

IMSPECTOR

imaging spectrographs

General Description

Middleton Research offers the complete line of Specim Ltd. ImSpector™ Series imaging spectrographs for spectral imaging applications in both industry and scientific research for every wavelength region. Spectrographs are complex optical components that change a camera to a hyperspectral imaging device with full contiguous spectral information and high spectral resolution. The spectrograph can be attached and integrated with a monochrome camera using a standard C- or U-mount to build a line imaging hyperspectral camera. The spectrograph may be integrated by the end-user. Specim Ltd. also offers an integration service; contact Middleton Research for more information.

The unique design of the transmission imaging technology makes the spectrograph an inexpensive, light-weight, rugged component designed to withstand industrial use and harsh environments. The ImSpector Series spectrographs combine high diffraction efficiency over a broad spectral range. The transmission grating-based optical design allows excellent image quality and a short focal length. The spectrograph designs are also independent of the polarization state of the incoming light. The spectrographs can be integrated with multi-channel fiber optic arrays, creating devices capable of simultaneous spectral measurement of up to 120 points.

Accessories

Various accessories can be combined or integrated with the spectrographs, including fore optics (special hyperspectral lenses), fiber optics, or filters to improve the quality of measured data. Hyperspectral fore optics are available for wavelength regions between 400 nm and 12,000 nm. Multiple point fiber optics are offered for wavelength regions between 200 nm and 2,500 nm. Find more details and options in the Accessories chapter.

Slits

Each ImSpector model has a standard input slit with a fixed length. The length of the slit defines the length of the usable spatial axis (i.e. sensor width) and thus also defines the spatial resolution. Together with the chosen lens, the length of the slit also determines the field-of-view.

The slit length is fixed in a spectrograph, however a range of standard slit widths are available for each ImSpector and must be defined at the time the spectrograph is ordered so that the installation and calibration can be performed at the factory. All default and standard slit widths are listed in the specifications tables for each ImSpector. Different slit widths can be manufactured, so a non-standard slit width may be chosen for an additional fee.

The slit width affects three parameters: spectral resolution, throughput, and the width of the imaged line. The spectral resolution can be improved by choosing a narrower slit width. However, please note that the pixel size of the focal plane detector and other optical design factors also affect the spectral resolution. The optical throughput of the spectrograph is also affected by the width of the slit. Decreasing the slit width will cause reduced throughput, which can be offset by an increase in the integration time or a brighter illumination source. The width of the slit (together with the lens) determines the width of the imaged line.



MWIR M50M ImSpector shown with lens

Selecting a Spectrograph

When choosing a spectrograph, the most important factors to consider are wavelength range and resolution. Minimizing aberrations is essential for high resolution applications. For more information on keystone and smile aberrations, please refer to the glossary at the end of the catalog.

The ImSpector spectrograph product line includes four different series: Enhanced, Standard, Fast, and M-Series.

- The Enhanced E-Series offers the best optical performance, and is recommended for high resolution applications (< 3 nm). Models are available for UV, visible, Raman, VNIR, NIR and SWIR ranges and are suitable for large area sensors. The enhanced series offers higher light throughput than the Standard Series and minimizes keystone and smile aberrations to sub-pixel levels.
- The Standard Series contains basic spectrographs used mainly for machine vision and other, less spectroscopically-demanding applications. Models are available for VIS and VNIR and for 2/3" or 1/2" sensors. The spectral resolution ranges from 6 - 11 nm.
- The Fast Series spectrograph for the VNIR region is designed for both high speed (> 200 fps) and low light level applications. The fast spectrograph is used to achieve short read-out time (high frame rate) and high light throughput (short integration time) at a lower spectral resolution (15 nm).
- The M-Series is a new line of spectrographs for the VNIR, MWIR, and LWIR ranges that produces the best image quality by providing an increase in spatial resolution. These spectrographs use a transmissive dispersive element based on a new optical design. As a result, the M-Series spectrographs are suitable for use with larger detectors while remaining lightweight and compact.

Wavelength Region	Spectral Range	Model	Spectral Resolution
Raman	530 – 630 nm	R6E	0.3 nm
	770 – 980 nm	R10E	0.3 nm
UV	200 – 400 nm	UV4E	2 nm
VIS	380 – 800 nm	V8H	8 nm
		V8	6 nm
		V8E	2 nm
VNIR	400 – 1000 nm	V10H	11.2 nm
	400 – 1000 nm	V10	9 nm
	400 – 1000 nm	V10E	2.8 nm
	400 – 1000 nm	Fast10	15 nm
	350 – 1000 nm	V10M	1.5 nm
NIR	900 – 1700 nm	N17E	5 nm
SWIR	1000 – 2500 nm	N25E	8 nm
MWIR	3000 – 5000 nm	M50M	35 nm
LWIR	8 – 12 μ m	*	*

* LWIR spectrographs are available only as full hyperspectral imaging cameras. Refer to Cameras chapter for details.



RAMAN SPECTROGRAPHS

530 – 630 nm & 770 – 980 nm

Raman is a very low light level technique, and even small improvements in the optical system can significantly expand detection capabilities.

+Raman scatter is a faint radiation detected close to the illuminating laser line, on the long wavelength side of the laser wavelengths. The Raman spectrographs have high performance necessary for optimum Raman spectroscopy applications that require high throughput, high spectral resolution, and the best possible imaging performance.

Spectrographs are available for system integration as either imaging or multichannel devices, providing easy integration with different types of CCD and CMOS cameras as well as microscopes.



There are two Raman spectrographs to choose from, depending on application requirements. Mechanically, these spectrographs differ slightly because they are optically designed for two distinct spectral ranges. The R6E covers the shorter wavelengths with a smaller range, while the R10E covers the longer wavelengths with a larger range. The R10E uses a larger spectral dispersion to achieve a larger spectral range. As an example, the pictures and mechanical drawings shown here depict the R6E spectrograph.

