

A person in silhouette is operating a spectrometer mounted on a ship's deck. The background shows a sunset over the ocean with a bright sun low on the horizon. The image has a green and yellow color overlay.

# Spectrometers

## INTRODUCTION

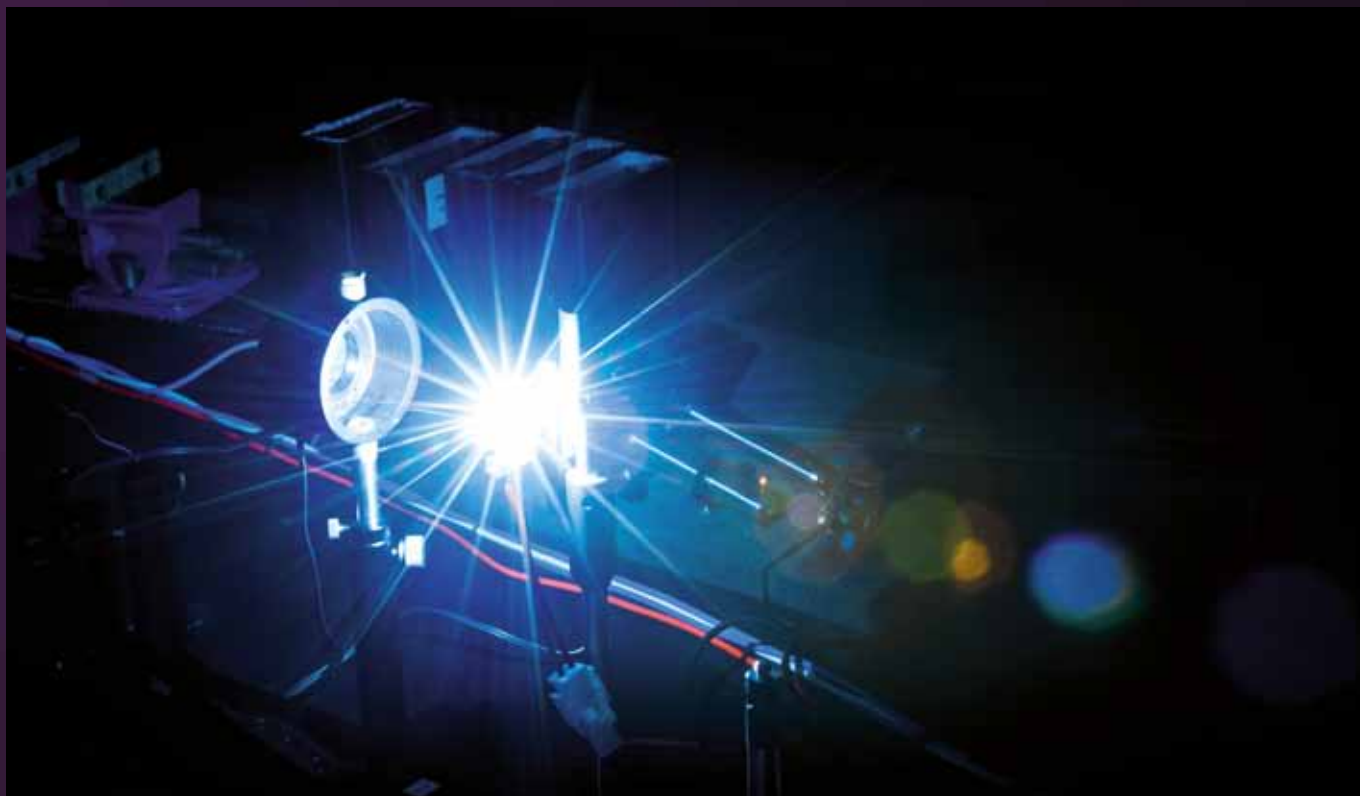
**Optical spectroscopy is a technique for measuring light intensity in the UV-, VIS-, NIR- and IR-regions of electromagnetic spectrum. Spectroscopic measurements are being used in many different applications, such as color measurement, concentration determination of chemical components or electromagnetic radiation analysis. A variety of common application setups are described in the Application chapter at the end of this catalog.**

A spectroscopic instrument or spectrometer generally consists of entrance slit, collimator, a dispersive element, such as a grating or prism, focusing optics and detector. In a monochromator system there is normally also an exit slit, and only a narrow portion of the spectrum is projected on a one-element detector. In monochromators the entrance and exit slits are in a fixed position and can be changed in width. Rotating the grating scans the spectrum.

The development of micro-electronics during the 90's in the field of multi-element optical detectors, such as Charged Coupled Devices (CCD) arrays and Photo-Diode (PD) arrays, enabled the production of low cost scanners, CCD cameras, etc. These same CCD and PDA detectors are now used in the Avantes AvaSpec line of spectrometers, enabling fast scanning of the spectrum, without the need for a moving grating.

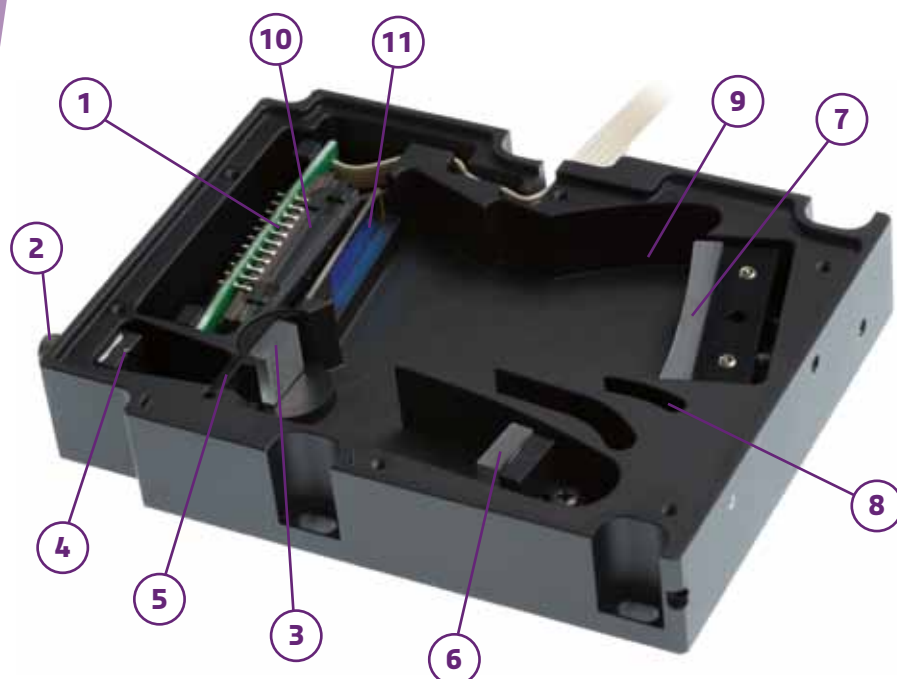
Thanks to the need for fiber-optics in the communication technology, low absorption silica fibers have been developed. Similar fibers can be used as measurement fibers to transport light from the sample to the optical bench of the spectrometer. The easy coupling of fibers allows a modular build-up of a system that consists of light source, sampling accessories and fiber-optic spectrometer. Furthermore fiber-optic enable the introduction of sampling into harsh and difficult to access environments.

The low cost, modularity, flexibility and speed of measurement made possible by fiber-optic spectrometers have resulted in wide adoption of this technology in a variety of industries.



Three years  
limited warranty on  
all Avantes spectrometers,  
light sources and accessories

## Optical Bench Design



The heart of most AvaSpec fiber-optic spectrometers is an optical bench with 37.5, 45, 50 or 75 mm focal length, developed in a symmetrical Czerny-Turner design. Light enters the optical bench through a standard SMA-905 connector and is collimated by a spherical mirror. A plain grating diffracts the collimated light; a second spherical mirror focuses the resulting diffracted light. An image of the spectrum is projected onto a 1-dimensional linear detector array.

Avantes AvaSpec-HS1024x58/122 high-sensitivity spectrometers have a revolutionary new optical bench design with multiple toroid mirrors which ensure that the full numerical aperture of the fiber entrance will be projected on the backthinned CCD array.

All of our optical benches have a number of components installed inside, allowing a wide variety of different configurations, depending on the intended application. The choice of these components such as the diffraction grating, entrance slit, order-sorting filter, and detector coating have a strong influence on system specifications such as sensitivity, resolution, bandwidth and stray-light. Each of these specification is discussed in detail in the following paragraphs.

