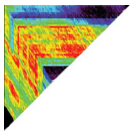
VariSpec™ Liquid Crystal Tunable Filters



VIS and NIR wavelength ranges.

Excellent image quality for a wide range of applications.

Solid-state; no moving parts with USB control.

User's Manual

October 2006

Notice

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Contents

Chapter 1

Introduction to VariSpec Liquid Crystal Tunable Filters

This chapter provides information about VariSpec liquid crystal tunable filters (LCTFs) that is common to all filter models. Appendices are used to provide additional information, specific to individual models.

Topics in this chapter: **Page**

Introduction

CRi's VariSpec LCTF family are tunable birefringent filters that can be used for both imaging and non-imaging spectral analysis. The filters function like high-quality interference filters, but the wavelengths of light they transmit are electronically tunable and allow for the rapid, vibration-less selection of any wavelength in the visible (VIS) or near-infrared (NIR) region that the filters have been constructed to operate in.

VariSpec filters employ electronically controlled liquid crystal elements to select a transmitted wavelength range while blocking all others. Filter transmittance is sensitive to polarization of the input beam, and is increased by a factor of two if the input beam is

polarized along the axis of the input polarizer. VIS models contain an integral, non-removable hot mirror for blocking unwanted NIR light. The product family includes the following models:

- **VIS:** Visible-wavelength filters with a wavelength range of 400 nm to 720 nm, bandwidths (FWHM) of 7 nm, 10 nm, or 20 nm, and working apertures of either 20 mm or 35 mm
- **SNIR:** Short-wavelength near-infrared filters with a wavelength range of 650 nm to 1100 nm, bandwidths (FWHM) of 7 nm or 10 nm, and a working aperture of 20 mm
- **LNIR:** Longer-wavelength near-infrared filters with a wavelength range of 850 nm to 1800 nm, bandwidths (FWHM) of 6 nm or 20 nm, and a working aperture of 20 mm
- **XNIR:** Longer-wavelength near-infrared filter with a wavelength range of 1200 nm to 2450 nm, bandwidth (FWHM) of 9 nm, and a working aperture of 20 mm
- **VISR:** Visible-wavelength filter with a wavelength range of 480 nm to 720 nm, extraordinarily narrow bandwidth (FWHM) of 0.25 nm (best effort), and a working aperture of 20 mm
- **NIRR:** Near-infrared wavelength filter with a wavelength range of 650 nm to 1100 nm, extraordinarily narrow bandwidth (FWHM) of 0.75 nm (best effort), and a working aperture of 20 mm

Important Features

Important features of VariSpec filters include:

- Ability to tune continuously over hundreds of nanometers in the VIS and NIR
- Excellent imaging quality
- Solid-state construction, with no moving parts
- Fast, random-access wavelength selection
- Compact, low-power design

Applications

VariSpec filters offer excellent imaging quality, making them ideal for use with imaging sensors such as silicon-based CCDs or InGaAs sensors. Additionally, they can be used as compact, robust spectrometers with high throughput, well-suited to applications where imaging may not even be required. Key applications include:

- Remote Sensing
- Machine vision QA/QC
- Astronomy
- CCD/Display characterization
- Raman chemical imaging
- General research involving spectral imaging

Glossary of VariSpec LCTF Terminology

Bandwidth

The Full-Width at Half-Maximum (FWHM), measured as the spectral separation between the two points where the filter's transmission attains 50% of the peak value. The passband center wavelength is the wavelength midway between these two points. VariSpec filters come in a variety of bandwidths, which are set during the design and manufacturing process and are not adjustable by the end-user.

Center Wavelength

Not necessarily the highest point in the T curve, this is defined as midway between the half-maxima points.

Off-Axis Performance at Limit of Angle-of-Acceptance

Off-axis rays at the limit of the angle-of-acceptance are permitted to be spectrally shifted by up to Bandwidth/8 from the on-axis ray value. So, in the worst case, the center ray could have a center wavelength which exceeds the ideal by +Bandwidth/8, and an off-axis ray could be shifted by +Bandwidth/8 red of that, or +Bandwidth/4 away from the ideal value.

Out-of-Band Transmittance or Contrast

The average ratio of transmission without the VariSpec filter in place to the transmission of unselected wavelengths with the filter in place. Typical performance is 0.01%.

Passband

The spectral region from [Center Wavelength – 1.2 * FWHM] to [Center Wavelength + 1.2 * FWHM].

Response Time

The time it takes to switch from one wavelength to another. Several factors affect this number, including the liquid crystal (LC) relaxation time from "charge" to "no charge" states under various ambient temperatures and the calculation time of the electronics controller box, which must send the correct voltages to each LC element for each change. Typically, this time is 50 ms to 150 ms.

Transmission

The percentage of linearly polarized light, oriented so that maximum transmission is attained, passing through the filter relative to the amount that entered. Since the entrance element of the filter is a linear polarizer, transmission of randomly polarized light is half that of linearly polarized light in the correct orientation. VariSpec transmission is wavelength-dependent.

Tuning Accuracy

The tuning accuracy specification is that the center wavelength be correct within the actual Bandwidth/8 +/- 0.5 nm. Tuning accuracy is specified for on-axis rays.

Operator and Equipment Safety

It is the responsibility of the purchaser to ensure that all persons who will operate the VariSpec LCTF are aware of the following cautionary statements. As with any scientific instrument, there are important safety considerations, which are highlighted throughout this User's Manual.

Cautionary Statements

READ AND UNDERSTAND THIS USER'S MANUAL BEFORE ATTEMPTING TO OPERATE, TROUBLESHOOT, OR MAINTAIN THE VARISPEC LCTF. READING THIS MANUAL FIRST MAKES IT EASIER AND SAFER TO OPERATE AND MAINTAIN THE FILTER.

Do not expose the optics module to prolonged heat above 40 °C.

Do not drop the optics module or the electronics controller module.

Do not expose the optics module to intense light from laser, focused arc or Hg lamp sources.

Do not operate the filter in places where it may be splashed with liquid. The optics module may be cleaned using the procedure described in the troubleshooting section of this User's Manual.

Do not operate the filter in an environment with explosive or flammable gases.

Use only the supplied cables. Some cables supplied with the system have proprietary specifications. Do not connect components supplied by CRi using unqualified cables or adapters. Doing so could result in damage, and voids the Warranty.

Use only a host computer that has a properly grounded power outlet.

Disconnect the USB cable before servicing the unit. Servicing should be performed by CRi authorized and trained personnel only.

For Technical Assistance

If you experience any difficulty setting up, operating, or maintaining your VariSpec LCTF, please contact your CRi representative. CRi's office hours are from 8:00 a.m. to 6:00 p.m. (US Eastern Standard/Daylight Time), Monday through Friday.

- Telephone (US Toll-Free): 1-800-383-7924
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- Facsimile (Worldwide): +1-781-935-3388
- Email: techsupport@cri-inc.com.

About This Manual

This manual is designed to serve users of the CRi VariSpec LCTF product family. Operating instructions, functional descriptions, troubleshooting, illustrations, and other relevant information are contained in this manual.

Your particular VariSpec LCTF may include additional support documentation from third-party vendors. Bear in mind that the VariSpec LCTF may have been modified or custom-designed, so treat such third-party documentation as supplemental material only. In cases where CRi and third-party documentation differ, and you have any doubt as to which applies to your system, contact an authorized CRi distributor or service representative.

Design Change Disclaimer

Due to design changes and product improvements, information in this manual is subject to change without notice. CRi reserves the right to change product design at any time without notice to anyone, which may subsequently affect the content of this manual. CRi will make every reasonable effort to ensure that this User's Manual is up to date and corresponds with the VariSpec LCTF as currently shipped.

Reproduction Disclaimer

CE Testing and Certification

The VariSpec LCTF has been tested by an independent CE testing facility, and bears the appropriate CE mark.

CE

The following is the CRi distributor in the European Union region authorized to function as primary contact for CE-related matters concerning CRi products:

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VariSpec Hardware Components

VariSpec filters consist of one or two matched sets of optics modules and electronics controller modules. Each electronics controller module provides the interface to a computer or other host device, as well as power via a Universal Serial Bus (USB) connector. The optics and electronics modules are connected by a shielded 2-meter cable.

Figure 1. VariSpec with 20 mm Optics and Electronics Module

Figure 2. VariSpec with 35 mm Optics and Electronics Module

VariSpec Optics Module

- The Entrance Aperture receives the light, and for VIS models is the side that contains the integral hot mirror. For 20 mm filters with a blue and gray housing, the Entrance Aperture is the blue side. For 35 mm filters with a black anodized housing, the Entrance Aperture is the side closest to the Drive Signal Connector.
- The Exit Aperture emits linearly polarized light. The orientation is the same or perpendicular to the entering light, depending on the design. For 20 mm filters with a blue and gray housing, the Entrance Aperture is the gray side. For 35 mm filters with a black anodized housing, the Entrance Aperture is the side furthest from the Drive Signal Connector.
- The Drive Signal Connector connects to the Electronics Module through a 26-pin high-density (HD) D-sub cable.

Caution! **DO NOT** connect a computer, function generator, or other signal source to this connector, as the liquid crystal elements may be destroyed. Doing so voids the warranty. The Optics Module is designed to be driven by the Electronics Controller Module ONLY. Do not disconnect the cable while the Electronics Controller Module is turned ON.

VariSpec Electronics Controller Module

The front panel of the Electronics Controller Module contains an LED labeled **Init** and an LED labeled **Status**.

- **Init** LED flashes during data communication between the Electronics Controller Module and the host computer.
- **Status** LED momentarily flashes Green during power-up and initialization (approximately 30 seconds). It may also turn Red if a garbled command is received or when an error condition exists. The Red error condition may be queried using the "R ?" query or cleared by the "R 1" command.

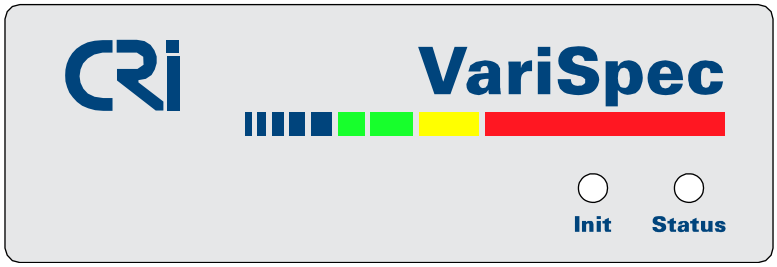

Figure 3. Front Panel of VariSpec Electronics Controller

The rear panel of the Electronics Controller Module contains four clearly labeled interface ports (left to right, viewed from the rear).

- **Optics A** is a 26-pin connector for the HD D-sub cable connecting the Optics and Electronics Controller modules.

- **TTL Sync** is a connector with a single trigger-detect line that can be configured to allow the filter to respond to a synchronization pulse generated by cameras, shutters, and other equipment.
- **USB** is a "Type-B" peripheral connector, like those used on commercial inkjet printers or external USB 2.0 hard disk drives, for direct interface to a host computer's USB Type-A port or a powered USB hub.
- **Optics B** is not normally utilized and features a blank cover.

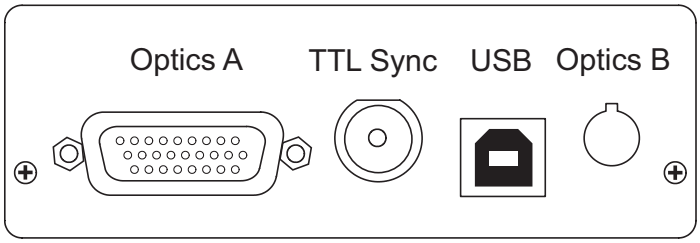

Figure 4. Rear Panel of VariSpec Electronics Controller

Optics-to-Electronics Cable

A 26-pin HD D-sub cable connects the Optics and Electronics modules. This cable is shielded and the present model utilizes twisted-pair construction for reduced crosstalk.

USB Peripheral Type-A to Type-B Cable

A USB Type-A to Type-B cable connects the VariSpec Electronics Controller Module to the host computer or a powered USB hub.

Mounting Block

Mounting Blocks may be attached to three sides of the optics module, to allow the use of the filters on an optical table or on conventional 1/4-20 UNC-2B threaded tripods. One Mounting Block is included per Optics Module. You may order more if you wish.

Mounting Inserts (optional accessory)

Stainless-steel dovetailed inserts with either male or female C-mount threads or a male T-mount thread can be placed into the round inset on either the front or rear of the small-aperture 20 mm optics module and held in place with setscrews. By default, a "blank" flat dovetailed insert with no threaded side is mounted on each side of new 20 mm aperture filters. Large-aperture 35 mm filters require a mounting assembly that includes a holder (attached to the filter's end plate) and one or more anodized aluminum T-mount inserts.

52 mm Camera Lens Thread Adapter (optional accessory)

The 52 mm Camera Lens Thread Adapter allows you to convert a male T-mount thread to a common 52 mm size. This enables you to attach the filter to the front of a camera lens. If the front of your camera lens is a different diameter, you can purchase "stepping rings" from camera stores or photographic supply companies to go from the 52 mm thread to

nearly any other thread size. For example, a 62 mm to 52 mm step-down ring lets you mount the VariSpec filter in front of a lens with a 62 mm thread diameter.

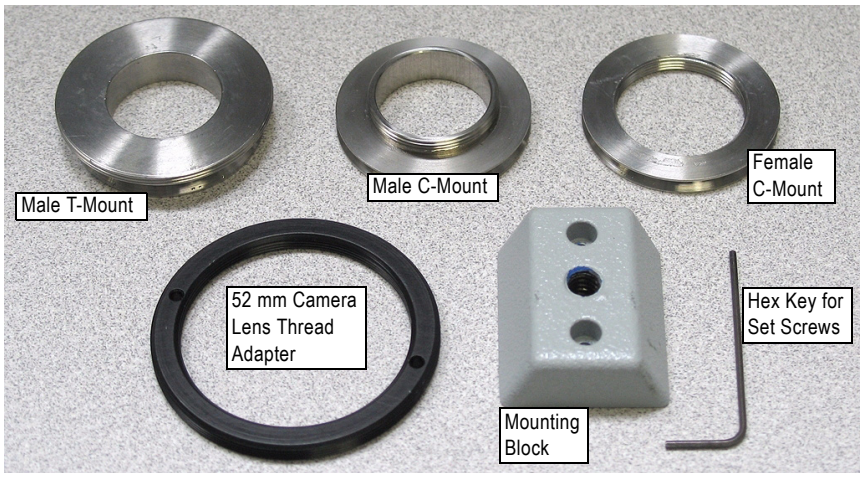

Figure 5. Mounting Block and Adapters for 20 mm Filter

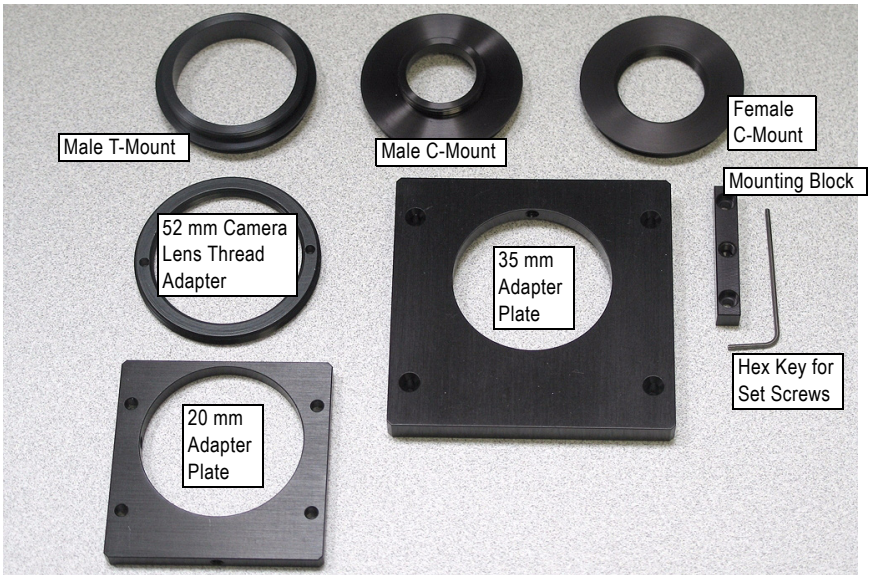

Figure 6. Mounting Block and Adapters for 35 mm Filter

VariSpec Software Developer's Kit (SDK) installation CD

The CD-ROM that comes with each filter is a Windows®-compatible CD-ROM containing the following components:

- Windows-compatible operating system installer for the CRi SDK
- Apple® Mac® OS X drivers for the USB interface
- Linux® drivers for the USB interface
- VariSpec User's Manual as an Adobe® PDF file

VariSpec User's Manual

A printed copy of the VariSpec User's Manual is provided with each new filter purchase. This document is also available as an Adobe PDF file.

Chapter 2

Controlling VariSpec Filters

Topics in this chapter: **Page**

Components of the VariSpec SDK

The VariSpec SDK is available on a Windows-compatible CD-ROM, as well as a downloadable file from the CRi web site and FTP site. The SDK consists of an executable installation program (.EXE) with a name similar to “VsRev1p35.exe“, as well as support files in a folder or ZIP-compressed archive.

Windows DLL

CRi provides a set of functions to control VariSpec filters, which may be called from C or C++ programs. The package incorporates all aspects of filter communications, including low-level serial routines. With these routines, you can address filters as virtual objects, with little need for detailed understanding of their behavior. This simplifies the programming task for those who want to integrate VariSpec filters into larger software projects. See the documentation that comes with the SDK for more detail.

National Instruments® LabVIEW™ Sub-VIs

CRi provides five sub-VI (virtual instrument) files for basic control of VariSpec filters. The .VI files may be copied to the user library directory within LabVIEW and then accessed from the functions palette to drag and drop into higher-level VI's. A "VS Getting Started" VI is also supplied, in order to illustrate a way to interconnect the lower-level sub-VI files.

MATLAB® M-Files

CRi provides a set of MATLAB m-files to control VariSpec filters. There is a core support .DLL file and a series of ".m" functions.

VsGui Program for Windows 2000 and Windows XP Professional

The CRi VsGui program is a Windows 2000 and Windows XP Professional compatible program that was written to demonstrate the capabilities of the VariSpec SDK. The VsGui program requires that the proper USB driver files be present, as well as the VsDrvr.dll be located in the same folder as the executable itself. The VsGui program is a very good troubleshooting tool, since it can help confirm that the filter is working properly with the host computer without the need to resort to using a terminal emulator to send ASCII character-based commands to the filter.

Controlling VariSpec Filters with Direct Serial Commands

This information is provided for standard single-housing models. See "Using HyperTerminal™ in the Windows Operating System to Control Dual-Housing Filter Models" on page 53 for more information on dual-housing models such as the LNIR-06-20, XNIR-09-20, VISR-0.25-20, and NIRR-0.75-20 filter models. Dual-housing models utilize a set of two Optics and two Electronics Controller Modules that are designed to work together.

The VariSpec filter contained in the Optics Module is controlled through the Electronics Controller Module. **Never connect a computer or other apparatus to the Optics Module, as the tunable elements may be damaged.**

Each Electronics Controlled Module offers USB interface and TTL Sync ports. All serial commands sent through the USB interface are ASCII text. The filter appears as a virtual COMx device at 9600 baud, but the actual data transmission occurs over the USB interface. The terminator is always <c/r>. It is also possible to control the filter using signals to the TTL Sync port, once the operating mode and wavelengths have been defined using the USB interface. This allows the VariSpec filter to respond to signals and synchronization pulses generated by cameras, shutters, and other equipment.