The current optical design of the Raman spectrographs is matched to Andor iStar 734 or Ixon 888, and Princeton instruments PI-MAX3-1024i or PI-MAX1K cameras with a 1024 x 1024 pixel sensor with 13 μm pixel size.

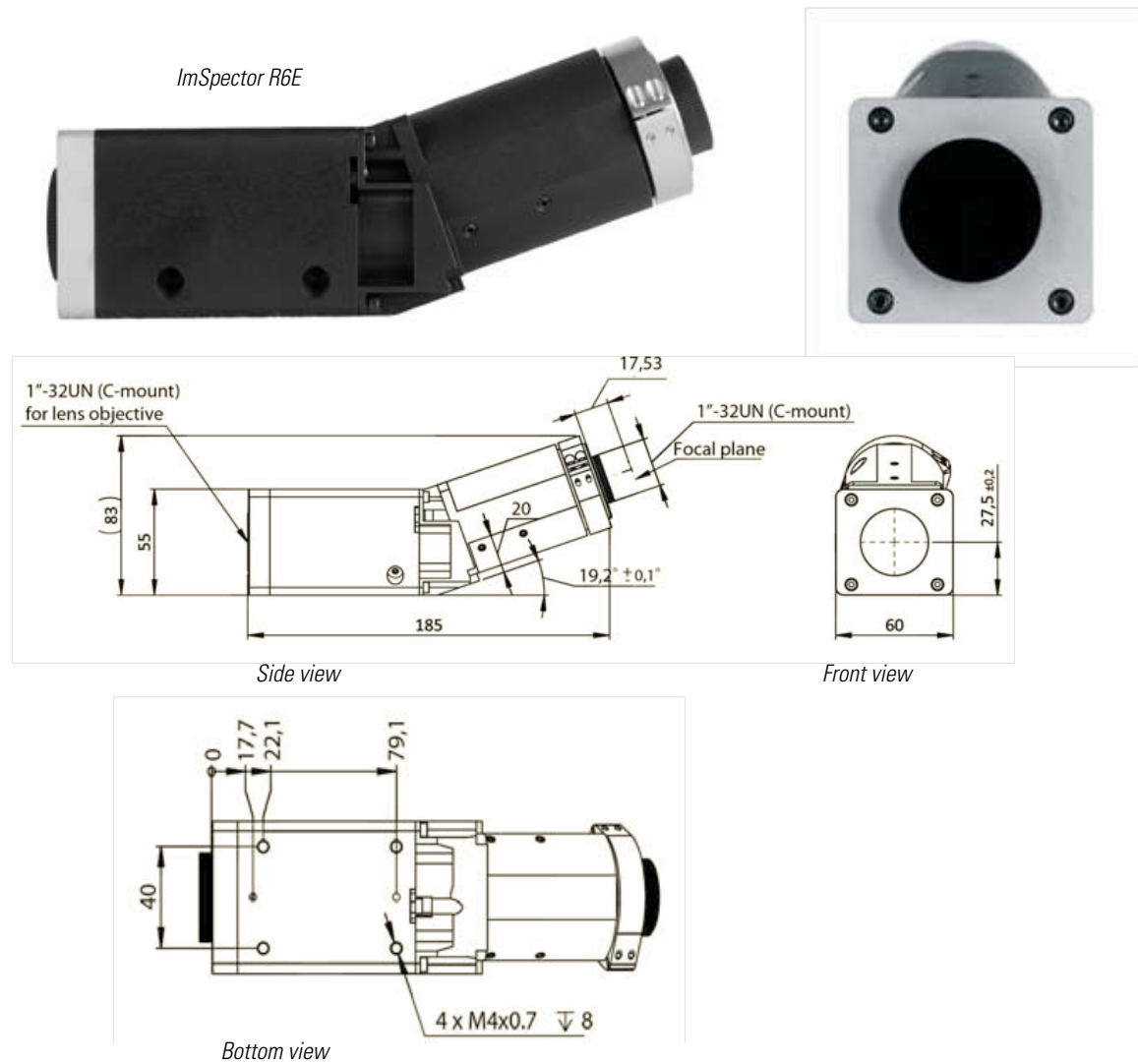
Raman Spectrograph Specifications

Optical Characteristics	R6E	R10E
Spectral Range	530 - 630 nm (18900 - 15900 cm^{-1})	770 - 980 nm (13000 - 10200 cm^{-1})
Spectral Dispersion	7.7 nm/mm	16.15 nm/mm
Spectral Resolution	0.3 nm ($\approx 10 \text{ cm}^{-1}$)	0.3 nm ($\approx 10 \text{ cm}^{-1}$)
Image Size (Spectral x Spatial)	13 x 13 mm	13 x 13 mm
Numerical Aperture	0.21 (F/2.4)	0.21 (F/2.4)
Optical Input	Telecentric	Telecentric
Average Diffraction Efficiency	> 65%	> 65%
Stray Light	< 0.5% (halogen lamp, 633 nm long-pass filter)	< 0.5% (halogen lamp, 633 nm long-pass filter)
Slit Width, default	30 μm (13, 18, 50, and 80 μm available on request)	30 μm (13, 18, 50, and 80 μm available on request)
Slit Length	14.3 mm	14.3 mm
Magnification	1:1	1:1
Aberrations		
Bending of Spectral Lines Across Spatial Axis	Smile < 3 μm (0.025%)	Smile < 3 μm (0.025%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 3 μm (0.025%)	Keystone < 3 μm (0.025%)
Astigmatism	None	None
Mechanical Characteristics		
Body	Anodized Aluminum Tube	Anodized Aluminum Tube
Size (W x H x L)	60 x 83 x 187 mm	60 x 83 x 187 mm
Weight	1100 g	1100 g
Lens Mount	Standard C-mount Adapter (removable)	Standard C-mount Adapter (removable)
Camera Mount	Standard C-mount Adapter (removable)	Standard C-mount Adapter (removable)
User Adjustments	Image axis rotation relative to detector rows, back focal length adjustable ± 1 mm (for both)	
Environmental Characteristics		
Storage Temperature, non-condensing	-20 $^{\circ}\text{C}$... + 85 $^{\circ}\text{C}$	-20 $^{\circ}\text{C}$... + 85 $^{\circ}\text{C}$
Operating Temperature, non-condensing	+ 5 $^{\circ}\text{C}$... + 40 $^{\circ}\text{C}$	+ 5 $^{\circ}\text{C}$... + 40 $^{\circ}\text{C}$