### Avaspec-ULS Optical Bench Design: Symmetrical Czerny-Turner

- |                        |                    |
|------------------------|--------------------|
| 1. Detector            | 7. Focusing mirror |
| 2. SMA Connector       | 8. CPC light traps |
| 3. Grating             | 9. CPC light traps |
| 4. Slit, mode stripper | 10. DCL-UV/VIS     |
| 5. 2nd mode stripper   | 11. OSC-filter     |
| 6. Collimating mirror  |                    |

## How to configure a spectrometer for your application?

The modular AvaSpec line of instruments provides you with a number of configuration options to optimize the optical and spectroscopic performance of your instrument for your application.

This section provides you some guidance on how to choose the right grating, slit, detector and other configuration options, to be installed in your AvaSpec.

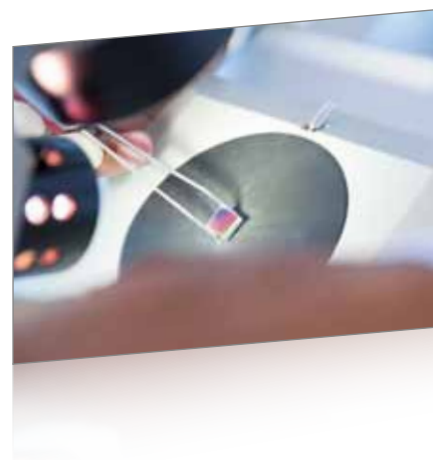
### Wavelength Range

In the determination of the optimal configuration of a spectrometer system the wavelength range is key parameter that defines the appropriate grating choice. If you are looking for a wide (broadband) wavelength range, we recommend the use of a 300 lines/mm grating known as an "A" type grating in Avantes product line. For lesser range (approximately 500 nm) but higher resolution, you might consider a 600 lines/mm or "B"-type grating. Higher lines/mm gratings (1200 – C type, 1800 – D type,

2400 – E type, 3600 – F type) provide higher resolution for applications that require this (see Grating selection table in the spectrometer product section). Broadband gratings provide the greatest flexibility but may not provide the best performance for specific application. Contact an Avantes Sales Engineer or representative for a recommended grating configuration.

### Detector Choice

The choice of your wavelength range along with the demands of your measurement speed and accuracy often suggests the appropriate detector for your application. Avantes offers 15 different detector types with each different sensitivity curves (see figure 3, page 19 and figure 4, page 21). The AvaSpec instrument line is divided into three groups based upon general requirements. The AvaSpec-Starline is comprised of general purpose UV/VIS instruments with low-cost CCD and PDA detectors. The AvaSpec Sensline is comprised of





higher performance back-thinned CCDs and thermo-electrically cooled CCDs UV/VIS instruments. The instruments are particularly better in the UV and NIR relative to standard CCD detectors. The AvaSpec NIRLine is comprised of instruments with InGaAs arrays for longer wavelength measurements from 900-2500 nm.

For high-speed applications, the 2048 pixel CCD detectors in the AvaSpec-2048 and AvaSpec-2048L from the StarLine are normally the best options. For VIS-only applications where high-resolution is not needed but speed and signal to noise are important, the 128 pixel PDA detector in the AvaSpec-128-USB2 may be the best option. For low-light level applications such as fluorescence and Raman, the SensLine instruments may be the most appropriate. The AvaSpec NIRLine features 7 different InGaAs detectors for various applications.

The modularity and inter-compatibility of the AvaSpec line also make it possible to combine two or more detectors in a single instrument enclosure to provide optimal performance over a broad wavelength range. For example, an AvaSpec StarLine (UV/VIS) spectrometer can be combined with a NIRLine spectrometer to enable measurements from 200-2500 nm in a single instrument.

### Optical Resolution & Slit size

If high optical resolution is required, you may want to consider a grating with higher lines/mm (1200 – C type, 1800 – D type, 2400 – E type, 3600 – F type), thus limiting the range of the instrument to a more narrow range. Additionally, it is advisable to consider a detector with 2048 or 3648 pixels and a small slit (10 or 25  $\mu\text{m}$ ). For the best resolution with all other criteria of lesser importance, the AvaSpec-3648 with a 10 micron slit is optimal.

Slit size is a key factor in determining both resolution and throughput into the optical bench. It is important to balance your need for resolution with the need for sensitivity and throughput into the optical bench. If resolution is optimized without considering the need for throughput, you may not have adequate light to get a stable measurement. As previously mentioned, for optimal resolution our smallest slit (10 microns) is recommended. If your application does not require the highest possible resolution and is not one that has an excess of light (laser measurement for example), we recommend that you consider as large a slit as possible to maximize throughput into the optical bench. New is the AvaSpec-RS with replaceable slit

that makes your spectrometer a versatile instrument for both high-resolution and high-sensitivity measurements.

### Sensitivity

When considering sensitivity, it is very important to distinguish between photometric sensitivity (How much light do I need for a detectable signal?) and chemometric sensitivity (What absorbance difference level can still be detected?)

#### a. Photometric Sensitivity

For the best photometric sensitivity a combination of a high-throughput optical bench and a high quantum-efficiency (QE) detector is recommended. The instruments in the AvaSpec SensLine are specifically optimized for photometric sensitivity.

For example fluorescence applications require high photometric sensitivity and Avantes AvaSpec-HS1024x122-TEC-USB2 is the highest performance instrument we offer for this application. For Raman applications where the combination of resolution and sensitivity is required, we recommend our AvaSpec-2048L-USB2 spectrometer. To further enhance photometric sensitivity, we recommend the user of a detector collection lens (DCL-UV/VIS or DCL-UV/VIS-200), which is a cylindrical lens with focuses light from larger core fiber-optics and bundles down onto the smaller detector pixels.

For additional photometric sensitivity, a larger slit or no slit and a 300 line/mm A-type grating to minimize light dispersion are available. Some more demanding applications also require thermo-electric cooling of the CCD detector (see product section AvaSpec-ULS2048L-TEC and AvaSpec-ULS3648-TEC, page 47) to minimize noise and increase dynamic range at long integration times (up to 60 seconds).

For each of our 15 detector types the photometric sensitivity is given in table 4 (page 18) and table 5 (page 20), the spectral sensitivity for each detector is depicted in figures 3 and 4.

#### b. Chemometric Sensitivity

To detect drastically different absorbance values, close to each other with maximum sensitivity, you need high Signal to Noise (S/N) performance. The detectors with best S/N performance are again in the AvaSpec SensLine series spectrometers with the AvaSpec-HS1024x122-TEC at the top of the line. The S/N performance can also be enhanced by averaging multiple spectra. The square root of the number of averages translates to the improvement in signal to noise.



### Timing and Speed

The data capture process is inherently faster with linear detector arrays and no moving parts as compared with a monochromator design, however, there are optimal detectors for each application. For high-speed applications such as measurements involving pulsed lasers and light sources, we recommend the AvaSpec-128-USB2, AvaSpec-ULS2048-USB2, AvaSpec-ULS2048L-USB2 or the AvaSpec-FAST spectrometers.

Each of these instruments supports high-speed data acquisition with the capability of starting an acquisition within 1.3 microseconds of receiving an external trigger. The AvaSpec-FAST spectrometers can support integration times as low as 0.5 milliseconds, the AvaSpec-128-USB2 supports 0.06 milliseconds and the AvaSpec-2048 and 2048L support 1.1 millisecond integration times. Since data transfer time is critical for these applications, Avantes' unique Store-to-RAM mode enables on board storage of up to 5000 spectra to the instrument RAM buffer.

The above parameters are the most important in choosing the right spectrometer configuration. Please contact our application engineers to optimize and fine-tune the system to your needs. Table 1 on this page provides a quick reference guide for spectrometer selection for many common applications. The system recommendations in this table are for simple configurations of mostly single channel spectrometers. For more elaborate explanations of specific explanations, see the applications section at the back of the catalog.