Previous-generation VariSpec filters utilized an RS-232 interface with essentially the same command set. However, these older filters had a slower response time and needed supplementary power transformers. A listing of the command set for the VariSpec filter appears later in this document.

Initialization

The VariSpec filter performs an initialization sequence automatically at power-up. A listing of the commands performed during this sequence may be found later in this section. For additional information on the commands used during initialization and power-up, see the descriptions of the “E” and “I” commands.

Palette Commands

After the VariSpec filter has been initialized, there are two ways to select the passband wavelength. The first is to issue a request to tune to a wavelength using the “W” command. This is the easiest method with current-generation filters.

Another method is to define a “palette” of wavelengths. When a wavelength is added to a palette as an “element,” the computer within the VariSpec Electronics Module calculates the required drive level for each tunable element within the Optics Module and stores the result in a table. Once a palette is defined, any of its elements may be rapidly accessed using the tabulated results. This results in a slight decrease in the amount of time required for a tuning operation (perhaps one or two milliseconds), but not as much as for previous-generation filters (tens to hundreds of milliseconds). The commands that provide for palette definition, revision, and use are described in detail later in this section.

Palette elements can be addressed in any order desired. It is also possible to step through the elements in a palette in sequence. When the last element is reached, the cycle continues with the first element. This is useful when cycling through a sequence repeatedly. Note that the palette commands have been retained more as a legacy feature than for any real performance gain.

VariSpec Control Modes

The VariSpec filter can be controlled using the TTL Sync port on the rear panel of the Electronics Controller Module. The TTL Sync port is a single-trigger detect line to allow synchronization with external TTL timing signals. Six control modes are possible, listed in the table below. In practice, only Modes 0 or 4 should be used. The Control Mode is selected by using the “M” command.

Mode 0 cycles the filter sequentially through the palette of wavelengths, triggered by receipt of pulses at the TTL Sync port. When the last palette element is reached, the sequence continues with the first element 0. This mode uses the TTL Sync port to select a palette element. Before you can use the TTL Sync port in this mode, you must define a palette containing elements (i.e. the wavelengths of interest).

Mode 4 executes a wavelength step upon receipt of pulses at the TTL/Sync port. This is useful for performing a spectral scan with a fixed step size. Before you can use the TTL Sync port in this mode, you must define the wavelength step increment (in nm) using the “J” command.

Modes 1 through 3, as well as Mode 5, are reserved. Do not implement these modes as they may cause unexpected results. In all hardware modes, the hardware control ports can be enabled or disabled using the “G” command. This configures the VariSpec hardware so that action is taken only after a specified number of sync or strobe pulses are received. This is useful when integrating a specified number of video frames, for example, at each filter setting. See the description of the “G” command later in this section.

TABLE 1. Control Modes

Mode	Description	Wavelength or Palette Access	Random or Sequential	Trigger Source
0	Cycle palette on sync	Palette	Sequential	Sync
1	Reserved	N/A	N/A	N/A
2		N/A	N/A	N/A
3		N/A	N/A	N/A
4	Wavelength sweep on sync	Wavelength	Sequential	Sync
5	Reserved	N/A	N/A	N/A

VariSpec TTL Sync Port

The TTL Sync Port requires a TTL-level input, and triggers on the downward edge of the pulse. It is a standard BNC jack. The TTL Sync signal is a timing sync input signal, to synchronize the filter tuning with an external TTL signal. The TTL Sync port is a single-trigger detect line to allow synchronization with external TTL timing signals.

VariSpec Error Codes

If the VariSpec filter receives an incorrect communication, the Status LED turns Red and an Error Code is recorded. Error Code can be read out using the “R” command as described later in this section. The LED remains lit Red until the error is cleared, but subsequent commands are processed normally. CRi recommends first retrieving the Error Code and then clearing the error condition before proceeding.

Putting the VariSpec Filter to Sleep

A filter can be put to sleep using the “S” command and awakened using the “A” command. All other commands and queries are ignored when the filter is asleep. Wavelength and other settings are retained upon awakening, if they were previously defined. The hardware USB and TTL Sync ports are serviced, if active. Characters are echoed, even if asleep.

Escape, Status-Check, and Busy-Check Characters

There are three special characters: the Escape <esc> character “ASCII 27”; the Status-Check character “@”; and the Busy-Check character “!”. These are processed immediately, before all pending commands, provided that the filter is awake. There is no need for a terminator for these characters.

The Escape character stops any command in process, and clears all characters from the USB command queue. This allows you to abort an extended operation or to belay pending commands.

The Status-Check character “@” provides various information on filter status. The VariSpec filter responds with a single, printable ASCII character response. Each bit in the response character indicates something about the filter status, listed in the table below.

The Busy-Check character "!" tests whether the VariSpec filter has completed all pending commands. If done, it responds with the ">" character. If busy with pending commands, it responds with the "<" character.

TABLE 2. Status-Check Characters

Bit	Description	Meaning, if 0 / 1
8 (msb)	Reserved	Always 0
7	Reserved	Always 1
6	Error status	None / Error pending
5	Terminator	Always 0
4	Brief Mode	Normal / Brief or Auto
3	Palette defined	None / Defined
2	Exercised?	No / Yes
1	Initialized?	No / Yes

Command Nomenclature

Several commands are available to control the VariSpec filter. Each command has a one-letter key, and can usually be used as a command or as a query.

In the following descriptions, <arg> can be a number value in fixed or floating-point format, or the query character "?". The command terminator, <term>, is the carriage-return character, <c/r>. The separator, <sep>, is a comma or any white-space character. Arguments in curly brackets are optional and may not be required for all forms of the command. Error handling is noted for each command.

All wavelengths are specified in nanometers, and need not be integral. Resolution is numerically limited to 0.01 nm, which generally exceeds the filter's optical tuning resolution.

The standard response format is: the command letter (uppercase), followed by the response value, then the <term> character. The format for wavelengths is xxxx.yy. Most other response values are integers, xxxxxx. Values are right justified, with leading spaces, rather than leading zeros.

Brief and Auto-Confirm Formats

Each VariSpec Electronics Controller Module can use a Brief Format when replying to queries, to decrease the number of characters sent. When the Brief Format is selected, the command key letter and all leading spaces are omitted.

Another format is provided, called Auto-Confirm format. When this is selected, the VariSpec filter replies to each command with the new value of the parameter that was set. This confirms that the command was received and processed. The Brief Format or the Auto-Confirm format is selected using the "B" command, described later in this section. Upon power-up the VariSpec filter uses the normal format.

Table of Commands

All serial commands sent through the USB interface are ASCII text. The filter appears as a virtual COMx device at 9600 baud, but the actual data transmission occurs over the USB interface. The terminator is always <c/r>.

See Legacy Hardware and Software Considerations for information on previous-generation filters controlled using the RS-232 interface.

TABLE 3. Commands

Command	Default Value	Function or Purpose
A(waken)	1 (awake)	Re-activate sleeping filter for USB control
B(rief)	0 (normal)	Select Normal, Brief, or Auto-Confirm Format
C(lear)	1 (clear)	Clear palette of all elements (wavelength entries)
D(efine)		Define palette element with specified wavelength
E(xercise)		Exercise filter to prepare for use
G(o)	1 (enabled)	Enable or Disable TTL/Sync port
I(nitialize)	1 (initialized)	Perform initialization sequence
J(ump)	5.00 nm	Set wavelength increment use in Mode 4
M(ode)	0	Select hardware Control Mode
P(alette)		Set filter to transmit selected palette element
R(eset)		Reset Status LED and clear Error condition
S(leep)	0 (awake)	Make filter inactive, unresponsive to commands
V(ersion)		Query the firmware revision and configuration
W(avelength)	Depends on filter type	Set wavelength to transmit specified wavelength (nm)
eX(ecute)		Simulates trigger at TTL port
Y(temperature)		Query temperature of LC elements of Optics Module

Descriptions of VariSpec Serial Commands

Awaken

A <arg> <term>

Command: awakens filter with ID number given by <arg>. The ID number is the filter's 5-digit serial number, such as 50527, 50782, etc.

Legal <arg> values: [0 - 65535]

Query reply: 1 if awake, no reply if asleep

Note: It is bad practice to query the awake/sleep status, as a sleeping filter will not reply.

Brief

B <arg> <term>

Command: If <arg> is 0, it selects the VariSpec filter's normal format for replying to queries. If <arg> is 1, it selects the brief format. If <arg> is 2, it selects the auto-confirm format. At power-up, the default is to use the normal format.

In Brief format, the VariSpec filter does not echo the command letter, and omits all leading spaces. Thus the normal reply

M 1<term>

becomes, in brief format,

1<term>

In auto-confirm format, replies are made every time a command is received. This is different from normal and brief mode, which only reply to queries. The auto-confirm mode replies include the command letter and spaces, like the normal format.

Legal <arg> values: [0, 1, 2]

Query reply: 0/normal, 1/brief, 2/auto-confirm

Clear Palette

C <arg> <term>

Command: clears the entire palette if <arg> is nonzero. It is not possible to selectively clear elements.

Legal <arg> values: [0, 1]

Query reply: 0

Define Palette Element

D <arg0> {<sep> <arg1>} <term>

Command: define palette with wavelength given by <arg0>. It is added to the end of the palette, unless <arg1> is given. In that case, palette element <arg1> is assigned a wavelength of <arg0>. Palette elements must be defined sequentially. If <arg1> points past the end of the palette, a fault is generated and no action is taken.

If <arg1> points to an existing element, and the wavelength <arg0> is given as -1, the existing element is removed. Any elements beyond this element in the palette are shifted down one to fill the gap.

The palette table uses 0-based indexing, so the first palette element is number 0, the next is number 1, and so on.

Legal <arg0> values: set by optics wavelength limit

Legal <arg1> values: [0 - last palette element]

Query reply: The unit responds with the number of elements defined, followed by all palette elements in sequence, separated by end-of-line terminators. So, if three elements were defined as 450 nm, 550 nm and 650 nm, the reply would be:
D 3<term>

D 450<term>
D 550<term>
D 650<term>

In brief format, the response would be:
3<term>
450<term>
550<term>
650<term>

Exercise

E <arg> <term>

Command: exercises the filter <arg> times. This places the liquid crystal elements into a known state. An <arg> of 3 is sufficient to fully exercise the optics at room temperature. If the filter has been powered off for only a few minutes, an <arg> value of 1 can be used. Each cycle takes about 12 seconds.

This command is needed only if the power-up initialization is disabled, as it is performed as part of the automatic power-on sequence.

Legal <arg> values: [0 - 255]

Query reply: number of E cycles pending

Go/Stop TTL Sync Port

G <arg> <term>

Command: this selects whether service of the TTL Sync port is enabled and the dwell time, in trigger pulses, at each setting. If <arg> is 0, service of the TTL Sync port is inhibited (stopped). This means that the wavelength is fixed at its present value, regardless of activity at the TTL Sync port, unless changed explicitly by the "P" or "W" commands.

If <arg> is positive, service is enabled, and the system dwells <arg> pulses at each setting. So, if "G" is set to 4, and the Electronics Module is in sequential mode 0, it advances to the next palette element every four sync pulses. At power-up, G is enabled and set to a value of 1.

Legal <arg> values: [0 - 255]

Query reply: current hardware service value

Initialize

I <arg> < term>

Command: initializes the VariSpec filter if <arg> is nonzero. The electronics module needs to perform an initialization sequence, which takes approximately 30 seconds before it is ready to tune properly.

This is performed as part of the automatic power-on sequence, so it is not necessary to request another initialization when the filter is operating, unless the power-on sequence has been disabled, if it has been more than 8 hours since the last initialization, or if the Optics Module's temperature has changed more than 3-degrees Centigrade since initialization.

If <arg> is 0, the Electronics Module performs an update to the tuning of the Optics Module using a predefined temperature coefficient correction without exercising the LC elements. This correction occurs within a millisecond or two.

Legal <arg> values: [0 or 1]

Query reply: 1 if initialized, 0 otherwise

Jump

J <arg> <term>

Command: defines the wavelength jump size. The jump can be positive (jump towards the red) or negative (jump towards the blue). The controller jumps this amount from its present wavelength, upon receipt of an eXecute command or an external hardware trigger pulse in mode 4. At power-up Jump is set to 5.00. The jump step can be any value consistent with the tuning range of the filter, given the specifications.

Legal <arg> values: determined by filter optics

Query reply: present jump size in nm

Mode Select

M <arg> <term>

Command: set the Control Mode. Legal modes are 0 (sequential on sync) and 4 (move wavelength step on sync).

Mode 0 is sequential. The filter changes wavelength upon receipt of the sync pulse. In Mode 4, the filter steps in wavelength as set by the “J” command, triggered by the sync signal.

Legal <arg> values: [0, 4]

Query reply: present mode

Palette Select

P <arg> <term>

Command: go to palette element <arg>. If that element is undefined, an error is generated and the Status LED is lit Red. The palette uses 0-based indexing, so the first element is element 0.

You may also use the “>” character as <arg>, to request the next palette element; or the “<” character, to request the previous palette element.

Legal <arg> values: [0 - 127], “<”, “>”

Query reply: present palette element number; 255 if palette element undefined

Reset

R <arg> <term>

Command: resets any pending fault conditions if <arg> is nonzero. This also resets (turns off) the Status LED if it is lit Red on the front panel. It is a good idea to send an <esc> before sending the “R” command, if previous commands were garbled in transmission. The <esc> clears the VariSpec communications buffer and insures the “R” command is received properly.

Legal <arg> values: [0 or 1]

Query reply: 0 if no fault, error code otherwise

Sleep

S <arg> <term>

Command: puts filter to sleep with ID number given by <arg>. The ID number is the filter's 5-digit serial number, such as 50527, 50782, etc.

Legal <arg> values: [0 - 65535]

Query reply: 1 if awake, no reply if asleep

Note: it is bad practice to query the awake/sleep status, as a sleeping filter will not reply.

Version

V <arg> <term>

This can be issued only as a query. It returns the VariSpec firmware revision number and other configuration data, in the following format:

v_ _ _ rrr_ _bbbb.bb_ _tttt.tt_sssss

where rrr is the firmware revision level; bbbb.bb (no leading spaces or leading zeroes) is the shortest wavelength the filter can tune to, in nm; tttt.tt is the longest wavelength the filter can tune to, in nm; and sssss is the serial number.

Note: each underscore represents one space between characters.

Legal <arg> values: Query only

Query reply: revision and configuration data as described above

Wavelength Select

W <arg> <term>

Command: tunes the filter to wavelength <arg>. The legal range of <arg> is determined by the optics module's construction and electronics module's configuration. If <arg> is out of range, it causes an error and lights the Status LED Red.

You can send ">" as the <arg>. This causes the filter to step to a wavelength longer than the one to which it is presently tuned. The step size is set by the "J" command. Similarly, if the "<" character is given as <arg>, the filter steps to a wavelength shorter than the one it is presently tuned to.

Legal <arg> values: [set by optics], ">", "<"

Query reply: present wavelength in nm

eXecute

X <arg> <term>

Command: issuing this command with <arg> nonzero is equivalent to sending a trigger pulse to the TTL Sync port. It causes the filter to jump to the next palette element, or shift the pass wavelength by an amount set by the Jump command.

Legal <arg> values: [0-255]

Query: 0

Temperature of LC elements in optics module

Y <arg> <term>

This can be issued only as a query. It returns the temperature of the liquid crystal elements of the VariSpec Optics Module in centigrade.

Legal <arg> values: Query only

Query reply: temperature of LC elements in

optics module in centigrade

Escape

<esc> (ASCII character code 27)

This character is processed immediately, with no need for a <term> character. The VariSpec filter stops processing all pending commands immediately. All characters in the communications buffer are erased, and the input buffer is reset. There is a latency of up to 20 milliseconds before the unit returns to the “idle” state.

There is no response if the unit is asleep, but the <esc> character is echoed like any other (if echo is enabled).

Status Check

@

This character is processed immediately, with no need for a <term> character. The VariSpec filter responds with a status character, whose bits indicate various status information about the filter. The table of character bits is located in the previous section of this manual (Escape, Status-Check, and Busy-Check Characters).

There is no response if the unit is asleep, but the “@” character is echoed like any other (if echo is enabled).

Busy Check

!

This character is processed immediately, with no need for a <term> character. The VariSpec filter responds with “<” if it is busy (processing other commands), or with “>” if it is idle (no pending commands).

There is no response if the unit is asleep, but the “!” character is echoed like any other (if echo is enabled).

Error Codes

When an error occurs, the VariSpec filter records an error code. This code is stored until the error is cleared using the “R” command, or until another error occurs. At that point, the error code changes to reflect the new error condition. The code can be read by querying the “R” parameter.

Errors can be caused by syntax errors, impossible argument values, or issuing commands before other, supporting commands have been performed. An example of this last type would be an attempt to tune to a palette element when no palette element has been defined.

Many of these errors do not interfere with the processing of subsequent commands, and the VariSpec filter continues to process commands even while an error is pending. Those errors listed as (internal) are usually caused by problems internal to the VariSpec filter, rather than commands sent to it.

TABLE 4. Error Codes

Code	Meaning
0	No errors pending
1	Syntax error
2	Attempt was made to set a read-only parameter
3	“E” (exercise) command was issued with illegal <arg> value
4	Attempt to set wavelength or palette while filter is uninitialized
5	“I” (initialize) command issued with illegal <arg> value
6	Mode error
7	“M” (mode) command issued with illegal <arg> value
8	Error calculating liquid crystal drive levels (internal)
9	Palette not defined
10	Palette not prepared (internal)
11	Palette element out of range
12	Wavelength out of range
13	Liquid crystal drive level out of range (internal)
14	Jump wavelength step too large
15	No longer used
16	No longer used
17	“G” (go) command issued with illegal <arg> value
18	No longer used

Code	Meaning
19	No longer used
*	Appears when the filter is set out of bounds, when initialization has not occurred, or when the filter cannot tune to a specified wavelength (not necessarily out of range)

Programming Examples

Here are several examples of how the VariSpec filter may be programmed, using the USB port and the command set described in the previous section. In the examples, commands sent to the VariSpec are shown in bold text and replies from the VariSpec are shown in normal text. Comments are placed within braces.

Example 1. Tuning by wavelength

In this example, a VIS-model VariSpec filter is controlled by a host computer using the USB port. This presumes that the proper USB driver files have been installed. The optics in this case can tune from 400 nm to 720 nm.

	{plug VariSpec electronics module into USB port and wait until initialization is complete}
W ? <c/r>	{wait for reply}
W 550.00 <c/r>	{VariSpec filter is tuned to the default 550.00 nm for this particular model}
W 500 <c/r>	{tune filter to 500.00 nm}
W 600 <c/r>	{tune filter to 600.00 nm}
W 488 <c/r>	{tune filter to 488.00 nm, altered spacing is okay}
W 900 <c/r>	{wavelength out of range, Status LED lights Red}
W ? <c/r>	{what wavelength is the filter currently set at?}
W 488.00 <c/r>	{filter stays at the last legal wavelength given}
R 1 <c/r>	{clear the Status LED and reset the error condition}

Example 2. Tuning with a palette

In this example, we set up a palette of wavelengths and then tune using the palette. The preamble is the same as the previous example.

