

Liquid Crystal Tunable Filters

Key Features and Benefits

- Revolutionary new design eliminates the need for a separate controller box (except for the XNIR-09-20 model)
- Solid-state design for rapid, vibrationless tuning
- Large apertures (up to 35 mm) with excellent imaging quality
- Variety of models offering tunability over hundreds of nanometers
- USB interface with free Software Developer's Kit (SDK) for efficient low-power operation

VariSpec

Effortlessly tune to any wavelength in the VIS or NIR range – without moving parts

VariSpec™ Liquid Crystal Tunable Filters (LCTFs) are like high-quality interference filters, but the wavelengths of light they transmit are electronically controllable, providing rapid, vibrationless selection of any wavelength in the visible and near-infrared spectra. VariSpec filters' wavelength selection, large apertures, and excellent imaging quality are valuable in a wide variety of applications such as remote sensing for agriculture and defense, chemical imaging, semiconductor process control, machine vision, and biomedical imaging.

Multispectral Imaging

Visible light is made up of a mixture of wavelengths that our eyes interpret as "color". Remarkably, although we can distinguish millions of different colors or color combinations, we cannot perceive all the wavelength (or "spectral") information in our visual environment. This is because our eyes (as well as conventional color films and color digital cameras) separate visible light, no matter how spectrally complex, into only three color bins: red, green, and blue (RGB).

Light with completely different spectral content can have precisely the same RGB coordinates. For example, when we see a yellow color, we cannot tell if it comes from a "pure" yellow color or from a mixture of red color and green color. Multispectral imaging can.

Multispectral imaging is a technique that provides images of a scene at multiple wavelengths and can generate precise optical spectra at every pixel. VariSpec filters represent an ideal technology for affordable, precise, and robust multispectral imaging.

How do VariSpec filters work?

Our patented VariSpec technology adds liquid crystal variable retarders to a Lyot filter design, enabling spectral tuning without moving parts. A series of optical elements are bonded together in series with index-matching epoxy. Each element (or stage) 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 within the wavelength range of the filter. Typical transmission outside the passband is 0.01% or less.

VariSpec Terminology and Principles of Operation

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.

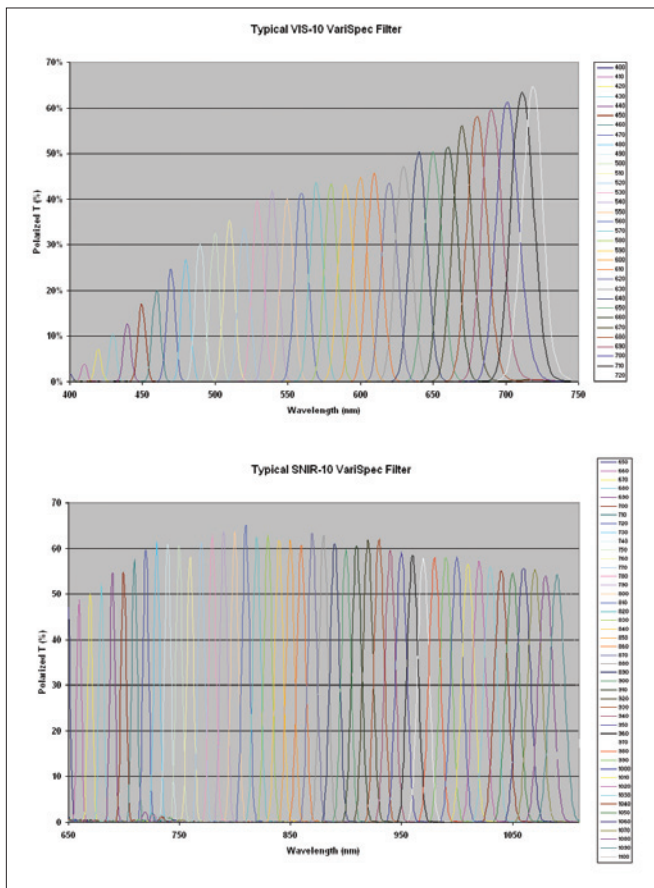


Figure 1. VariSpec filters come in a variety of models spanning the visible to near-infrared spectrum. Shown above are typical spectral scans, taken at 10-nm intervals, of a visible-wavelength (VIS) model filter and a short-wavelength near-infrared (SNIR) model filter.

Center Wavelength

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

Off-Axis Performance at Limit of Field-of-View (FOV)

Off-axis rays at the limit of the field-of-view (FOV) 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. Typically, this time is 50 ms for VIS models and 150 ms for others.