New is the AvaSpec-RS with replaceable slit that makes your spectrometer a versatile instrument for both high-resolution and high-sensitivity measurements

Application	AvaSpec-type	Grating	WL range (nm)	Coating	Slit (μm)	FWHM Resolution (nm)	DCL	OSF	OSC
<b>Biomedical</b>	ULS2048	NB	500-1000	-	50	1.2	-	475	-
<b>Chemometry</b>	ULS2048	UA	200-1100	-	50	2.0	-	-	OSC-UA
<b>Color</b>	128	VA	360-780	-	100	6.4	X/-	-	-
	ULS2048	BB	360-780	-	200	4.1	X/-	-	-
<b>Fluorescence</b>	ULS2048XL	V, VB, UB	350-1100, 300-800	-	200	8.0	X	305	OSC
	HS1024x122TEC	HS-500-0.33	200-1160	-	200	10.0	-	-	OSC
<b>Fruit-sugar</b>	128	IA	800-1100	-	50	5.4	X	600	-
<b>Gemology</b>	ULS2048	VA	350-1100	-	25	1.4	X	-	OSC
<b>High-resolution</b>	ULS2048	VD	600-700	-	10	0.07	-	550	-
	ULS3648	VD	600-700	-	10	0.05	-	550	-
<b>High UV/NIR-Sensitivity</b>	HS1024x122TEC	HS-500-0.33	200-1160	-	200	10.0	-	-	OSC
<b>Irradiance</b>	ULS2048	UA	200-1100	DUV	50	2.8	X/-	-	OSC-UA
<b>Laserdiode</b>	ULS2048	NC	700-800	-	10	0.1	-	600	-
<b>LED</b>	ULS2048	VA	350-1100	-	25	1.4	X/-	-	OSC
<b>LIBS</b>	ULS2048	D,E,F	200-900	DUV	10	0.09	-	-	-
<b>Raman</b>	ULS2048LTEC	NC	780-930	-	25	0.2	X	600	-
<b>Solar</b>	ULS2048XL	VA	300-1100	-	50	2.4	-	305	OSC
<b>Thin Films</b>	ULS2048	UA	200-1100	DUV	-	4.1	X	-	OSC-UA
<b>UV/VIS/NIR</b>	ULS2048	UA	200-1100	DUV	25	1.4	X/-	-	OSC-UA
	ULS2048XL	UA	200-1100	-	25	1.4	-	-	OSC-UA
<b>NIR</b>	NIR512-1.7TEC	NIR200-1.5	1000-1750	-	25	5.0	-	1000	-
	NIR256-2.0TEC	NIR150-2.0	1000-2000	-	50	10.0	-	1000	-
	NIR256-2.5TEC	NIR100-2.5	1000-2500	-	50	15.0	-	1000	OSC-NIR

Table 1 Quick reference guide for spectrometer configuration

The grating can only be changed by Avantes.  
Therefore, choose your grating wisely.  
Our application specialists are available to support you with your choice.  
In general, a higher resolution means a lower bandwidth.  
By combining multiple spectrometers  
in our AvaSpec-Dual or rack-mountable versions,  
you can create one virtual spectrometer with high-resolution  
and high bandwidth.

# How to choose the right Grating?

A diffraction grating is an optical element that separates incident polychromatic radiation into its constituent wavelengths. A grating consists of series of equally spaced parallel grooves formed in a reflective coating deposited on a suitable substrate. The way in which the grooves are formed separates gratings in two types, holographic and ruled.

The ruled gratings are physically formed onto a reflective surface with a diamond on a ruling machine. Gratings produced from laser constructed interference patterns and a photolithographic process are known as holographic gratings.

Avantes AvaSpec spectrometers come with a permanently installed grating that must be specified by the user. Additionally the user needs to indicate what wavelength range needs to reach the detector. Sometimes the specified usable range of a grating is larger than the range that can be projected on the detector. In order to cover a broader range, a dual or multi-channel spectrometer can be chosen. In this configuration each channel may have different

gratings covering a segment of the range of interest. In addition to broader range, a dual or multi-channel spectrometer also affords higher resolution for each channel. For each spectrometer type a grating selection table is shown in the spectrometer platform section.

Table 2 illustrates how to read the grating selection table. The spectral range to select in Table 2 depends on the starting wavelength of the grating and the number of lines/mm; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

In Figure 2a and 2b grating efficiency curves are shown. When looking at the grating efficiency curves, please realize that the total system efficiency will be a combination of fiber transmission, grating and mirror efficiency, detector quantum efficiency and coating sensitivities. The all new dual-blazed grating is a 300 lines/mm broadband grating (covering 200-1100 nm) that has optimized efficiency in both UV and NIR. In Figure 2c the grating dispersion curves are shown for the AvaSpec-ULS2048.

Different diffraction gratings

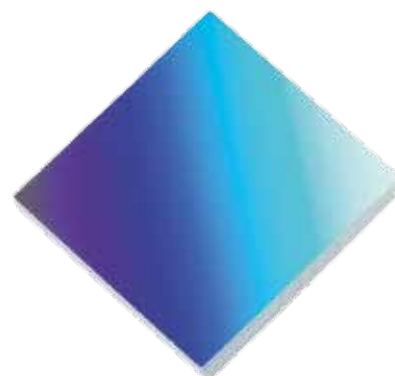


Table 2 Example of Spectral range and gratings

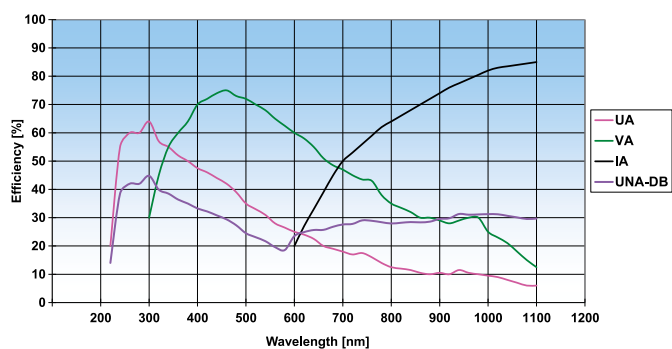
Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100	900	300	300	UA
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	220-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
		800			VA

Please select Spectral range bandwidth from the useable Wavelength range, for example: grating UE (200-315 nm)  
\* the spectral range depends on the starting wavelength of the grating; the higher the wavelength, the smaller the range. For example: Grating UE (510-580 nm)

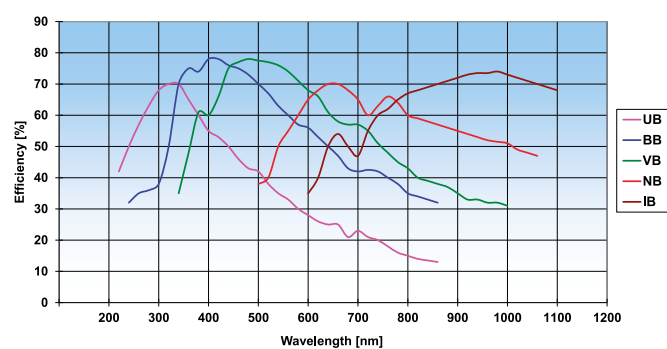
The order code is defined by 2 letters: the first is the Blaze (U= 250/300 nm or UV for holographic, B=400 nm, V=500 nm or VIS for holographic, N=750 nm, I=1000 nm) and the second the nr of lines/mm (Z=150, A=300, B=600, C=1200, D=1800, E=2400, F=3600 lines/mm)