	{plug VariSpec electronics module into USB port and wait until initialization is complete}
W ? <c/r>	{wait for reply}
W 550.00 <c/r>	{VariSpec filter is tuned to the default 550.00 nm for this particular model}
D 460 <c/r>	{define first palette element 0}
D 540 <c/r>	{define second palette element 1}
D 640 <c/r>	{define third palette element 2}

D ? <c/r>	{query what palette elements are}
D 3 <c/r>	{number of elements}
D 460.00 <c/r>	{wavelength of element 0}
D 540.00 <c/r>	{wavelength of element 1}
D 640.00 <c/r>	{wavelength of element 2}
P 0 <c/r>	{tune to element 0}
W ? <c/r>	{query pass wavelength}
W 460.00 <c/r>	{wavelength is 460.00 nm}
P 2 <c/r>	{tune to element 2}
W ? <c/r>	{query pass wavelength}
W 640.00 <c/r>	{wavelength is 640.00 nm}
D 550 1 <c/r>	{change element 1 wavelength to 550.00 nm}
W ? <c/r>	{query pass wavelength}
W 640.00 <c/r>	{filter is still at old 640.00 nm wavelength}
P 1 <c/r>	{tune to element 1}
W ? <c/r>	{query pass wavelength}
W 550.00 <c/r>	{wavelength is 550.00 nm}

Example 3. Cycling through various wavelengths using the TTL Sync port

Here we define a palette and then use a 10 Hz TTL signal generator at the TTL Sync port to cycle through the palette elements in sequence.

	{plug VariSpec electronics module into USB port and wait until initialization is complete}
W ? <c/r>	{wait for reply}
W 550.00 <c/r>	{VariSpec filter is tuned to the default 550.00 nm for this particular model}
G 0 <c/r>	{disable sync}
D 460 <c/r>	{define first palette element 0}
D 540 <c/r>	{define second paletteelement 1}
D 640 <c/r>	{define third palette element 2}
P ? <c/r>	{query present element}
P 255 <c/r>	{palette code for “palette element undefined”}
	{attach TTL signal generator to TTL Sync port, set rep rate at 10 Hz}
M 0 <c/r>	{select mode 0, sequential on sync port signal}
P ? <c/r>	{query present element}
P 255 <c/r>	{palette code for “palette element undefined”}

G 1 <c/r>	{enable sync port service for every pulse}
	{filter cycles through the palette at 10 Hz}
G 2 <c/r>	{enable sync port service for every second pulse}
	{filter cycles through the palette at 5 Hz}
P ? <c/r>	{query present element}
P 1 <c/r>	{element will be 0, 1, or 2, depending on timing}
	{filter continues to cycle through the palette at 5 Hz}

Controlling VariSpec Filters with Other Operating Systems

CRi does not directly support the use of VariSpec filters on operating systems other than Windows 2000 or Windows XP Professional. However, VariSpec filters can be controlled using other operating systems when the appropriate drivers are used. USB drivers are available for Apple Mac OS X and Linux. Contact CRi for further information.

Chapter 3

Frequently Asked Questions & Troubleshooting

FAQs

How large an aperture can I buy?

VIS filters come in 20 mm and 35 mm apertures. All others come in 20 mm apertures. Because of the lack of availability of large uniform pieces of true imaging-quality material, near-infrared (SNIR, LNIR, XNIR) models cannot be made in larger aperture sizes at this time.

See the current Price List for a full list of available filter models.

What is your definition of bandwidth?

The Full-Width at Half-Maximum (FWHM), measured as the spectral separation between the two points where the filter's transmission attains 50% of the peak value. The passband center wavelength is the wavelength midway between these two points. VariSpec filters come in a variety of bandwidths, which are set during the design and manufacturing process and are not adjustable by the customer.

Nominal bandwidth is measured at a wavelength about halfway within the wavelength range of the particular filter: e.g. 550 nm for VIS models and 850 nm for SNIR models. The actual width of the passband is constant in terms of center wavenumber, but varies in terms of center wavelength such that a center wavelength selected closer to the blue will have a narrower passband width than a center wavelength selected closer to the red.

What is the transmission of the filters?

The percentage of linearly polarized light, oriented so that maximum transmission is attained, passing through the filter relative to the amount that entered. Since the entrance element of the VariSpec filter is a linear polarizer, transmission of randomly

polarized light is half that of linearly polarized light in the correct orientation. VariSpec transmission is wavelength dependent. Typical spectral curves taken across the wavelength range of each type of filter are available from CRi in graphical form. Contact CRi for more information.

What is the tuning speed of the filters?

Several factors affect this number, including the liquid crystal relaxation time from "charge" to "no charge" states under various ambient temperatures and the calculation time of the electronics controller box, which must send the correct voltages to each liquid crystal element for each change (this can be minimized by using "palettes" of wavelengths stored in the box's firmware). Typically, this time is 50 ms to 150 ms.

Current filters utilize a USB serial interface. These filters also utilize a fast microprocessor to calculate the necessary voltages in order to control the liquid crystal (LC) elements inside the optics module. Older filters with an RS-232 interface used a previous-generation microprocessor that required much longer times to calculate these voltages-sometimes hundreds of milliseconds. Therefore, in order to minimize tuning time, users would typically store wavelengths of interest (up to 128) in a palette using the "P" commands. These commands remain, as a legacy feature, in the current command set, but no longer result in significantly faster tuning speeds.

CRi has performed tests at various ambient temperatures to determine the typical transition times of each model. Contact CRi for more detail.

What is the damage threshold of the filters?

The damage threshold for reasonably long-term exposure of the filters to VIS and NIR energy is 500 mW/cm^2. Note that the filters absorb light that you do not want to see or otherwise detect. VIS filters have a near-infrared hot mirror to reflect some unwanted near-infrared light, but longer wavelength near-infrared light, such as thermal energy, can damage the filters. Keep in mind that many detectors, such as CCD or CMOS sensors, may not be able to detect this energy. It is good practice to check the temperature of the filter optics to make sure the tuning elements are not subjected to excess heat.

Typically the epoxy and polarizing material will be damaged first, followed by the coatings, glass, and the liquid crystal material itself.

The enclosure has been designed to withstand moderate impacts, but a major component by weight of most VariSpec filter models is glass, so inadvertent impacts can damage the filter. Nevertheless it is quite rare for a VariSpec filter to break in the field.

The electronics is a surface-mount PCB with re-writable EEPROM for configuration data and firmware programming. Power supplied by the USB port. Tests (such as CE testing) have shown the enclosure to be resistant to EMI. Nevertheless, exposing the electronics to voltage spikes or sags or a large static discharge can render the filter inoperable or, worse, damage the electronics.

I have two filters of the same model, can I interchange the optics and electronics?

No. VariSpec Optics and Electronics Controller Modules are a matched set with configuration data unique to a particular optics module loaded into the memory of the electronics module.

Can I use a longer 26-pin cable between the optics and electronics modules?

CRi does not recommend this, since the added length may cause excessive signal loss in some models.

Why do some of your filters have a blue and gray enclosure and others have a black anodized aluminum enclosure?

Large aperture 35 mm filters have a black anodized aluminum enclosure with optional mounting adapter frames and side mounts for use on an optical table. Some small aperture 20 mm filters that are popular for OEM customers also have a black anodized aluminum enclosure. Newer 20 mm aperture filters have a blue-and-gray enclosure with an integral mounting space for dovetailed inserts. The inserts come as standard male or female C-mounts or a male T-mount. A 52 mm camera lens flange adapter is also available.

When used outdoors and exposed to direct sunlight, often in hot desert environments, the temperature of filters enclosed in a black aluminum housing was often found to exceed the maximum recommended operating temperature. The blue and gray color of the newer filters helps to reflect more light and also serves to brand the filters in CRi's corporate colors. A blue-and-gray enclosure for the 35-mm filters has not yet been designed.

What are the differences in LCTF and AOTF technology?

As described earlier, CRi VariSpec filters are Liquid Crystal Tunable Filter (LCTF) designs. The liquid crystal (LC) material is a so-called *nematic* LC. Nematic LC is used in many imaging applications such as liquid crystal display (LCD) monitors and screens. Nematic material can be easily controlled using relatively low voltages and responds consistently to repeated signals. Image quality is very high and the field-of-view is relatively wide (from 3.5-degrees to 7.5-degrees, depending on the model). Although tunable filters can be manufactured using other designs to enable wavelength tuning, CRi's Lyot designs are among the most widely recognized and, thus, the term LCTF is usually associated with VariSpec filters.

Acousto-Optic Tunable Filters (AOTF) use a crystal in which vibrational waves at radio frequencies allow a single wavelength of light to pass. The wavelength of light is a function of the frequency of the radio waves applied to the crystal. Transmission can be high, but without the superior out-of-band transmittance performance of an LCTF. There is also a so-called *blur* effect that can compromise the spatial imaging quality of the filter in many applications. Very narrow bandwidth filters can be built-some as narrow as CRi's VISR or NIRR designs. Field-of-view is narrower than with VariSpec LCTFs because of the requirements of the AOTF design. Tuning speeds can be as fast as 20 microseconds because all that is required is that the radio waves penetrate the crystal.

Do VariSpec filters polarize the light that passes through them?

Yes. CRi's patented VariSpec technology is a variation of an optical filter design described by Bernard Lyot in 1933. While the so-called "Lyot" design provides a static bandpass, the addition of liquid crystal variable retarders provides spectral tuning ability. In essence, a series of optical elements, including liquid crystal cells, fixed retarders, and polarizers are bonded together. Each element transmits light with transparency that varies sinusoidally as a function of wavelength. The transmitted light adds constructively in the desired bandwidth region and destructively everywhere else, with minimal transmission for wavelengths outside the passband. The liquid crystal components allow the transmission bandwidth region to be shifted throughout the spectral range of the filter, without moving parts.

Unpolarized light that enters the filter becomes linearly polarized, and the light that exits the filter is linearly polarized. Of course, if the light entering the filter is linearly polarized in the same orientation as the filter, efficiency is doubled as compared with unpolarized light. Contact CRi if you would like to know the axis of polarization for the entrance and exit apertures for a particular filter model.

I need a multispectral imaging system, and your VariSpec filter technology looks ideal. But I don't want to do any system integration. Do you have a turnkey solution?

Yes. We also manufacture and sell the Nuance™ Multispectral Imaging System and the R&D 100 Award-winning Maestro™ In-Vivo Fluorescence Imaging System. Contact CRi for more information (sales@cri-inc.com).

- Nuance systems can be used for a wide variety of brightfield and fluorescence applications, including FISH and FRET experiments, multicolor immunohistochemistry, general fluorescence or brightfield microscopy, tissue microarray investigation, and high-content screening research. The Nuance optics module is compact and robust, with standard C-mount coupling for easy integration onto existing microscopes. A tripod socket is supplied for remote-sensing, forensic, machine vision, or other macroscopic applications. A workstation computer with Windows-compatible multispectral imaging software is also included.
- Maestro systems are affordable, breakthrough instruments for fluorescence-based *in-vivo* molecular imaging. Using multispectral acquisition and analysis, they provide dramatically improved sensitivity, multicolor flexibility and quantitative accuracy for both visible and near-infrared labels. The systems virtually eliminate contrast-robbing autofluorescence, revealing otherwise invisible targets that appear bright against a near-black background. This dramatic improvement in the signal-to-noise ratio can increase sensitivity many fold, allowing much smaller or fainter targets to be detected. A workstation computer with Windows-compatible multispectral imaging software is also included.

Troubleshooting

When I connect the USB cable from the VariSpec filter's Electronics Controller module to my computer, Windows XP Professional asks me where 'ftdibus.sys' and 'ftser2k.sys' are. What can I do? The filter does not seem to be recognized by the Windows operating system.

Sometimes the Windows 2000 and Windows XP Professional operating system's Plug and Play feature for new devices does not work entirely seamlessly. If you followed the directions to install the SDK onto your computer and received no error messages during or after the installation, those files should be located in: C:\Program Files\Cri\VariSpec\USB. Use the Detect New Hardware wizard to browse to that location and select the appropriate file. After the Detect New Hardware wizard is finished, the VariSpec filter should operate normally as a new USB serial device.

I was plugging and unplugging my USB devices and I ran out of COM ports. This makes it hard to control the VariSpec filter. What can I do to make these phantom COM ports disappear?

If you have Windows system administrator privileges and perform a series of actions involving USB devices (plugging and unplugging connectors or installing over previous installations), you can create multiple phantom COM ports, each associated with an older USB session. So the COMx port to which the VariSpec filter gets assigned changes, and there are fewer and fewer choices left in the normal range, COM1-COM8. The Windows operating system remembers which physical USB port to which a particular device was attached. So if you plug the USB device into another USB port, a different virtual COM port number is assigned to the device.

Here is CRi's recommendation to delete the phantom COM ports:

1. Disconnect the USB device (in this case, the VariSpec filter's USB cable).
2. Uninstall the USB serial port using the standard Windows tools: e.g. **Start > Settings > Control Panel > Add/Remove Programs**.
3. **IMPORTANT:** Do not uninstall ports to which you already have a device assigned (e.g. your modem or keyboard or mouse).
4. Shut down your computer: **Start > Turn Off Computer > Turn Off**.
5. DISCONNECT THE SYSTEM FROM THE NETWORK.
6. Reboot your computer while disconnected from the network.
7. Reconnect to the network.
8. Restart your computer: **Start > Turn Off Computer > Restart**.
   This flushes both the non-network and network copies of the Windows configuration, so the phantom USB ports will be eliminated in both of them.
9. Reinstall the VariSpec USB interface software by connecting the USB cable to the computer. Point the hardware wizard to the installation CD, or to the directory where you unzipped the USB support to (if downloaded from the web). Follow the directions in the wizard.

10. Right-click on **My Computer** and choose **Properties**. Go to the **Hardware** tab and click on the **Device Manager** button. Go to the **Ports** item and click on the "**+**" symbol. Locate the new USB COM port.
11. Right-click on this COM port and choose **Properties**. Select **Port Settings** and click the **Advanced** button.
12. UNCHECK the **Serial Enumerator** box.
13. Use the select box to choose one of the COMx ports that is not actually connected to any existing RS-232 hardware, like a modem, mouse, or keyboard.
14. These will probably say "COMx (in use)" but proceed anyway.
15. Click **OK** on the **Port Settings** and **OK** on the **COM Properties** box.
16. The USB COM port will now be visible in the Device manager at the new COMx setting
17. Repeat steps 2 through 4 for all the other phantom COMx settings. This will render them available for future use.

The filter works with your demonstration software and when I use HyperTerminal. But when I try to use your LabVIEW sub-VIs, I cannot communicate with it. What can I do?

If you open LabVIEW 6 or later, and then attach the VariSpec filter to the USB port of the computer, LabVIEW will not dynamically update its COM port list. In order to see the USB devices, you have to close LabVIEW and relaunch it (there is no "refresh" button. Closing the sub-VI is not enough: the whole environment has to be closed.

When this happens, you can enter the Windows hardware (Device) manager to check the assigned COM port numbers and manually enter these COM port numbers into the enumerated VISA resource controls. This works well if the assigned COM port numbers have not changed for specific USB ports. So even though the enumerated VISA resource controls don't list the COM ports, you can enter their names in manually, allowing communication to the filters when programs are run. Hard-coding in COM port numbers might solve these issues, as long as the same USB ports are used.

I want to clean the glass surface of the VariSpec Optics Module from fingerprints and other debris. How do I clean it?

Use a compressed air can to clean surface dust off the glass surfaces. Hold the can upright so that no freezing-temperature liquid comes out. If the glass surface has fingerprints or other residue, use isopropyl alcohol or commercial lens cleaner. You may also try distilled water or spectroscopic-grade methanol. Minimize the use of commercial glass cleaners containing ammonia, since the anti-reflective (AR) coatings may be damaged over time.

Use gloves and apply the cleaning solution to lint-less lens tissue. Drag-wipe over the surface and discard the tissue. Repeat if necessary. Do not press down on or rub the glass surface, since the AR coatings may be damaged.

Appendix A. System Specifications & Dimensions

Operating Specifications

Note that these specifications represent typical VariSpec filters as of October 2006 and are subject to change.

Parameter	VariSpec VIS	VariSpec SNIR	VariSpec LNIR	VariSpec XNIR	VariSpec VISR	VariSpec NIRR
Wavelength range (nm)	400-720	650-1100	850-1800	1200-2450	480-720	650-1100
Bandwidth FWHM (nm)	7, 10, or 20	7 or 10	6 or 20	9	0.25 (best effort)	0.75 (best effort)
Working aperture (mm)	22 or 35	22	22	22	22	22
Angle-of-acceptance (half-angle)	7.5 degrees	7.5 degrees	3.5 degrees	3.5 degrees	3.5 degrees	3.5 degrees
Optics response time (ms) [1]	50	150	150	50	150	150
Single or dual-housing design[2]	Single	Single	Single: 20-nm Dual: 06-nm	Dual	Dual	Dual
Wavelength accuracy	Bandwidth/8		Bandwidth/8		Bandwidth/8	
Maximum optical input	500 mW/cm^2		500 mW/cm^2		500 mW/cm^2	
Operating temperature	10-40 ºC		10-40 ºC		10-40 ºC	
Storage temperature	-15-55 ºC		-15-55 ºC		-15-55 ºC	
Computer interface	USB 1.1		USB 1.1		USB 1.1	
Power supply	USB bus-powered		USB bus-powered		USB bus-powered	

1. Optics response time depends on a number of factors including ambient temperature (colder temperatures cause the liquid crystal material to become more viscous and slower to respond) and model (NIR models are slower to respond than VIS models). Older filters (with electronics designed with a RS-232 serial interface) used a microprocessor than was not as fast as newer versions and, unless the palette function was utilized, might respond in 300 ms or more.
2. Dual-housing filters use two sets of optics and electronics. They must both be sent identical commands, but do not need to be addressed simultaneously.

