristics of a diffraction grating. For a reflection grating, efficiency is defined as the energy flow (power) of monochromatic light diffracted into the order being measured, relative either to the energy flow of the incident light (absolute efficiency) or to the energy flow of specular reflection from a polished mirror substrate coated with the same material (relative efficiency). Efficiency is defined similarly for transmission gratings, except that an uncoated substrate is used in the measurement of relative efficiency.

High-efficiency gratings are desirable for several reasons. A grating with high efficiency is more useful than one with lower efficiency in measuring weak transition lines in optical spectra. A grating with high efficiency may allow the reflectivity and transmissivity specifications for the other components in the spectrometer to be relaxed. Moreover, higher diffracted energy may imply lower instrumental stray light due to other diffracted orders, as the total energy flow for a given wavelength leaving the grating is conserved (being equal to the energy flow incident on it minus any scattering and absorption).

Control over the magnitude and variation of diffracted energy with wavelength is called blazing, and it involves the manipulation of the micro-geometry of the grating grooves. The energy flow distribution (by wavelength) of a diffraction grating can be altered by modifying the shape of the grating grooves. The blaze wavelength is the wavelength where the grating efficiency is enhanced by shaping the grating grooves. Although holographic gratings are not shaped like ruled gratings, the peak grating efficiency wavelength is also referred to as the blaze wavelength.

The choice of an optimal efficiency curve for a grating depends on the specific application. Often the desired instrumental efficiency is linear; that is, the intensity of light transformed into signal at the image plane must be constant across the spectrum. To approach this as closely as possible, the spectral emissivity of the light source and the spectral response of the detector should be considered, from which the desired grating efficiency curve can be derived. Usually this requires peak grating efficiency in the region of the spectrum where the detectors are least sensitive.

In many instances, the diffracted power depends on the polarization of the incident light. For completely unpolarized incident light, the efficiency curve will be exactly halfway between the P and S efficiency curves. Anomalies are locations on an efficiency curve (efficiency plotted vs. wavelength) at which the efficiency changes abruptly. These sharp peaks and troughs in an efficiency curve are sometimes referred to as Wood's anomalies.

The efficiency curves shown are relative (not absolute) and were measured using an in-plane near Littrow configuration. Please use the curves as a guide and not as absolute data. Grating diffraction is dependent on the polarization of the radiation incident on the grating.

Software such as the Mono Utility and Oriel’s TracQ Basic may be configured to switch between gratings at a specific wavelength. Typically, the most efficient grating is selected, so this switchover wavelength would be where the two efficiency curves meet. To determine empirically the ideal switchover wavelength, the output should be measured by an optical detector. Run a scan in the crossover region using only Grating 1. Repeat the scan using only Grating 2. Where the detector readings are closest is the optimal switchover wavelength. For a triple grating instrument, this process can be repeated for Grating 2 and Grating 3.

If the selected grating’s efficiency has a sudden increase or decrease at a particularly critical wavelength and the application demands extreme accuracy, it may be more desirable to select the grating with the more gradual change in efficiency.

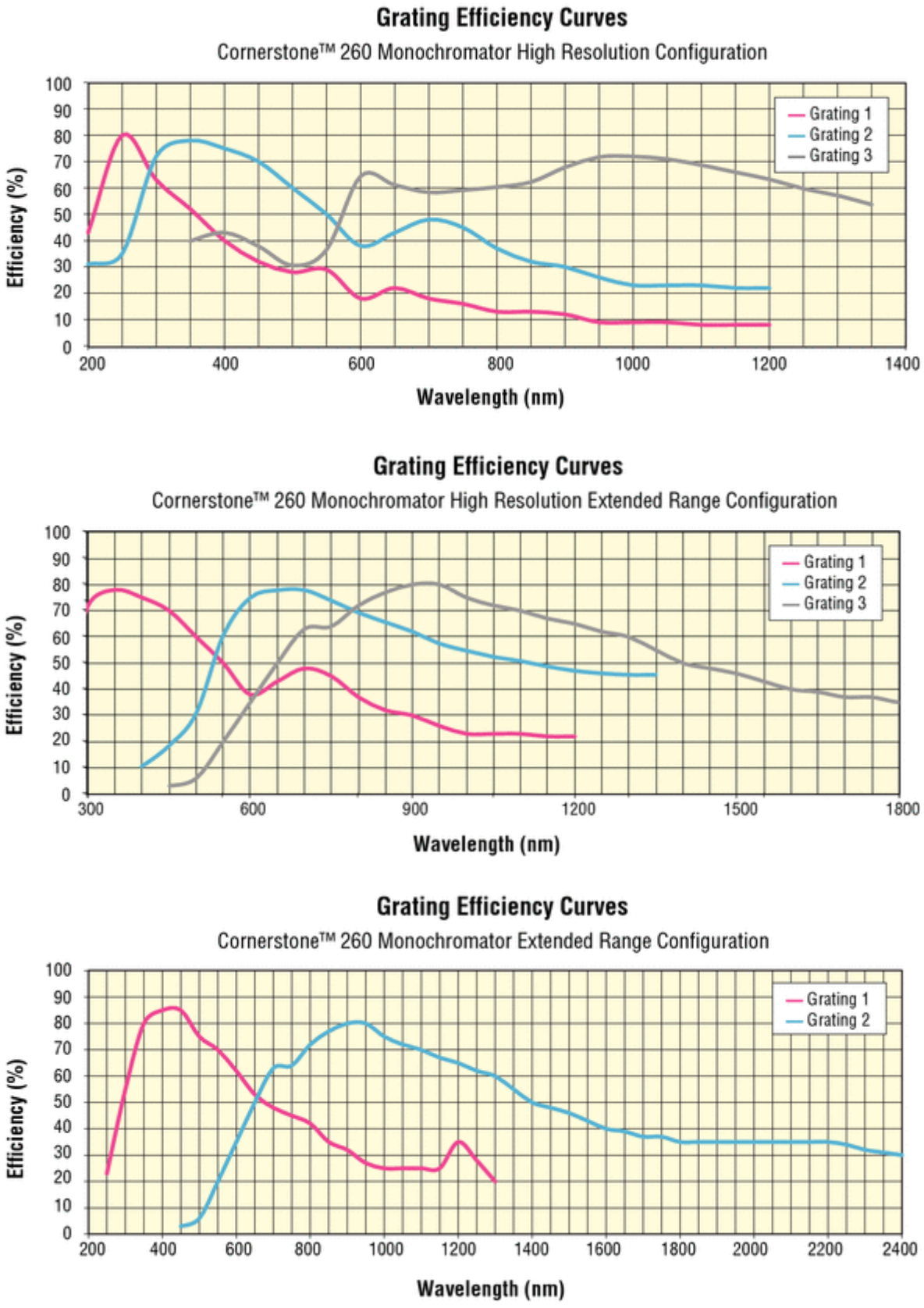


Figure 17: Grating Efficiency Curves, High Resolution and Extended Range Models

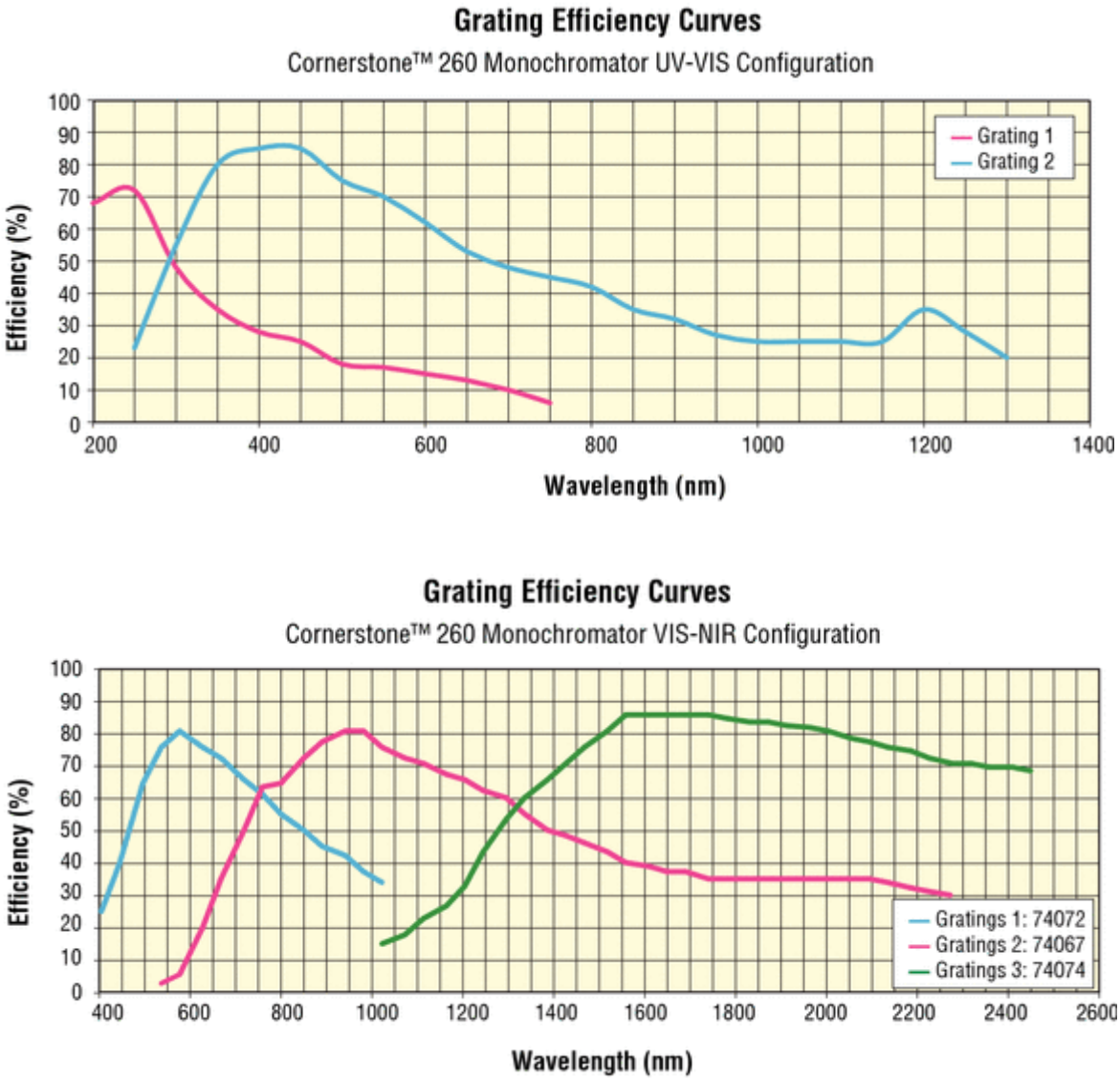


Figure 18: Grating Efficiency Curves, UV-VIS and VIS-NIR Models

6.3 POLARIZATION EFFECTS

The diffraction efficiency from a grating usually depends on the polarization of the radiation incident on the grating. There can be significant differences between the efficiency for radiation with the electric field vector parallel to the grating grooves and radiation with the electric vector perpendicular to the grooves.

Radiation with the electric vector restricted to a specific direction is linearly polarized. Linearly polarized radiation with the electric vector parallel to the grooves is P-polarized. Radiation polarized perpendicular to the grooves is S-polarized. For Oriel's monochromators and spectrographs, P-polarized radiation has the polarization axis parallel to the entrance slit. In most laboratory applications with the instrument sitting on its mounting surface on a horizontal bench or optical table, P-polarized radiation is vertically polarized.

Note: this definition of S- and P-polarization for diffraction gratings does not follow the general rules for S and P-polarization for optics where the plane of incidence rather than the grooves are used to define parallel and perpendicular.

The graphs for the Cornerstone 260 configurations have one efficiency curve per grating. This is representative of 45-degree polarization, which is the average of the P-polarization and S-polarization efficiency curves.

Typically, the efficiency curve for P-polarized light peaks slightly lower than the nominal blaze wavelength and smoothly declines to 0% at about three times the blaze wavelength. The curves for P-polarization are generally smooth, without dramatic changes in direction or sharp features.

The curves for S-polarized light peak slightly above the nominal blaze wavelength and decline. However, the efficiency can recover dramatically and show good efficiency over a broader wavelength range. The S-polarization curves can show sharp features (anomalies) which complicate data deconvolution from spectral scans.

If a source is being measured close to an anomaly, then the real feature may be dramatically distorted. If possible, a grating should be selected (or polarization) which has no significant anomaly in the spectral region of interest. Contact an Oriel sales engineer for more information on the effects of polarized light in terms of grating efficiency.

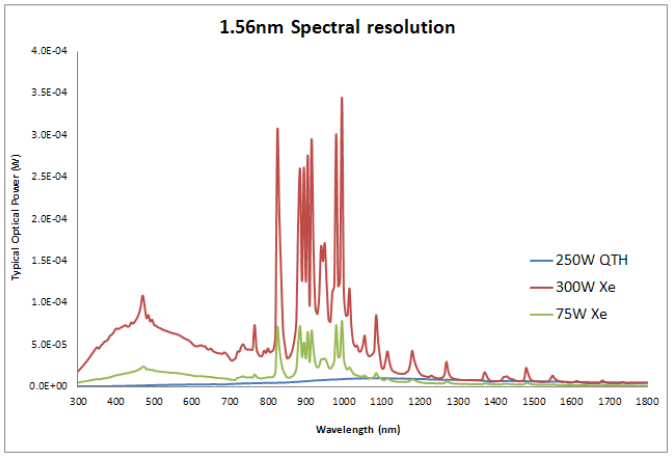
7 MONOCHROMATOR RESOLUTION

Gratings are available in various groove densities (i.e. lines/mm). Higher groove densities give higher reciprocal dispersion and therefore higher resolution. The monochromator bandpass with a 1200 lines/mm grating is half that of the same arrangement with a 600 lines/mm grating. Note that this simple relationship is not accurate for slit widths below 50 µm, as the optical aberrations begin to play a role in the bandpass and resolution.

Using a grating with a high groove density may increase resolution, but the spectral range narrows. The dispersion of a grating changes inversely with the groove density. If the groove density is halved, the dispersion is doubled. A monochromator mechanism can only tilt the grating through a limited range of angles. The angle and groove density determine the transmitted wavelength.

The gratings can be tilted to 0 degrees, so the lowest possible wavelength for a UV grating is set by the transmittance of air at about 180 nm. The ability to output wavelengths below 180 nm is also dependent on the efficiency characteristics of the grating.

The following graphs are intended to illustrate the effects of slit width selection, in terms of throughput and resolution. This data was taken using Oriel's Tunable Light Source (TLS) systems, using various slit widths to change the resolution. The TLS systems employ a Cornerstone 130 monochromator. However, the concept of resolution vs. slit width is the same for the Cornerstone 260 monochromators.