Figure 2a Grating Efficiency Curves

## 300 lines/mm Gratings

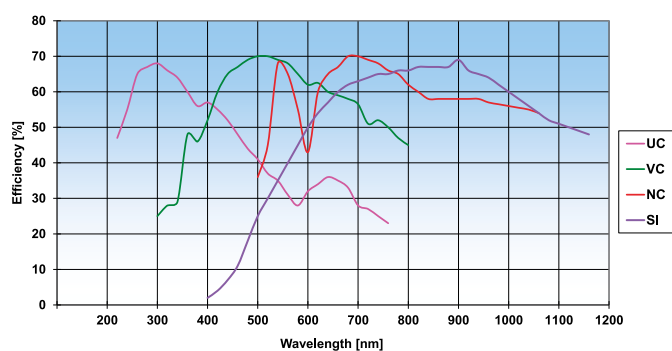


## 600 lines/mm Gratings

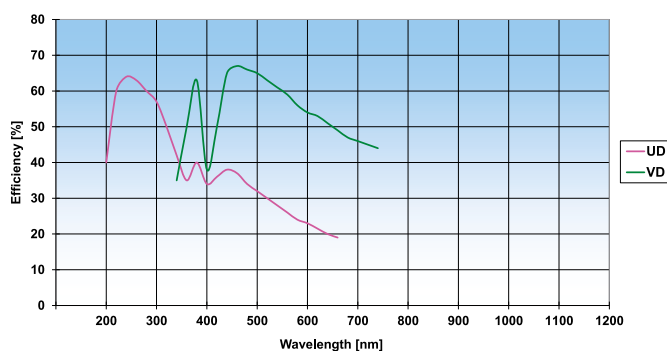


Page 1

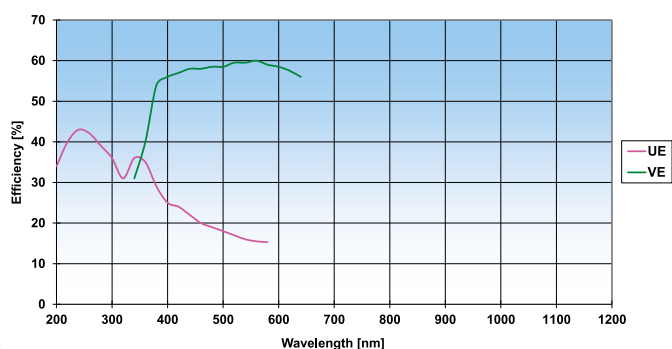
## 1200 lines/mm Gratings



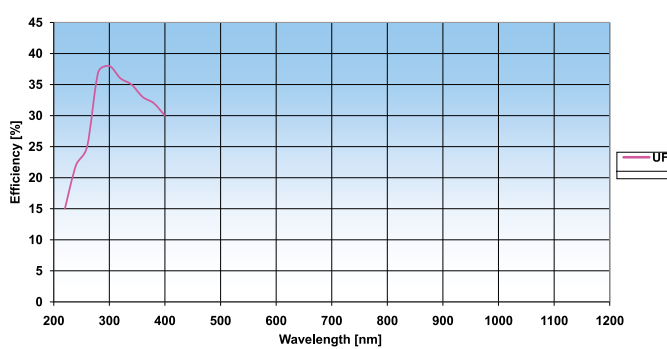
## 1800 lines/mm Gratings



## 2400 lines/mm Gratings

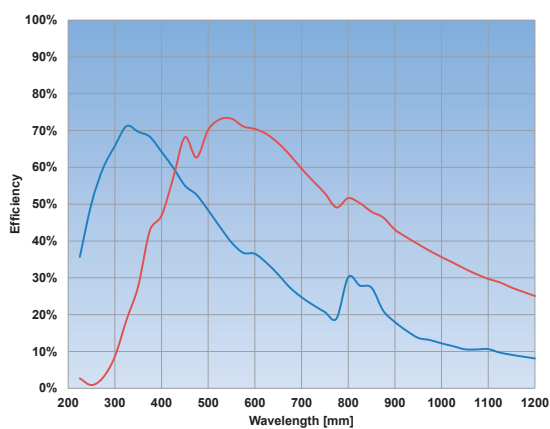


## 3600 lines/mm Grating

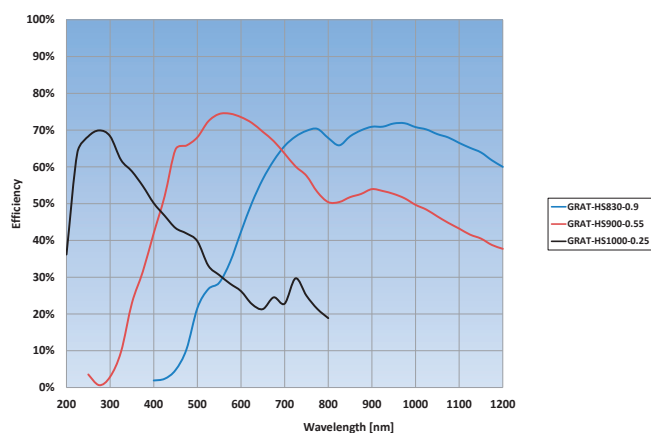


**Figure 2b Grating Efficiency Curves**

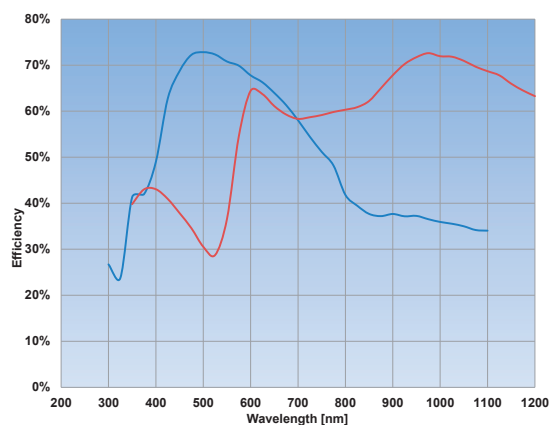
HS 500 lines/mm Gratings



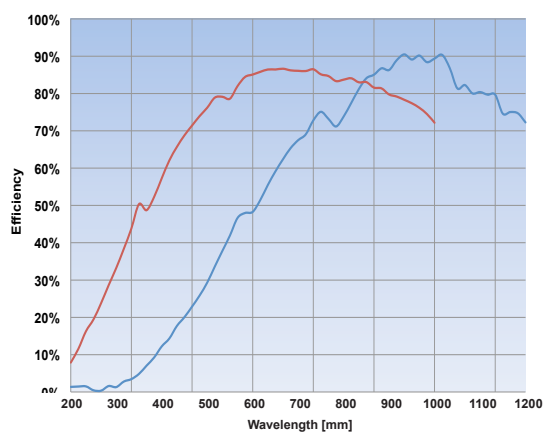
HS 830-1000 lines/mm Gratings



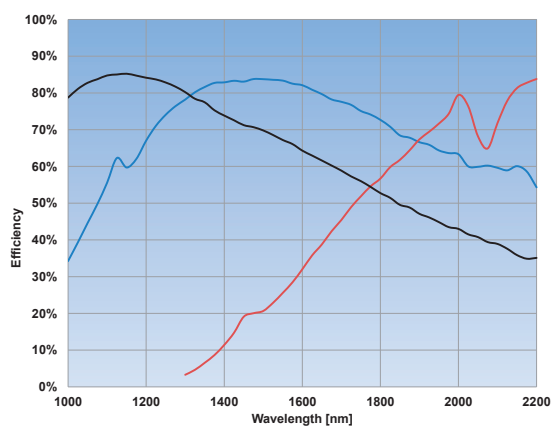
HS 1200 lines/mm Gratings



NIR 100-200 lines/mm Gratings



NIR 200-300 lines/mm Gratings



NIR 300-400 lines/mm Gratings

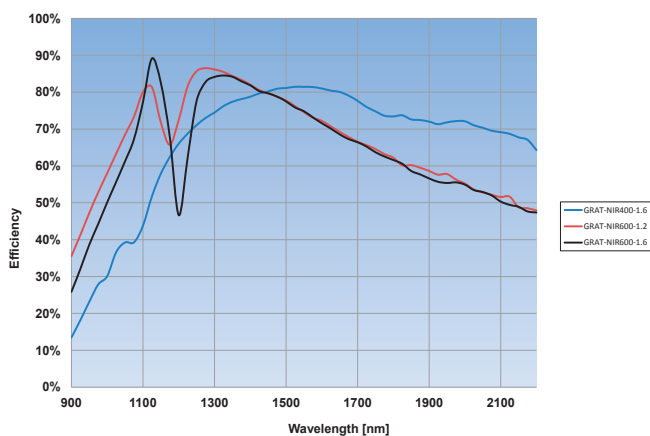
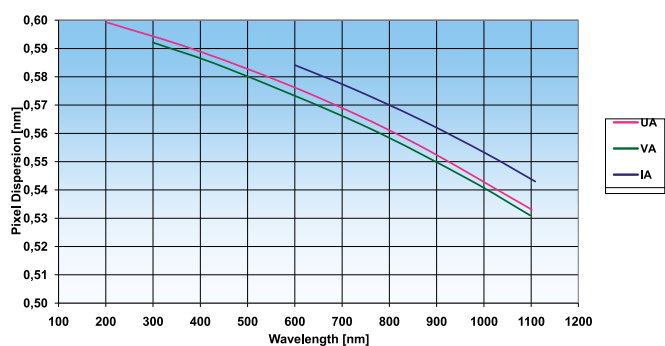