Mechanical Dimensions (Optics Module)

VariSpec 20 mm Aperture Standard Enclosure

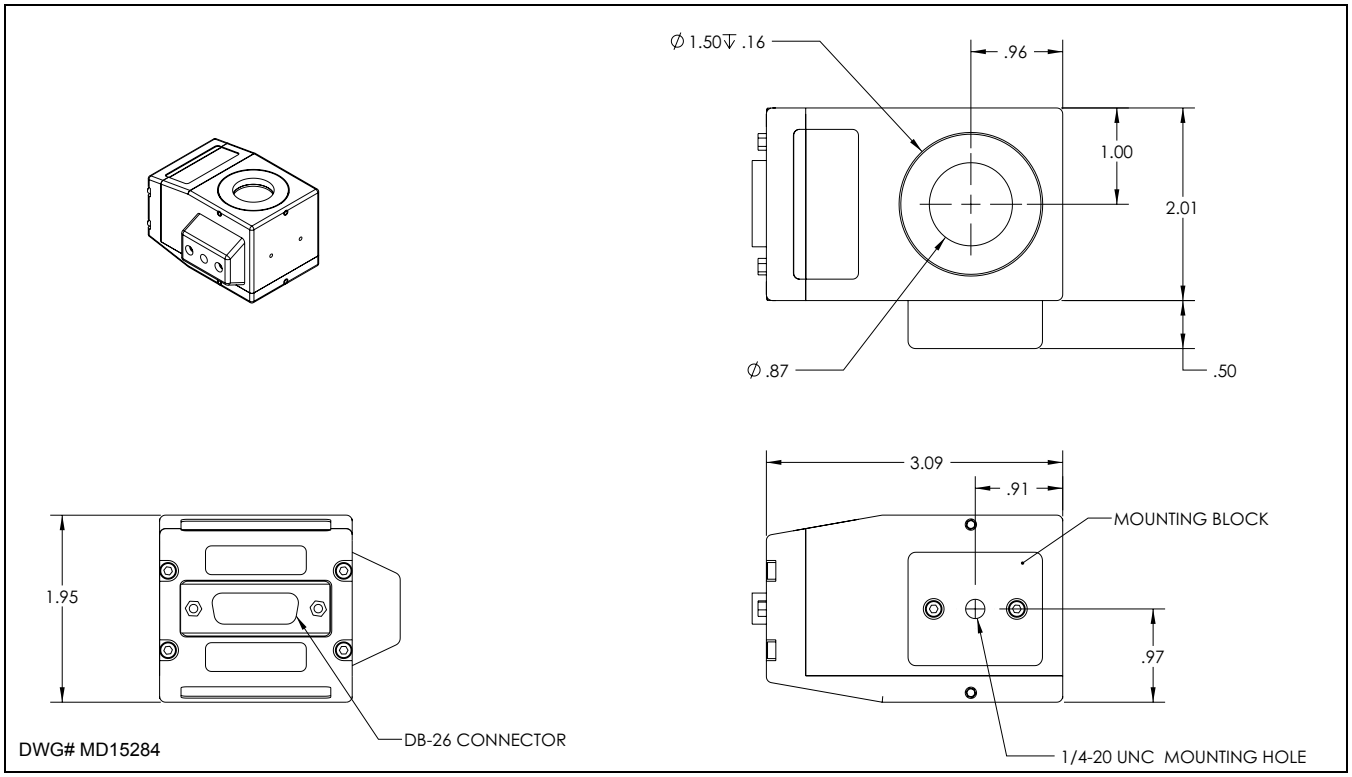

Figure 7. Exterior of a 20 mm Aperture Enclosure

VariSpec 20 mm Aperture Dual-Housing Enclosure

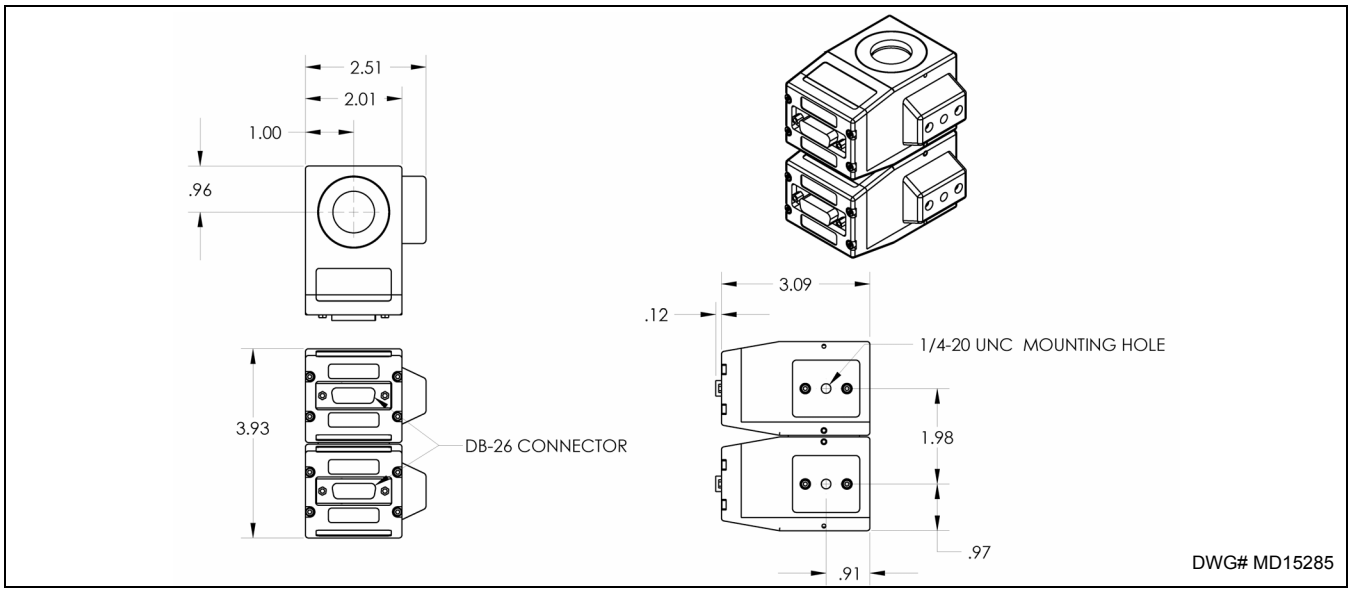

Figure 8. Exterior of a 20 mm Dual-Aperture Enclosure

VariSpec 20 mm Aperture Enclosure for the XNIR-09-20 Model

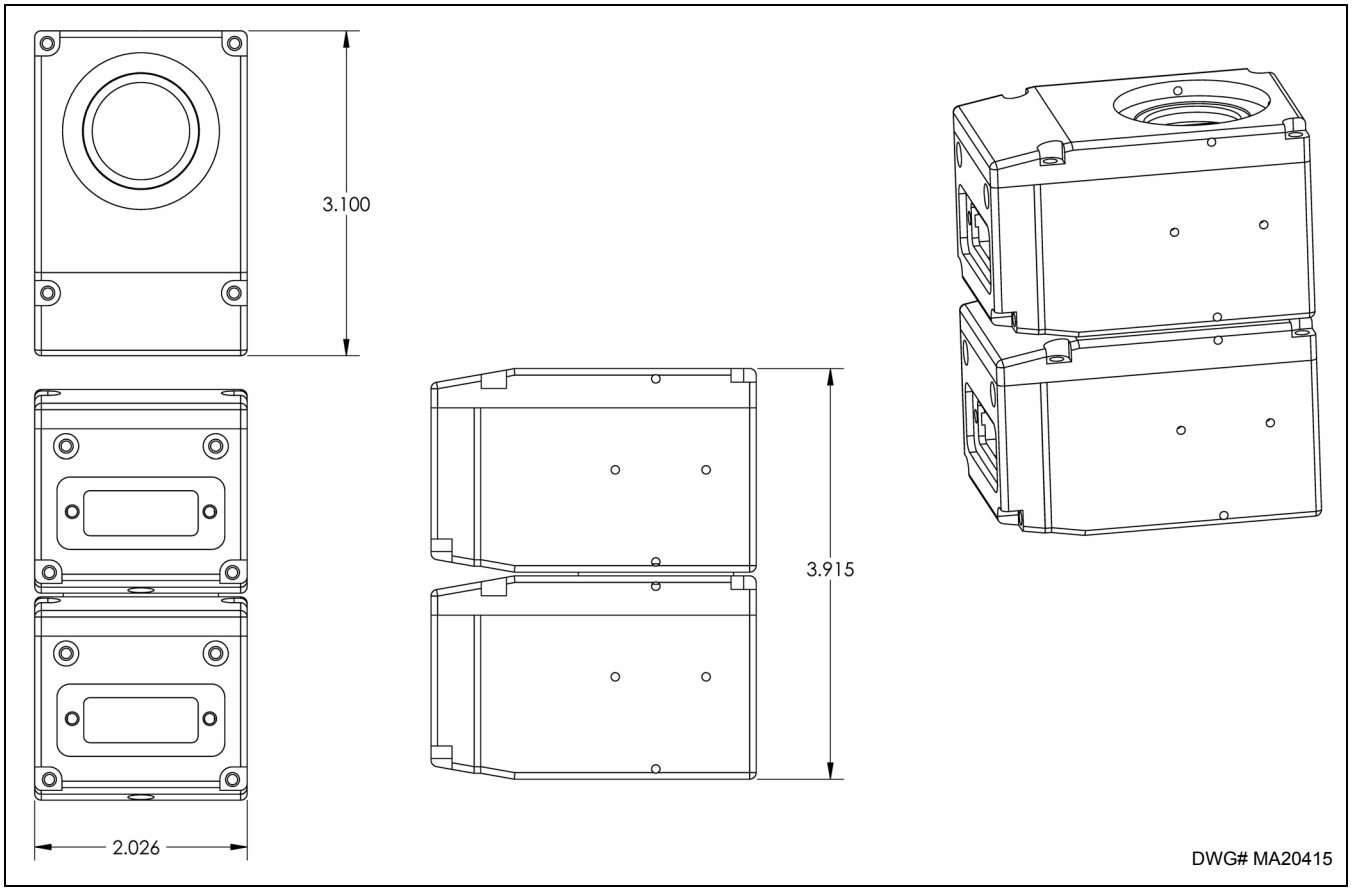

Figure 9. Exterior of the Unique XNIR-09-20 Dual-Aperture Enclosure

VariSpec Mounting Adapters for 20 mm Aperture Models

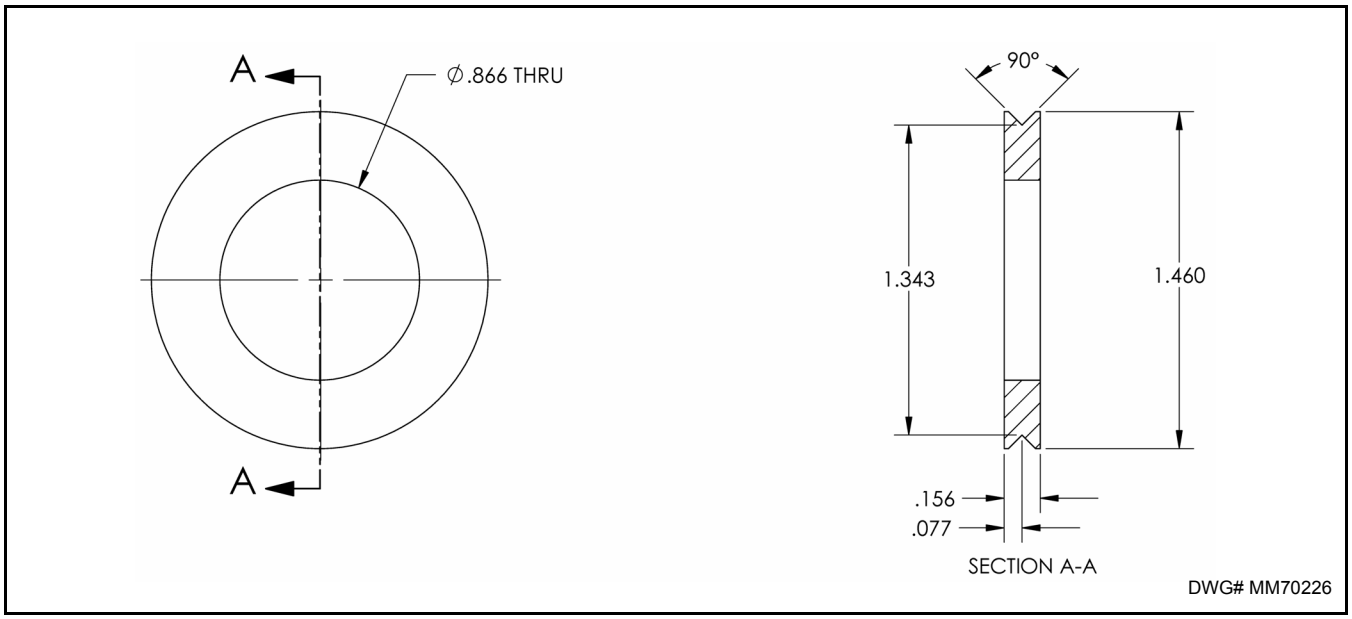

Figure 10. Stainless Steel Insert — Default, Blank

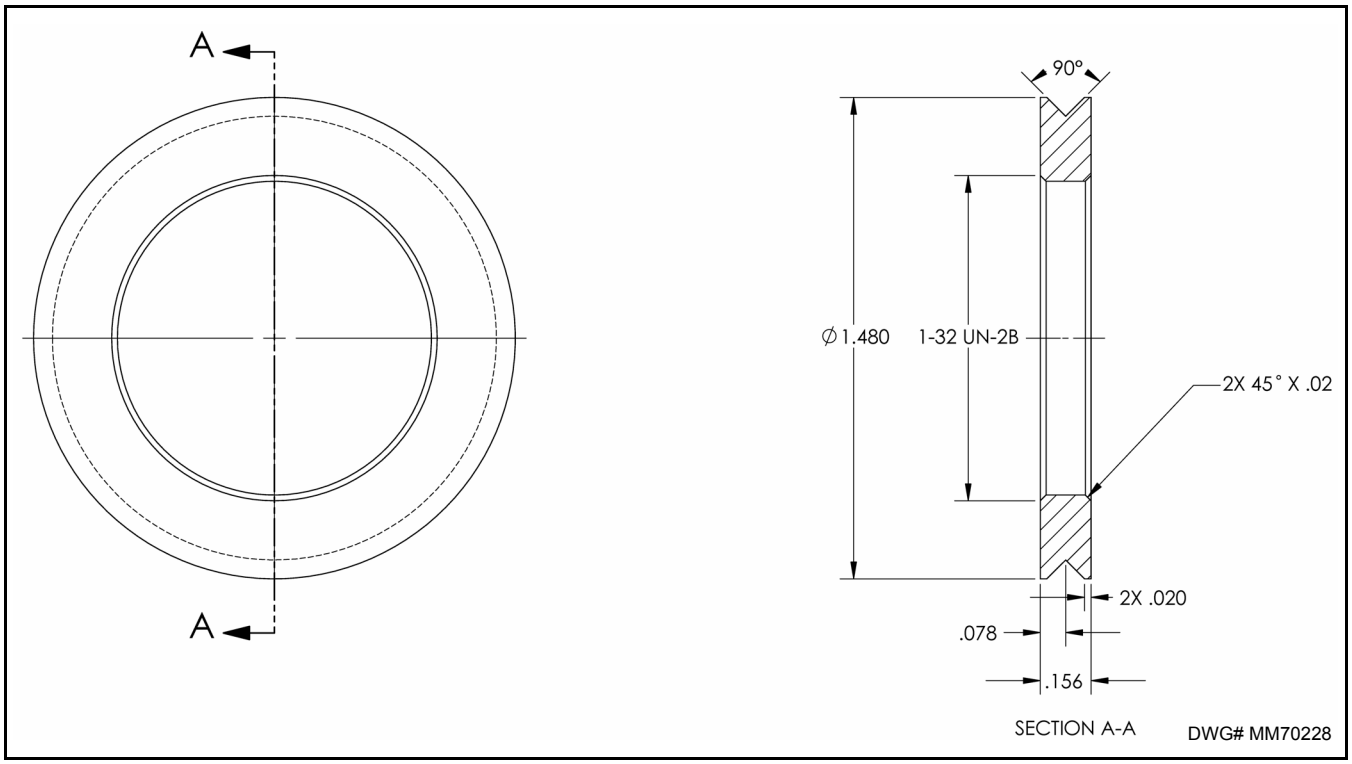

Figure 11. Stainless Steel Insert — Female C-mount

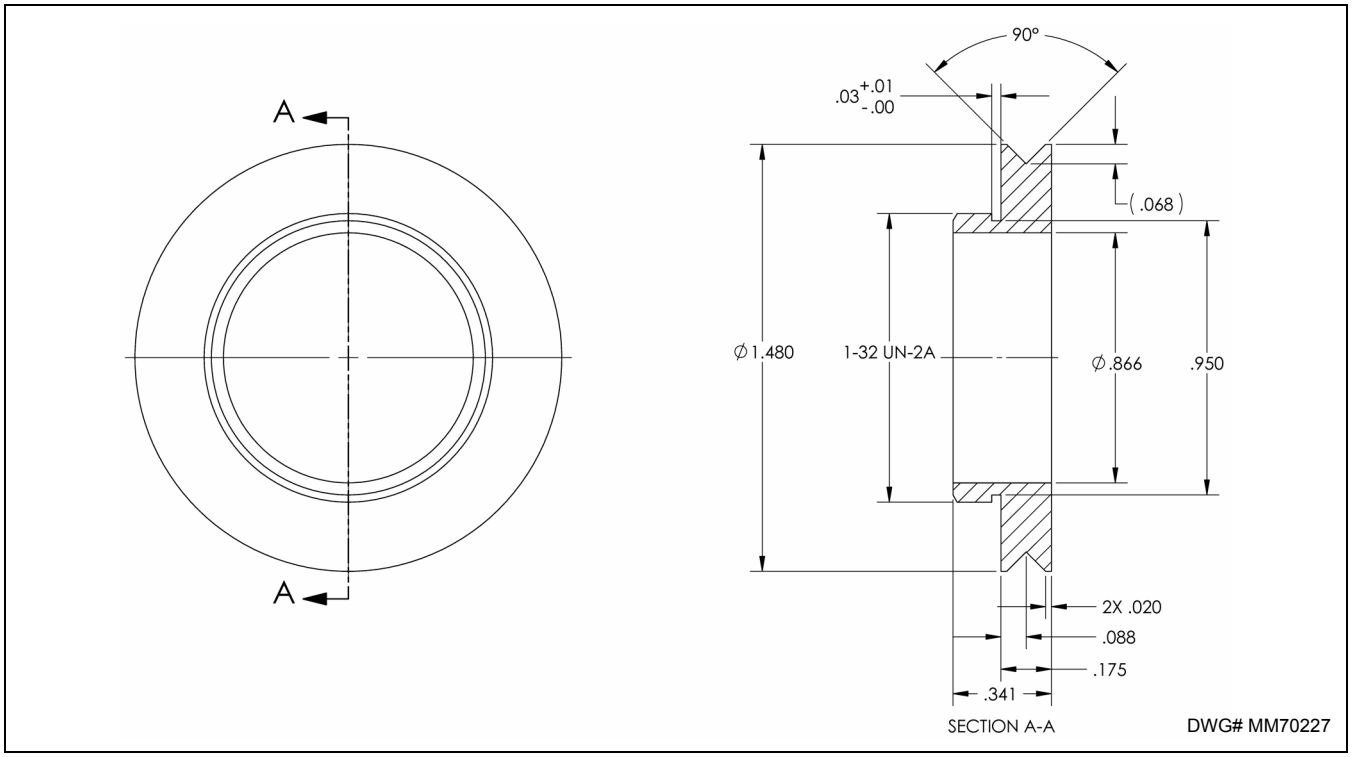

Figure 12. Stainless Steel Insert — Male C-mount

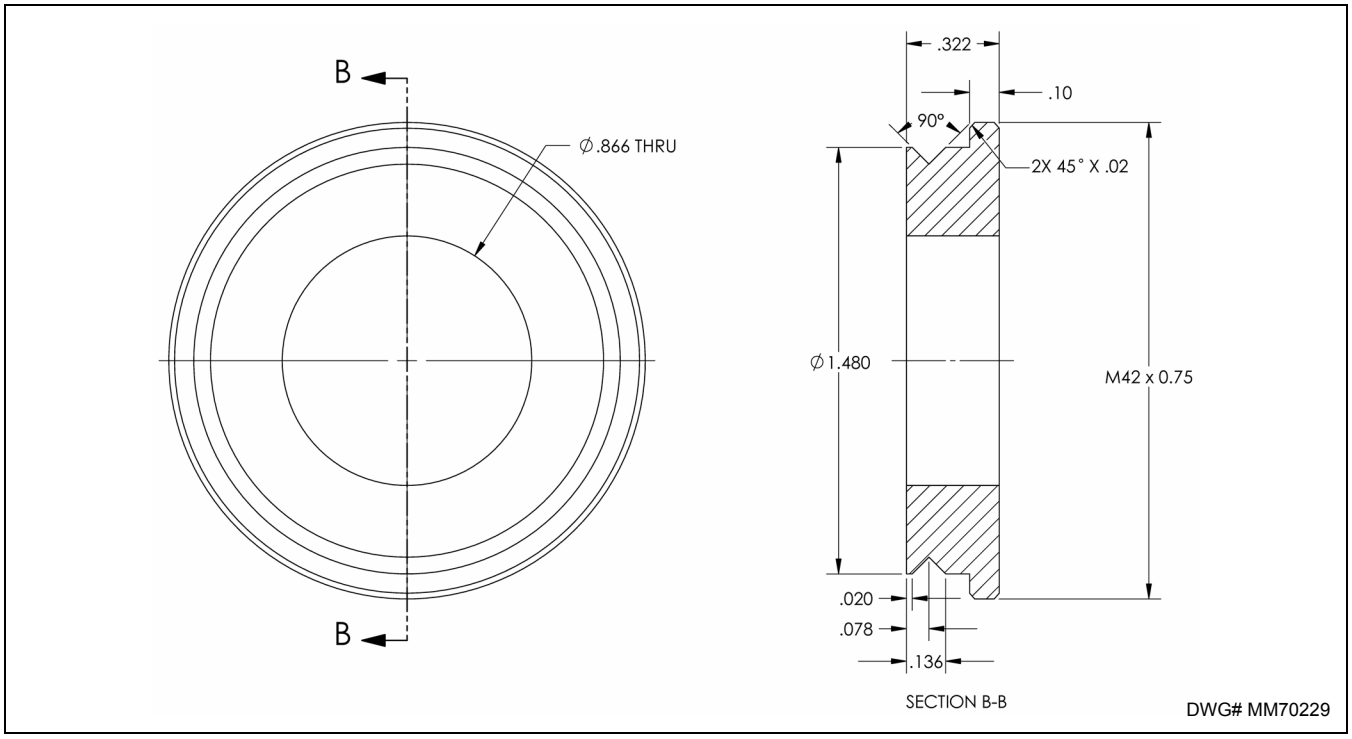

Figure 13. Stainless Steel Insert — Male T-mount

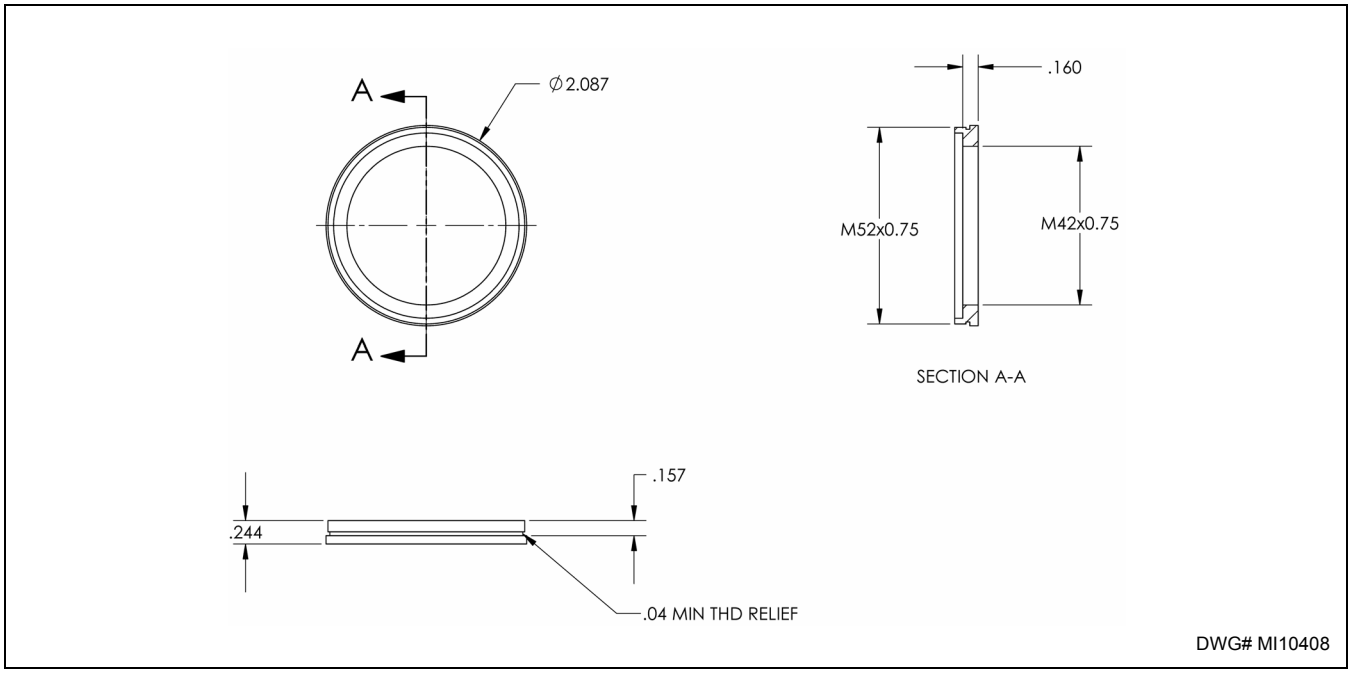