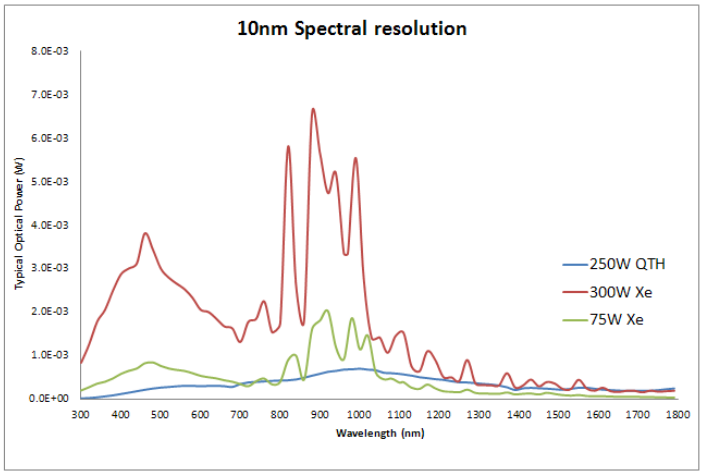


Figure 19: Resolution vs. Throughput

7.1 DETERMINING RESOLUTION

All monochromators featuring fixed slit holders require fixed slits to be installed at the input and output ports. Fixed slits are ordered separately, and should be the same size at the input and output ports. Micrometers adjustable slits allow for continuous variation of the width and height. Use the table below for guidance on resolution vs. slit width. For slit widths not specified in the table, multiply the micrometer adjustable slit width setting (mm) by the reciprocal dispersion (nm/mm) to calculate the resolution for each grating.

Resolution is calculated for each grating at the grating's blaze wavelength, i.e. the wavelength with the greatest efficiency. Actual performance is determined by the monochromator wavelength accuracy, precision and calibration. Newport suggests having the monochromator recalibrated annually by a qualified service technician.

Calculation of Resolution Based on Fixed Slit Selection				
		Grating 1	**Grating 2**	**Grating 3**
Fixed Slit	**Slit Width**	**High Resolution Configuration**		
77222	10 µm*	0.03 nm	0.25 nm**	0.03 nm
77220	25 µm*	0.08 nm	0.25 nm**	0.08 nm
77219	50 µm*	0.16 nm	0.35 nm**	0.16 nm
77218	120 µm	0.38 nm	0.50 nm**	0.38 nm
77217	280 µm	0.90 nm	0.90 nm	0.90 nm
77216	600 µm	1.9 nm	1.9 nm	1.9 nm
77215	760 µm	2.4 nm	2.4 nm	2.4 nm
77214	1.24 mm	4.0 nm	4.0 nm	4.0 nm
77213	1.56 mm	5.0 nm	5.0 nm	5.0 nm
77212	3.16 mm	10 nm	10 nm	10 nm
77211	6.32 mm	20 nm	20 nm	20 nm

* For slits with widths of 50 µm or less, aberrations begin to play a role in the actual achievable resolution. The values noted above, unless otherwise stated, are calculations based on the slit widths and grating dispersions.

** Empirically measured resolution values shown which differ from calculations due to aberrations present when using narrow slit widths.

Calculation of Resolution Based on Fixed Slit Selection				
		Grating 1	Grating 2	Grating 3
Fixed Slit	Slit Width	High Resolution Extended Range Configuration		
77222	10 µm*	0.03 nm	0.25 nm **	0.06 nm
77220	25 µm*	0.08 nm	0.25 nm **	0.16 nm
77219	50 µm*	0.16 nm	0.35 nm **	0.32 nm
77218	120 µm	0.38 nm	0.50 nm **	0.77 nm
77217	280 µm	0.90 nm	0.90 nm	1.8 nm
77216	600 µm	1.9 nm	1.9 nm	3.8 nm
77215	760 µm	2.4 nm	2.4 nm	4.9 nm
77214	1.24 mm	4.0 nm	4.0 nm	7.9 nm
77213	1.56 mm	5.0 nm	5.0 nm	10 nm
77212	3.16 mm	10 nm	10 nm	20 nm
77211	6.32 mm	20 nm	20 nm	40 nm

Calculation of Resolution Based on Fixed Slit Selection					
		Grating 1	Grating 2	Grating 1	Grating 2
Fixed Slit	Slit Width	UV-VIS Configuration		Extended Range Configuration	
77222	10 µm*	0.06 nm	0.07 nm	0.07 nm	0.06 nm
77220	25 µm*	0.16 nm	0.16 nm	0.16 nm	0.16 nm
77219	50 µm*	0.32 nm	0.33 nm	0.33 nm	0.32 nm
77218	120 µm	0.77 nm	0.78 nm	0.78 nm	0.77 nm
77217	280 µm	1.8 nm	1.8 nm	1.8 nm	1.8 nm
77216	600 µm	3.8 nm	3.9 nm	3.9 nm	3.8 nm
77215	760 µm	4.9 nm	4.9 nm	4.9 nm	4.9 nm
77214	1.24 mm	7.9 nm	8.1 nm	8.1 nm	7.9 nm
77213	1.56 mm	10 nm	10 nm	10 nm	10 nm
77212	3.16 mm	20 nm	21 nm	21 nm	20 nm
77211	6.32 mm	40 nm	41 nm	41 nm	40 nm

* For slits with widths of 50 µm or less, aberrations begin to play a role in the actual achievable resolution. The values noted above, unless otherwise stated, are calculations based on the slit widths and grating dispersions.

** Empirically measured resolution values shown which differ from calculations due to aberrations present when using narrow slit widths.

Calculation of Resolution Based on Fixed Slit Selection				
		Grating 1	Grating 2	Grating 3
Fixed Slit	Slit Width	VIS-NIR Configuration		
77222	10 µm*	0.13 nm	0.06 nm	0.13 nm
77220	25 µm*	0.32 nm	0.16 nm	0.32 nm
77219	50 µm*	0.64 nm	0.32 nm	0.65 nm
77218	120 µm	1.54 nm	0.77 nm	1.55 nm
77217	280 µm	3.58 nm	1.8 nm	3.61 nm
77216	600 µm	7.68 nm	3.8 nm	7.74 nm
77215	760 µm	9.73 nm	4.9 nm	9.80 nm
77214	1.24 mm	16 nm	7.9 nm	16 nm
77213	1.56 mm	20 nm	10 nm	20 nm
77212	3.16 mm	40 nm	20 nm	41 nm
77211	6.32 mm	81 nm	40 nm	82 nm

* For slits with widths of 50 µm or less, aberrations begin to play a role in the actual achievable resolution. The values noted above, unless otherwise stated, are calculations based on the slit widths and grating dispersions.

** Empirically measured resolution values shown which differ from calculations due to aberrations present when using narrow slit widths.



Figure 20: Some of the Fixed Slit Sizes Available

8 GETTING LIGHT INTO A MONOCHROMATOR

8.1 ACCEPTANCE PYRAMID

The figure below shows the optical path of the light input to the instrument. The monochromator has an acceptance pyramid, often described by an F/#. The position and dimensions of the internal optics determines the pyramid. The optical equivalent is a grating image located behind the slit as shown in below. Only light that passes through the slit in the direction of this grating image is useful.

Always fill the acceptance pyramid of the instrument with light.

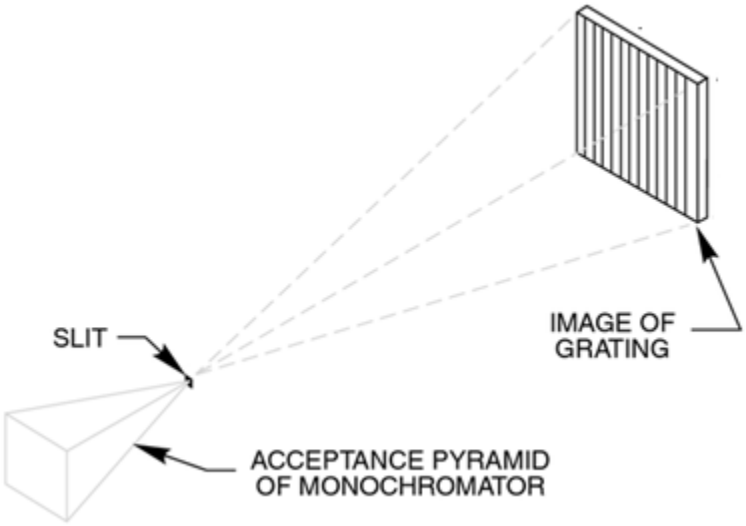


Figure 21: Acceptance Pyramid of Monochromator



Figure 22: Grating Correctly "Filled" with Light

8.2 F NUMBER MATCHING

The Cornerstone 260 monochromator is an F/3.9 instrument. Without matching the F/# of the incoming light beam, stray light increases and throughput of desired signal suffers. To illustrate this, the photos below show a fiber optic cable placed at the entrance of a monochromator. Fibers are typically F/2. The Oriel model 77529 may be used to match the F/# to the monochromator.

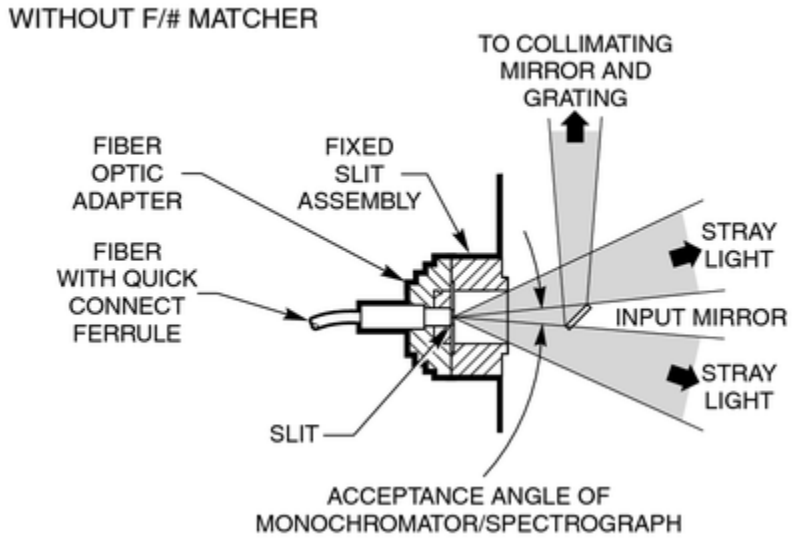


Figure 23: Mismatched F Numbers Resulting in Stray Light

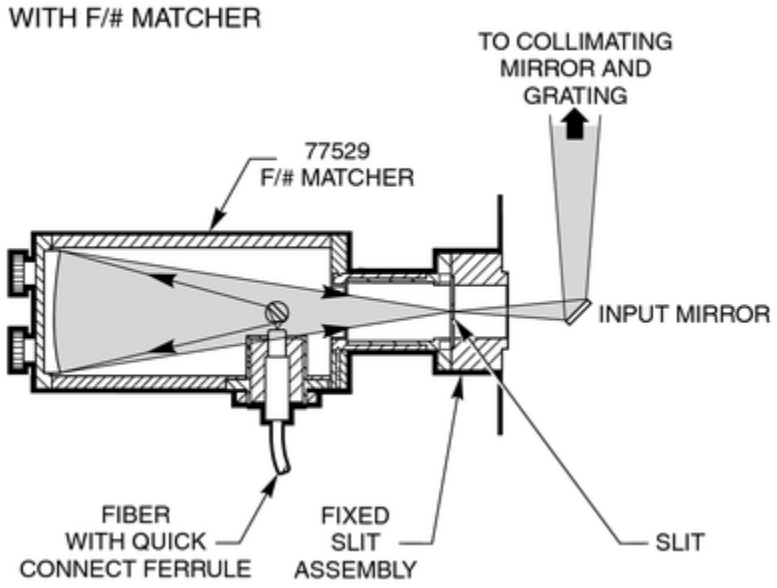


Figure 24: F Number Matcher Used with Fiber Optic Cable

9 BLOCKING HIGHER ORDER RADIATION

Detailed information regarding grating physics can be found in the Appendix of this user's manual. A summary of grating physics is noted here.

- Only wavelengths that satisfy the grating equation pass through the output port of the instrument.
- The remainder of the light is scattered and absorbed inside the instrument.
- The grating is rotated to bring different wavelengths of light in line with the output.

- A grating creates interference patterns when light is shown onto it.
- Different wavelengths interfere at different angles off the grating.
- Light occurs when there is constructive interference, called grating orders.
- All wavelengths interfere at one specific angle of the grating. This is called the "zero order".

- When a parallel beam of monochromatic light is incident on a grating, the light is diffracted from the grating in directions corresponding to m = -2, -1, 0, 1, 2, 3, etc.
- When a parallel beam on polychromatic light is incident on a grating, the light is dispersed so that each wavelength satisfies the Grating Equation.
- Usually only the first order is desired. The other wavelengths in higher orders may need to be blocked.
- **The input spectrum and detector sensitivity determine whether order sorting or blocking filters are needed.**

9.1 ORDER SORTING FILTERS

For meaningful spectral measurements, care should be taken to remove unwanted orders of radiation, particularly if the input radiation is intense or the detector more sensitive at the higher order.

Erroneous measurements may be taken because what was thought to be a measurement with a single wavelength was actually a measurement using radiation at that wavelength – but contaminated with higher order radiation. Consider using Newport's Colored-Glass Alternative Filters for blocking higher order diffraction.

Example 1:

- A monochromator is set to output 600 nm and the signal read by a UV-enhanced Si detector with a spectral responsivity range of 200 nm to 1100 nm.
- Additional output will be 300 nm (600/2) and 200 nm (600/3). These are the second and third order wavelengths.
- The second and third order wavelengths are within the responsivity range of this detector.
- In order to block these extra orders, a filter needs to be inserted into the optical path.

Example 2:

- A monochromator is set to output 1200 nm and the signal read by a Ge detector with a spectral responsivity range of 700 nm to 1800 nm.
- Additional output will be 600 nm (1200/2) and 400 nm (1200/3). These are the second and third order wavelengths.
- The second and third order wavelengths are outside the responsivity range of this detector.

10 COMMUNICATION METHODS

In order to satisfy the needs of as many users as possible, the Cornerstone 260 is designed to be controlled from a variety of sources.

The Cornerstone 260 is capable of automatically controlling an optional filter wheel, Model 74010 . It is also able to interface with the motorized filter wheel included with Oriel's APEX2 light sources. These filter wheels hold up to six 1-inch [25.4 mm] diameter filters. Neutral density filters can be used for intensity adjustment. Order sorting filters may be installed to block higher order diffraction.