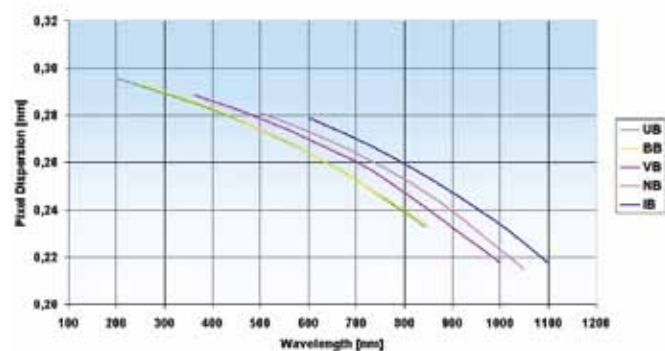


Figure 2c Grating Dispersion Curves

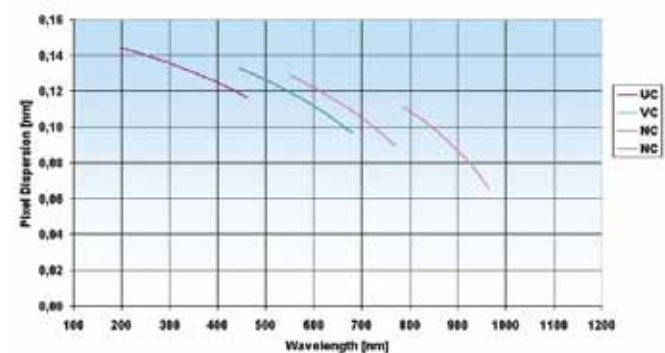
300 lines/mm Gratings



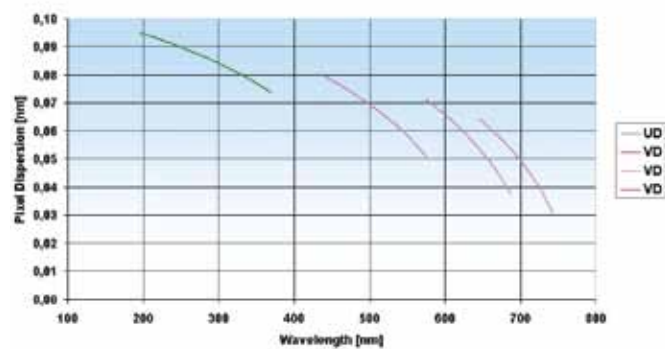
600 lines/mm Gratings



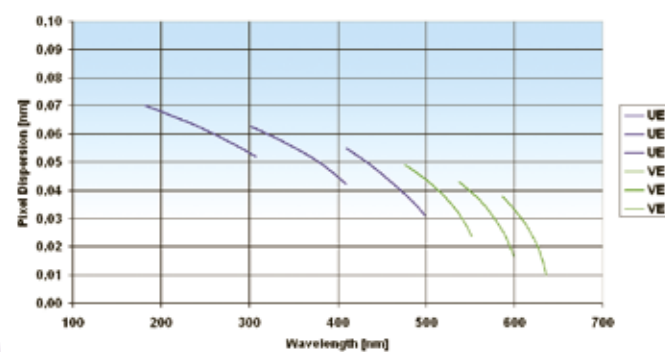
1200 lines/mm Gratings



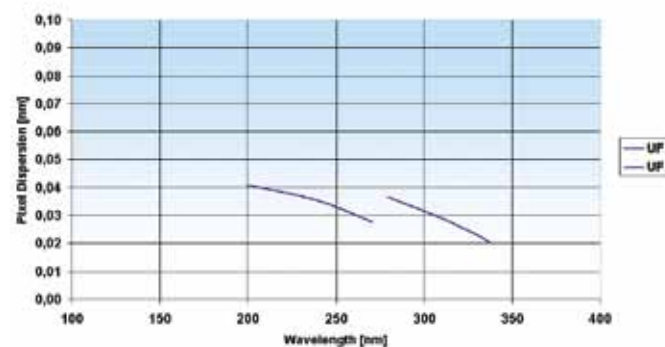
1800 lines/mm Gratings



2400 lines/mm Gratings



3600 lines/mm Gratings



# How to select optimal Optical Resolution?

The optical resolution is defined as the minimum difference in wavelength that can be separated by the spectrometer. For separation of two spectral lines it is necessary to image them at least two array-pixels apart.

Because the grating determines how far different wavelengths are separated (dispersed) at the detector array, it is an important variable for the resolution. The other important parameter is the width of the light beam entering the spectrometer. This is basically the installed fixed entrance slit in the spectrometer, or the fiber core when no slit is installed.

For AvaSpec spectrometers the available slit widths are 10, 25, 50, 100, or 200  $\mu\text{m}$  wide x 1000  $\mu\text{m}$  high, or 500  $\mu\text{m}$  wide x 2000  $\mu\text{m}$  high. The slit image on the detector array for a given wavelength will cover a number of pixels. For two spectral lines to be separated, it is necessary that they be dispersed over at least this image size plus one pixel. When large core fibers are used the resolution can be improved by a slit of smaller size than the fiber core. This effectively reduces the width of the light beam entering the spectrometer optical bench. The influence of the chosen grating and the effective width of the light beam (fiber core or entrance slit) are shown in the tables provided for each AvaSpec spectrometer instrument.

In Table 3 the typical resolution can be found for the AvaSpec-2048. Please note that for the higher lines/mm gratings the pixel dispersion varies along the wavelength range and gets better towards the longer wavelengths (see also Figure 3).

The resolution in this table is defined as Full Width Half Maximum (FWHM), which is defined as the width in nm of the peak at 50% of the maximum intensity (see Figure 4).

Graphs with information about the pixel dispersion can be found in the gratings section as well, so you can optimally determine the right grating and resolution for your specific application.

For larger pixel-height detectors (3648, 2048L, 2048XL) in combination with thick fibers ( $>200 \mu\text{m}$ ) and a larger grating angle the actual FWHM value can be 10-20% higher than the value in the table. For best resolution small core diameter fibers are recommended.

All data in the resolution tables are based on averages of actual measured data (with 200  $\mu\text{m}$  fibers) of our Quality Control System during the production process. A typical standard deviation of 10-25%, depending on the slit diameter and the grating should be taken into account. For 10  $\mu\text{m}$  slits the typical standard deviation is somewhat higher, which is inherent to the laws of physics. The peak may fall exactly within one pixel, but may cover 2 pixels causing lower measured resolution.

New is the replaceable slit feature, available on all ULS spectrometers. The spectrometers come with one installed slit and a slit kit which includes all four slit sizes, so you can opt for higher resolution (25  $\mu\text{m}$  slit) or higher throughput (200  $\mu\text{m}$  slit) or somewhere in between (50 or 100  $\mu\text{m}$  slits).

## Installed Slit in SMA Adapter



**Table 3 Resolution (FWHM in nm) for the AvaSpec-ULS2048-USB2**

Grating (lines/mm)	Slit size ( $\mu\text{m}$ )					
	10	25	50	100	200	500
<b>300</b>	0.80 – 0.90*	1.10-1.20*	2.30	4.60	9.00	22.0
<b>600</b>	0.40 – 0.50*	0.63	1.15	2.31	4.50	11.0
<b>830</b>	0.28	0.40	0.80	1.60	3.20	8.0
<b>1200</b>	0.18 – 0.22*	0.29	0.61	1.18	2.20	5.5
<b>1800</b>	0.10 – 0.16*	0.19	0.35-0.42*	0.80	1.60	4.0
<b>2400</b>	0.08 – 0.11*	0.10 – 0.15*	0.28	0.55	1.10	2.8
<b>3600</b>	0.05 – 0.08*	0.10	0.18	0.38	0.75	1.9

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the higher the resolution

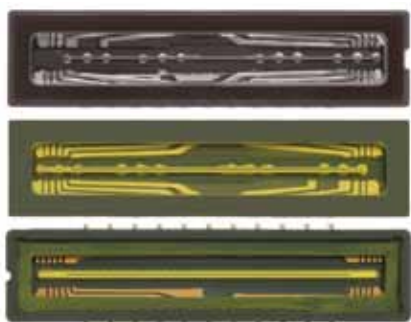
## Detector arrays

The AvaSpec line of spectrometers can be equipped with several types of detector arrays. Presently we offer silicon-based CCDs, back-thinned CCDs, and Photo-Diode Arrays for the 200-1100 nm range. A complete overview of each is given in the next section "Sensitivity" in Table 4. For the NIR range (1000-2500 nm) InGaAs arrays are implemented.