Figure 14. 52 mm Camera Lens Thread Adapter

Standard 20 mm Aperture Filter Mounting Block

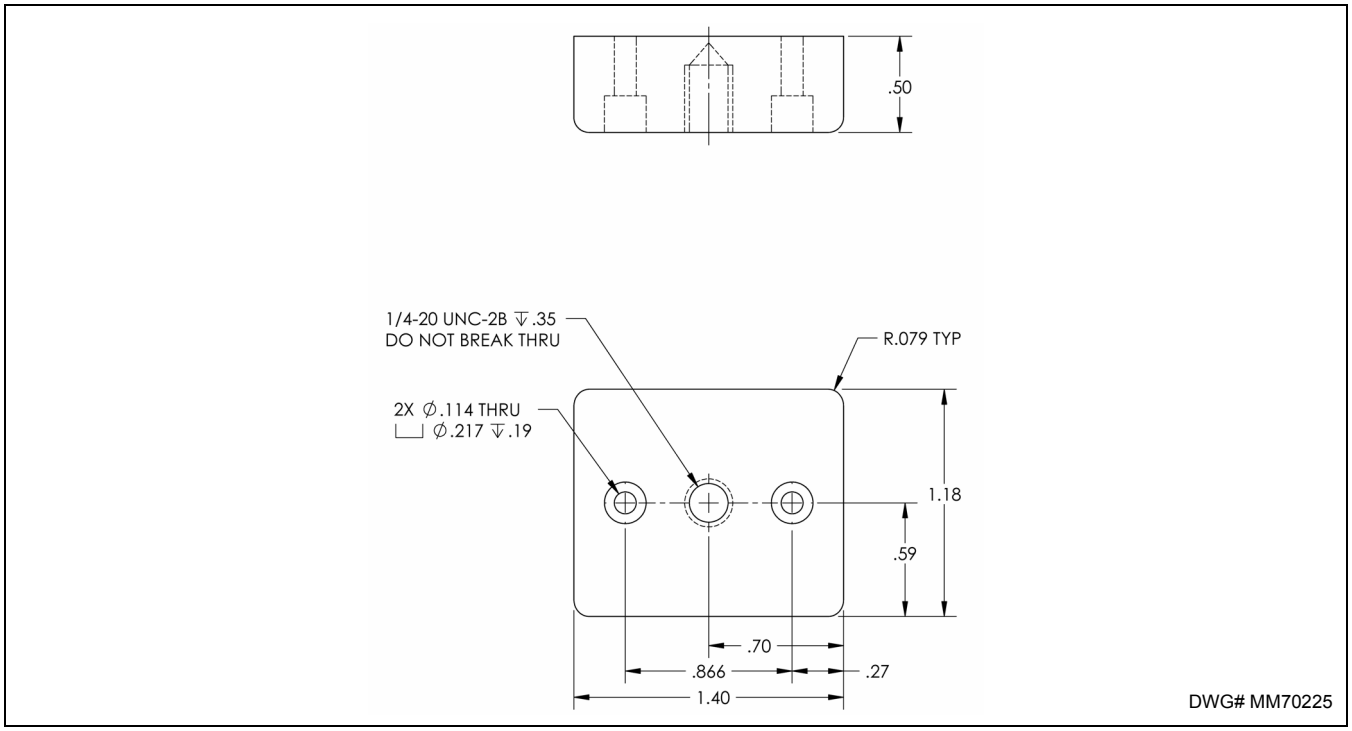

Figure 15. VariSpec Mounting Block for 20 mm Aperture Filters

VariSpec 20 mm Aperture Enclosure for the LNIR-20-20 Model

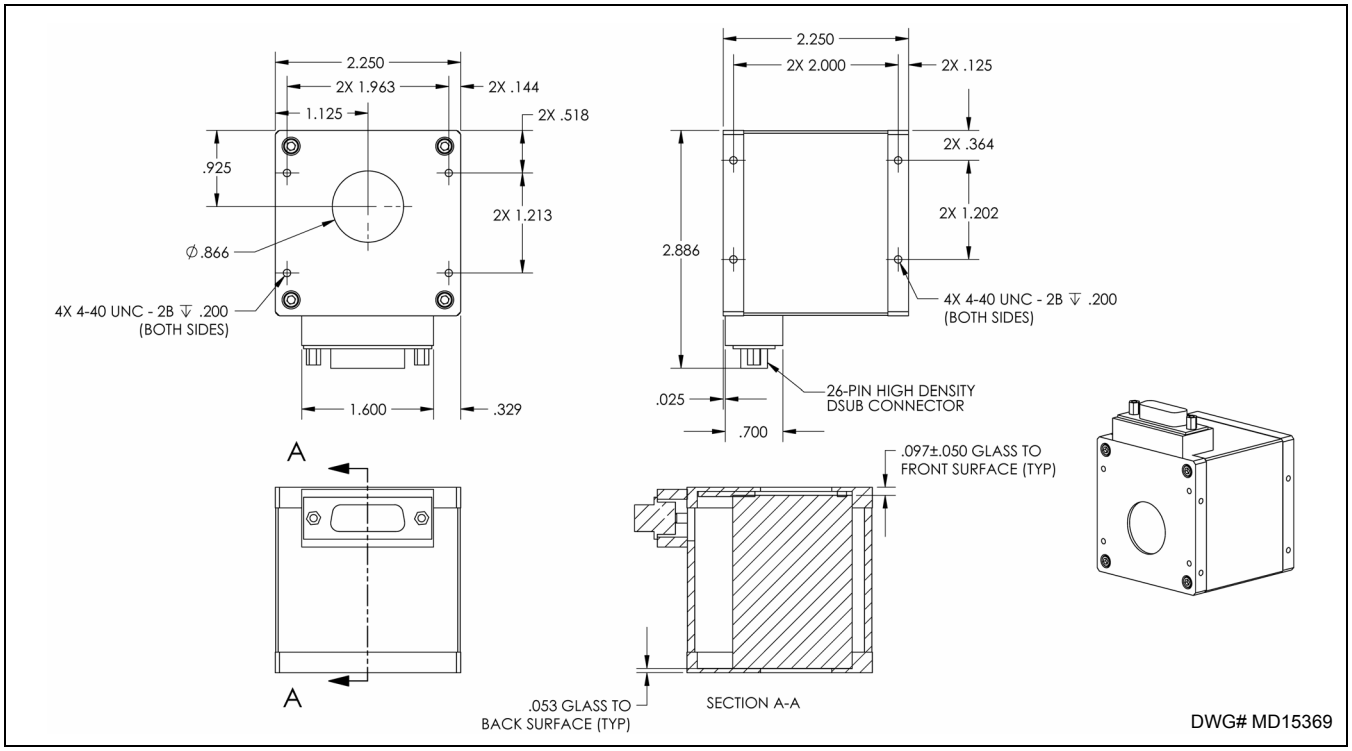

Figure 16. Exterior of the Unique LNIR-20-20 Dual-Aperture Enclosure

Mounting Assembly for the LNIR-20-20 Model

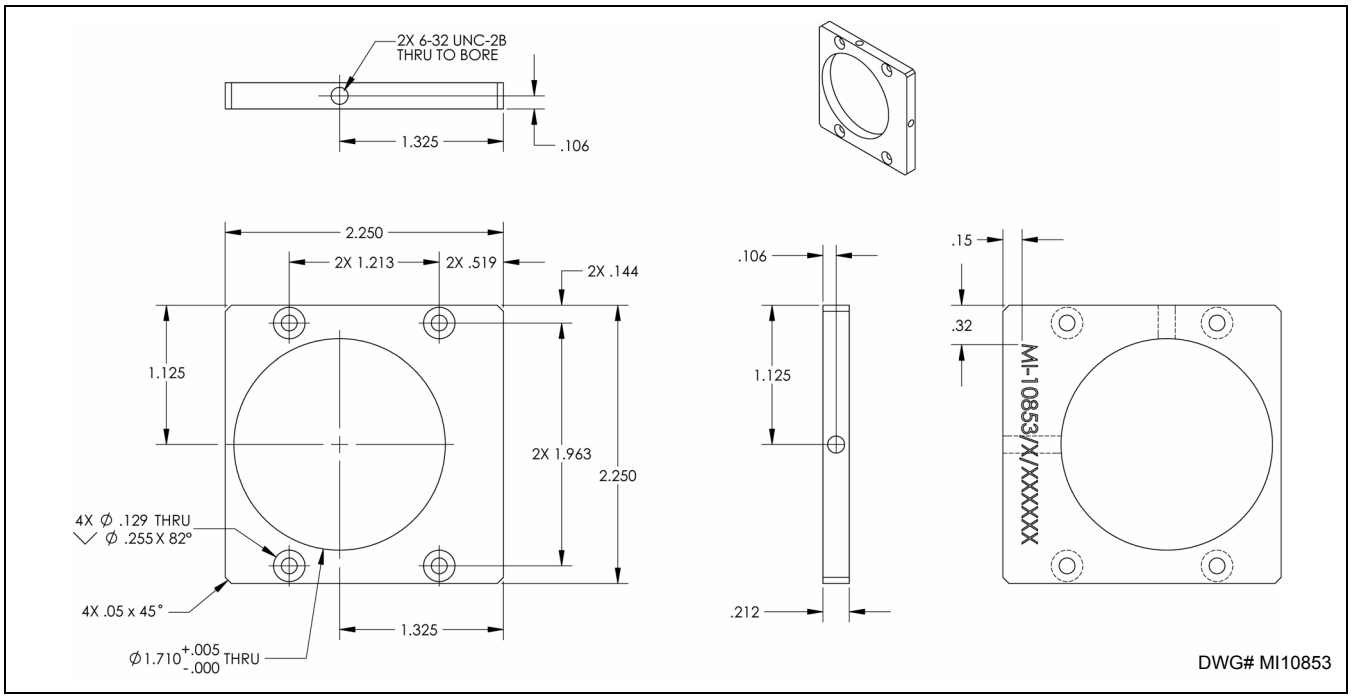

Figure 17. Mounting Assembly for the LNIR-20-20 Filter

Aluminum Inserts

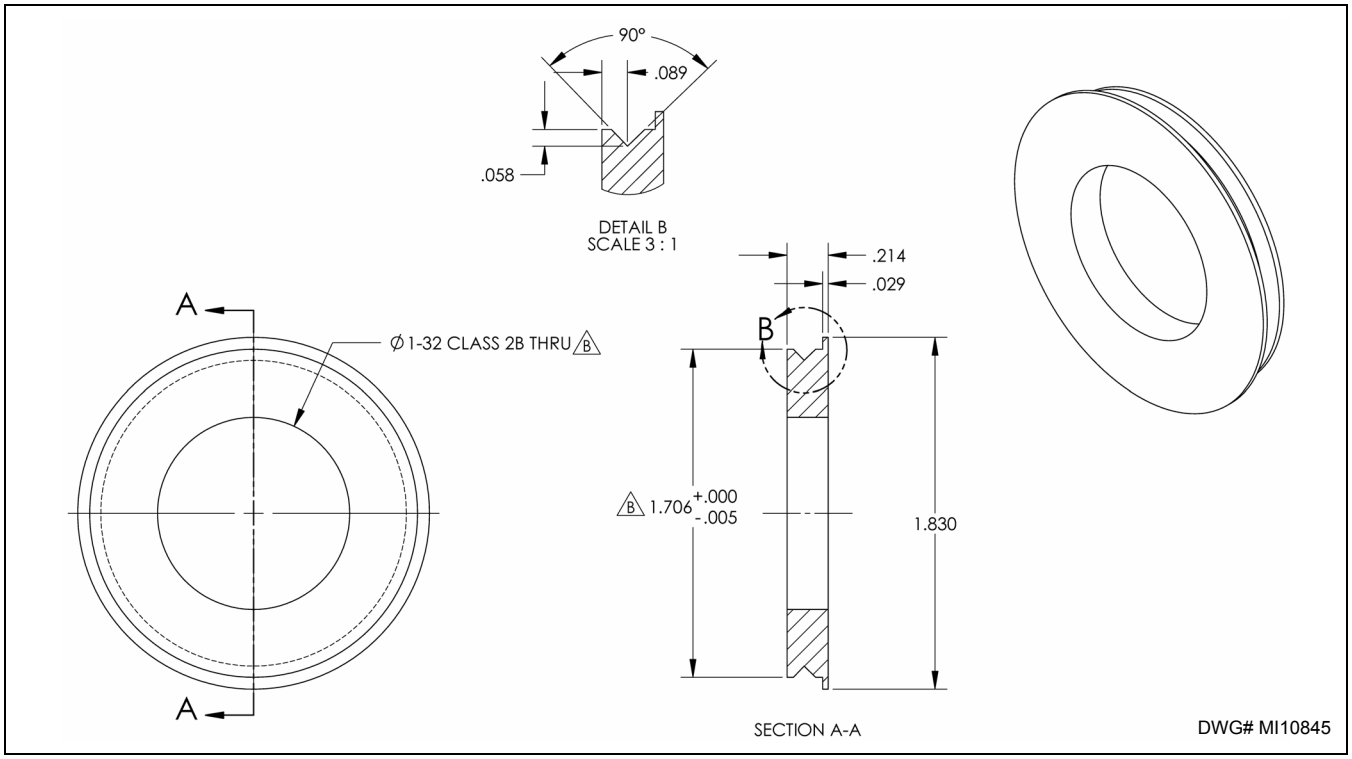

Figure 18. Aluminum Insert — Female C-mount

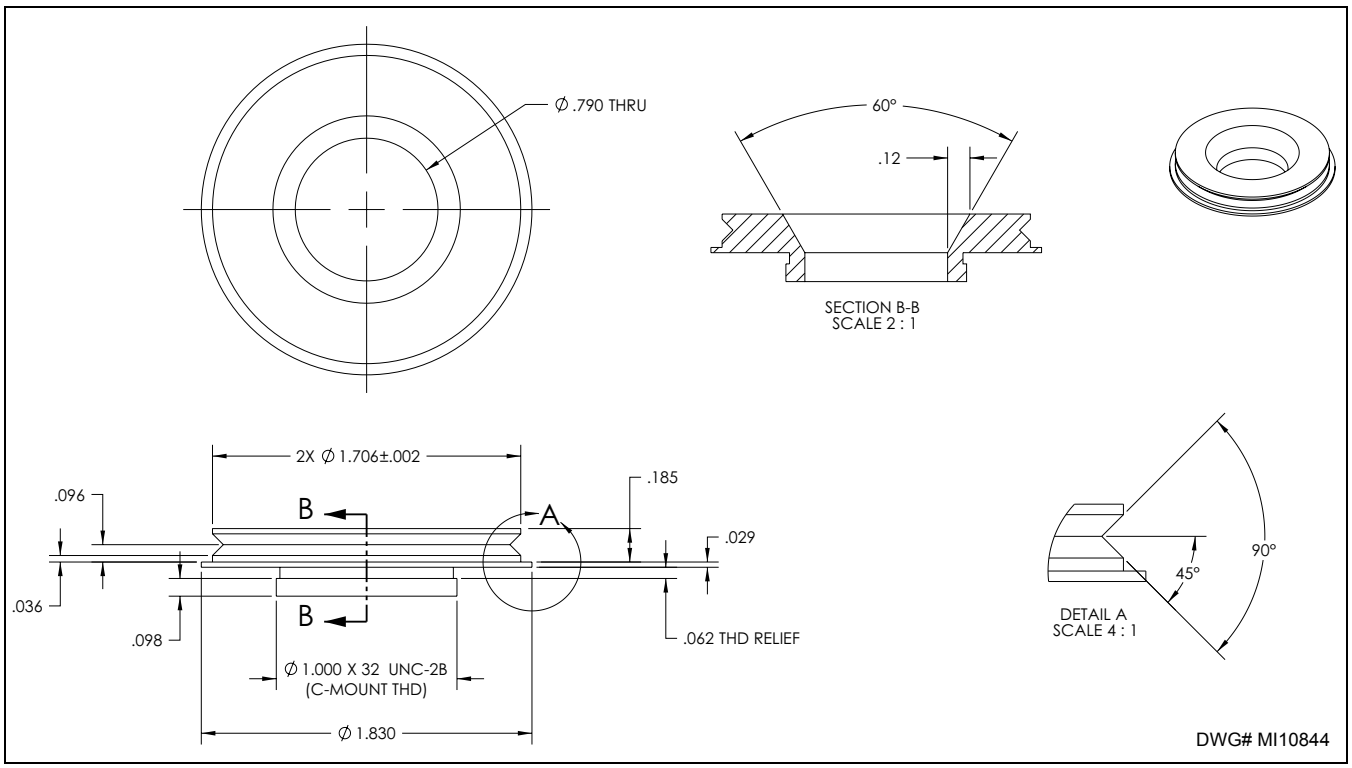

Figure 19. Aluminum Insert — Male C-mount

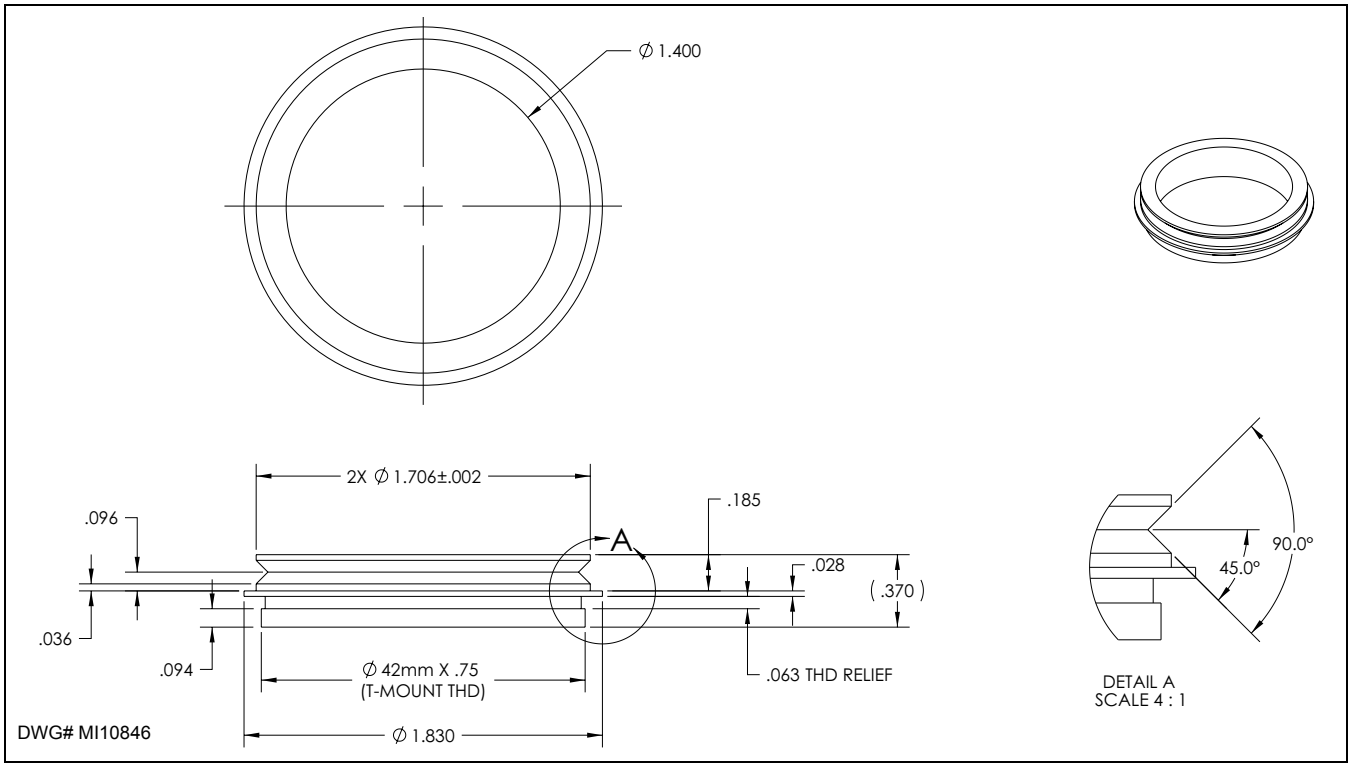

Figure 20. Aluminum Insert — Male T-mount

VariSpec 35 mm Aperture Enclosure

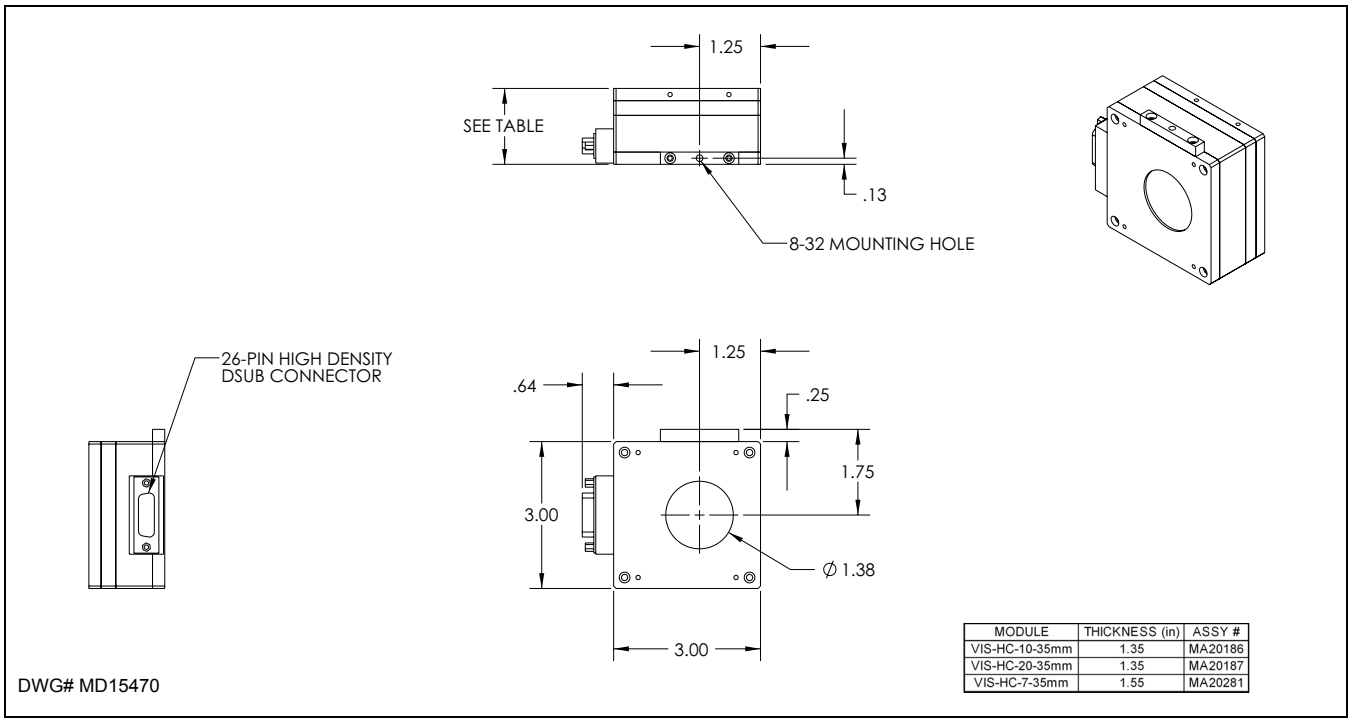

Figure 21. Exterior of a 35 mm Aperture Enclosure

Mounting Assembly for the 35 mm Aperture Enclosure

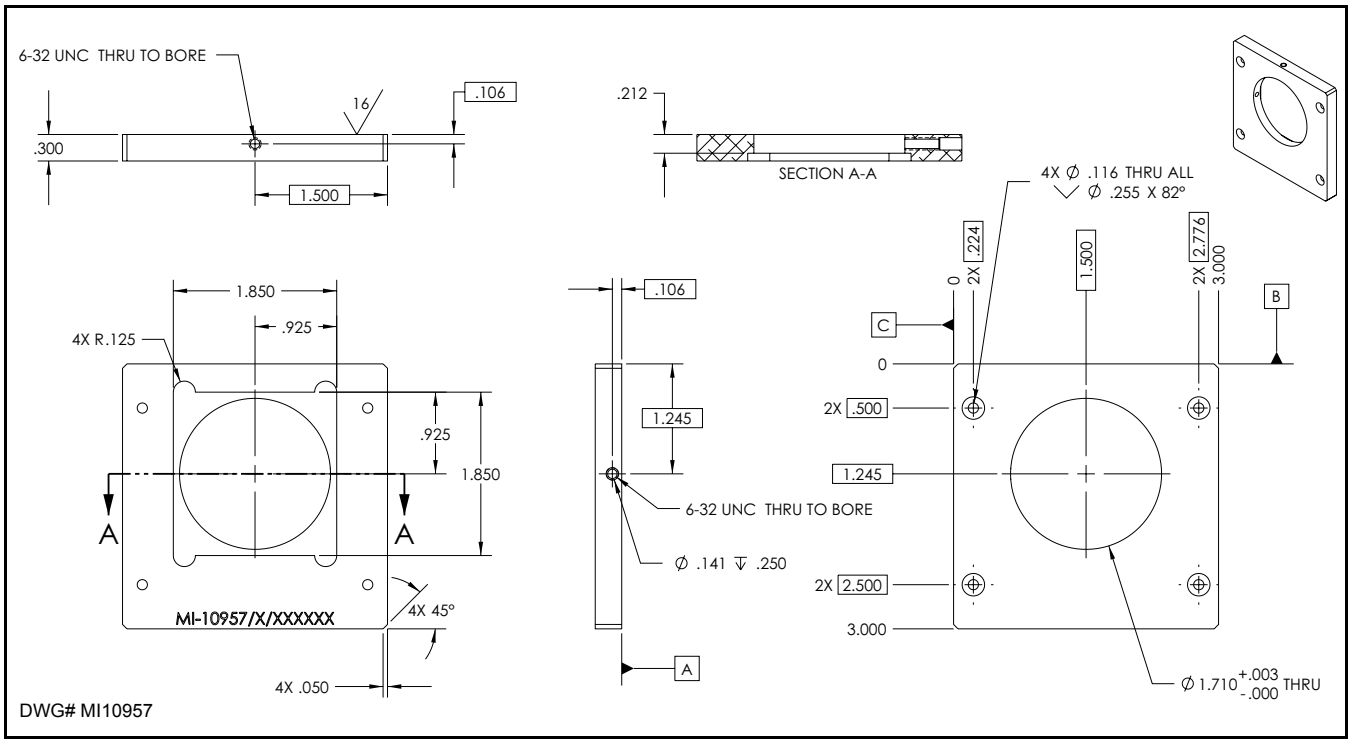