The filter wheel can be mounted to the male flanges of the monochromator slits or slit holders. The filters are mounted external to the monochromator. Thus, the refractive index and thickness of the filters do not significantly affect the focal distance to the collimating mirror inside the monochromator. With internal filters, this distance would be different for every wavelength and every filter, and would therefore adversely affect resolution. The Cornerstone 260 is designed and manufactured to have errors of only a fraction of a millimeter in the focal distance. Positioning the filters externally, usually before the input slit, has only a slight effect on the light throughput. Since the slit acts as a secondary source, the focal distance is not affected.



Figure 25: Model 74010 Filter Wheel

10.1 UTILITY SOFTWARE

LabVIEW-based utility software is included at no extra cost with all Cornerstone models to control both the monochromator and filter wheel accessory. The utility software provided with the monochromator includes USB drivers for Windows 7 32-bit and 64-bit operating systems. The software can also control the instrument through an RS232 or GPIB connection.

Please refer to the Quick Start Guide provided with the monochromator for instructions on installation and use.

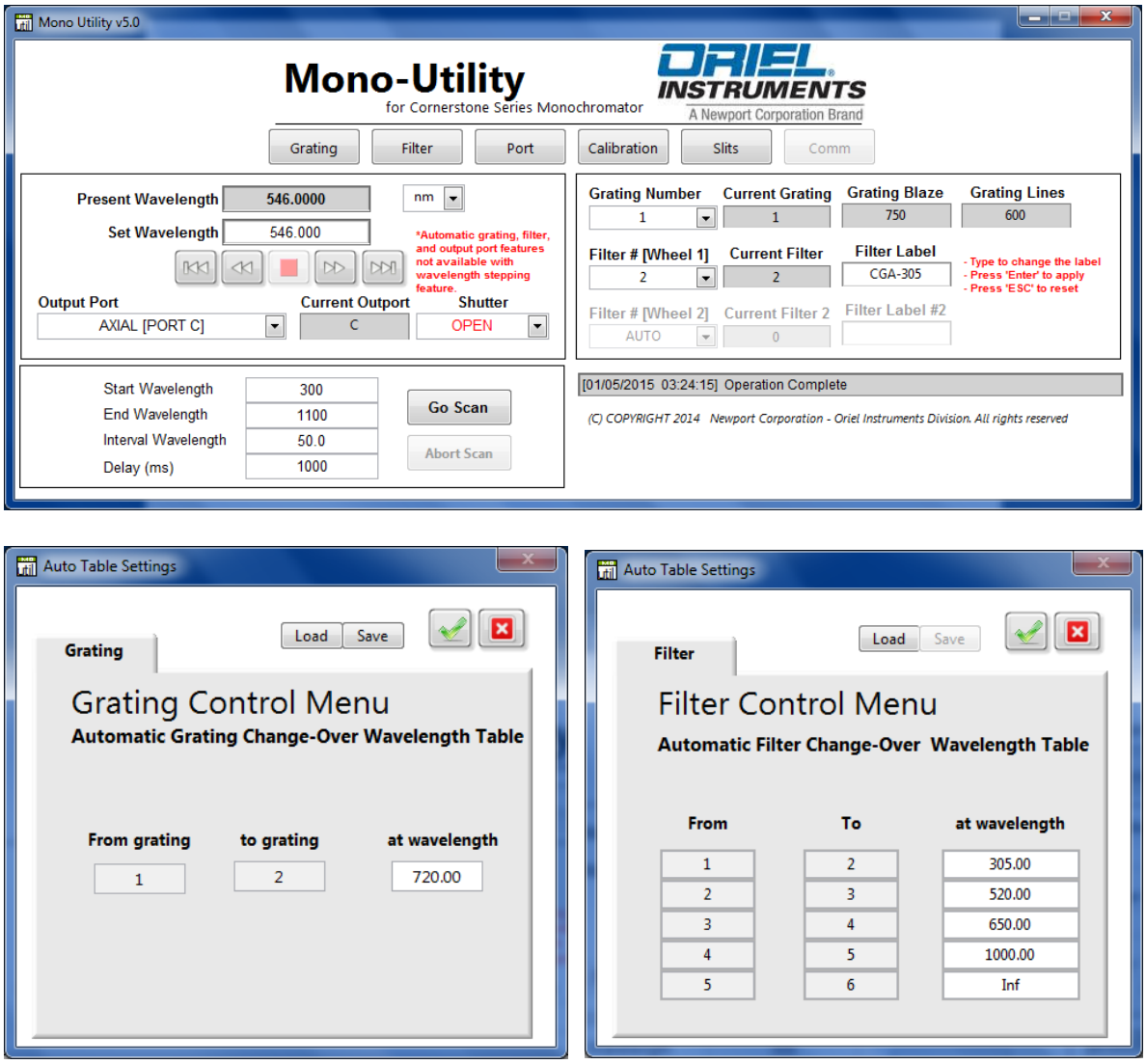


Figure 26: Mono Utility Software Screens

10.2 HAND CONTROLLER

The optional 74009 Hand Controller is designed specifically for use with Oriel's Cornerstone series monochromators and MS260i spectrographs. It is very easy to set up – simply plug it into the instrument and it's ready to go. There is no need to purchase a computer and set up the software. The Hand Controller is a very convenient option in locations where security is a concern, such as defense facilities and universities.

There is no need to memorize commands or key sequences. The 24 keys are clearly labeled with functions like "Shutter", "Go Wave" and "Filter". The backlit LCD display provides information on the grating selection, grating line density, active filter position, current wavelength and shutter status. Using the Hand Controller is intuitive and provides access to nearly all the functionality of the monochromators and spectrographs. It comes with a 14 foot [4.3 meter] long cable.

Hand Controller commands are listed in the Appendix of this user's manual.



Figure 27: Cornerstone 260 Monochromator with 74009 Hand Controller

10.3 TRACQ BASIC SOFTWARE

Oriel's optional TracQ Basic Data Acquisition and Radiometery Software is an instrument control package that includes data acquisition and processing. TracQ Basic allows users to acquire spectroscopic measurement data quickly and easily, without requiring any programming knowledge. TracQ Basic is true radiometry software, which enables users to acquire basic voltage measurements or use the built-in algorithms for spectroscopic measurements. Data acquisition and processing occurs in real time.

TracQ Basic is an application integrating Oriel monochromators with various detection instruments, such as the Newport Optical Power and Energy Meters, 1918-R, 1936-R and 2936-R, plus Oriel's LIDA-SRS-KIT. Software prompts guide users through the measurement process. Instruments are controlled and scan parameters are set up through simple, intuitive dialog boxes. The front panel of the software allows one to see instrument status, present wavelength, signal reading and the selected wavelength units.

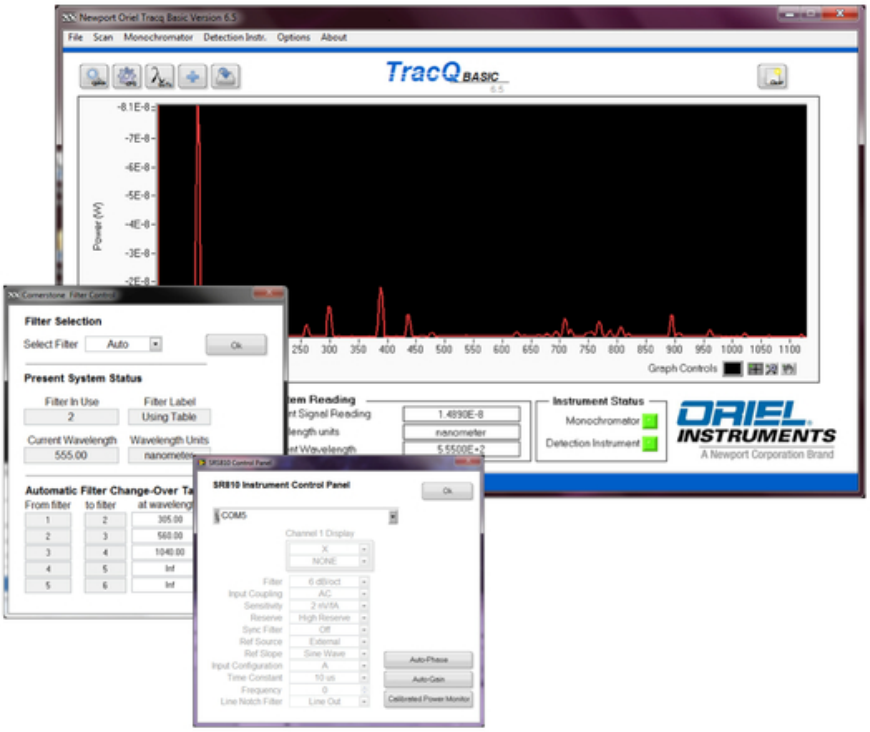


Figure 28: TracQ Basic Screens

10.4 LOW-LEVEL COMMANDS

An intuitive command set is provided for those wishing to create their own programming. A list of these commands is provided in the user's manual included with the monochromator. Commands are simple to use. For example, to query the wavelength, enter "WAVE?" The command to close the shutter is "SHUTTER C". A full list of commands is available in the Appendix of this user's manual.

10.5 MONO TERM SOFTWARE AND LABVIEW EXAMPLES

For those users who are developing their own LabVIEW based programs, an Application Programming Interface (API) document is included with the instrument. The Oriel MonoTERM utility is also provided for sending low-level commands to the monochromator. This is very convenient for assisting programmers in their software development efforts.

The MonoTERM utility was developed in National Instruments LabVIEW. It's open source code, so it may be used to provide LabVIEW programming examples.

The MonoTerm software is included on the memory stick provided with the instrument.

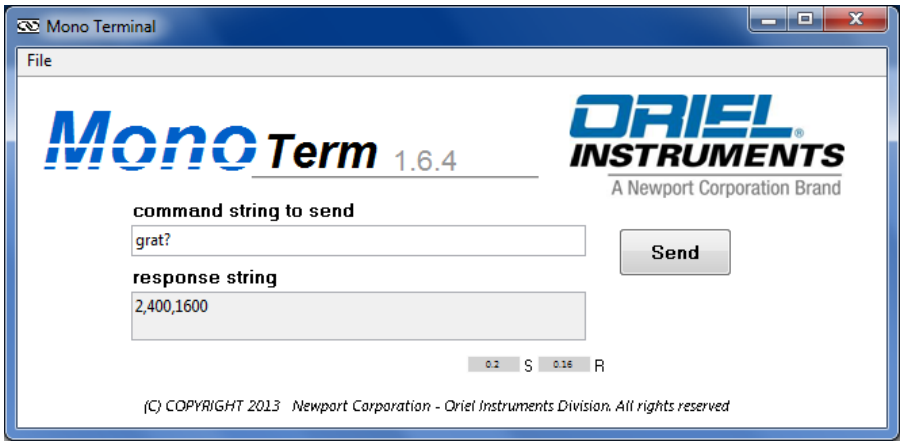


Figure 29: Query Using MonoTerm Software

11 GRATING INSTALLATION AND CALIBRATION

Grating installation and field calibration are typically performed at one of Newport's manufacturing location, or by qualified field service personnel. The instructions provided in this section are for advanced users only.

11.1 RECALIBRATION SERVICES

Newport suggests that monochromators be returned annually for service. In addition to verifying the calibration, the instrument would be fully inspected. Any refurbishment required, such as fresh lubrication on the worm gear, would be included in the servicing of the instrument.

11.2 SETTING THE WAVELENGTH OFFSET

A wavelength offset is used to shift the wavelength position to either a higher or a lower wavelength. For example, if a HeNe laser operating at 632.8 nm is sent through the monochromator and the output is visible when the monochromator is set to 640 nm, an offset can be introduced.

When performing this procedure, it is necessary to use a light source with a known spectral line appearing within the operating range of the grating. Oriel offers a number of pencil calibration lamps for this purpose, such as the model 6035 Hg lamp. Another line source such as a laser may also be used. Always be sure to follow the appropriate safety precautions when dealing with any light source.

Procedure:

1. Select a radiation source that has at least one narrow spectral line in the wavelength region of interest.
2. Select a detector with an operating range appropriate for the spectral line.
3. Focus the radiation onto the entrance slit (the monochromator is F/3.9). Note that a narrower slit provides greater resolution.
4. Ensure the focused beam is parallel to the monochromator's optical axis.
5. Command the monochromator to select the grating for which the offset is to be applied to.
6. Use the STEP command to move the grating position until the spectral line is visible at the output.
7. Use the CALIBRATE command to enter the exact wavelength of the spectral line. The Cornerstone wavelength offset has now been entered into memory. This offset applies to all other wavelength positions when using this grating.
8. Repeat the process for the second and third gratings, if required. Depending on the configuration, the monochromator may have two or three gratings installed.

11.3 DETERMINING THE GRATING CALIBRATION FACTOR

The following procedure allows advanced users to perform a two-point grating calibration.

Procedure:

1. Select a radiation source that has at least two narrow spectral lines in the wavelength region of interest.
2. Select a detector with an operating range appropriate for the spectral lines.
3. Focus the radiation onto the entrance slit (the monochromator is F/3.97). Note that a narrower slit provides greater resolution.
4. Ensure the focused beam is parallel to the monochromator's optical axis.
5. Command the monochromator to select the grating to be recalibrated.
6. Use the STEP command to move the grating position until the first spectral line is visible at the output.
7. Note the wavelength at which this first spectral line peak appears.
8. Use the STEP command to move the grating position until the second spectral line is visible at the output.
9. Note the wavelength at which this second spectral line peak appears.
10. Use the formula to calculate the new Grating Factor.
11. Use the utility software to enter the new Grating Factor. The GRATINGn FACTOR command may also be used
12. Repeat the process for the second and third gratings, if required. Depending on the configuration, the monochromator may have two or three gratings installed.

	Spectral Line	Observed Peak
Wavelength 1		
Wavelength 2		

FACTOR = | L1 – L2 | / | P1 – P2 |

Example:

	Spectral Line	Observed Peak
Wavelength 1	*546*	*577*
Wavelength 2	*365*	*372*

FACTOR = |546 – 365| / |577 – 372| = 181 / 205 = 0.8829268

11.4 GRATING INSTALLATION

Each grating comes mounted and aligned on a grating mount. For most applications, there is no need to adjust this grating holder. Refer to the general warnings and precautions section of this manual regarding the care and handling of diffraction gratings. Note that only one grating should be replaced at a time.