All detectors are tested in incoming goods inspection, before they are used in our instruments. Avantes offers full traceability on following detector specifications:

- Dark noise
- Signal to noise
- Photo Response Non-Uniformity
- Hot pixels

### StarLine CCD Detectors (AvaSpec-ULS2048/2048L/3648)



The Charged Coupled Device (CCD) detector stores the charge, dissipated as photons strike the photoactive surface. At the end of a controlled time-interval (integration time), the remaining charge is transferred to a buffer and then this signal is being transferred to the AD converter. CCD detectors are naturally integrating and therefore have enormous dynamic range, only limited by the dark (thermal) current and the speed of the AD converter. The 3648-pixel CCD has an integrated electronic shutter function, so an integration time of 10 $\mu$ s can be achieved.

- Main disadvantage is the lower S/N ratio relative to other detector types.

#### UV enhancement

For applications below 350 nm with the AvaSpec-2048/2048L/3648 a special DUV-detector coating is required. The uncoated CCD-response below 350 nm is very poor; the DUV lumogen coating enhances the detector response in the region 150-350 nm. The DUV coating has a very fast decay time, typ. in ns range and is therefore useful for fast-trigger LIBS applications.

- + Advantages for the CCD detectors are large numbers of pixels (2048 or 3648), high-sensitivity and high-speed.

### Photo-Diode Arrays (AvaSpec-128)



A silicon photodiode array consists of a linear array of multiple photo-diode elements, for the AvaSpec-128 this is 128 pixels. Each pixel consists of a P/N junction with a positively doped P-region and a negatively doped N-region. When light enters the photodiode, electrons will become excited and generate an electrical signal. Most photodiode arrays have an integrated

signal processing circuit with readout/integration amplifier on the same chip.

- + Advantages for the Photodiode detector are high NIR sensitivity and high-speed.
- Disadvantages are limited amount of pixels and no UV-response.

### SensLine Back-thinned CCD Detectors (AvaSpec-ULS2048XL/-HS1024x58/122)



For applications requiring high quantum efficiency in the UV (200-350 nm) and NIR (900-1160 nm) range, combined with good S/N and a wide dynamic-range, back-thinned CCD detectors are the right choice. Both uncooled and cooled backthinned CCD detectors are offered, the uncooled backthinned CCD detector has 2048 pixels with a pixel pitch of 14  $\mu$ m and a height of 500  $\mu$ m, to have more sensitivity and a better S/N performance.

For even better sensitivity and S/N the cooled backthinned CCD detector is the best choice, it has 1024 pixels, each of them with 58 or 122 vertically binned pixels, giving an effective detector height of 1.4 mm or nearly 3.0 mm

- + Advantage of the back-thinned CCD detector is the good UV and NIR sensitivity, combined with good S/N and dynamic range.
- Disadvantage is the relatively higher cost.

## NIRLine InGaAs linear image sensors

### (AvaSpec-NIR256/512)

The InGaAs linear image sensors deliver high-sensitivity in the NIR wavelength range. The detector consists of a charge-amplifier array with CMOS transistors, a shift-register and timing generator. For InGaAs detectors the dynamic range is limited by the dark noise. For ranges up to 1.75  $\mu\text{m}$  no cooling is required and these detectors are available in both 256 and 512 pixels. Detectors for the extended range 2.0-2.5  $\mu\text{m}$  all have 2-stage TE-cooling to reduce dark noise and are available in 256 and 512 pixel versions (1.7 and 2.2 detectors only).

7 versions of detectors are available:

- 256 pixel non-cooled InGaAs detector for the 900-1750 nm range
- 256/512 pixel cooled InGaAs detector for the 900-1750 nm range
- 256 pixel 2-stage cooled Extended InGaAs detector for the 1000-2000 nm range
- 256/512 pixel 2-stage cooled Extended InGaAs detector for the 1000-2200 nm range
- 256 pixel 2-stage cooled Extended InGaAs detector for the 1000-2500 nm range



## Sensitivity

The sensitivity of a detector pixel at a certain wavelength is defined as the detector electrical output per unit of radiation energy (photons) incident to that pixel. With a given A/D converter this can be expressed as the number of counts per mJ of incident radiation.

The relation between light energy entering the optical bench and the amount hitting a single detector pixel depends on the optical bench configuration. The efficiency curve of the grating used, the size of the input fiber or slit, the mirror performance and the use of a Detector Collection Lens are the main parameters. With a given set-up it is possible to do measurements over about 6-7 decades of irradiance levels. Some standard detector specifications can be found in Table 4 detector specifications. Optionally a DCL (Cylindrical Detector Collection) lens can be mounted directly on the detector array. The quartz lens (DCL-UV/VIS for AvaSpec-2048/3648) will increase the system sensitivity by a factor of 3-5, depending on the fiber diameter used. The DCL-UV/VIS-200 can be used for the AvaSpec-2048L/3648/2048XL to have a better vertical distribution of light focusing on the detector and is primarily for fiber diameters larger than 200  $\mu\text{m}$  and round-to-linear assemblies.

The SensLine has the most sensitive detectors in Avantes' instrument line, three backthinned detectors and two cooled CCD detectors.

In Table 4 the UV/VIS detectors are depicted with their specifications, please find below some additional information on how those specifications are determined.

### Pixel Well Depth (electrons)

This value is specified by the detector supplier and defines how many electrons can fit in a pixel well before it is saturated, this value determines the best reachable Signal to Noise ( $=\sqrt{\text{Pixel well depth}}$ ).

### Sensitivity in Photons/count @ 600 nm

The number of Photons of 600 nm that are needed to generate one count of signal on a 16-bit AD converter, the lower this number is, the better is the sensitivity of the detector.

The calculation of the number of Photons/count is  $(\text{Pixel Well depth in electrons}) / (16\text{-bit AD} / \text{Quantum Efficiency @ 600 nm})$ .

### Sensitivity in counts/ $\mu\text{W}$ per ms integration time

Sensitivity here is for the detector types currently used in the UV/VIS AvaSpec spectrometers as output in counts per ms integration time for a 16-bit AD converter. To compare the different detector arrays we have them all built up with an optical bench with UA 300 lines/mm grating covering 200-1100 nm (AvaSpec-128 with grating VZ 350-1100 nm), DCL if applicable, and 50  $\mu\text{m}$  slit.



The measurement setup for 350-1100 nm has a 600  $\mu\text{m}$  fiber connected to an AvaSpere-50-LS-HAL, equivalent to an optical power of 1.14  $\mu\text{W}$ .

For the UV/VIS measurement at 220-1100 nm we connected the 600  $\mu\text{m}$  fiber to an AvaLight-DHS through a CC-VIS/NIR diffuser, equivalent to 2.7  $\mu\text{W}$  power.

#### Peak wavelength and QE @ peak

The peak wavelength is provided by the detector supplier as well as the Quantum Efficiency, defined as the number of electrons generated by one photon.

#### Signal/Noise

Signal/Noise is measured for every detector at Avantes' Quality Control Inspection and defined as the illuminated maximum Signal/Noise in Root Mean Square for the shortest integration time. The RMS is calculated over 100 scans.

#### Dark Noise

Dark noise is measured for every detector at Avantes' Quality Control Inspection and defined as the non-illuminated noise in Root Mean Square for the shortest integration time. The RMS is calculated over 100 scans.

#### Dynamic Range

The dynamic range is defined as the (maximum signal level- baseline dark level)/dark noise RMS.

#### Photo Response Non-Uniformity

Photo Response Non-Uniformity is defined as the max difference between output of pixels when uniformly illuminated, divided by average signal of those pixels. PRNU is measured for every detector at Avantes' Quality Control Inspection.

#### Frequency

The frequency is the clock frequency at which the data pixels are clocked out through the AD-converter.