Figure 22. Mounting Assembly for the 35 mm Aperture Enclosure

35 mm Aperture Filter and LNIR-20-20 Filter Mounting Block

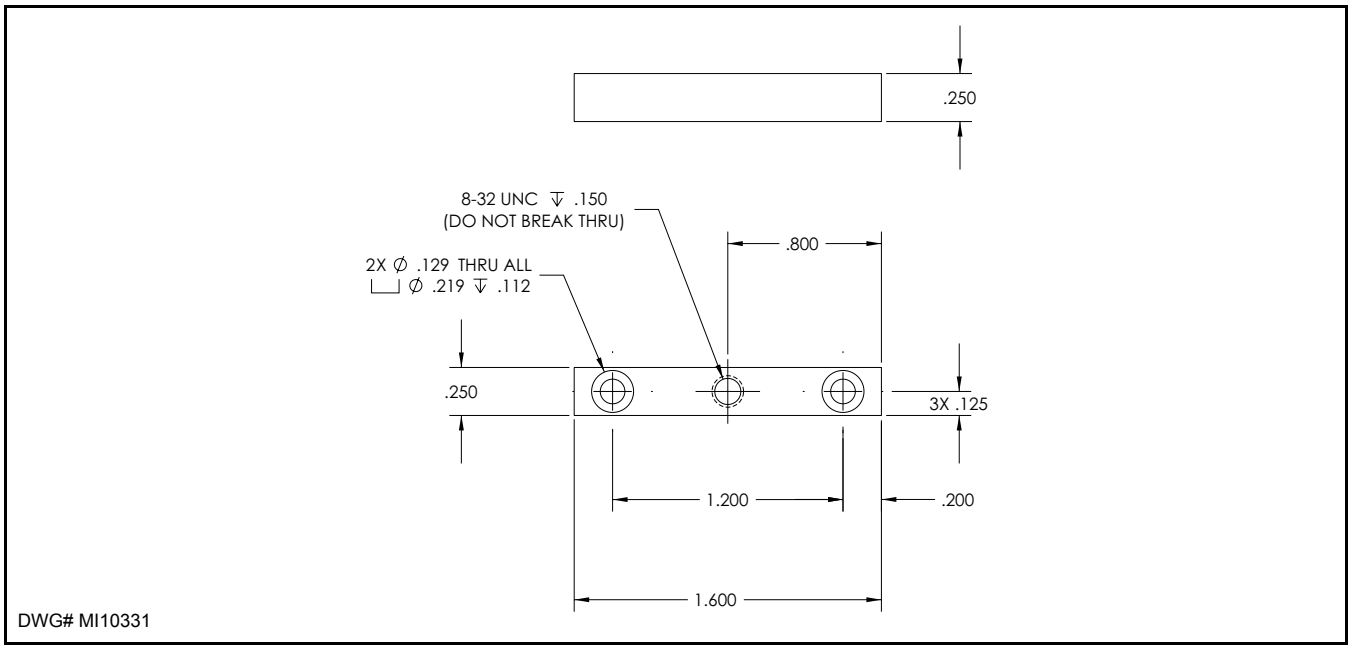

Figure 23. VariSpec Mounting Block for the 35 mm Aperture and LNIR-20-20 Filters

Electronics Controller Module

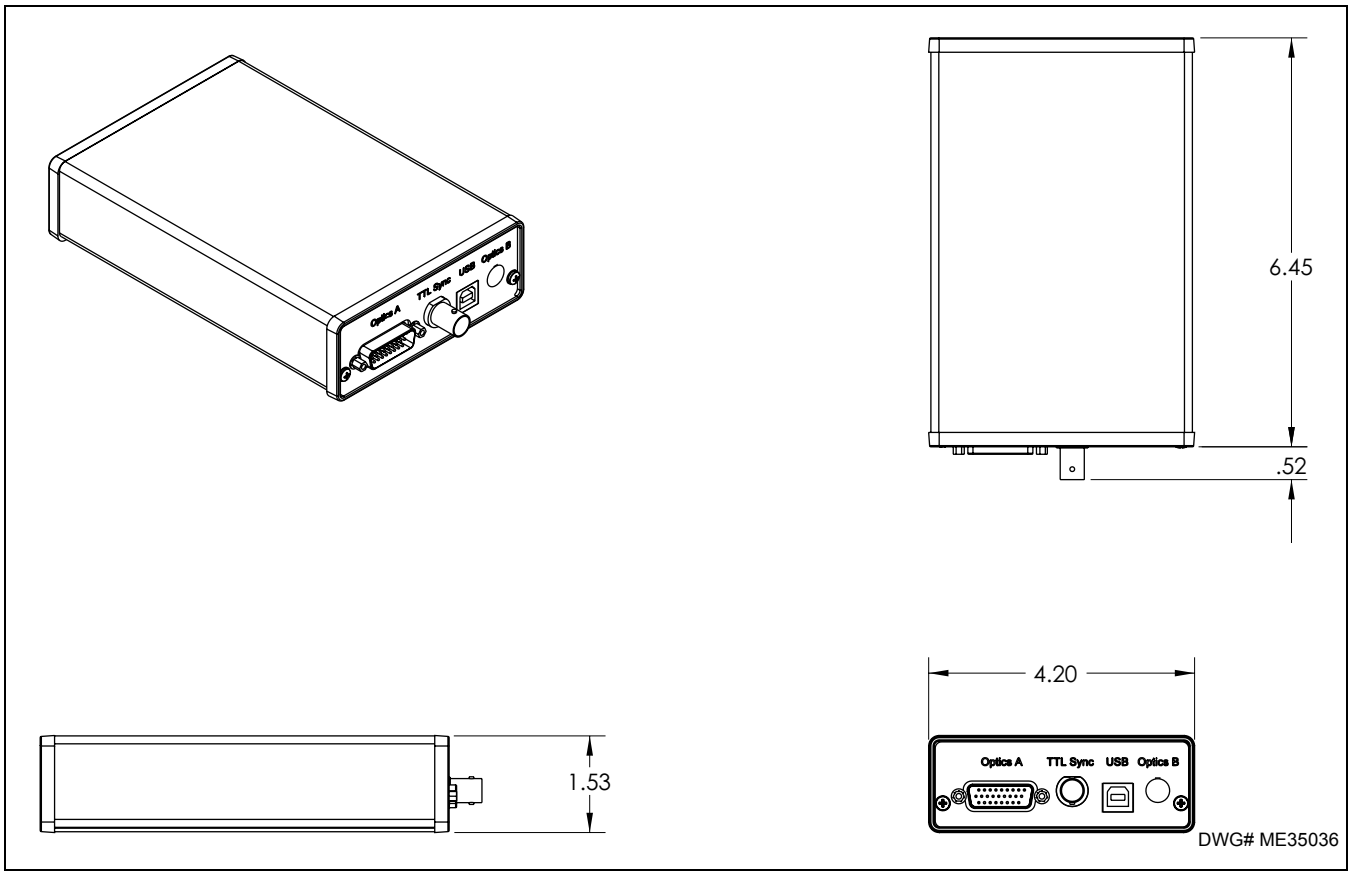

Figure 24. Electronics Controller Module

Optics-to-Electronics Cable

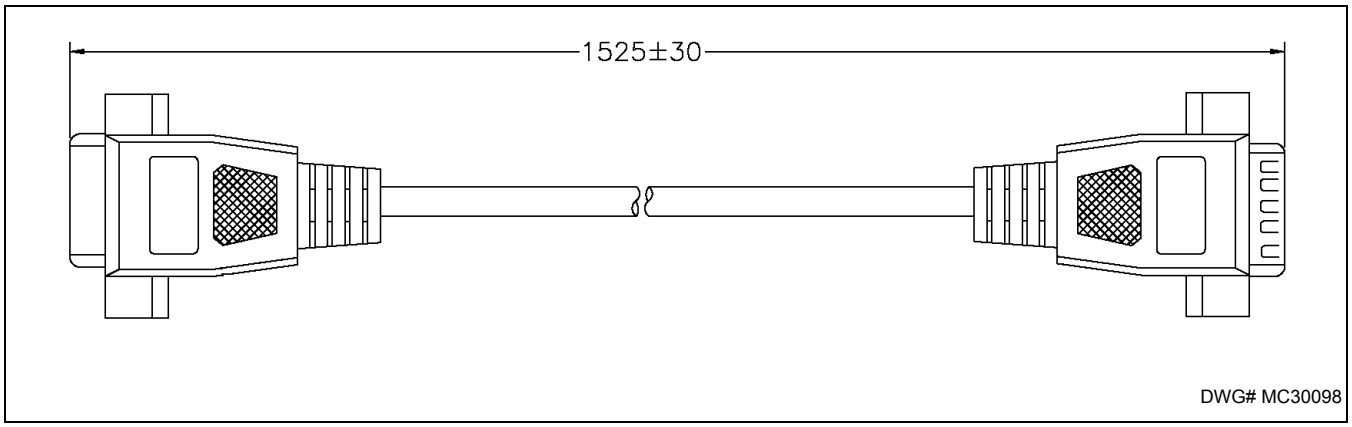

Figure 25. End Connectors of the 26-pin HD Cable with Specified Length

Appendix B. Setting Up a VariSpec Filter

Unpacking the VariSpec Filter and Accessories

Upon receiving your VariSpec LCTF, carefully unpack the components and compare the contents against the shipping list. Be careful with the glass surfaces of the optics module, since they have anti-reflective (AR) coatings that might be scratched if not handled carefully. Make sure that all the appropriate components are present. The following should be included with most models:

- VariSpec Optics Module (20 mm model shown; you may receive two if you ordered a dual-housing model)
- VariSpec Electronics Controller Module (you may receive two if you ordered a dual-housing model)
- 26-pin HD cable for connecting the Optics and Electronics Modules (you may receive two if you ordered a dual-housing model)
- USB interface cable, Type A to Type B for connecting the Electronics Module to your host computer (you may receive two if you ordered a dual-housing model)
- CD-ROM containing the VariSpec SDK installer
- Additional adapters and mounts for Optics Module(s) (mounts for 20 mm model shown; optional)
- VariSpec User's Manual in printed form (not shown)
- Test Summary and Spectral Scan in printed form

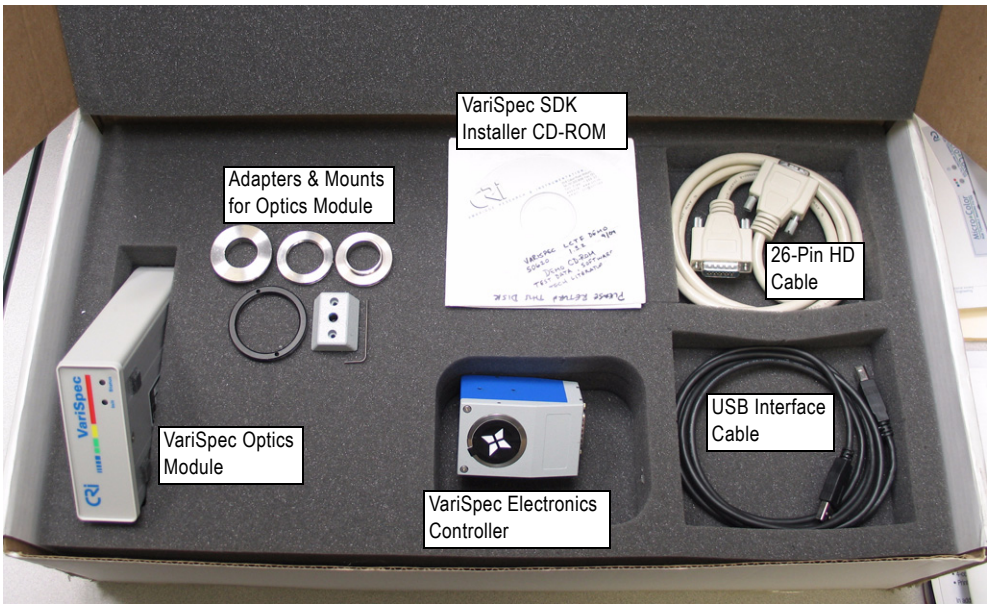

Figure 26. VariSpec Filter and Accessories

Important! Do not connect the VariSpec Electronics Module to your host computer until you have installed the appropriate USB drivers.

Installing the VariSpec Windows-Compatible Software Developer's Kit (SDK)

VariSpec filters feature a self-powered Universal Serial Bus 1.1 (USB) interface to host computers. CRi supplies a Windows-compatible SDK installation CD-ROM with each VariSpec filter. Sample code and documentation are specific to Windows C++. However, you may contact CRi if you are interested in drivers for other operating systems.

Note that these instructions apply to standard single-housing filter designs. Dual-housing designs require two optics modules and two electronics controller boxes. The demonstration software does not support this configuration. But the existing drivers or LabVIEW sub-VIs can be used to write programs fully capable of controlling these models. You can also use HyperTerminal or similar terminal emulators to send the appropriate serial (ASCII character-based) commands to each Electronics Controller Module.

Your host computer will need to be running Windows 2000 or Windows XP. Logging on as an Administrator will prevent any future difficulty with different users accessing the installed software. You must have a USB port available and the port must be able to provide the standard USB power load. If you have other USB devices daisy-chained on the same physical port, you may need to utilize a powered USB hub.

1. DO NOT attach the VariSpec filter hardware to your host computer yet. Turn on your host computer and allow it to boot into the Windows 2000 or Windows XP operating system.
2. Insert the CD-ROM containing the VariSpec demonstration and SDK software into your CD-ROM drive.
3. Locate the Microsoft installer file, most likely named something similar to "VsRev1p35.msi" or "VsRev1p35.exe." The revision number indicates how recently the installation program was released: a file name of "VsRev1p35.msi" indicates that the installation program is more recent than one named "VsRev1p32.msi." The installation program may be located in a folder named "Developers Software" or "Latest VS Software." Double-click the icon to launch the Installation Wizard.
4. Choose the "Full" installation type if you want to install the National Instruments LabVIEW drivers and any additional Windows-compatible drivers for future use. Continue with the Wizard until you can click the **Finish** button.

Connecting a VariSpec Filter to Your Host Computer

1. Connect the VariSpec Optics Module and the Electronics Controller Module with the included 26-pin HD D-sub cable. Make sure not to bend any of the pins. Tighten the locking screws on the cable.

Figure 27. Connect VariSpec Optics Module and Electronics Controller Module using the 26-pin HD D-Sub Cable

2. Connect the Electronics Controller Module and your host computer with the included USB Type A to Type B cable. The rectangular end goes into your host computer's USB port and the other end goes into the rear panel of the Electronics Controller Module.

Figure 28. Connect Electronics Controller Module and Host Computer using the USB Cable

3. Your host computer may sense the presence of new hardware and launch a **Found New Hardware Wizard**. DO NOT proceed until the VariSpec **Status** indicator light on the front of the Electronics Controller Module has finished blinking and is illuminated steady green. The blinking indicates that the filter is initializing the exercising the

liquid crystal (LC) elements in the optics module and bringing the filter to a known state. For example, 550 nm in the case of a visible-wavelength (VIS) model.

4. When the filter has completed its initialization (about 30 seconds), click the **Next** button in the **Add New Hardware Wizard**. (If your computer did not sense the presence of the VariSpec filter, and the wizard did not start automatically, launch the **Add New Hardware Wizard** from the Windows Control Panel.)

5. Choose to "Search for a suitable driver for my device" and click the **Next** button. A **Files Needed** window may appear. Windows may ask if it can install the software automatically or from a list or special location. Choose "automatically or the CD-ROM/installation folder" as the search location. Windows should find a file on the CD-ROM named "ftdibus.inf." Click **Next**. Windows should then find a file named "ftdiport.inf." Click **Next** and then click **Finish**. If Windows cannot find the files, go back and manually locate the files.

6. After the **Add New Hardware Wizard** has finished, you will see a new program group icon appear: **Start > Programs > CRi.** This program group includes the demonstration software "VsGui.exe" and a PDF copy of the User's Manual.

VsGui Program for the Windows 2000 and Windows XP Professional Operating Systems

The CD-ROM that comes with each filter contains a Windows-based installer that installs the VsGui demonstration program on your computer. The program can be used to verify correct filter operation and demonstrate the filter's capabilities.

When launched (select **Start > Programs > CRi > VsGui.exe**), the **VariSpec Control Panel** will appear. You may initially receive an error message saying that software cannot connect to a COM port (Error Code 104) on your host computer. If this occurs, click **OK** and then click the **Configure** button to open the **VariSpec Configuration** window (Figure 30) and select an interface, such as COM1, COM2, COM3, etc.

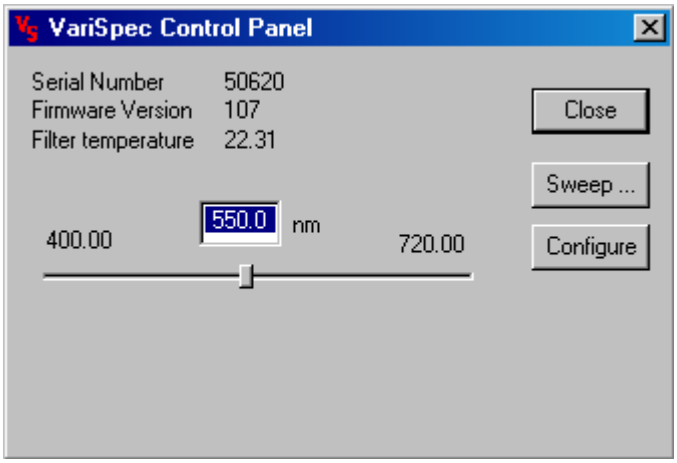

Figure 29. VariSpec Control Panel

The interface for current VariSpec filters is self-configuring, and the **Auto-detect** button should find the correct virtual COM port. Older legacy filters with the RS-232 interface require you to select an available interface. Click the **Close** button when finished to return to the **VariSpec Control Panel**.

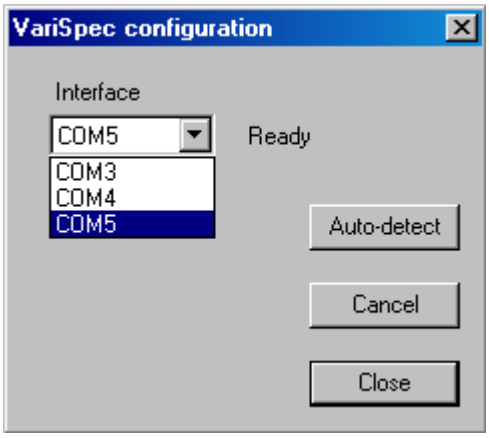

Figure 30. VariSpec Configuration Panel

(You may also check available Windows COM ports by going to the Windows Device Manager.) The VariSpec Windows USB driver utilizes a virtual COM port in case the physical ports are all being used. So you may see a COM4, even if you only had three physical COM ports assigned to your computer before you installed the VariSpec software.

The **VariSpec Control Panel** (Figure 29) allows you to select a wavelength by manually entering a wavelength in nm or by clicking and dragging the slider along a linear scale representing your filter's wavelength range. Your filter's **Serial Number** and **Firmware Version** are displayed and cannot be edited.

Clicking the **Sweep** button opens the **Sweep** window. This window allows you to set a **Wavelength Range** to which the filter is to be tuned, and **Step Size** (in nanometers). You can also set the amount of time you want the filter to remain at each wavelength and whether or not you want the action to be performed only once or repeated indefinitely.

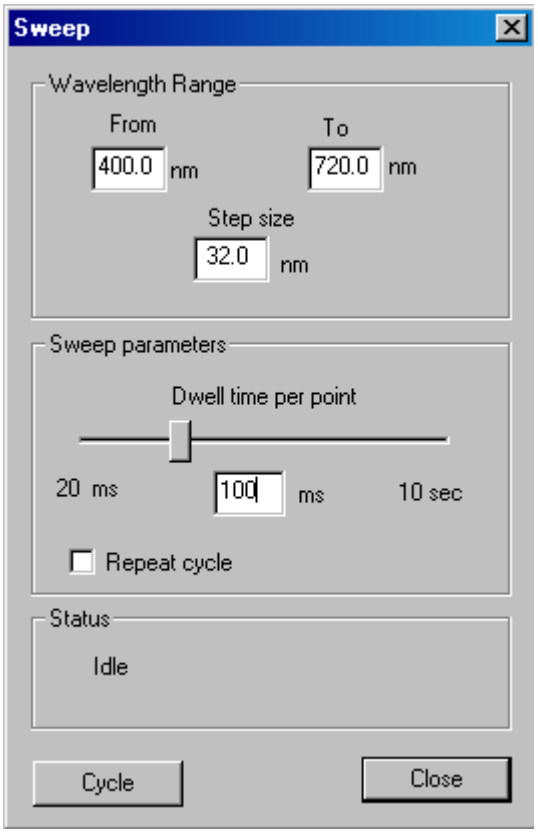

Figure 31. VariSpec Sweep Panel

The VsGui program does not interface with commercial image-capture hardware, but the underlying DLL can be used, along with the previously-mentioned SDK, to create your own application. If you want to write software to control the VariSpec filter using CRi's DLL driver, you may refer to the publication *"Programmer's Guide to VsDrvr"* available separately. The CD-ROM that comes with each filter contains an installer that places this (as a PDF file), along with sample code and the previously-mentioned demo program on your hard drive. The most recent revision of this installer program can be downloaded from CRi's web site or obtained by contacting CRi or your authorized local distributor.

Appendix C. Operating Considerations

This section supplies operating considerations with which you should be familiar to maximize the operation of your VariSpec filter.

Variation of FWHM with Pass Wavelength

The bandwidth of the VariSpec filter is defined as the full-width at half-maximum (FWHM) of the transmission curve. As with all Lyot filters, its bandwidth is constant in wavenumber as the filter is tuned. That means that the FWHM varies with wavelength as $\lambda/8$. This property is intrinsic to all types of Lyot filters. Except for this inherent bandwidth variation, the bandwidth of the VariSpec filter is fixed and cannot be adjusted in the field.

Bandwidth Center Across Angle-of-Acceptance

For standard, single-housing models, the bandwidth uniformity is specified over a 7.5-degree (half-angle) viewing cone, to the normal of the optical surface, and within this cone the passband center does not deviate more than the specified amount. For dual-housing models, the bandwidth uniformity is specified over a 3.5-degree (half-angle) viewing cone. The shift is not the same as for interference filters, where there is a blueshift with increasing angle off-axis.

For the VariSpec filter, the deviation of the curve has a saddle shape. Maximum chromatic shift to the blue occurs for shifts in altitude, maximum chromatic shift to the red occurs for shifts in azimuth, while isochromatic contours are found along the lines at +/- 45º where altitude = +/- azimuth.

Response Time versus Tuning Wavelength

There is no simple relationship between the response time to change from one wavelength to another, and the wavelengths involved, unless they are within about one FWHM of one another. Because of the way the filter is tuned-each stage is operated in high-order, and is only tuned through its free spectral range-some wavelengths requests tune more LC elements than others, resulting in shorter or longer tuning speeds. The electronics must also calculate the relevant element voltages. So, for excursions larger than about one FWHM, the LC element drive state is not easily related to the wavelengths, and the slewing behavior is not easily predicted by the wavelength excursion.

Thermal Drift and Re-Initialization

The VariSpec filter has a slight drift when the optics module temperature changes. This results in a slight wavelength error, in absolute terms. Performing the initialization routine renders the filter insensitive to temperature, to the first order, and so reduces this error greatly. If the ambient temperature has changed by more than +/- 3 ºC, it is wise to perform an initialization ("I 1" or "I 0" commands).

Note that for ratiometric work, it is better not to re-initialize between scans being ratioed, as correcting the absolute wavelength scale for one scan but not the other can exacerbate the effects of drift.

Response Time versus Temperature

The liquid crystal variable retarders set the response time of the filter, and their viscosity varies with the temperature. At 35 ºC, the viscosity is only half its 20 ºC value, allowing faster operation in a warm environment. Elevated temperature use is the single easiest way to improve the response speed. Similarly, if the optics is cooler than 20 ºC, the response time is longer than that given in the Specifications.

Fringing in Coherent Light

The optical module contains several dozen optical elements, cemented together with index-matching epoxies, and in many cases, coated with thin film coatings. As a result, there is spatial fringing when the light being sent through the filter has a coherence length greater than 75 microns. Generally, this is not a problem except when using laser sources, atomic (mercury) lamps, or inorganic fluorescence phosphors. In these cases, the light can be intrinsically monochromatic enough to produce fringes.

Tuning Latency

When the VariSpec tuning is synchronized with an external signal via the TTL/Sync port, there is a slight delay, or latency, before the electronics module actually issues the signals to tune the filter. This latency comes about because of the need to synchronize tuning operations with other processes being performed.

Latency delay does not materially affect the tuning speed. However, because the latency depends on the exact task the electronics is performing when a tuning request is made, the latency has some fluctuation or "jitter". This jitter causes slight variations in the time to tune to the desired wavelength. The magnitude of the jitter does not exceed the worst-case latency, which is 2 milliseconds.

Near-Infrared Warning

Visible-wavelength and a near-infrared wavelength filters do not respond the same to infrared light. Infrared light causes heat. The great majority of energy in halogen lamps,

for example, is in the infrared band (perhaps 90% or more or the total output). VariSpec VIS filters contain a dielectric hot-mirror that reflects this infrared energy away. So the VIS filter is not heated by the infrared light. However, SNIR, LNIR, and XNIR filters do not utilize a hot mirror and they receive all of this infrared energy and are heated by it.

There are two concerns when using an infrared light source: heat at the filter and heat at the sample. For example, the LNIR-06-20-STD filter has a 6 nm bandwidth (FWHM) and transmission of 30%. The total bandwidth for infrared light is 1200 nm. So the fraction of light than passes to the sample is:

transmitted energy function = 0.30 * 6 nm / 1200 nm = 0.0015 or 0.15%.

That means the filter receives 6600 times more energy than the sample! This is one reason why the filter may get hot, even though the sample may not.

Given sufficient heat, delamination may occur in the index-matching epoxy that holds the LC cells to the retarders and polarizers. To cause delamination, two factors must be present: heat and stress. Mechanical stress may be produced by the thermal expansion of the LC cell and other components.

It seems remarkable, but heat can travel through an entire filter. We must distinguish between heat transmission and optical transmission. The filter acts to stop light passing through it, except for the desired wavelength. Energy is absorbed by the filter's optics. Heat can then easily travel through the filter by conduction. Note that the filter is enclosed in an aluminum housing, and aluminum is an excellent conductor of heat.

Using HyperTerminal™ in the Windows Operating System to Control Dual-Housing Filter Models

Certain models of VariSpec filter utilize an optical design that requires two optics modules each with their own matched set of electronics modules. The electronics modules must be sent identical signals from the host computer in order for the filter to function correctly. The demonstration program that CRi provides for free is not designed to drive these filter models.

Custom-written third-party software is usually utilized by OEM customers of these filters. In fact, CRi recommends that those considering the purchase of a VariSpec dual-housing filter make sure they do have appropriate programming resources to properly control these models.

Nevertheless, for demonstration and troubleshooting purposes, the filters can be controlled using the free HyperTerminal program that is included with nearly all computers running the Windows 2000 and Windows XP Professional operating systems.

Your host computer must have two available USB ports and the HyperTerminal program (written by Hilgraeve and distributed by Microsoft).

Installing the Hardware

Skip steps 1 through 8 if you have already performed these steps as part of the Unpacking and Setting-Up section.