Procedure:

1. Using the Cornerstone Hand Controller or utility software, close the shutter.
2. Command the Cornerstone to go to the grating that is to be replaced.
3. Go to wavelength 0. The grating facing the collimating mirror is the grating that was selected.
4. Turn off the power switch on the monochromator and unplug the instrument from the electrical mains.
5. Remove all screws holding the monochromator cover in place, then remove the cover.
6. Two long screws, one on each side of the grating, must be removed. Used a screwdriver to loosen these screws.
7. Grasp the sides of the grating mount with one hand and firmly pull the grating up and out of the instrument. Pull in a direction parallel to the grating face – not directly upwards. During this process, ensure the other grating or gratings do not move. They should be held in place using a free hand by grasping or pressing down on the remaining grating holder(s).
8. Carefully uncover the new grating to be installed and set aside.
9. Use the cover from the new grating to protect the grating that was just removed.
10. Install the new grating onto the grating platform and ensure the new grating is parallel to the other gratings. The grating should fit into a pin located on the platform.
11. Push the new grating up against the large central pin in the middle of the platform.
12. Re-install the long screws that held the previous grating in place. Use only firm finger pressure to tighten them. Do not tighten one completely while the other screw is loose. It is best to alternate tightening between the two screws. Ensure the screws line up parallel with the grating face.
13. Replace the cover on the monochromator and secure using all screws provided. Failure to use all hardware will result in increased stray light.
14. Connect the monochromator to the electrical mains and switch on the power.
15. Follow the procedures outlined in this manual to determine the grating factor and any offset.
16. Use the Mono utility software to update the calibration parameters as needed.
17. It is suggested to verify the calibration factors and offsets of the other gratings that were not replaced, as they may have accidentally been moved during this process.

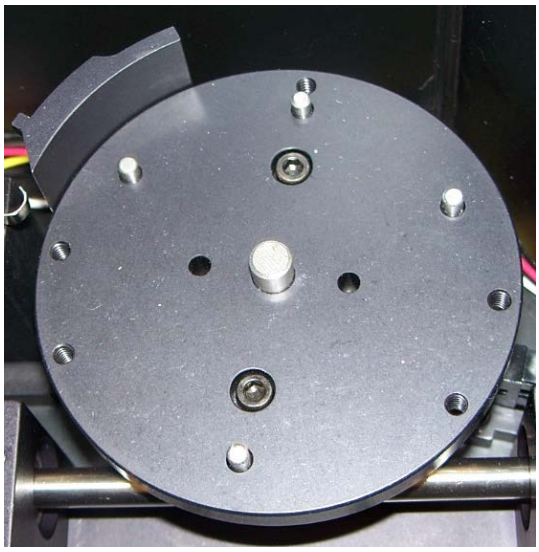


Figure 30: Grating Platform Without Gratings



Figure 31: Grating Platform With Three Gratings Installed

12 TROUBLESHOOTING

This section suggests solutions to potential issues that may be encountered when operating the Cornerstone monochromator. If the tips in this section do not restore the instrument to working condition, contact Newport to arrange for technical support or repair. Contact information can be found in the Warranty and Service section of this user's manual.

12.1 CORRUPTED MEMORY

The monochromator comes with calibration parameters, which are stored in a file on the memory stick shipped with the instrument. If these parameters were corrupted from, possibly, performing an incorrect field calibration, they will need to be reset. Other possible causes include electrostatic discharge or other high field radiation near or in contact with the instrument.

The instrument parameters need to be reloaded from the calibration parameter sheet. Use the utility program and select the first grating. Update the parameters for this grating. Then go to the second grating and third grating (if equipped) to also update these parameters.

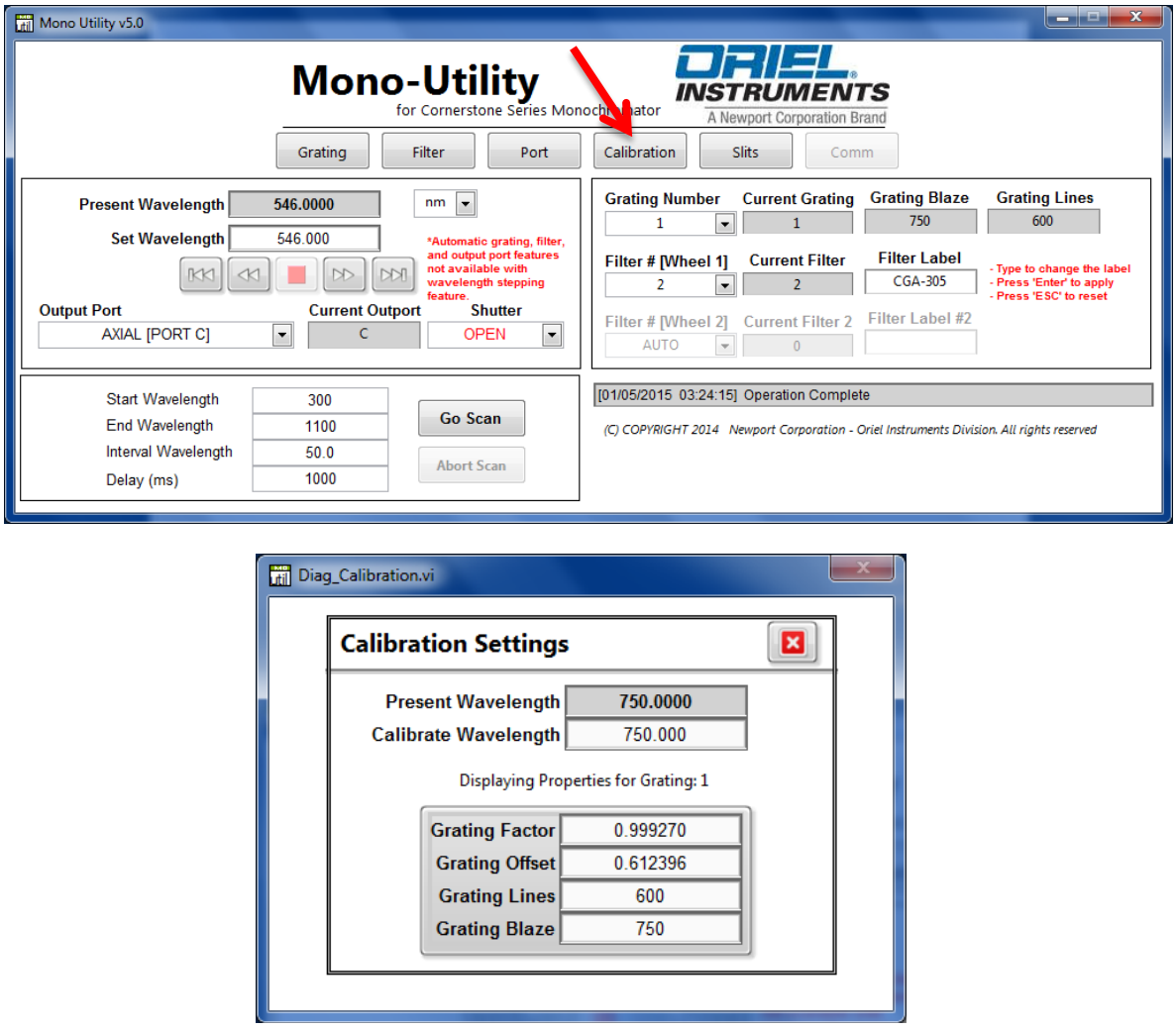


Figure 32: Entering Calibration Values in Utility Software

12.2 GRATING TURRET POSITION ERROR

The photo below shows the inside of a Cornerstone 260 monochromator. Normally two or three gratings are mounted on the rotating turret. They are not shown in the photo for clarity. The instrument senses the turret's angle of rotation based on a sensor. A small pin mounting just under the turret is seen by the sensor. The pin position may shift to a location where it cannot be picked up by the sensor when the instrument is turned on. This may be due to a sudden power outage, inadvertently toggling the power switch very rapidly or entering an incorrect calibration value (most often a decimal point error).

To correct this situation, the shaft with the worm gear attached needs to be manually rotated to bring this pin back to its normal operating range. The normal operating range is shown in green in the photo below.

Be sure to turn off the monochromator and unplug it prior to performing this procedure. Take all necessary precautions outlined in this user's manual to ensure the optics are not damaged through inadvertent contact.

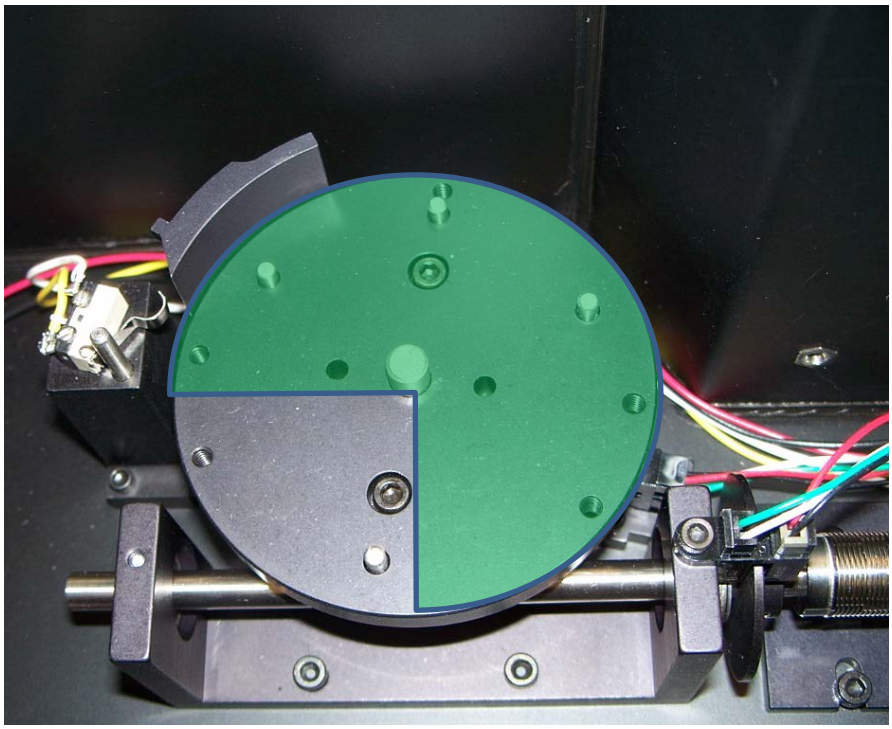


Figure 33: Grating Turret Position Sensor Pin Range

13 SPECIFICATIONS

General Specifications	
Focal Length	260 mm
F/#	F/3.9
Wavelength Selection	Motorized
Usable Wavelength Range	180 to 2500 nm, grating dependent
Spectral Resolution	Grating dispersion and slit width dependent
Wavelength Accuracy	0.35 nm
Wavelength Precision	0.08 nm
Maximum Slew Rate	205 nm/s with 1200 line/mm grating
Stray Light	0.03%
Input Ports	1 input port, expandable to two input sources using optional 77765 Beam Steerer
Output Ports	Axial (all models) and Lateral (dual port models)
External Shutter Control	BNC connector (normally closed), TTL low or short opens shutter
Shutter minimum exposure	0.2 s
Shutter maximum repetition	0.5 Hz
Motorized Filter Wheel	Filter Wheel Model 74010, Apex2 Filter Wheel
Utility Software Requirements	Windows 7 32-bit or 64-bit operating system (Windows XP compatible software also available)
TracQ Basic Software Compatible	Yes
74009 Hand Controller Compatible	Yes
100-240 VAC, 47-63 Hz	100-240 VAC, 47-63 Hz
Weight	21 lb [9.5 kg]

Micrometer Adjustable Slit Specifications	
Width Range	4 µm to 3 mm
Height Range	3 mm to 12 mm
Repeatability	± 10 µm
Accuracy	± 10 µm (width from 4 µm to 250 um) ± 5% (width from 250 µm to 3 mm)

Motorized Slit Specifications	
Width Range	6 µm to 2 mm, in 6 µm increments
Height	15 mm
Repeatability	±5 µm
Accuracy	±10 µm

Wavelength Accuracy: the capability of the monochromator to output the desired wavelength.

Wavelength Precision: the ability of a wavelength to be consistently reproduced and the number of significant digits to which it has been reliably measured.