**Table 4 Detector Specifications (based on a 16-bit AD converter)**

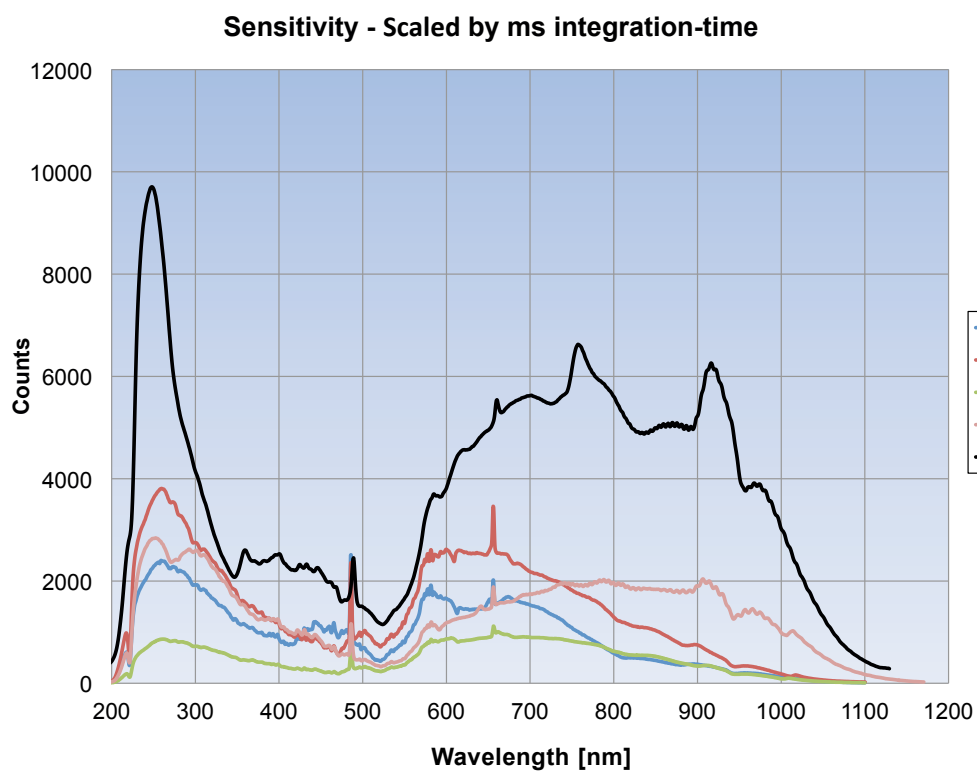
	StarLine				SensLine		
Detector	TAOS128	SONY2048	SONY2048L	TOS3648	HAM2048XL	HAM1024x58	HAM1024x122
Type	Photo-diode array	CCD linear array	CCD linear array	CCD linear array	Back-thinned CCD array	Cooled Back-thinned CCD array	Cooled Back-thinned CCD array
# Pixels, pitch	128, 63.5 $\mu\text{m}$	2048, 14 $\mu\text{m}$	2048, 14 $\mu\text{m}$	3648, 8 $\mu\text{m}$	2048, 14 $\mu\text{m}$	1024 x 58, 24 $\mu\text{m}$	1024 x 122, 24 $\mu\text{m}$
Pixel width x height ( $\mu\text{m}$ )	55.5 x 63.5	14 x 56	14 x 200	8 x 200	14 x 500	24 x 24 (total height 1.4 mm)	24 x 24 (total height 2.9 mm)
Pixel well depth (electrons)	250,000	40,000	90,000	120,000	200,000	1,000,000	1,000,000
Sensitivity Photons/count @600 nm	10	2	4	5	4	16	16
Sensitivity in counts/ $\mu\text{W}$ per ms integration time	430,000 (AvaSpec-128)	310,000 (AvaSpec-ULS2048)	470,000 (AvaSpec-ULS2048L)	160,000 (AvaSpec-ULS3648)	460,000 (AvaSpec-ULS2048XL)	850,000 (AvaSpec-HS1024x58)	1,270,000 (AvaSpec-HS1024x122)
Peak wavelength	750 nm	550 nm	450 nm	550 nm	650 nm	650 nm	650 nm
QE (%) @ peak	40%	40%	40%	40%	78%	92%	92%
Signal/Noise	500:1	200 :1	300 :1	350 :1	450 :1	1000:1	1000:1
Dark noise (counts RMS)	15	33	20	34	17	8	8
Dynamic Range	4380	2000	3300	1900	3800	8,000	8,000
PRNU**	$\pm 4\%$	$\pm 5\%$	$\pm 5\%$	$\pm 5\%$	$\pm 3\%$	$\pm 3\%$	$\pm 3\%$
Wavelength range (nm)	360-1100	200*-1100	200*-1100	200*-1100	200-1160	200-1160	200-1160
Frequency	2 MHz	2 MHz	2 MHz	1 MHz	1 MHz	250 kHz	250 kHz

\* DUV coated

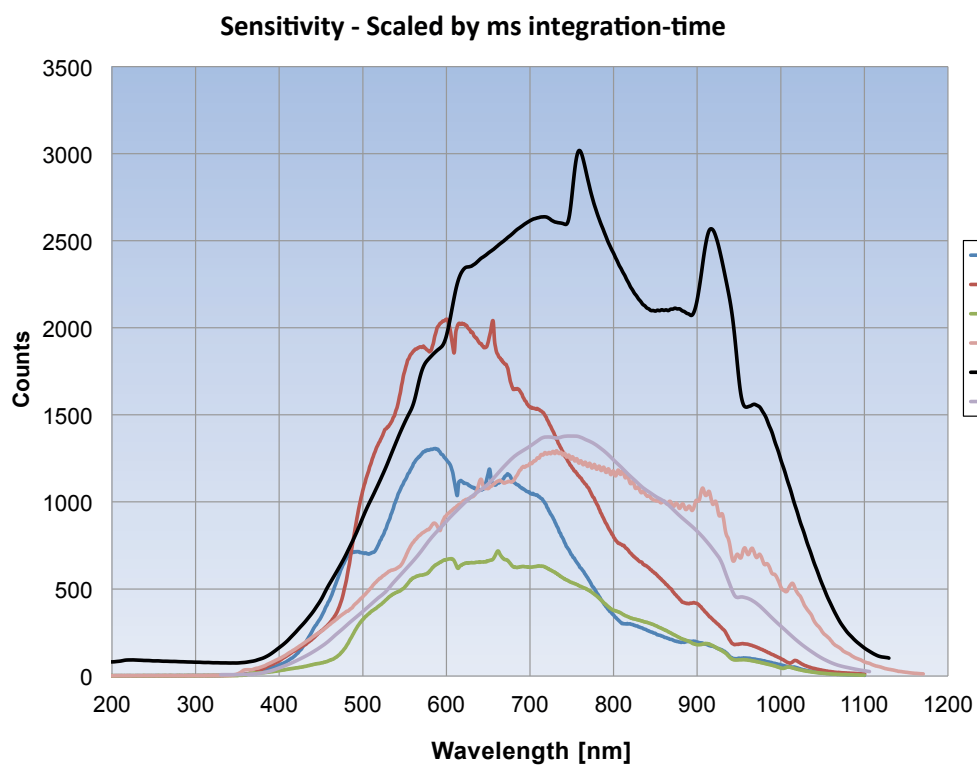
\*\* Photo-Response Non-Uniformity



**Figure 3a Sensitivity Curve UV/VIS**



**Figure 3b Sensitivity Curve VIS/NIR**



In Table 5 the specification is given for the NIR spectrometers, in Figure 3 and Figure 4 the spectral response curves for the different detector types are depicted as built into the respective products and with the same configuration, all scaled to the counts/ms integration time.

### Sensitivity

For NIR detectors 2 different modes are available, the default setting is for high-sensitivity mode (HS), this means more signal at a shorter integration time. The other mode of operation is low-noise (LN), this means a better S/N performance. Sensitivity, S/N, dark noise and Dynamic Range are given as HS and LN values.