A complete Raman measurement system consists of:

- Excitation laser
- Block filter for illumination
- Front optics – multichannel fiber or imaging lens
- Raman spectrograph
- Sensitive CCD or CMOS detector

The ImSpector Raman spectrograph should be used as a part of the measurement system, where all the remaining components are also optimized for the measurement setup. The ImSpector Raman spectrograph can also be used as high resolution spectrograph for standard spectral imaging or multichannel measurements.



Raman Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-318-001-01	ImSpector - Enhanced Raman Spectrograph R6E, 30 μm slit* (default)	ImSpector R6E
MRC-318-001-02	ImSpector - Enhanced Raman Spectrograph R10E, 30 μm slit* (default)	ImSpector R10E

* When ordering please specify if different slit width is needed.

UV SPECTROGRAPH 200 – 400 nm



The ImSpector UV4E provides high image quality and optical throughput from 200 - 400 nm. UV spectrographs include an order blocking filter already installed. The UV spectrograph can be integrated with a UV sensitive CCD or CMOS camera, creating a line-scan hyperspectral imaging device. The camera system can be used for UV imaging applications.

UV Spectrograph Specifications

Optical Characteristics	UV4E
Spectral Range	200 - 400 nm
Spectral Dispersion	56.5 nm/mm
Spectral Resolution	2 nm (30 μ m slit)
Spatial Resolution	rms spot radius < 30 μ m
Image Size (Spectral x Spatial)	3.54 x 8.8 mm
Numerical Aperture	F/2.8
Optical Input	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 633 nm long-pass filter)
Slit Width, default	50 μ m (80 μ m slit available on request)
Slit Length	9.8 mm
Magnification	1:1

Aberrations

Bending of Spectral Lines Across Spatial Axis	Smile \leq 0.1 nm (0.05%)
Bending of Spatial Lines Across Spectral Axis	Keystone \leq 3 μ m (0.034%)
Astigmatism	None

Mechanical Characteristics

Body	Anodized Aluminum
Size (W x H x L)	50 x 55 x 165 mm
Weight	320 g
Lens Mount	Standard C-mount Adapter
Camera Mount	Standard C-mount Adapter
User Adjustments	Rotating image axis relative to detector rows, adjustable back focal length \pm 1 mm

Environmental Characteristics

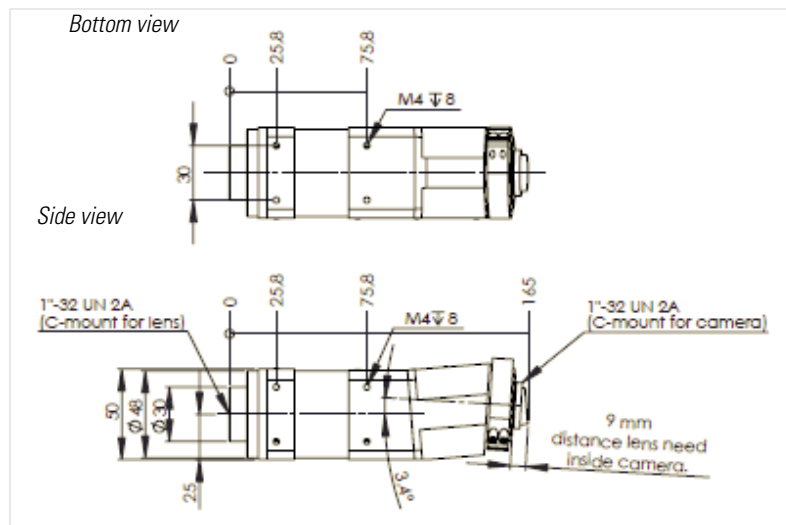
Storage Temperature, non-condensing	-20 $^{\circ}$ C ... + 80 $^{\circ}$ C
Operating Temperature, non-condensing	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C



ImSpector UV4E



UV4E as part of the UV hyperspectral camera



UV Spectrographs Ordering Information

Part Number	Description	Product Name
MRC-305-004-01	ImSpector - Enhanced UV Spectrograph. UV4E, 50 μ m slit* (default)	ImSpector UV4E

* When ordering please specify if different slit width is needed.

VISIBLE SPECTROGRAPHS 380 – 800 nm



The ImSpector Series offers several imaging spectrograph options designed for the visible (380 - 800nm) wavelength range. These spectrographs permit straightforward and cost-effective integration. Combining a visible spectrograph with a scientific grayscale CCD or CMOS camera produces a high performance line-scan hyperspectral imaging device. The use of an order blocking filter (OBF450) is optional for visible spectrographs, but will improve performance in some cases. Consult Middleton Research for details.