14 DIMENSIONS

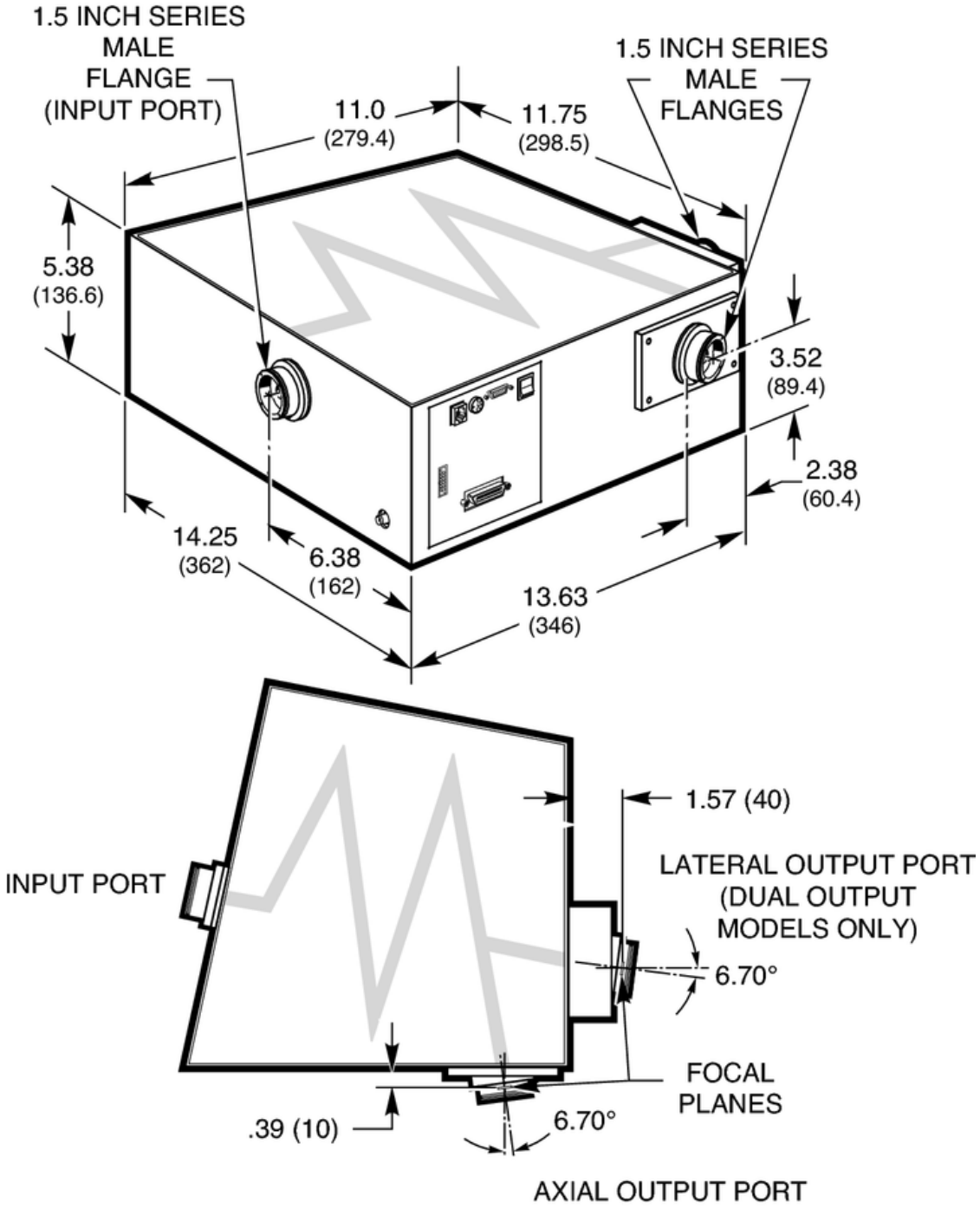


Figure 34: Cornerstone 260 Dimensions

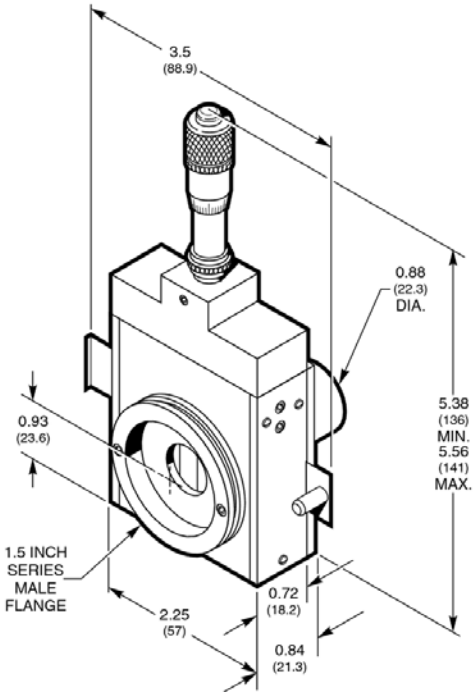


Figure 35: Micrometer Adjustable Slit Dimensions

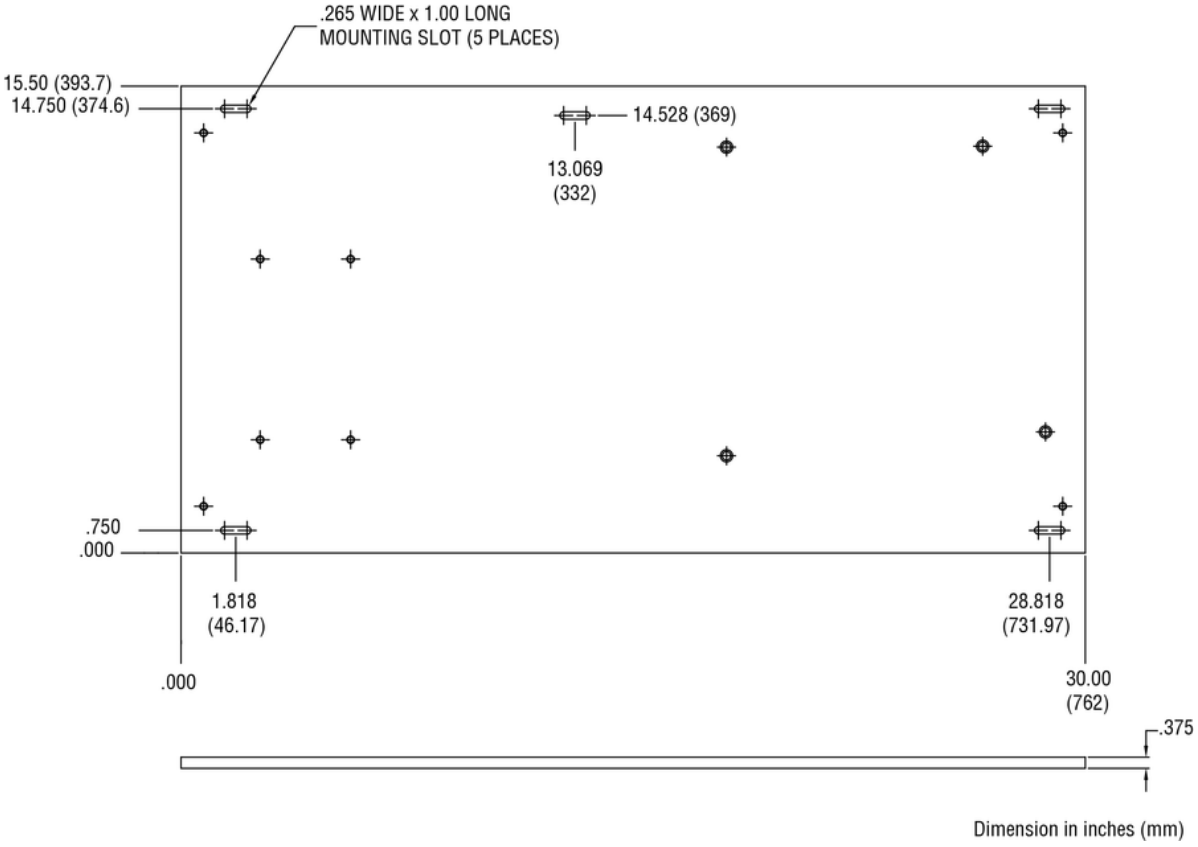


Figure 36: Model 74104 Mounting Kit

15 EU DECLARATION OF CONFORMITY

We declare that the accompanying product, identified with the CE mark, complies with requirements of the Electromagnetic Compatibility Directive, 2014/30/EU and the Low Voltage Directive 2006/95/EC.

Model Numbers:
CS260-RG-1-FH-A, CS260-RG-2-FH-A, CS260-RG-3-FH-A, CS260-RG-4-FH-A, CS260-RG-1-FH-D, CS260-RG-2-FH-D, CS260-RG-3-FH-D, CS260-RG-4-FH-D, CS260-USB-1-FH-A, CS260-USB-2-FH-A, CS260-USB-3-FH-A, CS260-USB-4-FH-A, CS260-USB-1-FH-D, CS260-USB-2-FH-D, CS260-USB-3-FH-D, CS260-USB-4-FH-D, CS260-RG-1-MC-A, CS260-RG-2-MC-A, CS260-RG-3-MC-A, CS260-RG-4-MC-A, CS260-RG-1-MC-D, CS260-RG-2-MC-D, CS260-RG-3-MC-D, CS260-RG-4-MC-D, CS260-USB-1-MC-A, CS260-USB-2-MC-A, CS260-USB-3-MC-A, CS260-USB-4-MC-A, CS260-USB-1-MC-D, CS260-USB-2-MC-D, CS260-USB-3-MC-D, CS260-USB-4-MC-D, CS260-RG-1-MT-D, CS260-RG-2-MT-D, CS260-RG-3-MT-D, CS260-RG-4-MT-D, CS260-USB-1-MT-D, CS260-USB-2-MT-D, CS260-USB-3-MT-D, CS260-USB-4-MT-D, CS260-RG-Q-FH-A, CS260-RG-Q-MC-A, CS260-USB-Q-FH-A, CS260-RG-Q-MC-A

Year CE mark affixed: 2015

Type of Equipment: Electrical equipment for measurement, control and laboratory use in industrial locations.

Manufacturer: Newport Corporation
1791 Deere Avenue
Irvine, CA 92606

Standards Applied:

Compliance was demonstrated to the following standards to the extent applicable:
BS EN61326-1: 2013 “Electrical equipment for measurement, control and laboratory use – EMC requirements” for use in a controlled electromagnetic environment.

Mark Carroll

Mark Carroll
Sr. Director, Instruments Business
Newport Corporation
1791 Deere Ave, Irvine, CA92606 USA

16 APPENDIX I: LOW LEVEL COMMANDS AND QUERIES

16.1 OPENING LOW LEVEL COMMUNICATION INTERFACE

Commands and Queries may be sent using Oriel's MonoTerm software, HyperTerminal or other similar terminal emulation programs. Settings are as follows:

Baud Rate:	9600
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	None

Once the terminal program is open and running, select a COM port and configure it according to the parameters previously listed. Additionally, set the terminal to "Send line ends with line feeds". There is no reason to turn on the local echo since Cornerstone will automatically echo each character as it is typed. All Cornerstone responses end with a carriage return and linefeed. Likewise, all messages sent to Cornerstone must end with the linefeed character.

16.2 COMMAND AND QUERY SYNTAX

For the purposes of this discussion, communications with the instrument is divided into two parts. The messages sent to the monochromator are called "Statements". The messages received from the monochromator are called "Responses". When communicating with the instrument, two types of Statements are used: "Commands" and "Queries". A Command causes some physical action or sets an internal parameter. A Query asks a question of the instrument and automatically returns a Response. Fundamentally, the syntax is the same for all messages.

Termination
Both Statements and Responses end with a carriage return (ASCII character code 13 decimal) and linefeed (ASCII character code 10 decimal). This manual will show the termination as [cr][lf]. It may be more convenient to end Statements with only the linefeed [lf]; this is also acceptable.

Capitalization
Statements may be sent in upper case, lower case, or in any combination of the two. Responses are returned in upper case. For clarity throughout this manual, Statements are shown in upper case (i.e. STATEMENT) and Responses are shown in upper case italics (i.e. *RESPONSE*).

Parameters
Some Statements require a parameter. In this manual numeric parameters are shown as "XX"; each X will fill a numeric position and decimals are used to indicate where floating point number should be expected. Numeric notation is not strict and integers can be substituted for floating point numbers as desired. There are some specific cases where alphanumeric values or exponential notation may be required; these special Statements are detailed in this manual.

16.3 STANDARD MODE

Most normal communication with the Cornerstone, especially communication handled inside closed application software, is done in Standard Mode. This mode follows all of the rules on the previous page, plus there are some additional features for error handling.

The Cornerstone stores errors internally in a status byte and an error byte, where each bit has a specific meaning. Details of the status and error bytes can be found in this manual under Error Codes.

In all cases, Statements must be terminated properly with [lf] for Cornerstone to take any action. Statements that are not understood or parameters that are unacceptable generate an error code in the status byte, i.e. status byte not equal to 0. Moreover, the status byte must be explicitly read. It is not returned after general Statements.

Correct Statements are handled as follows:

Commands
Under RS-232, Statements are echoed back to the PC. Thus, after sending a Command you should read back this echo. There is no further response to a Command.

Example:

Send: GOWAVE 500[lf]	Response: GOWAVE 500[lf]

Under IEEE-488 and USB, there is no echo. There is no automatic response to a Command.

Example:

Send: GOWAVE 500[lf]	Response: {none}

Queries
Under RS232, Statements are echoed back to the PC. Additionally, there will be an explicit response to that query. Thus, after sending a Query the echo and the answer should be read back together.

Example:

Send : WAVE?[lf]	Response: WAVE?[lf]500[cr][lf]

Under IEEE-488 and USB, there is no echo. Thus, the Response can be read back by itself.

Example:

Send : WAVE?[lf]	Response: 500[cr][lf]

16.4 HANDSHAKE MODE

This communications mode is most useful for methods development, troubleshooting or in the early stages of programming. Use the command: “HANDSHAKE 1[lf]” to put Cornerstone into Handshake Mode. This mode follows the command syntax listed in this manual, but in addition, every Statement is acknowledged. The “handshake” that received is the status byte.

The Cornerstone stores errors internally in a status byte and an error byte, where each bit has a specific meaning. Details of the status and error bytes can be found in this manual under Error Codes.

In all cases, Statements must be terminated properly with [lf] for Cornerstone to take any action. Statements that are not understood or parameters that are unacceptable generate an error code in the status byte, i.e. status byte 0.

This status byte will be reported immediately if it contains an error, otherwise the status byte “00” will be returned upon completion of the Statement.

Correct Statements are handled as follows:

Commands
Under RS-232, Statements are echoed back to the PC. Thus, after sending a Command, this echo should be read back. Additionally, the status byte is reported when the action is complete.

Example:
Send: GOWAVE 500[lf] Response: GOWAVE 500[lf]00[cr][lf]

Under IEEE-488 and USB, there is no echo. The only response will be the status byte.

Example:
Send: GOWAVE 500[lf] Response: 00[cr][lf]

Queries
Under RS-232, Statements are echoed back to the PC. Additionally, there will be an explicit response to that query, and the statues byte. After sending a Query, a three-part answer should be read back.

Example:
Send : WAVE?[lf] Response: WAVE?[lf]500[cr][lf]00[cr][lf]

Under IEEE-488 and USB, there is no echo. Thus, you will read back the Response and the status byte.

Example:
Send : WAVE?[lf] Response: 500[cr][lf]00[cr][lf]

16.5 COMMAND REFERENCE SUMMARY

Command	Query	Hand Controller Key
ABORT		[ABORT]
ADDRESS XX	ADDRESS?	
BANDPASS XXX.XX	BANDPASS?	[SHIFT 1]
CALIBRATE XXX.XXX		[CALIB]
	ERROR?	
FILTER X	FILTER?	[FILTER]
FILTER1LABEL TTTTTTTT	FILTER1LABEL?	[SHIFT LABEL]
GOWAVE XXX.XXX	WAVE?	[GO WAVE]
GRAT X	GRAT?	[GRAT]
GRAT1FACTOR XXX.XXX	GRAT1FACTOR?	
GRAT1LABEL TTTTTTTT	GRAT1LABEL?	[SHIFT LABEL]
GRAT1LINES XXXX	GRAT1LINES?	[LINES]
GRAT1OFFSET XXX.XXX	GRAT1OFFSET?	
GRAT1ZERO XXX.XXX	GRAT1ZERO?	
GRAT2FACTOR XXX.XXX	GRAT2FACTOR?	
GRAT2LABEL TTTTTTTT	GRAT2LABEL?	[SHIFT LABEL]
GRAT2LINES XXXX	GRAT2LINES?	[LINES]
GRAT2OFFSET XXX.XXX	GRAT2OFFSET?	
GRAT2ZERO XXX.XXX	GRAT2ZERO?	
GRAT3FACTOR XXX.XXX	GRAT3FACTOR?	
GRAT3LABEL TTTTTTTT	GRAT3LABEL?	[SHIFT LABEL]
GRAT3LINES XXXX	GRAT3LINES?	[LINES]
GRAT3OFFSET XXX.XXX	GRAT3OFFSET?	
GRAT3ZERO XXX.XXX	GRAT3ZERO?	
HANDSHAKE X	HANDSHAKE?	
INFO?		[LOCAL]
SHUTTER T	SHUTTER?	[SHUTTER]
SLIT1MICRONS XXXX	SLIT1MICRONS?	[1]
SLIT2MICRONS XXXX	SLIT2MICRONS?	[2]
SLIT3MICRONS XXXX	SLIT3MICRONS?	[3]
	STB?	
STEP XXX	STEP?	[STEP UP]
UNITS TT		[SHIFT UNITS]

16.6 DETAILED COMMAND REFERENCE

This section describes the exact syntax, acceptable parameters, and functionality for every Cornerstone 260 Command. For each corresponding Query, in braces { }, type of Response expected is also listed. Where appropriate, the corresponding Hand Controller key, in brackets [ ], is also listed. Finally, there are some warnings as to possible errors that may occur if a command is not used properly.