1. Click on the Windows **Start** button and go to **Settings > Control Panel > System**. Click on the **Hardware** tab and then the **Device Manager** button. Click on the '**+**' symbol next to the **Ports (COM & LPT)** list item. Note the COM ports that you have on your computer. If you have any other serial devices, such as modems, filter wheels, mice, or keyboards attached to your computer, they will be represented by a particular COM port.
2. Attach the VariSpec electronics module whose serial number has the suffix “A” to the optics module whose serial number has the suffix “A”.
3. Attach the VariSpec electronics module whose serial number has the suffix “B” to the optics module whose serial number has the suffix “B”.
4. Attach the square end of one of the USB cables to the USB connector on the rear panel of the electronics module labeled “A”. Attach the rectangular end of the cable to a USB port on your host computer.
5. If you have not previously used a VariSpec USB filter on your host computer, it will detect the presence of the filter and ask you to locate the USB driver file. If you have the VariSpec CD-ROM in your disk drive, check the box indicating that you wish to have the computer search the CD-ROM for the driver file(s). If you downloaded the driver files from the web site, click **Browse** and select the location of the downloaded and decompressed driver folder.
6. Once the driver files have been installed, your host computer should be able to recognize the filter. You may notice a new COM port or two appear in the **Device Manager Ports** list if your computer has previously assigned the COM ports to other devices. You may close the **Device Manager**.
7. Attach the square end of one of the USB cables to the USB connector on the rear panel of the electronics module labeled “B”. Attach the rectangular end of the cable to a USB port on your host computer.
8. Wait for both sets of optics/electronics modules (A and B) to finish initializing (about 30 seconds, depending on the ambient temperature).
9. Launch the **HyperTerminal** program (usually located in Start > Program Files > Accessories > Communications > HyperTerminal). If it is not present on your computer, you can install it from your original Windows installation CD-ROM using the Add/Remove Programs feature in the Windows Control Panel.

10. The **Connection Description** window will appear. Enter a name such as xNIR01 and click the **OK** button.

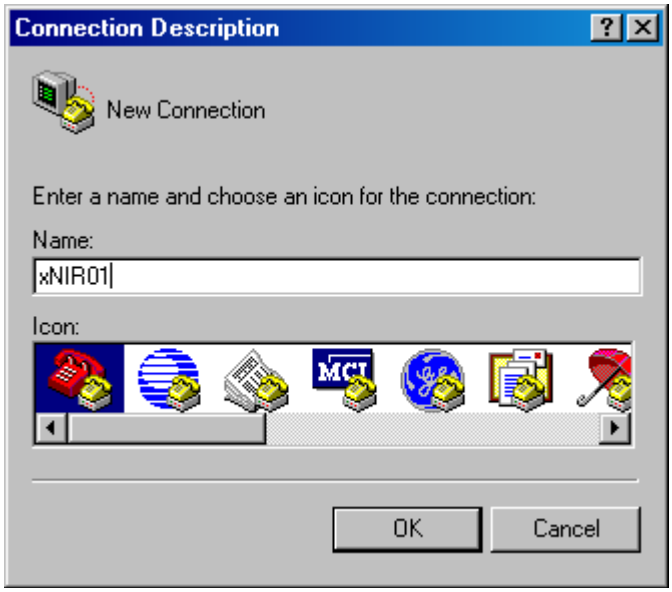

Figure 32. Connection Description

11. In the **Connect To** window, choose a COM port. Notice that in the example, COM 3 has already been assigned to a built-in modem, so is unavailable for use.

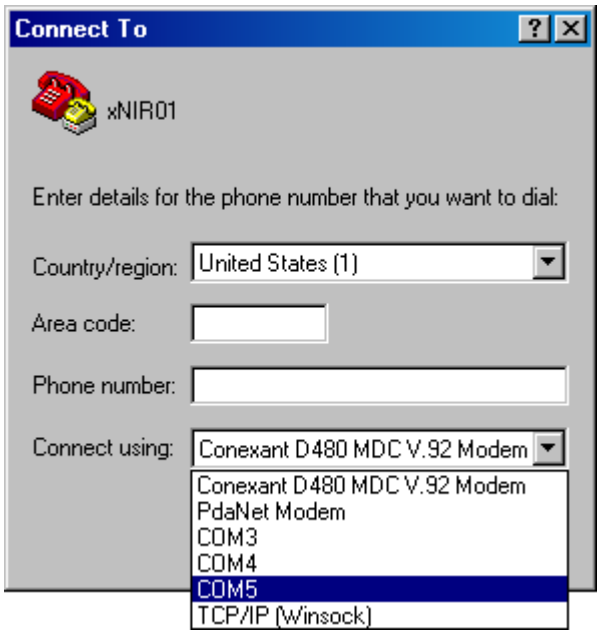

Figure 33. Connect To

12. In the **COMx Properties** window, select the following settings: **Bits per second:** 9600, **Data bits:** 8, **Parity:** None, **Stop bits:** 1, **Flow control:** None. Click the **OK** button.

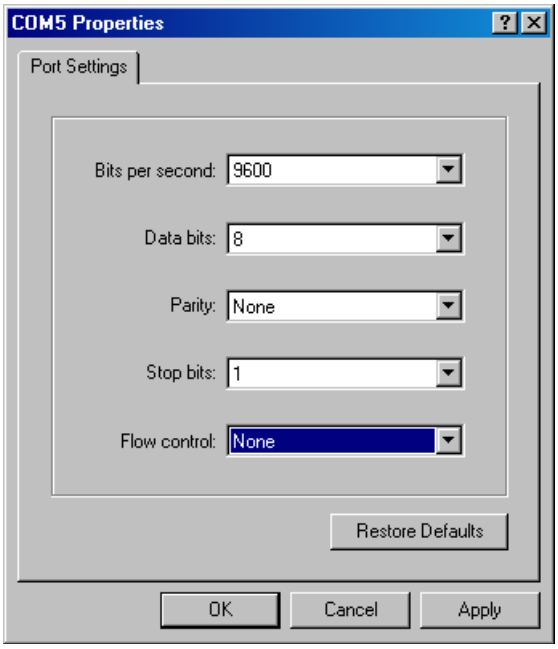

Figure 34. COMx Properties

13. Select the **Properties** item from the **File** menu drop-down list. Click on the **Settings** tab then the **ASCII Setup...** button and select the following settings: "Append line feeds to incoming line ends," and "Wrap lines that exceed terminal width."

14. Click the **OK** button to close the **ASCII Setup...** window. Then click the **OK** button to close the **Properties** window. These settings make it easier to see the commands and responses in the **HyperTerminal** window.

15. You may now type characters that will be sent to the VariSpec filter each time the Enter or Return key is pressed.

16. Repeat steps 9 to 13 if you have a dual-housing model filter. Make sure you select the correct COM port for each optics/electronics set. While both optics/electronics module pairs need to receive the same commands in order for the set to function (and the commands do not have to be sent simultaneously), the delay between commands to each optics/electronics pair should be kept to a minimum.

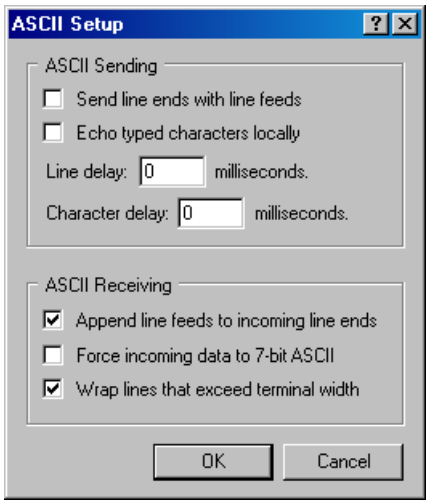

Figure 35. ASCII Setup

Appendix D. Legacy Hardware and Software Considerations

Optics and Electronics Controller Modules

Previous-generation VariSpec filters utilize an RS-232 serial interface. The rear panel of the VariSpec electronics module features an RJ-12 connector and 18VAC 50/60 Hz AC jack. Each filter requires an appropriate power transformer for the country it is to be used in. The US and Japan transformer is an 18V, 880 mA model.

An RJ-12 straight-through modular data cable is plugged into the RS-232 connector. The other end is plugged into an RJ-12 to DB-9 adapter for the host computer's serial (COM) port. COM port settings for legacy filters are identical to the COM port settings for current USB filters: Bits per second: 9600, Data bits: 8, Parity: None, Stop bits: 1, Flow control: None.

The form-factor of the optics modules for legacy filters may differ from the mechanical drawings included in this publication.

Previous-generation filters utilized a much slower microprocessor for wavelength tuning calculations. The use of palette functions is encouraged as a way to tune as fast as possible, given a set of wavelengths of interest. Random tuning using the 'W' command can result in transition times in the hundreds of milliseconds. Accessing a stored wavelength using the palette commands results in much faster transition times from 50 ms to 150 ms. Current filters with USB electronics always tune as fast as they are capable (at a given ambient temperature). See the Specifications section.

Handheld Controller

A handheld controller that interfaces with the previous-generation filters using the RS-232 connector is available. Current filters that use the USB interface do not need this accessory, since they can be installed and tested more easily using more recent software releases and host computers with available USB ports.

Legacy Software

Software available from CRi prior to the release of filters with USB control consisted of the following:

- CRiS3: an obsolete standalone program compiled using the LabVIEW programming environment. Older LabVIEW sub-VIs were also available and are no longer supported. Current, updated sub-VIs are available from CRi for those who wish to use LabVIEW.

- VSGui Software Developer's Kit and demonstration executable (revisions prior to 1.2): an obsolete standalone program that will allow a programmer to use a CRi-written Windows dynamically-linked library (DLL) to control the filter from the CRi-written demonstration program or a user-written program. Current versions will work with both present USB and most legacy RS-232 serial hardware.

Contact CRi if you have legacy hardware and/or software and wish to upgrade or purchase new software or hardware.

Appendix E. CRi Software End-User License Agreement

The following is an agreement (the "Agreement") between you and Cambridge Research & Instrumentation Inc., 35-B Cabot Road, Woburn, MA 01801 ("CRi") for software known as the VariSpec Software Developer's Kit (SDK) and its accompanying documentation (collectively, the "Software"). By installing and/or using the Software, you agree to the following terms and conditions. If you do not agree to all of the terms and conditions in this Agreement, you may not install or use the Software.

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Miscellaneous. This Agreement contains the entire agreement of the parties with respect to the subject matter hereof and supersedes any proposal or prior agreement, written or oral, and any other communications between the parties relating to the subject matter hereof. No modification or waiver of any provision of this Agreement shall be effective unless in writing and signed by the parties. No delay or failure on the part of any party in exercising any right under this Agreement shall impair any such right or any remedy of such party, nor shall it be construed to be a waiver of any continuing breach or default under this Agreement. In the event any provision of this Agreement is held to be unenforceable, the remaining provisions of this Agreement will remain in full force and

effect. This Agreement shall be governed by the laws of the State of New York without regard to principles of conflicts of laws. Any disputes relating hereto shall be adjudicated only in the state or federal courts in New York County, New York State, and you hereby consent to the exclusive jurisdiction of those courts. This Agreement shall not be governed by the United Nations Convention on Contracts for the International Sale of Goods, the application of which is expressly excluded. You may not assign or otherwise transfer this Agreement or any of your rights or obligations therein without the prior written consent of CRi. You may not use the Software for any unlawful purpose nor export or re-export the Software except as authorized by law.

Should you have any question concerning this Agreement, you may contact CRi by writing to CRi, 35-B Cabot Road, Woburn, MA 01801. You may also call 1-800-383-7924 in the US or +1-781-935-9099 elsewhere.

VariSpec™ Quick Start Guide for a Windows®-based Host Computer

MD15473 Rev. A, October 2006

⚠ New VariSpec liquid crystal tunable filters (LCTFs) feature a self-powered Universal Serial Bus (USB) interface to host computers. CRi supplies Windows-compatible demonstration software and a software developer's kit (SDK) on the CD-ROM that comes with each VariSpec filter. Sample code and documentation are specific to Windows C++. However, you may contact CRi (techsupport@cri-inc.com, Tel: +1 781-935-9099, Fax: +1 781-935-3388) if you are interested in drivers for other operating systems. National Instrument's LabVIEW™ sub-VIs are also included on the CD-ROM, and may be installed if desired.

⚠ These Quick Start instructions apply to standard *single-housing* filter designs. *Dual-housing* designs such as the 0.25 nm narrowband, LNIR-06-20, or XNIR-09-20 models require two optics modules and two electronics controller boxes. The demonstration software does not support these configurations at this time. But the existing drivers or sub-VIs can be used to write programs fully capable of controlling these models. See the most recent VariSpec User's Manual for more information, or contact your authorized CRi distributor or CRi technical support.

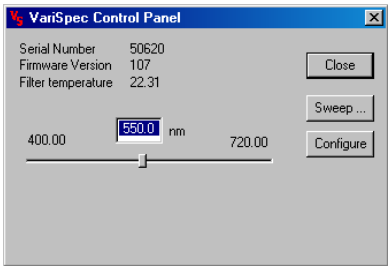
⚠ Your host computer needs to be running Windows 2000 or Windows XP Professional. Logging on as an Administrator will prevent any future difficulty with different users accessing the installed software. You must have a USB port available and the port must be able to provide the standard USB power load. If you have other USB devices daisy-chained on the same physical port, you may need to utilize a powered USB hub.

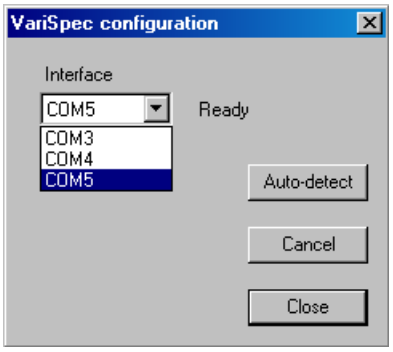
1. Unpack the VariSpec filter. Make sure that all components are present. Be careful with the glass surfaces of the optics module, since they have anti-reflective (AR) coatings that might be scratched if not handled carefully.
2. DO NOT attach the VariSpec filter hardware to your host computer yet. Turn on your host computer and allow it to boot into the Windows 2000 or Windows XP operating system.
3. Insert the CD-ROM containing the VariSpec demonstration and SDK software into the host computer's CD-ROM drive.
4. Locate the Microsoft installer file, most likely named something similar to "VsRev1p35.msi" or "VsRev1p35.exe." The revision number indicates how recently the installation program was released: a file name of "VsRev1p35.msi" indicates that the installation program is more recent than one named "VsRev1p32.msi". The installation program may be located in a folder named "Developers Software" or "Latest VS Software." Double-click the icon to launch the Installation Wizard.

5. Choose the "Full" installation type if you want to install the National Instruments LabVIEW drivers and any additional drivers for future use. Continue with the Wizard until you can click on the **Finish** button.
6. Connect the VariSpec optics module and the electronics controller box with the included 26-pin HD cable. Make sure not to bend any of the pins. Tighten the locking screws on the cable.

7. Connect the electronics controller box and your host computer with the included USB Type A to Type B cable. The rectangular end goes into your host computer's USB port and the other end goes into the back panel of the electronics controller box.
8. Your host computer may sense the presence of new hardware and launch a **Add New Hardware Wizard**. DO NOT proceed until the VariSpec **Status** indicator light on the controller box has finished blinking and is illuminated steady green. The blinking indicates that the filter is initializing and exercising the liquid crystal (LC) elements in the optics module and bringing the filter to a known state. For example 550 nm in the case of a visible-wavelength (VIS) model.
9. When the filter has completed its initialization (about 30 seconds), click the **Next** button in the **Add New Hardware Wizard**. (If your computer did not sense the presence of the VariSpec filter, and the wizard did not start automatically, launch the **Add New Hardware Wizard** from the Windows Control Panel.

10. Choose to “Search for a suitable driver for my device” and click the **Next** button. A **Files Needed** window may appear: Windows may ask you if it can install the software automatically or from a list or special location. Choose “Automatically or the CD-ROM/ installation folder” as the search location. Windows should find a file on the CD-ROM named “ftdibus.inf.” Click **Next**. Windows should then find a file named “ftdiport.inf.” Click **Next** and then **Finish**. If Windows cannot find the files, go back and manually locate the files.
11. After the **Add New Hardware Wizard** has finished, you will see a new program group icon appear: **Start > Programs > CRi**. This program group includes the demonstration software “VsGui.exe” and a PDF copy of the User's Manual.
12. Choose the **VsGui.exe** menu item in **Start > Programs > CRi**. The **VariSpec Control Panel** should launch. If it does not, you may have other serial devices on your host computer, or at least have some COM ports already assigned to other devices. You may see an error message such as one that says “Unable to connect to Port COM0.” Click **Okay** until the **VariSpec Control Panel** appears.
13. Click the **Configure** button to select a COM port. Continue down the list until the software recognizes the filter hardware and displays the filter serial number, firmware revision number, and wavelength range.
14. You may also check the available Windows COM ports by going to the Windows Device Manager. The VariSpec Windows USB driver utilizes a “virtual” COM port in case the physical ports are all utilized. So you may see a COM4, even if you only had three physical COM ports assigned to your computer before you installed the VariSpec software.





Congratulations! You may now use the demonstration software to tune the VariSpec filter. The software makes a great troubleshooting tool if you are writing your own software, or if you simply wish to manually tune the filter.

Operational Notes:

- Unplugging the VariSpec filter from the physical USB connection will not harm it under normal circumstances. But plugging it back into the USB port will require another initialization cycle (about 30 seconds) in order for the filter to begin accepting and processing commands. While the filter is initializing, a communications buffer will store commands sent to it, for immediate processing once initialization has completed.
- The VariSpec filter has a transition time of approximately 50 ms for VIS models and 150 ms for near-infrared (SNIR, LNIR, or XNIR) models. Selecting a faster interval between selected wavelengths will result in the filter being placed into unknown and uncharacterized transitional states. Transition time is affected by the ambient temperature: higher temperatures allow the LC to become less viscous and faster. Nevertheless, always stay within the recommended operating temperature and maximum input flux (500 mW/cm^2 to prevent damage to the LC.
- Longer or extended 26-pin cables may allow the VariSpec filter to function correctly, but if the drive impulses utilized by the electronics controller box are too weak, you will see an error condition of “Drive levels out of range.”

Older-model serial (RS-232) interface filters:

- You may utilize the software and SDK, so long as you remember that you must manually select the COM port in the **VariSpec Configuration** window in the VsGui.exe program.

Technical Assistance:

Having difficulty setting up, operating, or maintaining your VariSpec LCTF? Contact your local CRi representative.

CRi's main US office hours are from 8:00 a.m. to 6:00 p.m. (Eastern Standard/Daylight Time), Monday through Friday.

- Telephone (US Toll-Free): 1-800-383-7924
- Telephone (Worldwide): +1-781-935-9099
- Facsimile (Worldwide): +1-781-935-3388
- E-mail: techsupport@cri-inc.com

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Warranty

CRi warrants its VariSpec LCTFs for a period of one (1) year from date of shipment against defects in material and/or workmanship, provided its installation, application, and maintenance are within specifications. Normal wearing parts are excluded. This warranty covers only items manufactured by CRi. CRi will correct, by repair or replacement-at its option and its expense-any proved defects in items of its manufacture, subject to above, provided immediate written notice of such defects is given.

A valid Return Materials Authorization (RMA) must be obtained by contacting CRi before items may be returned to the factory. Repair or replacement will be provided F.O.B. (Freight On Board) at CRi's factory. The total financial obligation of CRi, under this warranty, does not exceed the purchase price of the items of its manufacture as set forth on normal pricing schedules. We will not assume any expense or liability for repairs made by others without our prior written consent.

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TO PLACE AN ORDER OR RECEIVE TECHNICAL ASSISTANCE

For more information, contact CRi or your local authorized CRi distributor:

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