VIS Spectrograph Specifications

Optical Characteristics	V8H	V8	V8E
Spectral Range	380 - 800 nm	380 - 800 nm	380 - 800 nm
Spectral Dispersion	93.6 nm/mm	66 nm/mm	65 nm/mm
Spectral Resolution	8 nm (w/ 80 μ m slit)	6 nm (w/ 80 μ m slit)	2 nm (w/ 30 μ m slit)
Spatial Resolution	RMS spot radius < 30 μ m	RMS spot radius < 30 μ m	RMS spot radius < 9 μ m
Image Size (Spectral x Spatial)	4.8 x 6.6 mm	6.6 x 8.8 mm	6.15 x 14.2 mm
Numerical Aperture	F/2.8	F/2.8	F/2.4
Optical Input	Standard	Standard	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization	> 50%, independent of polarization	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 633 nm long-pass filter)	< 0.5% (halogen lamp, 633 nm long-pass filter)	< 0.5% (halogen lamp, 633 nm long-pass filter)
Slit Width, default	50 μ m (25, 80 and 150 μ m available on request)	50 μ m (25, 80 and 150 μ m available on request)	30 μ m (18, 50, 80 and 150 μ m available on request)
Slit Length	9.8 mm	9.8 mm	14.3 mm
Magnification	1:1	1:1	1:1

Aberations

Bending of Spectral Lines Across Spatial Axis	Smile < 30 μ m (0.70%)	Smile < 45 μ m (1.05%)	Smile < 1.5 μ m (0.035%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 20 μ m (0.30%)	Keystone < 40 μ m (0.61%)	Keystone < 1 μ m (0.015%)
Astigmatism	Insignificant	Insignificant	None

Mechanical Characteristics

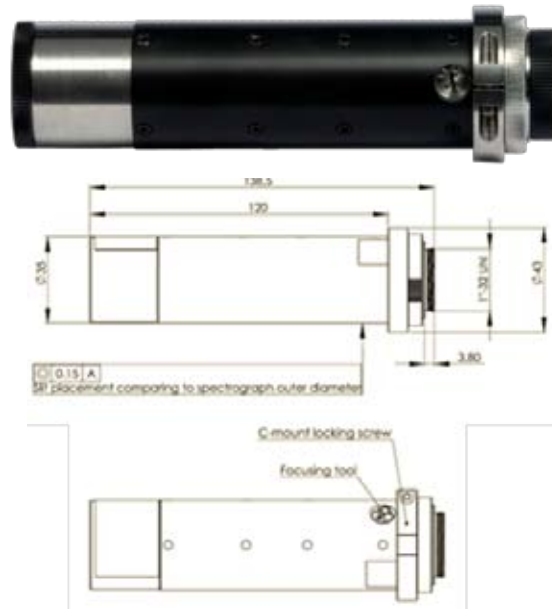
Body	Anodized Aluminum Tube	Anodized Aluminum Tube	Anodized Aluminum Tube
Size (W x H x L)	35 x 35 x 139 mm	35 x 35 x 139 mm	60 x 60 x 175 mm
Weight	300 g	300 g	1100 g
Lens Mount	Standard C-mount adapter	Standard C-mount adapter	Standard C-mount adapter
Camera Mount	Standard C-mount adapter	Standard C-mount adapter	Standard C-mount adapter
User Adjustments	Image axis rotation relative to detector rows, adjustable back focal length \pm 1 mm (for all)		

Environmental Characteristics

Storage Temperature, non-condensing	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C
Operating Temperature, non-condensing	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C

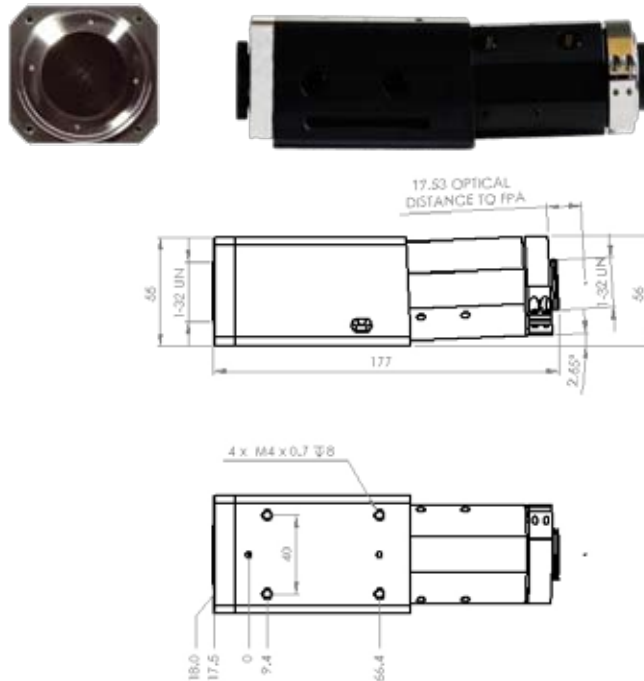
ImSpectors V8H and V8

There are two separate models for the standard VIS spectrograph, the V8 for 2/3" sensors and the V8H for 1/2" sensors. Both of these models share the same mechanical characteristics as shown in these drawings.



ImSpector V8E

The E-Series model is also available for VIS imaging applications that require higher spectral or spatial fidelity.



Visible Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-304-001-01	ImSpector - Standard VIS Spectrograph V8, 50 μm slit* (default)	ImSpector V8
MRC-304-001-02	ImSpector - Standard VIS Spectrograph V8H, 50 μm slit* (default)	ImSpector V8H
MRC-305-001-01	ImSpector - Enhanced VIS Spectrograph V8E, 30 μm slit* (default)	ImSpector V8E

* When ordering please specify if different slit width is needed.

VNIR SPECTROGRAPHS 400 – 1000 nm



Many spectrograph options are available in the VNIR (400 - 1000nm) wavelength range. The VNIR family of spectrographs provides high optical resolution while minimizing keystone and smile aberrations. The gratings and optics are designed to cover the full wavelength range from 400 to 1000 nm from the first order dispersion. The second order overlaps with first order dispersion and an order blocking filter is necessary to remove the second order dispersion. Inserting an order blocking filter in front of the sensor allows full wavelength coverage with one spectrograph and one camera sensor. Filters are available in different sizes and holders and are ordered separately. Please refer to the Filter section of the Accessories chapter for further details. The VNIR spectrographs can transform a scientific gray scale CCD or CMOS camera into a line-scan spectral imaging device.