Cornerstone Motion Commands

UNITS TT {UNITS?} [UNITS]
Specifies the operational units designated by the mnemonic parameter “TT”. Possible parameters are:
“NM” for nanometers, “UM” for micrometers, “WN” for wavenumbers (cm^{-1}).

By default, the Cornerstone uses nanometers. Parameters for all motion Statements are handled in the current units. When changing from nanometers to micrometers, GOWAVE parameter must be entered in micrometers. Likewise, WAVE? answers will be returned in micrometers. The response to UNITS? is always the two character mnemonic for the current units.

GOWAVE XXX.XXX {WAVE?} [GO WAVE]
Moves the wavelength drive at maximum speed to the step position closest to the specified wavelength parameter. This parameter must be in the current units and may be either a floating point number or an integer, i.e. “GOWAVE 500.00[lf]” and “GOWAVE 500[lf]” will be understood the same way. For each grating, there is a maximum possible wavelength (approximately 1600 nm for a 1200 l/mm grating, thus 800 nm for a 600 l/mm, etc.) This command will generate an error if the parameter is larger than the maximum wavelength. The response to WAVE? will be a floating point number indicating the exact wavelength position. Current units are assumed and so no units are passed with the floating point number.

CALIBRATE XXX.XXX [CALIB]
This command is used to make minor corrections to the wavelength calibration of the Cornerstone. It is used when installing new gratings, or at any point when the wavelength calibration is disrupted. Execute this command to define the current position as the wavelength specified in the numeric parameter XXX.XXX. Calculates a new OFFSET for the grating and saves it accordingly. A calibration procedure is outlined in this user’s manual.

ABORT [ABORT]
Stops any wavelength motion immediately, i.e. GOSCAN, GOWAVE, STEP, etc.

STEP XXXX {STEP?} [STEP UP] / [STEP DOWN]
Moves the wavelength drive by the integer number of steps indicated in XXXX. The parameter can be positive or negative, however, one step is the smallest increment the Cornerstone can move, and so this parameter must be an integer. The response to STEP? is the current step position as measured from the physical home sensors.

Cornerstone Grating Commands

GRAT X {GRAT?} [GRAT]
Moves the wavelength drive to the grating specified in the integer parameter. The parameter should be either "1", "2" or “3”. When changing to grating #1 the instrument stops at the maximum wavelength for that grating. When changing to grating #2 or #3, the system stops at the zero order position for that grating. Therefore, this command is usually followed by a GOWAVE command. The response to GRAT? contains three parameters separated by commas without spaces. The first parameter is the grating number, then the lines/mm, then the label for that grating. For example: “1,1200,BLUE[cr][lf]”.

GRAT1LABEL TTTTTTT {GRAT1LABEL?} [SHIFT LABEL]
Sets the user defined “label” for the grating #1 to the < 9 character parameter “TTTTTTTT”. The parameter can letters or numbers. This label is for informational purposes only. Oriel uses these labels to indicate blaze wavelength for those gratings that are installed in Cornerstone at the factory. Note: that the Hand Controller only displays four characters, however all eight may be entered. Also, the Hand Controller only changes the current grating parameters.

GRAT2LABEL TTTTTTT {GRAT2LABEL?} [SHIFT LABEL]
Sets the user defined “label” for the grating #2 to the < 9 character string parameter “TTTTTTTT”. The parameter can letters or numbers. This label is for informational purposes only. Oriel uses these labels to indicate blaze wavelength for those gratings that are installed in Cornerstone at the factory. Note: that the Hand Controller only displays four characters, however all eight may be entered. Also, the Hand Controller only changes the current grating parameters.

GRAT3LABEL TTTTTTT {GRAT3LABEL?} [SHIFT LABEL]
Sets the user defined “label” for the grating #3 to the < 9 character string parameter “TTTTTTTT”. The parameter can letters or numbers. This label is for informational purposes only. Oriel uses these labels to indicate blaze wavelength for those gratings that are installed in Cornerstone at the factory. Note: that the Hand Controller only displays four characters, however all eight may be entered. Also, the Hand Controller only changes the current grating parameters.

GRAT1LINES XXXX {GRAT1LINES?} [LINES]
Sets the lines per millimeter of grating #1 to the integer parameter specified as XXXX. Warning: this value is used to calculate wavelength motion. Lines/mm is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Newport. Note, the Hand Controller only changes the current grating parameters.

GRAT2LINES XXXX {GRAT2LINES?} [LINES]
Sets the lines per millimeter of grating #2 to the integer parameter specified as XXXX. Warning: this value is used to calculate wavelength motion. Lines/mm is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Newport. Note, the Hand Controller only changes the current grating parameters.

GRAT3LINES XXXX {GRAT3LINES?} [LINES]
Sets the lines per millimeter of grating #3 to the integer parameter specified as XXXX. Warning: this value is used to calculate wavelength motion. Lines/mm is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Newport. Note, the Hand Controller only changes the current grating parameters.

GRAT1FACTOR XXX.XXX {GRAT1FACTOR?}
Sets the calibration factor of grating #1 to the numeric parameter specified as XXX.XXX. Warning: this value is used to calculate wavelength motion. Factor is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Oriel.

GRAT2FACTOR XXX.XXX {GRAT2FACTOR?}
Sets the calibration factor of grating #2 to the numeric parameter specified as XXX.XXX. Warning: this value is used to calculate wavelength motion. Factor is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Oriel.

GRAT3FACTOR XXX.XXX {GRAT3FACTOR?}
Sets the calibration factor of grating #3 to the numeric parameter specified as XXX.XXX. Warning: this value is used to calculate wavelength motion. Factor is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Oriel.

GRAT1OFFSET XXX.XXX {GRAT1OFFSET?}
Sets the calibration offset for grating #1 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Offset is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Newport. This value is automatically changed via the CALIBRATE command. A calibration procedure is outlined in this user's manual.

GRAT2OFFSET XXX.XXX {GRAT3OFFSET?}
Sets the calibration offset for grating #1 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Offset is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Oriel. This value is automatically changed via the CALIBRATE command. A calibration procedure is outlined in this user's manual.

GRAT3OFFSET XXX.XXX {GRAT2OFFSET?}
Sets the calibration offset for grating #3 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Offset is usually changed only when installing a new grating, and in that case, the parameter should match the value provided by Oriel. This value is automatically changed via the CALIBRATE command. A calibration procedure is outlined in this user's manual.

GRAT1ZERO XXX.XXX {GRAT1ZERO?}
Sets the zero parameter for grating #1 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Zero is usually changed only when changing the instrument from a double grating configuration to triple grating configuration, or visa versa. The value for a double grating configuration is 0.0875665. For a triple grating configuration, the value is 0.0872665. Please note that this instrument may hold one, two or three gratings. The configuration indicates the maximum number of gratings that may be potentially installed. This is dependent on the style of mount the grating is bonded to.

GRAT2ZERO XXX.XXX {GRAT2ZERO?}
Sets the zero parameter for grating #1 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Zero is usually changed only when changing the instrument from a double grating configuration to triple grating configuration, or visa versa. The value for a double grating configuration is 3.2288591. For a triple grating configuration, the value is 2.1816616.

GRAT3ZERO XXX.XXX {GRAT3ZERO?}
Sets the zero parameter for grating #1 as the floating point parameter specified in XXX.XXX. Warning: this value is used to calculate wavelength motion. Zero is usually changed only when changing the instrument from a double grating configuration to triple grating configuration, or visa versa. The value for a double grating configuration is 3.2288591. For a triple grating configuration, the value is 4.2760567.

Cornerstone Accessory Commands

SHUTTER T {SHUTTER?} [SHUTTER]
Closes or opens the shutter depending upon the single letter mnemonic parameter (T). Closing the shutter requires "C", whereas opening it requires "O". The response to SHUTTER? is simply the one character parameter describing the current state. When using the Hand Controller key [SHUTTER] no parameter is necessary. Pressing this key toggles the shutter out of the current state into the other state. Look to the display to check shutter position.

FILTER X {FILTER?} [FILTER]
Moves the filter wheel to the position specified in the single integer parameter “X”. Acceptable values range from 1 through 6. The response to FILTER? is the integer value describing the current filter position; if there is no filter wheel connected, or if the wheel is out of position, “0” is returned and an error is set in the status byte. Sending this command while the filter wheel is out of position will cause the wheel to search for #1 and then move to the requested position. This search occurs at power on too.

FILTER#LABEL TTTTTTTT {FILTER#LABEL?} [SHIFT LABEL]
Sets the label for the filter position specified by # to the < 9 character string parameter “TTTTTTTT”. Valid values of # are 1-6, using any other value will result in a status byte error indicating a bad command, not a bad parameter. The value of “TTTTTTTT” can be letters or numbers. This label is for informational purposes only.

SLIT1MICRONS XXXX {SLIT1MICRONS?} [1]
Commands the motorized slit at the input port to open to the size specified by the integer parameter in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6. If the query responds with 0, there is a problem with the slit.

SLIT2MICRONS XXXX {SLIT2?MICRONS} [2]
Commands the motorized slit #2 to open to the size specified by the integer parameter in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6. If the query responds with 0, there is a problem with the slit.

SLIT3 XXXX {SLIT3?} [3]
Commands the motorized slit #3 to open to the size specified by the integer parameter in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6. If the query responds with 0, there is a problem with the slit.

BANDPASS XXX.XX {BANDPASS?} [SHIFT 1]
The 74000 uses the Bandpass parameter to automatically adjust all the slits. The floating point parameter is the wavelength resolution to automatically adjust slits for. If Bandpass is not set at zero the 74000 will be adjust all slits to maintain the Bandpass resolution at wavelength moves and grating changes. Setting Bandpass to 0 turns off this automatic adjustment. Slit range is 6-2000 microns, in 6 micron resolution steps. For Bandpass adjustments requiring slit openings larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6. Note; for Bandpass slit size calculations to function properly, Slit1 must be at the input port.

OUTPORT X {OUTPORT?} [SHIFT PORT]
Moves the motorized flip mirror inside the monochromator to select either the axial or lateral output port, as specified by the single integer parameter “X”. The axial port is designated as 1, and the lateral port is designated as 2. The response to OUTPORT? is the integer value describing the current output port.

Cornerstone System Commands

{INFO?} [LOCAL]
Query for basic instrument information. Generates the same response as the GPIB specific *IDN? That response is “Oriel, Model 74100 Cornerstone 260,SNXXX,VYY.YY.YY” where XXX is the unit's serial number and YY.YY.YY is the version number for internal firmware. This information is displayed for 3 seconds when [LOCAL] is pressed on the Hand Controller. Model 74100 is displayed for RS232/GPIB instruments. Model 74125 is displayed for USB instruments.

HANDSHAKE X {HANDSHAKE?}
This command turns Handshake Mode on and off. Setting the parameter “X” to “1” causes Cornerstone to acknowledge command completion according to the description given in 5.1.2 Standard Mode. Setting the parameter to “0” returns the Cornerstone to normal operation according to the description given in the section in this manual entitled Standard Mode. The response to the query HANDSHAKE? is the single integer describing the current mode, “0” or “1”.

{STB?}
Use this query to check for Cornerstone error conditions. The response will be “32” when an error occurred or “00” when no error is present. Reading this code clears the status byte. Further information can be obtained using the ERROR? query below. A detailed discussion of error handling is provided in this user’s manual.

{ERROR?}
Use this query to obtain further information about an error state reported in the Status byte. The response will be an integer from 0 through 9. The definition of each error code and a detailed discussion of error handling are provided in this user’s manual.

ADDRESS XX {ADDRESS?}
Use this command to change the IEEE-488 primary address for the Cornerstone if the default address (4) conflicts with another instrument in the laboratory. Turn off the other instrument(s), establish communication with Cornerstone, and then send this command with the integer parameter from 1 to 30. If successful, the address change takes place immediately and any further communication using the previous address will cause an IEEE-488 error. If unsuccessful, an error will be reported in the Status byte.

16.7 ERROR CODES FOR LOW LEVEL COMMANDS

Cornerstone errors are stored internally in the Status byte and Error code. The Status byte is usually empty (decimal value 0) but if an error condition occurs, bit 5 of the Status byte will be set (decimal value 32). By checking this byte, all error conditions can be checked at once. Further information is provided in the individual error codes. There is a detailed list of error codes later in this . There are two ways to check for errors. First, one can explicitly query the Status Byte. This method is used for most communication and programming and is described in in the section for Standard Mode.

Use the query “STB?” to get the decimal value of the Status Byte, either “00” for success or non-zero for error. If the response is not a zero then you should check the code for that particular error using the query “ERROR?”. Please note that reading the Status Byte and the Error Code resets them back to “0”.

Errors may be checked for immediately in Handshake Mode. Turn this mode on with the command “HANDSHAKE 1[lf]”. Handshaking causes Cornerstone to respond to every Statement with the Status byte. The exact syntax is discussed in the section covering Handshaking Mode. Again, if the response is “20” then you should check the code for that particular error using the query “ERROR?”. Likewise, the Status Byte is cleared after it is reported as the handshake.

Read Status Byte with:	STB?	00 indicates no error 20 indicates error condition.
Read Error Code with:	ERROR?	Error codes are listed below.

Error code	Condition
1	Command not understood
2	Bad parameter used in Command
3	Destination position for wavelength motion not allowed
6	Accessory not present (usually filter wheel)
7	Accessory already in specified position
8	Could not home wavelength drive
9	Label too long
0	System error (miscellaneous)

17 APPENDIX II: HAND CONTROLLER COMMANDS

The optional 74009 Hand Controller is designed specifically for use with Oriel's Cornerstone series monochromators and MS260i spectrographs. It is very easy to set up – simply plug it into the instrument and it's ready to go. There is no need to purchase a computer and set up the software. The Hand Controller is a very convenient option in locations where security is an issue, such as defense facilities and universities.

There is no need to memorize commands or key sequences. The 24 keys are clearly labeled with functions like "Shutter", "Go Wave" and "Filter". The backlit LCD display provides information on the grating selection, grating line density, active filter position, current wavelength and shutter status. Using the Hand Controller is intuitive and provides access to nearly all the functionality of the monochromators and spectrographs. It comes with a 14 foot [4.3 meter] long cable.