Transmission

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

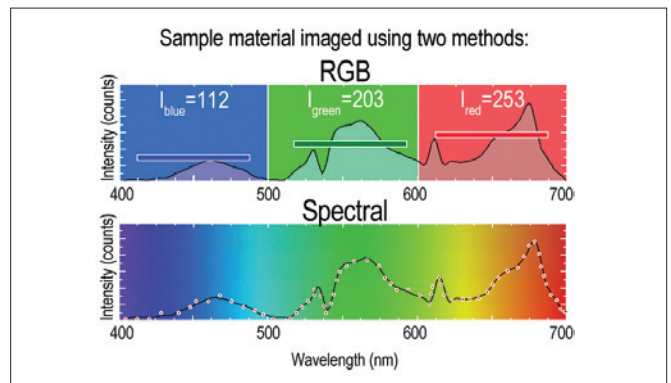


Figure 2. Multispectral imaging can capture information about your sample that would normally be lost using conventional color imaging where the nuances of the complex spectral curve shown above are 'binned' into only three values for red, green, and blue. VariSpec filters let you capture all of the spectral information from your sample instead of just an average.

Tuning Accuracy

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

Damage Threshold of the Filters

The damage threshold for reasonably long-term exposure to visible (VIS) and near-infrared (NIR) energy is 500 mW/cm². VariSpec filters absorb light that you do not want transmitted.

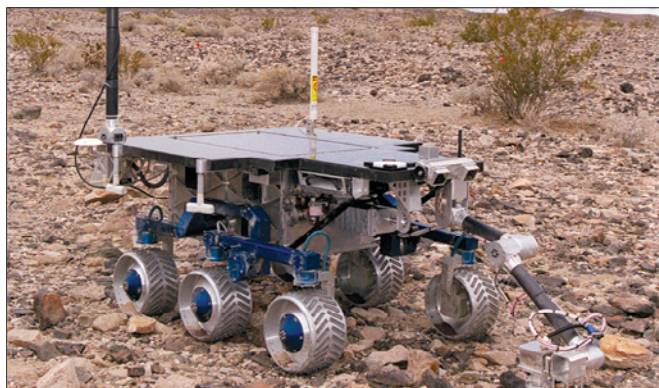
VIS model filters have an integral hot-mirror element to reflect unwanted NIR light, but UV light and longer wavelength light in the form of thermal energy can damage the filters.

Filter Thickness

Standard VIS and SNIR model filters' optical elements are about 1.5 inches thick. Other models may be thicker. Contact us for more information on specific models.

Specifications

	VariSpec VIS/VISR	VariSpec SNIR/NIRR	VariSpec LNIR	VariSpec XNIR
Spectral range	400 - 720 nm (VIS) 480 - 720 nm (VISR)	650 - 1100 nm	850 - 1800 nm	1200 - 2450 nm
Bandwidth	7, 10, or 20 nm (VIS) 0.25 nm (VISR)	7 or 10 nm (SNIR) 0.75 nm (NIRR)	6 or 20 nm	9 nm
Aperture	20 or 35 mm	20 mm	20 mm	20 mm
Angle-of-acceptance	7.5° half-angle (VIS) 3.5° half-angle (VISR)	7.5° half-angle (SNIR) 3.5° half-angle (NIRR)	3.5° half-angle	3.5° half-angle
Response time (room temp)	50 ms (VIS) 150 ms (VISR)	150 ms	150 ms	150 ms
Wavelength accuracy	Bandwidth/8 \pm 0.5 nm	Bandwidth/8 \pm 0.5 nm	Bandwidth/8 \pm 0.5 nm	Bandwidth/8 \pm 0.5 nm
Maximum optical throughput	500 mW/cm ²	500 mW/cm ²	500 mW/cm ²	500 mW/cm ²
Operating temp	10 to 40 °C	10 to 40 °C	10 to 40 °C	10 to 40 °C
Storage temp	-15 to 55 °C	-15 to 55 °C	-15 to 55 °C	-15 to 55 °C
Computer interface	USB 1.1	USB 1.1	USB 1.1	USB 1.1
Power supply	USB bus-powered	USB bus-powered	USB bus-powered	USB bus-powered
Software	Free SDK, demo program	Free SDK, demo program	Free SDK, demo program	Free SDK, demo program



Tunable filter modules have been flight-qualified for NASA space missions, such as the Rocky 7 Mars Rover shown above, and have been used in airborne remote-sensing platforms for many years.

Nuance™, Vectra™, TRIO™ and Maestro™ Multispectral Imaging Systems

Rely on our powerful and easy to use turnkey systems for an integrated multispectral imaging solution.

Nuance and TRIO systems for your microscope enable you to clearly visualize multiplexed brightfield and fluorescent markers. Nuance systems can also be used in the field for remote sensing or industrial applications. Vectra systems offer automated imaging and analysis for up to 200 slides at a time. Maestro in vivo imaging systems outperform all other imaging systems in their ability to detect and separate even weak overlapping fluorescent signals in live animals, such as nude mice.

For more information, please visit www.CaliperLS.com/VariSpec

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