VNIR Spectrograph Specifications

Optical Characteristics	V10H	V10	V10E
Spectral Range	400 - 1000 nm	400 - 1000 nm	400 - 1000 nm
Spectral Dispersion	139 nm/mm	93.9 nm/mm	97.5 nm/mm
Spectral Resolution	11.2 nm (w/ 80 μ m slit)	9 nm (w/ 80 μ m slit)	2.8 nm (w/ 80 μ m slit)
Spatial Resolution	RMS spot radius < 40 μ m	RMS spot radius < 40 μ m	RMS spot radius < 9 μ m
Image Size (Spectral x Spatial)	4.8 x 6.6 mm	6.6 x 8.8 mm	max 6.15 x 14.2 mm
Numerical Aperture	F/2.8	F/2.8	F/2.4
Optical Input	Standard	Standard	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization	> 50%, independent of polarization	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 633 nm notch filter)	< 0.5% (halogen lamp, 633 nm notch filter)	< 0.5% (halogen lamp, 633 nm notch filter)
Slit Width, default	50 μ m (25, 80, and 150 μ m available on request)	50 μ m (25, 80, and 150 μ m available on request)	30 μ m (13, 18, 50, 80, and 150 μ m available on request)
Slit Length	9.8 mm	9.8 mm	14.3 mm
Magnification	1:1	1:1	1:1

Aberrations

Bending of Spectral Lines Across Spatial Axis	Smile < 30 μ m (0.698%)	Smile < 45 μ m (0.68%)	Smile < 1.5 μ m (0.024%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 20 μ m (0.303%)	Keystone < 40 μ m (0.45%)	Keystone < 1 μ m (0.007%)
Astigmatism	Insignificant	Insignificant	None

Mechanical Characteristics

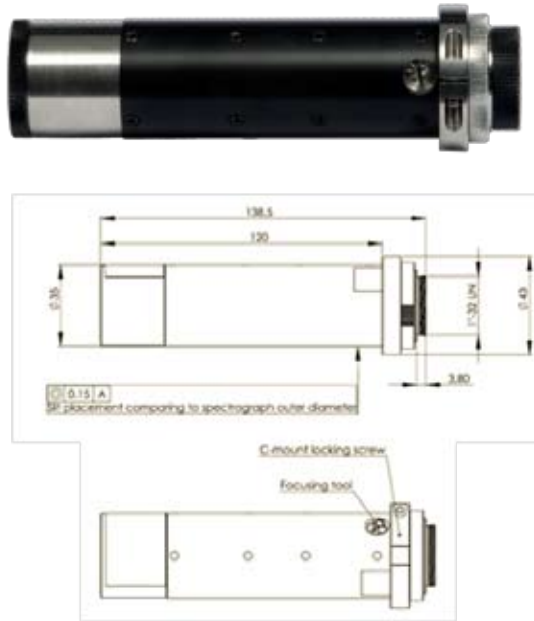
Body	Anodized Aluminum Tube	Anodized Aluminum Tube	Anodized Aluminum Tube
Size (W x H x L)	35 x 35 x 139 mm	35 x 35 x 139 mm	60 x 60 x 175 mm
Weight	300 g	300 g	1100 g
Lens Mount	Standard C-mount adapter	Standard C-mount adapter	Standard C-mount adapter
Camera Mount	Standard C-mount adapter	Standard C-mount adapter	Standard C-mount adapter
User Adjustments	Image axis rotation relative to detector rows, back focal length adjustable \pm 1 mm (for all)		

Environmental Characteristics

Storage Temperature, non-condensing	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C	-20 $^{\circ}$ C ... + 85 $^{\circ}$ C
Operating Temperature, non-condensing	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C

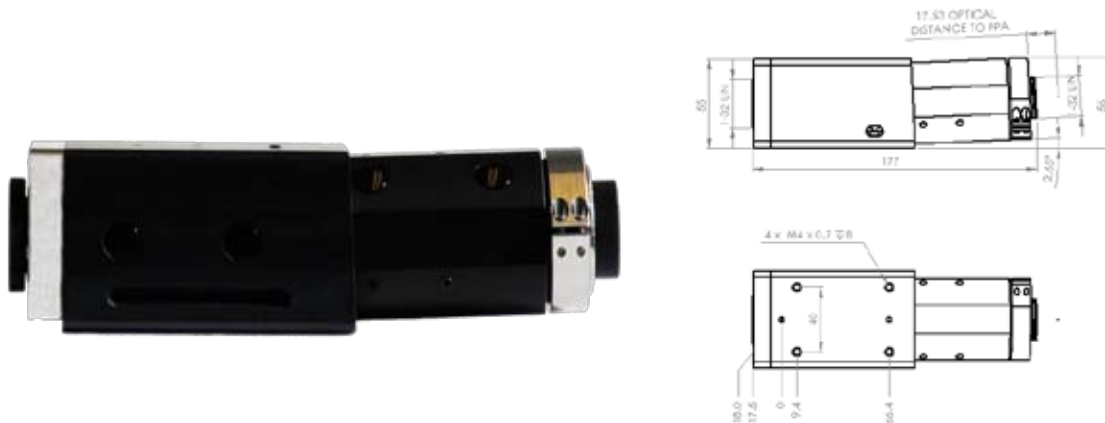
ImSpectors V10H and V10

As with the visible range of spectrographs, there are two separate models for the standard VNIR spectrograph, the V10 for 2/3" sensors and the V10H for 1/2" sensors. Both of these models share the same mechanical characteristics as shown in these drawings.



ImSpecter V10E

The VNIR range of spectrographs also includes an E-Series model suitable for imaging applications that require higher spatial or spectral fidelity than available with a standard spectrograph.



VNIR Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-304-002-01	ImSpector – Standard VNIR Spectrograph V10, 50 μm slit* (default)	ImSpector V10
MRC-304-002-02	ImSpector – Standard VNIR Spectrograph V10H, for 1/2" image sensor, 50 μm slit* (default)	ImSpector V10H
MRC-305-002-01	ImSpector – Enhanced VNIR Spectrograph V10E, 30 μm slit* (default)	ImSpector V10E

* When ordering please specify if different slit width is needed.