17.1 ACTIVATING THE HAND CONTROLLER

With the Hand Controller connected, turn on power to the Cornerstone. You will see a horizontal cursor in the upper left corner of the display. Press the LOCAL key to activate communications through the Hand Controller. Please note that if the Hand Controller is active (the display is lit and information fills the screen), you cannot command the Cornerstone via either RS-232 , IEEE-488 or USB. Press the LOCAL key again to deactivate the Hand Controller, allowing PC communications.

17.2 USING THE KEYPAD

Some keys are divided into top and bottom halves. The function for the yellow top half is called a "shifted" function. To activate these commands press the SHIFT key in the bottom left corner and then press the function key.

Many of the Cornerstone commands require a numeric parameter. First, press the function key for your command. The bottom line of the LCD display will then show an abbreviated form of the command and the current parameter. There is no need to erase this number; simply typing the first key for your desired parameter will overwrite the current value. To execute the command press the ENTER key in the bottom right corner.

While entering parameters, if you mistype one digit press SHIFT and then DEL (above the decimal point in the numeric keypad); this will move backward one display position and delete that character.



Figure 37: 74009 Hand Controller Keypad

17.3 KEY REFERENCE

These commands are listed based on the key locations from the top of the controller to the bottom, left to right.

ABORT- If you accidentally press a function key or enter a bad parameter you may press the ABORT key to clear that command before it executes. The ABORT key has no effect on most functions once the command is executed (by pressing ENTER). However, wavelength motion will stop immediately upon ABORT and the display will update to show the wavelength where motion was halted.

STEP DOWN Press this key once to move the Cornerstone to shorter wavelengths by the smallest possible increment. Holding this key causes rapid single stepping toward lower wavelengths. Press SHIFT and then STEP DOWN, you can use the keypad to define a number of steps to move at once. Press ENTER to execute this larger move.

STEP UP Press this key once to move the Cornerstone to higher wavelengths by the smallest possible increment. Holding this key causes rapid single stepping toward higher wavelengths. Press SHIFT and then STEP UP, you can use the keypad to define a number of steps to move at once. Press ENTER to execute this larger move.

GO WAVE This key induces wavelength motion to a specified position. Press GO WAVE, then use the keypad to enter the desired wavelength, and finally press ENTER to execute the move.

GRAT Press this key to move to the other grating position. Press GRAT, then press either 1 or 2 on the numeric keypad, and finally press ENTER to execute the change. The display will update to show the correct parameters for the new grating.

SHIFT LABEL This key (located directly above GRAT) provides access to the grating label. The label is an eight character alpha-numeric field that is used for information only. Newport puts the grating blaze wavelength as the label during calibration. However, you can use the keypad to type any number, then press ENTER to accept that new value. The Hand Controller display only shows the first four digits of the label, and you can only enter numbers.

LINES Press this key to change the lines/mm of the grating. This value is used for wavelength calculations and will affect your calibration. This parameter should be changed only when adding a new grating.

SHIFT CALIB- This button is used to change the wavelength calibration of the current grating. Use the GO WAVE, STEP DOWN, and STEP UP keys to move to a known wavelength (often the intensity peak for a spectral calibration lamp). If the wavelength shown in the top row of the display does not match the known value, press SHIFT CALIB and use the numeric keypad to enter the known wavelength. Then press ENTER to change the calibration. The current grating is thus calibrated over its entire range.

SHUTTER Alternately, open and close the shutter by pressing this button. The shutter position is shown in the display as “OPN” for open and “CLS” for closed.

SHIFT PORT To change the port, press this key. Followed by either 1 or 2 and then press ENTER. The number 1 corresponds to the axial port and the number 2 corresponds to the lateral output port.

FILTER Move the 74010 Filter Wheel accessory to the specified position. Press FILTER, then type the number 1, 2, 3, 4, 5, or 6 indicating the desired position, then finally press ENTER to execute the move.

SHIFT LABEL This key (located directly above FILTER) provides access to the filter label. These labels are eight character alpha-numeric fields, used for information only. You can use the keypad to type any number, then press ENTER to accept that new value. The Hand Controller display only shows the first four digits of the label, and you can only enter numbers.

LOCAL Use this key to toggle between "local" communication through the Hand Controller and "remote" communication with a computer. Please note that if you press LOCAL to activate the Hand Controller (the display is lit and information fills the screen), you also lock out PC communications. You cannot command the Cornerstone via either RS-232, IEEE-488 or USB while the Hand Controller is active.

SHIFT UNITS To change the wavelength units press this key, followed by either 1, 2, or 3 and then press ENTER. Those three number keys are labeled with the corresponding units: 1 is nanometers (nm), 2 is micrometers (µm), and 3 is wave numbers (cm^{-1}) shown as " □".

1 Pressing the 1 key when not in a function parameter edit mode brings ups the *"Slit1um>"* prompt to edit/enter the slit 1 size, (the slit at the input port), the integer parameter is the open size specified in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6.

SHIFT 1 Pressing the SHIFT-1 key when not in a function parameter edit mode brings ups the *"Bandpass>"* prompt. The floating point parameter is the wavelength resolution to automatically adjust slits for. If Bandpass is not set at zero the 74000 will be adjust all slits to maintain the Bandpass resolution at wavelength moves and grating changes. Setting Bandpass to 0 turns off this automatic adjustment. Slit range is 6-2000 microns, in 6 micron resolution steps. For Bandpass adjustments requiring slit openings larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6. Note; for Bandpass slit size calculations to function properly, Slit1 must be at the input port.

2 Pressing the 2 key when not in a function parameter edit mode brings ups the *"Slit2um>"* prompt to edit/enter the slit 2 size, the integer parameter is the open size specified in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6.

3 Pressing the 3 key when not in a function parameter edit mode brings ups the *"Slit3um>"* prompt to edit/enter the slit 3 size, the integer parameter is the open size specified in microns. Slit range is 6-2000 microns, in 6 micron resolution steps; for values larger than 2000 the slit goes to 2000, for values 0-6 the slit goes to 6.

18 APPENDIX III: USB DLL

The Cornerstone USB DLL “Cornerstone.dll” is located in the C:\Program Files\Newport\Mono Utility x.x.x\Cornerstone DLL directory, with “x.x.x” indicating the revision level of the software.

The following DLLs are provided:

Cornerstone.dll
CyUSB.dll

This section details how to interface with the instrument from either C#.NET or C++. Other .NET languages can also interface with the C#.NET DLL, as this is a function of the .NET languages. Please see Microsoft documentation on how to adapt code accordingly.

18.1 GENERAL CONSIDERATIONS

Before using any of these programming examples, the Cornerstone must be set up and configured for use. It is suggested to review the complete user’s manual to become familiar with the instrument..

The correct USB drivers need to be installed on the machine. Please note that they are compatible with a Microsoft Windows operating system only.

Verify the DLL is in the same folder or in command path of executable before running, or it will not be found.

18.2 LABVIEW USERS

LabVIEW users should refer to the MonoTerm software for example VIs.

The following directory contains a source distribution .zip file composed in LabVIEW 2009:
C:\Program Files\Newport\MonoTerm

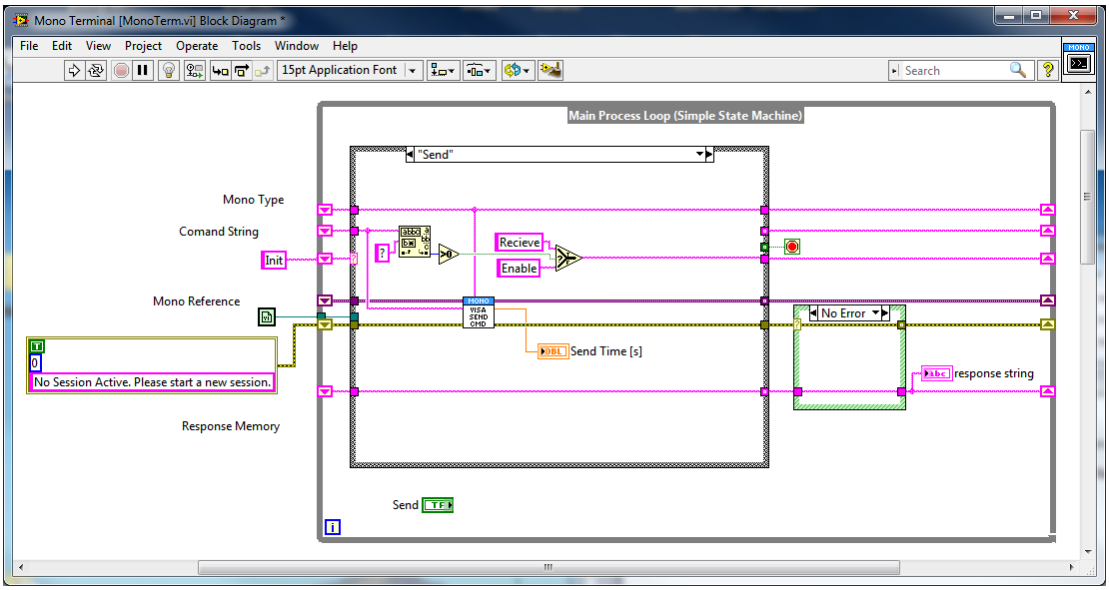


Figure 38: MonoTerm LabVIEW Source Code

18.3 C# USERS

This demonstrates how to call the DLL in C# .NET.
Below the code is how to add a DLL Reference to a .NET project.

Summary:

1. Add Code Reference to both the Cornerstone DLL and the CyUSB (Cypress) DLL
2. In the Form Designer file {Form.D} add the 'using' sections
3. {Form.D} Create new Cornerstone object
4. {Form.D} (optional)

Changes to (Form Designer) file:

```
//…
using CyUSB;
using CornerstoneDll;


namespace CornerstoneApp

{
   partial class MainForm
   {
      /// <summary>
//….

      USBDeviceList usbDevices;

      CyUSBDevice cornerstone;

      Cornerstone cs = new Cornerstone(true);


      Int32 deviceCount = 0;


      public MainForm()

      {
         InitializeComponent();       // This is C# standard form init function

         connect();

         usbDevices.DeviceAttached += new EventHandler(usbDevices_DeviceAttached);

         usbDevices.DeviceRemoved += new EventHandler(usbDevices_DeviceRemoved)
      }

   /// These two functions below handle dynamic USB plug and unplug events

      void usbDevices_DeviceRemoved(object sender, EventArgs e)
      {
```

```
        USBEventArgs usbEvent = e as USBEventArgs;
        cs.disconnect();
    }

    void usbDevices_DeviceAttached(object sender, EventArgs e)
    {
        USBEventArgs usbEvent = e as USBEventArgs;
        cs.connect();
        connect();
    }

    void connect()
    {
        cornerstone = cs.device;
        usbDevices = cs.usbDevices;
        deviceCount = usbDevices.Count;
    }

    void toggleButtons(Boolean toggle)
    {
        btnResponse.Enabled = toggle;
        btnSend.Enabled = toggle;
        btnQuery.Enabled = toggle;
    }
```

C# (Form file) code:

```
namespace CornerstoneApp
{
    public partial class MainForm : Form
    {

        public Int32 nActiveUnit = 1;   // Used only for multiple devices (default) below



        private void btnSend_Click(object sender, EventArgs e)
        {
            cs.sendCommand(txtComand.Text);
            txtInfo.Text = cs.getLastMessage();
        }

        private void btnResponse_Click(object sender, EventArgs e)
        {
            txtInfo.Text = cs.getResponse();
        }


        //=====================    Second Controls for second device if needed
       //  NOT needed for only one device.

        private void btnSend2_Click(object sender, EventArgs e)
        {
            cs.setActiveDevice(cs.usbDevices.Count);
            cs.sendCommand(txtComand2.Text);
```

```
    txtInfo.Text = cs.getLastMessage();
    cs.setActiveDevice(nActiveUnit);
}

private void btnResponse2_Click(object sender, EventArgs e)
{
    cs.setActiveDevice(cs.usbDevices.Count);
    txtInfo.Text = cs.getResponse();
    cs.setActiveDevice(nActiveUnit);
}
```

18.4 C++ USERS

Oriel_USB.h file provides a COriel_USB class that links DLL functions to connect and control the Cornerstone.

Reminder: Verify the DLL is in the same folder or in command path of executable before running.

Summary:

Add Oriel_USB.h, Cornerstone.dll and CyUSB.dll to project
Add Oriel_USB.h to #include in header file of project.
Create class object with “COriel_USB myDevice;”
Call functions in DLL such as write: “myDevice.Send(strCommand);”

Functions Defined in class:

```
char * GetLibraryVersion(void);

INT32 Send(const char* strCommand);

INT32 Read(LPSTR strReturn);

INT32 Query(const char* strCommand, char* strReturn);
```

Sample Query code:

```
void OnBtnQuery()

{
 CString strCommand;
CString strCommunication;
 char strPass[256];
char strReturn[1024];

// Command to send
 GetDlgItemTextW(cntlCommand, strCommand);
 strcpy_s(strPass, CStringA(strCommand).GetString());

 strcpy_s(strReturn, "");
 LPSTR pstrReturn = strReturn;   // Response variable

 // Query instrument
 INT32 bSuccess = myDevice.Query(strPass, pstrReturn);

 if (bSuccess)
 {
        strCommunication.Append(CString(strReturn));
 }
 else
 {
        strCommunication.Append(L"Attempting Read... Failed");
 }

 History.SetWindowTextW(strCommunication);
}
```

19 APPENDIX IV: GRATING PHYSICS TUTORIAL

19.1 THE GRATING EQUATION

A typical diffraction grating consists of a substrate, usually of an “optical material”, with a large number of parallel grooves ruled or replicated in its surface and overcoated with a reflecting material such as aluminum. The quality and spacing of the grooves are crucial to the performance of the grating, but the basic grating equation may be derived by supposing a section through the grating surface, normal to the ruling direction as a sawtooth pattern, shown below.

Light rays A and B, of wavelength λ, incident on adjacent grooves at angle I to the grating normal are shown. Consider light at angle D to the grating normal; this light originates from the A and B rays as they strike the grating. The path difference between the A1 and B1 rays can be seen to be: a sin I + a sin D.

Summing of the rays A1 and B1 results in constructive interference if the path difference is equal to any integer multiple of the wavelength λ:

$$a(\sin I + \sin D) = m\lambda$$

Where m = an integer, and is the order of diffraction

This is the basic grating equation. Note that if D is on the opposite side of the grating normal from I, it is of the opposite sign.

We have considered only two grooves. Including all the other grooves does not change the basic equation but sharpens the peak in the plot of diffracted intensity against angle D.