VNIR 400 – 1000 nm, continued

In addition to the standard and enhanced models available for the VNIR region, two unique spectrographs are also available from the Fast and M-Series lines. These additional models expand the options available to meet the specific needs of particular applications.

ImSpector Fast10

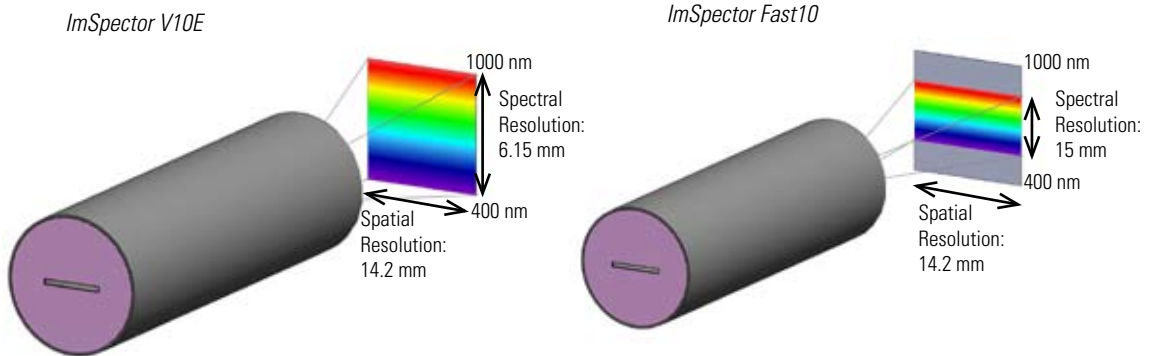
This high intensity imaging spectrograph allows spectral imaging to be used for high-speed industrial applications such as on-line color sorting and agricultural produce inspection. The compressed spectral scale makes high-speed spectral imaging acquisition possible, at speeds of up to 1500 lines per second. Using reduced spectral dispersion, the ImSpector Fast10 allows the highest possible light throughput to create maximum light intensity on the camera pixels, allowing shorter integration time. The compressed spectral scale allows faster readout rates when using cameras with range-of-interest (ROI) readout features. ImSpector Fast10 can also be combined with high speed industrial CCD and CMOS cameras to produce ultra-fast measurements.



Fast10 spectrograph with camera

Comparison of Fast10 and V10E

As seen in the comparison of the spectral dispersion of the two spectrographs in the figure below, the Fast10 spectrograph offers the full VNIR spectrum of 400 – 1000 nm, but it is dispersed over a much narrower region. This allows for shorter, faster readout times while maintaining the same spatial information.



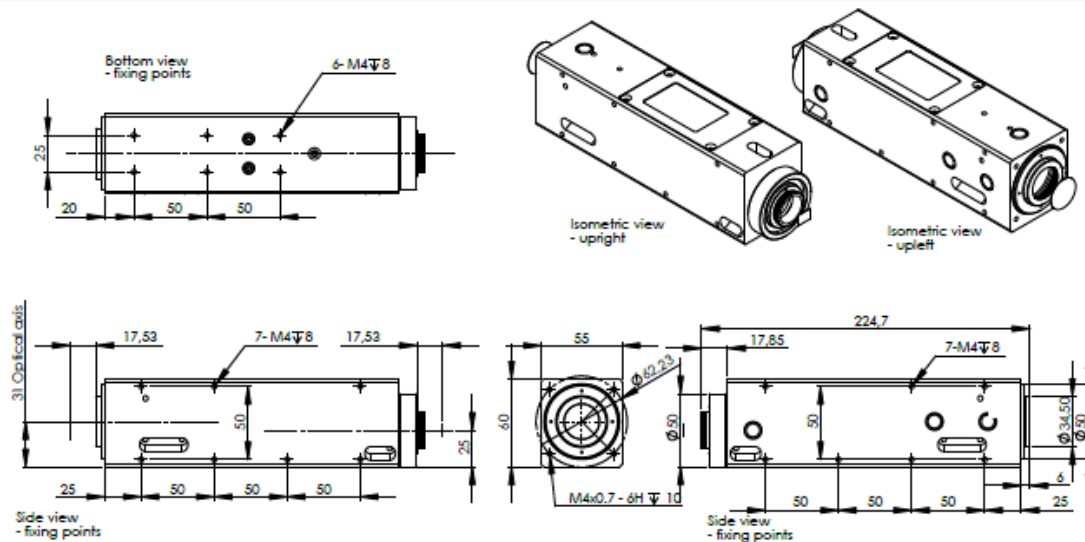
VNIR ImSpector Fast-Series Specifications

Optical Characteristics	Fast10
Spectral Range	400 - 1000 nm
Spectral Dispersion	750 nm/mm
Spectral Resolution	15 nm (with 18 μ m slit)
Spatial Resolution	RMS spot radius < 9 μ m
Image Size (Spectral x Spatial)	0.78 x 14.3 mm
Numerical Aperture	F/3.2
Optical Input	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 633 nm long-pass filter)
Slit Width, default	18 μ m (13 and 30 μ m available on request)
Slit Length	14.3 mm
Magnification	1:1

Aberrations	
Bending of Spectral Lines Across Spatial Axis	< 4 μ m (0.51%)
Bending of Spatial Lines Across Spectral Axis	< 4 μ m (0.028%)
Astigmatism	None
Vignetting	\approx 0%

Mechanical Characteristics	
Body	Anodized Aluminum
Size (W x H x L)	55 x 60 x 225 mm
Weight	1530 g
Lens Mount	Standard C-mount adapter
Camera Mount	Standard C-mount adapter
User Adjustments	Image axis rotation relative to detector rows, back focal length adjustable \pm 1 mm

Environmental Characteristics	
Storage Temperature, non-condensing	- 20 $^{\circ}$ C ... + 80 $^{\circ}$ C
Operating Temperature, non-condensing	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C



VNIR Fast10 Spectrograph Ordering Information		
Part Number	Description	Product Name
MRC-306-002-01	ImSpector – Fast VNIR Spectrograph Fast10, 18 μ m slit* (default)	ImSpector Fast10

* When ordering please specify if different slit width is needed.

VNIR 400 – 1000 nm, continued

ImSpector V10M

This ImSpector model from the new M-series line of imaging spectrographs supports a large spatial image size for sensor sizes up to 24 mm and has an extended operating range of 350 to 1000 nm. The V10M combines excellent performance with a lightweight, compact size in an off-the-shelf spectrograph that can be used in defense, security, and industrial applications. This spectrograph provides high resolution hyperspectral imaging performance in a compact format required for unmanned aerial vehicles (UAV's) and other demanding applications. Due to the larger format and the unique optical design, the light throughput of the V10M is superior to the Standard or Enhanced Series spectrographs, allowing for an even higher signal-to-noise ratio.



ImSpector V10M integrated with fore optics and high resolution camera



VNIR ImSpector M-Series Specifications

Optical Characteristics	V10M
Spectral Range	350 - 1000 nm
Spectral Dispersion	111 nm/mm
Spectral Resolution	1.5 nm (with 18 µm slit)
Spatial Resolution	RMS spot diam. < 7 µm
Image Size (Spectral x Spatial)	Max. 7.0 x 24.0 mm
Numerical Aperture	F/2.4
Optical Input	Telecentric
Average Diffraction Efficiency	> 50%
Stray Light	< 0.5% (halogen lamp, 633 nm long-pass filter)
Slit Width, default	18 µm (30 µm available on request)
Slit Length	30.0 mm
Magnification	3:4

Aberrations

Bending of Spectral Lines Across Spatial Axis	Smile < 2 µm (0.029%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 2 µm (0.008%)
Astigmatism	None
Vignetting	None

Mechanical Characteristics

Body	Anodized Aluminum Tube
Size (W x H x L)	115 x 95 x 100 mm
Weight	600 g
Lens Mount	M42 or F-Mount
Camera Mount	Custom adapter
User Adjustments	Back focal length adjustable ± 1 mm

Environmental Characteristics

Storage Temperature, non-condensing	- 40 °C ... + 71 °C
Operating Temperature, non-condensing	+ 5 °C ... + 40 °C

* This product line is under development. The above specifications may change without notice.

VNIR V10M Spectrograph Ordering Information		
Part Number	Description	Product Name
MRC-317-002-01	ImSpector – V10M VNIR Spectrograph, 18 µm slit* (default)	V10M

* When ordering please specify if different slit width is needed.

NIR SPECTROGRAPH 900 – 1700 nm

The NIR spectrograph offers high optical performance and easy integration for the NIR range. This spectrograph is designed to complement a camera that contains an InGaAs sensor and operates in the NIR (900 – 1700 nm) wavelength range.



NIR Spectrograph Specifications

Optical Characteristics	N17E
Spectral Range	900 - 1700 nm
Spectral Dispersion	110 nm/mm
Spectral Resolution	5 nm (w/ 30 µm slit)
Spatial Resolution	RMS spot radius < 15 µm
Image Size (Spectral x Spatial)	max. 7.6 x 14.2 mm
Numerical Aperture	F/2.0
Optical Input	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 1400 nm long-pass filter)
Slit Width, default	30 µm (50, 80 and 150 µm available on request)
Slit Length	14.3 mm
Magnification	1:1

Aberrations

Bending of Spectral Lines Across Spatial Axis	Smile < 5 µm (0.066%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 5 µm (0.035%)
Astigmatism	None

Mechanical Characteristics

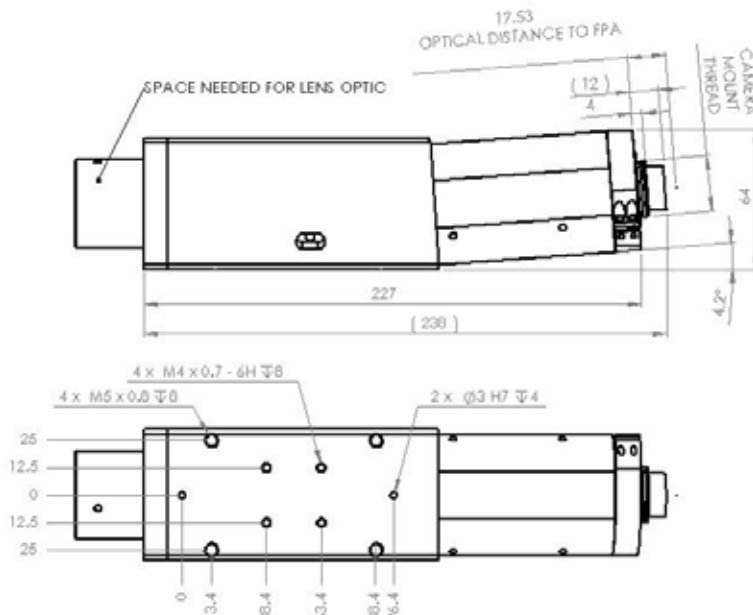
Body	Anodized Aluminum Tube
Size (W x H x L)	60 x 60 x 220 mm
Weight	1500 g
Lens Mount	Standard C-mount
Camera Mount	Standard C-mount or U-mount
User Adjustments	Image axis rotation relative to detector rows, back focal length adjustable ±1 mm

Environmental Characteristics

Storage Temperature	- 20 °C ... + 85 °C, non-condensing
Operating Temperature	+ 5 °C ... + 40 °C, non-condensing



Inspector N17E imaging spectrograph



Mechanical dimensions of Inspector N17E imaging spectrograph.

NIR Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-305-003-01	ImSpector – Enhanced NIR Spectrograph N17E, 30 μ m slit* (default)	ImSpector N17E

* When ordering please specify if different slit width is needed.