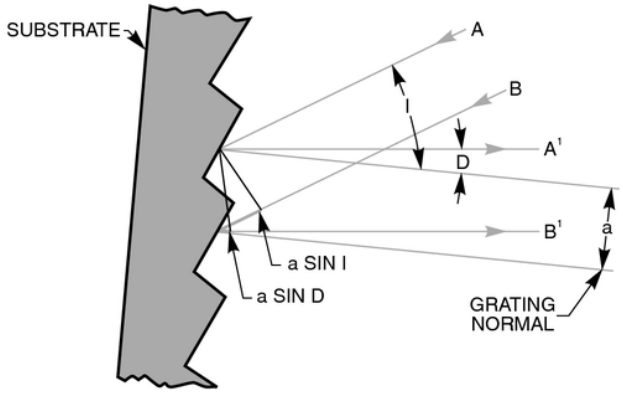


Figure 39: The Sawtooth Pattern of a Grating Section

19.2 THE GRATING EQUATION IN PRACTICE

When a parallel beam of monochromatic light is incident on a grating, the light is diffracted from the grating in directions corresponding to m = -2, -1, 0, 1, 2, 3, etc. When a parallel beam of polychromatic light is incident on a grating then the light is dispersed so that each wavelength satisfies the grating equation. Positive orders have been eliminated from the illustration for clarity.

In most monochromators, the input slit and collimating mirror fix the direction of the input beam that strikes the grating. The focusing mirror and exit slit fix the output direction. Only wavelengths that satisfy the grating equation pass through the exit slit. The remainder of the light is scattered and absorbed inside the monochromator. As the grating is rotated, the angles I and D change, although the difference between them remains constant and is fixed by the geometry of the monochromator. A more convenient form of the grating equation for use with monochromators is:

$$m\lambda = 2 \times a \times \cos\varphi \times \sin\theta$$

Where: φ = Half the included angle between the incident ray and the diffracted ray at the grating
θ = Grating angle relative to the zero order position

These terms are related to the incident angle I and diffracted angle D by:
$I = \theta + \varphi$ and $D = \theta - \varphi$

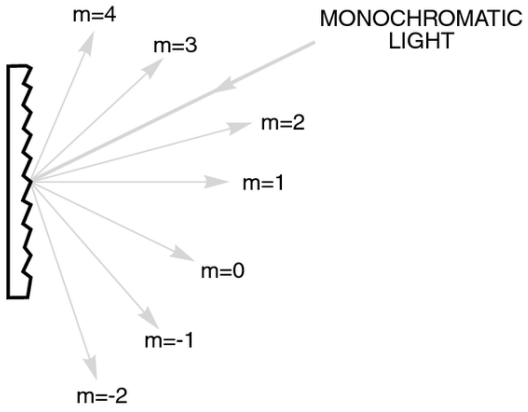


Figure 40: The Grating Equation Satisfied for a Parallel Beam of Monochromatic Light

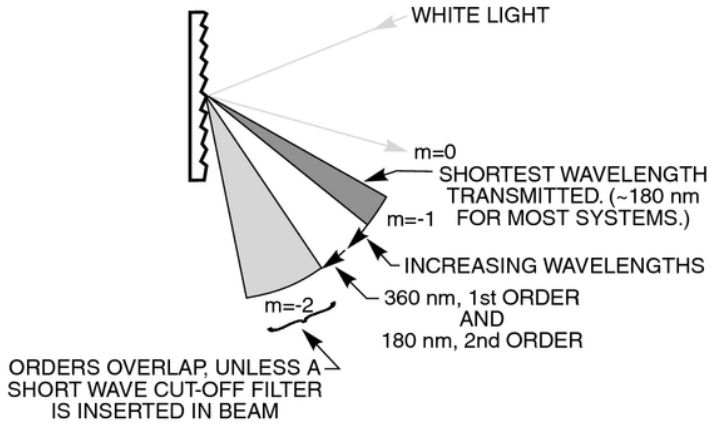


Figure 41: Polychromatic Light Diffracted From a Grating

19.3 GRATING ORDER

It is important to note the sign of “m” is given by either form of the grating equation and can be positive or negative. In a monochromator, the angles I and D are determined by the rotational position of the grating. We use the sign convention that all angles that are counter clockwise from the grating normal are positive, and all angles that are clockwise to the grating are negative. See Fig. 4. The incident light, diffracted light and grating rotation can be at positive or negative angles depending on which side of the grating normal they are. The half angle is always regarded as positive.

If the angle D is equal to I and of opposite sign, then the grating angle and order are zero, and the light is simply being reflected. If the grating angle is positive then the order is positive (m=1), if the grating angle is negative, then the order is negative (m = -1). The half angle of the Cornerstone 130 is 5.1 and the orders are positive. With Oriel’s Cornerstone 260 monochromators, the half angle is 11.83 and the orders are positive.

The grating equation is also satisfied for wavelengths in higher orders, when | m | is >1. Therefore λ2 = λ1/2 for m = ±2, λ3 = λ1/3 for m = ±3, etc. The wavelength λ2 is in the second order and λ3 is in the third order, etc. Again, this concept is illustrated on the previous page.

Usually only the first order, positive or negative, is desired. The other wavelengths in higher orders may need to be blocked. The input spectrum and detector sensitivity determine whether order sorting or blocking filters are needed.

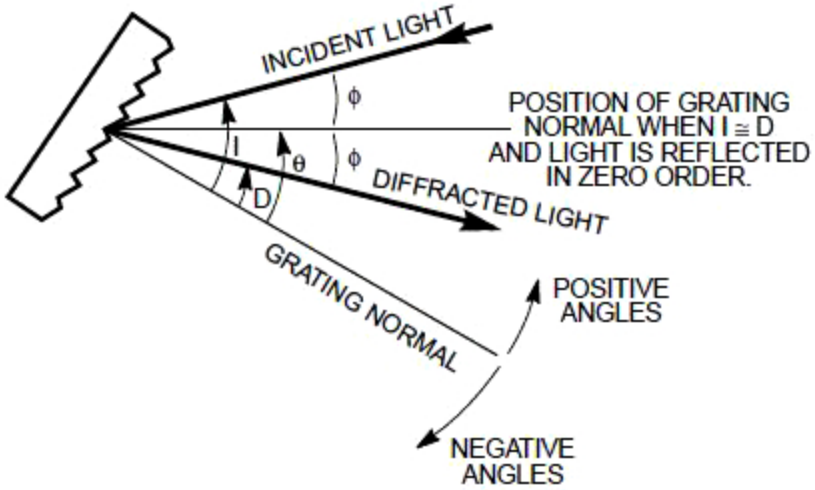


Figure 42: Sign Convention for the Angle of Incidence, Angle of Diffraction and Grating Angle

19.4 GRATING DISPERSION

If we fix the angle I in the grating equation and differentiate with respect to wavelength we get:

$$a \times \cos D \times \delta D = m \times \delta\lambda$$

Thus:

$$\frac{\delta D}{\delta\lambda} = \frac{m}{a \times \cos D}$$

δD/δλ is the angular dispersion or change of diffraction angle corresponding to a small change in wavelength. It is greater for smaller groove spacing, a (greater number of lines per millimeter); larger orders, m; and larger diffraction angles, D.

The linear dispersion, δL/δλ, at a monochromator's exit slit will vary with output focal length, f, and angle D and is the product of the focal length and angular dispersion:

$$\frac{\delta L}{\delta\lambda} = f \times \frac{\delta D}{\delta\lambda} = \frac{f \times m}{a \times \cos D}$$

Normally, we use the "reciprocal linear dispersion", which gives the wavelength dispersion in nm/mm of slit width.

19.5 GRATING ILLUMINATION AND RESOLUTION

The resolving power R of a grating is defined in terms of wavelengths λ and λ + δλ, where λ + δλ is the closest wavelength to λ that can be resolved. Theoretically:

$$R = \frac{\lambda}{\delta\lambda} = \frac{W(\sin I + \sin D)}{\lambda}$$

Where:
δλ = Resolution
W = Illuminated width of the grating.

Normally the smallest slit available and optical aberrations, rather than the grating, determine the attainable resolution. As an example, a monochromator (in this case Oriel's MS257 model) is set to λ = 500 nm, with a 1200 l/mm grating, R is 60000 with a fully illuminated grating. Based on this, δλ is 0.008 nm. With 25 µm slits the product of slit width and reciprocal linear dispersion is 0.09 nm, which is close to the measured value of 0.1 nm and R = 5000 instead of 60000.

If however, only a few mm of the grating are illuminated, as is sometimes the case with laser sources incorrectly coupled to the monochromator, the grating resolution can broaden the measured bandwidths. For example, if a laser illuminates only 2 mm of the grating width, the measured bandwidth will be 0.2 nm, even for a very narrowband laser. Very short pulse (ps) lasers will only illuminate a small portion of the grating at any instant. The resolution is degraded in agreement with Heisenberg's Uncertainty Principle.

If two monochromators are used in tandem then the reciprocal linear dispersion of the combination is half that of a single monochromator.

20 WARRANTY AND SERVICE

20.1 CONTACTING NEWPORT CORPORATION

Oriel Instruments belongs to Newport Corporation's family of brands. Thanks to a steadfast commitment to quality, innovation, hard work and customer care, Newport is trusted the world over as the complete source for all photonics and laser technology and equipment.

Founded in 1969, Newport is a pioneering single-source solutions provider of laser and photonics components to the leaders in scientific research, life and health sciences, photovoltaics, microelectronics, industrial manufacturing and homeland security markets.

Newport Corporation proudly serves customers across Canada, Europe, Asia and the United States through numerous international subsidiaries and sales offices worldwide. Every year, the Newport Resource catalog is hailed as the premier sourcebook for those in need of advanced technology products and services. It is available by mail request or through Newport's website. The website is where one will find product updates, interactive demonstrations, specification charts and more.

To obtain information regarding sales, technical support or factory service, United States and Canadian customers should contact Newport Corporation directly.

Newport - Oriel Instruments
1791 Deere Avenue
Irvine, CA 92606 USA

Telephone: 800-222-6440 (toll-free in United States)
949-863-3144

Fax: 949-253-1680

Sales: oriel.sales@newport.com
Technical assistance: oriel.tech@newport.com
Repair Service: rma.service@newport.com

Customers outside of the United States must contact their regional representative for all sales, technical support and service inquiries. A list of worldwide representatives can be found on the following website: http://www.newport.com/oriel.

20.2 REQUEST FOR ASSISTANCE / SERVICE

Please have the following information available when requesting assistance or service:

Contact information for the owner of the product.
Instrument model number (located on the product label).
Product serial number and date of manufacture (located on the product label).
Description of the problem.

To help Newport's Technical Support Representatives diagnose the problem, please note the following:

Is the system used for manufacturing or research and development?
What was the state of the system right before the problem?
Had this problem occurred before? If so, when and how frequently?
Can the system continue to operate with this problem, or is it non-operational?
Were there any differences in the application or environment before the problem occurred?

20.3 REPAIR SERVICE

This section contains information regarding factory service for this product. The user should not attempt any maintenance or service of the system beyond the procedures outlined in this manual. This product contains no user serviceable parts other than what is noted in this manual. Any problem that cannot be resolved should be referred to Newport Corporation.

If the instrument needs to be returned for service, a Return Material Authorization (RMA) number must be obtained prior to shipment to Newport. This RMA number must appear on both the shipping container and the package documents.

Return the product to Newport, freight prepaid, clearly marked with the RMA number and it either will be repaired or replaced it at Newport's discretion.

Newport is not responsible for damage occurring in transit. The Owner of the product bears all risk of loss or damage to the returned Products until delivery at Newport's facility. Newport is not responsible for product damage once it has left the facility after repair or replacement has been completed.

Newport is not obligated to accept products returned without an RMA number. Any return shipment received by Newport without an RMA number may be reshipped by Newport, freight collect, to the Owner of the product.

20.4 NON-WARRANTY REPAIR

For Products returned for repair that are not covered under warranty, Newport's standard repair charges shall be applicable in addition to all shipping expenses. Unless otherwise stated in Newport's repair quote, any such out-of-warranty repairs are warranted for ninety (90) days from date of shipment of the repaired Product.

Newport will charge an evaluation fee to examine the product and determine the most appropriate course of action. Payment information must be obtained prior to having an RMA number assigned. Customers may use a valid credit card, and those who have an existing account with Newport Corporation may use a purchase order.

When the evaluation had been completed, the owner of the product will be contacted and notified of the final cost to repair or replace the item. If the decision is made to not proceed with the

repair, only the evaluation fee will be billed. If authorization to perform the repair or provide a replacement is obtained, the evaluation fee will be applied to the final cost. A revised purchase order must be submitted for the final cost. If paying by credit card, written authorization must be provided that will allow the full repair cost to be charged to the card.

20.5 WARRANTY REPAIR

If there are any defects in material or workmanship or a failure to meet specifications, notify Newport Corporation promptly, prior to the expiration of the warranty.

Except as otherwise expressly stated in Newport's quote or in the current operating manual or other written guarantee for any of the Products, Newport warrants that, for the period of time set forth below with respect to each Product or component type (the "Warranty Period"), the Products sold hereunder will be free from defects in material and workmanship, and will conform to the applicable specifications, under normal use and service when correctly installed and maintained. Newport shall repair or replace, at Newport's sole option, any defective or nonconforming Product or part thereof which is returned at Buyer's expense to Newport's facility, provided, that Buyer notifies Newport in writing promptly after discovery of the defect or nonconformity and within the Warranty Period. Products may only be returned by Buyer when accompanied by a return material authorization number ("RMA number") issued by Newport, with freight prepaid by Buyer. Newport shall not be responsible for any damage occurring in transit or obligated to accept Products returned for warranty repair without an RMA number. The buyer bears all risk of loss or damage to the Products until delivery at Newport's facility. Newport shall pay for shipment back to Buyer for Products repaired under warranty.

WARRANTY PERIOD
All Products (except consumables such as lamps, filters, etc.) described here are warranted for a period of twelve (12) months from the date of shipment or 3000 hours of operation, whichever comes first.

Lamps, gratings, optical filters and other consumables / spare parts (whether sold as separate Products or constituting components of other Products) are warranted for a period of ninety (90) days from the date of shipment.

WARRANTY EXCLUSIONS
The above warranty does not apply to Products which are (a) repaired, modified or altered by any party other than Newport; (b) used in conjunction with equipment not provided or authorized by Newport; (c) subjected to unusual physical, thermal, or electrical stress, improper installation, misuse, abuse, accident or negligence in use, storage, transportation or handling, alteration, or tampering, or (d) considered a consumable item or an item requiring repair or replacement due to normal wear and tear.

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20.6 LOANER / DEMO MATERIAL

Persons receiving goods for demonstrations or temporary use or in any manner in which title is not transferred from Newport shall assume full responsibility for any and all damage while in their care, custody and control. If damage occurs, unrelated to the proper and warranted use and performance of the goods, recipient of the goods accepts full responsibility for restoring the goods to their original condition upon delivery, and for assuming all costs and charges.

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