SWIR SPECTROGRAPH 1000 – 2500 nm

The imaging spectrograph designed for the SWIR (1000 - 2500 nm) wavelength range can be used to transform a SWIR camera with a wide spectral range sensor, such as a cooled mercury-cadmium-telluride (MCT) sensor, into a line-scan hyperspectral imaging device. In the SWIR range, this spectrograph offers the highest optical performance on the market, by reducing keystone and smile aberrations to sub-pixel levels.



SWIR Spectrograph Specifications

Optical Characteristics	N25E
Spectral Range	1000 - 2500 nm
Spectral Dispersion	208 nm/mm
Spectral Resolution	8 nm
Spatial Resolution	RMS spot radius < 15 μ m
Image Size (Spectral x Spatial)	max. 7.6 x 14.2 mm
Numerical Aperture	F/2.0
Optical Input	Telecentric
Average Diffraction Efficiency	> 50%, independent of polarization
Stray Light	< 0.5% (halogen lamp, 1400 nm long-pass filter)
Slit Width, default	30 μ m (50 and 80 μ m available on request)
Slit Length	14.3 mm
Magnification	1:1

Aberrations

Bending of Spectral Lines Across Spatial Axis	Smile < 5 μ m (0.066%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 5 μ m (0.035%)
Astigmatism	None

Mechanical Characteristics

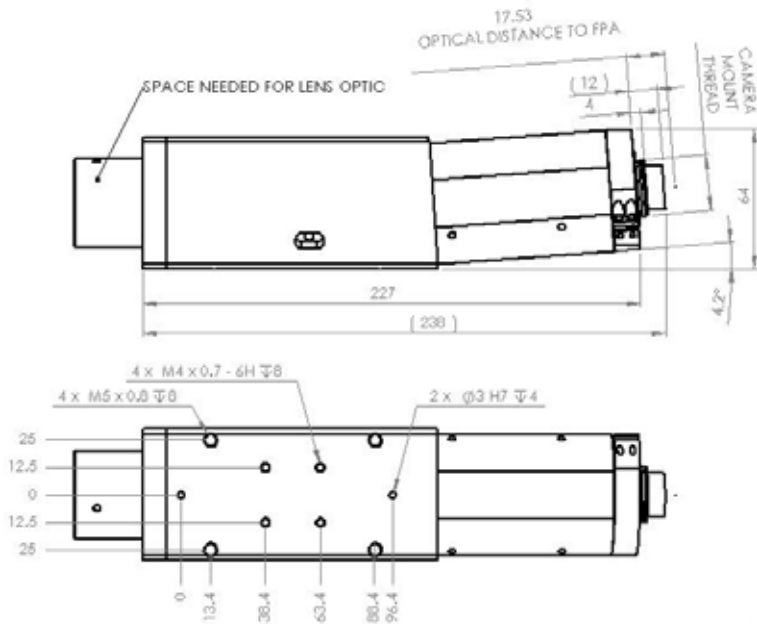
Body	Anodized Aluminum Tube
Size (W x H x L)	60 x 60 x 220 mm
Weight	1500 g
Lens Mount	Standard C-mount Adapter
Camera Mount	Standard U-mount Adapter
User Adjustments	Image axis rotation relative to detector rows, back focal length adjustable \pm 1 mm

Environmental Characteristics

Storage Temperature	- 20 $^{\circ}$ C ... + 80 $^{\circ}$ C, non-condensing
Operating Temperature	+ 5 $^{\circ}$ C ... + 40 $^{\circ}$ C, non-condensing



ImSpector N25E imaging spectrograph



Mechanical dimensions of ImSpector N25E imaging spectrograph

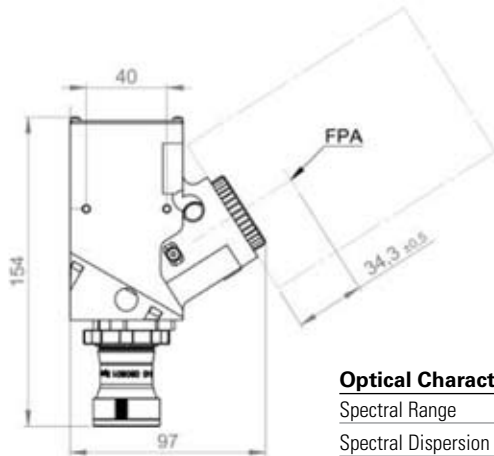
SWIR Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-305-005-01	ImSpector – Enhanced SWIR Spectrograph N25E, 30 μ m slit* (default)	ImSpector N25E

* When ordering please specify if different slit width is needed.



MWIR SPECTROGRAPH 3000 – 5000 nm

The MWIR spectrograph is designed for the 3 - 5 μm range. It is intended to explore and remotely identify solids, liquids and gases in the C-H, O-H, N-H stretching vibration region. At this time, these spectrographs are available only for integration with certain camera types. For custom integration to your camera, please contact Middleton Research.



Optical Characteristics	M50M
Spectral Range	3000 - 5000 nm
Spectral Dispersion	560 nm/mm
Spectral Resolution	35 nm
Spatial Resolution	RMS spot radius < 60 μm
Image Size (Spectral x Spatial)	3.57 x 9.6 mm
Numerical Aperture	F/2.0
Optical Input	Standard
Average Diffraction Efficiency	> 65%
Transmission of Optics	> 65%
Stray Light	< 0.5% (halogen lamp, 1400 nm long-pass filter)
Slit Width, default	120 μm
Slit Length	19 mm
Magnification	1:2

Aberrations	
Bending of Spectral Lines Across Spatial Axis	Smile < 2 μm (0.056%)
Bending of Spatial Lines Across Spectral Axis	Keystone < 4 μm (0.042%)

Mechanical Characteristics	
Body	Aluminum casting
Size (W x H x L)	60 x 97 x 154 mm
Weight	770 g
Lens Mount	Custom
Camera Mount	Custom

* This product line is under development. The above specifications may change without notice.

MWIR Spectrographs Ordering Information		
Part Number	Description	Product Name
MRC-305-006-01	ImSpector Enhanced MWIR Spectrograph. M50M, 120 μm slit	ImSpector M50M