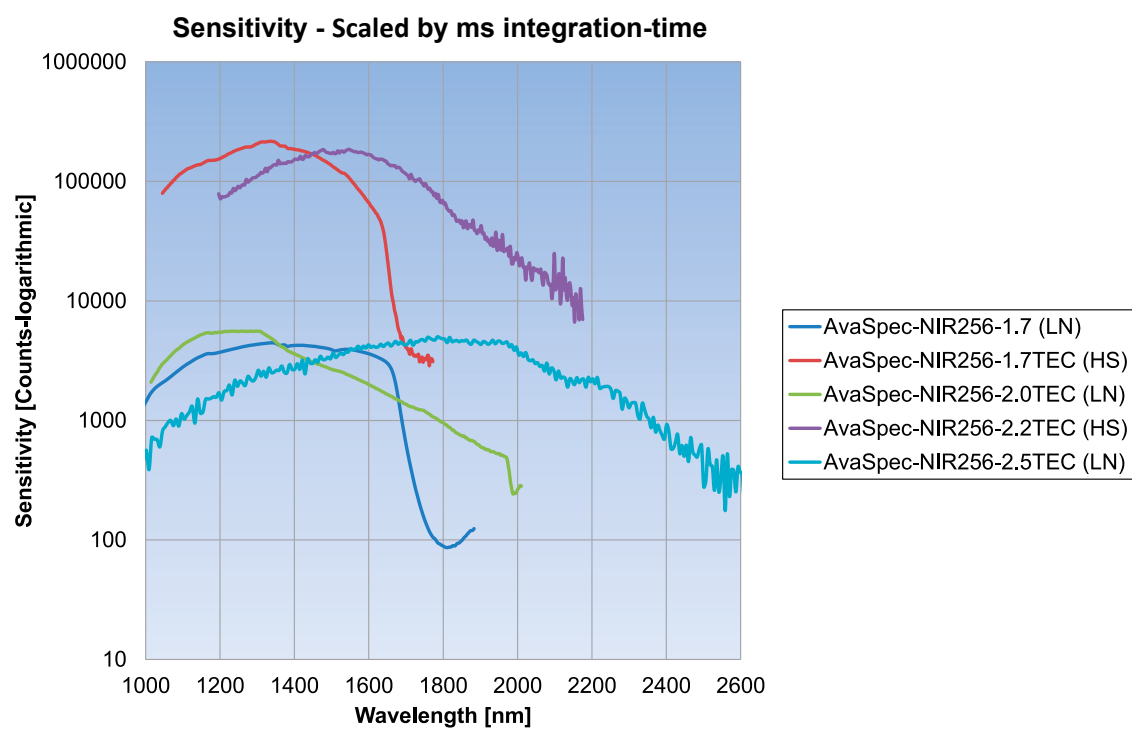
**Table 5 NIRLine Detector Specifications**

Detector	NIR256-1.7	NIR256-1.7TEC	NIR512-1.7TEC	NIR256-2.0TEC	NIR256-2.2TEC	NIR512-2.2TEC	NIR256-2.5TEC
Type	Linear InGaAs array	Linear InGaAs array with 2-stage TE cooling	Linear InGaAs array with 2-stage TE cooling	Linear InGaAs array with 2-stage TE cooling	Linear InGaAs array with 2-stage TE cooling	Linear InGaAs array with 2-stage TE cooling	Linear InGaAs array with 2-stage TE cooling
# Pixels, pitch	256, 50 $\mu\text{m}$	256, 50 $\mu\text{m}$	512, 25 $\mu\text{m}$	256, 50 $\mu\text{m}$	256, 50 $\mu\text{m}$	512, 25 $\mu\text{m}$	256, 50 $\mu\text{m}$
pixel width x height ( $\mu\text{m}$ )	50 x 500	50 x 500	25 x 500	50 x 250	50 x 500	25 x 500	50 x 250
Sensitivity HS in counts/ $\mu\text{W}$ per $\mu\text{s}$	167,000 (integral 1000-1750 nm)	1,320,000 (integral 1000-1750 nm)	610,000 (integral 1000-1750 nm)	70,000 (integral 1000-2000 nm)	77,000 (integral 1200-2200 nm)	38,500 (integral 1200-2200 nm)	70,000 (integral 1000-2500 nm)
Signal/Noise (HS)	2000:1	1700:1	1700:1	1500 :1	1200 :1	1200:1	1500 :1
Dark noise HS (counts RMS)	14	13	13	21	12	12	23
Dynamic Range HS	4000	5000	5000	3300	4800	4800	2800
Sensitivity LN in counts/ $\mu\text{W}$ per $\mu\text{s}$	9,000 (integral 1000-1750 nm)	4,400 (integral 1000-1750 nm)	2,200 (integral 1000-1750 nm)	4,000 (integral 1000-2000 nm)	2,750 (integral 1200-2200 nm)	1,375 (integral 1200-2200 nm)	4,000 (integral 1000-2500 nm)
Signal/Noise (LN)	6000:1	3600:1	3600:1	4000:1	4100:1	4100:1	2700:1
Dark noise LN (counts RMS)	8	8	8	16	8	8	18
Dynamic Range LN	8000	8000	8000	4000	8000	8000	3600
Peak wavelength	1550 nm	1500 nm	1500 nm	1850 nm	2000 nm	2000 nm	2300 nm
QE (%) @ peak	90%	70%	70%	80%	60%	60%	65%
PNRU**	$\pm 5\%$	10%	10%	$\pm 5\%$	10%	10%	$\pm 5\%$
Defective pixels (max)	0	0	0	12	5	10	12
Wavelength range (nm)	900-1750	900-1750	900-1750	1000-2000	1000-2200	1000-2200	1000-2500
Frequency	500 kHz	2.4 MHz	2.4 MHz	500 kHz	2.4 MHz	2.4 MHz	500 kHz

\*\* Photo-Response Non-Uniformity

Add flexibility  
to your spectrometer with  
the Replaceable Slit (-RS) option

**Figure 4 Sensitivity Curve NIR**

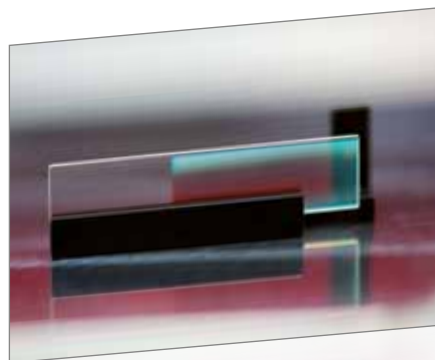


## Stray-Light and second order effects

Stray-light is radiation of undesired wavelengths that activates a signal at a detector element. Sources of stray-light can be:

- Ambient light
- Scattering light from imperfect optical components, or reflections of non-optical components
- Order overlap

### Order-Sorting Window in holder



Avantes symmetrical Czerny-Turner optical bench designs favor stray-light rejection relative to crossed designs. Additionally, Avantes Ultra-Low Stray-light (AvaSpec-ULS) spectrometers have a number of internal measures to reduce stray-light from zero order and backscattering.

When working at the detection limit of the spectrometer system, the stray-light level from the optical bench, grating and focusing mirrors will determine the ultimate limit of detection. Most gratings used are holographic gratings, known for their low level of stray-light. Stray-light measurements are conducted using a halogen light source and long-pass or band-pass filters.

Typical stray-light performance for the AvaSpec-ULS and a B-type grating is <0.04% at 250-500 nm. Second order effects, which can play an important role for gratings with low groove frequency and therefore a wide wavelength range, are usually caused by the 2<sup>nd</sup> order diffracted beam of the grating. The effects of these higher orders can often be ignored, but sometimes need to be addressed using filtering. The strategy is to limit the light to the region of the spectra, where order overlap is not possible.

Second order effects can be filtered out, using a permanently installed long-pass optical filter in the SMA entrance con-

ductor or an order-sorting coating on a window in front of the detector. The order-sorting coatings on the window typically have one long-pass filter (600 nm) or 2 long-pass filters (350 nm and 600 nm), depending on the type and range of the selected grating.

In Table 6 a wide range of optical filters for installation in the optical bench can be found. The filter types that are 3 mm thick give much better 2<sup>nd</sup> order reduction than the 1 mm filters. The use of following long-pass filters is recommended: OSF-475-3 for grating NB and NC, OSF-515-3/550-3 for grating NB and OSF-600-3 for grating IB. For backthinned detectors, such as the 2048XL and 1024x58/122 we recommend an OSF-305 Filter, when the starting wavelength is 300 nm and higher.

In addition to the order-sorting coatings, we apply partial DUV coatings on the Sony 2048 detectors to avoid second-order effects from UV response and to enhance sensitivity and decrease noise in the visible range.

This partial DUV coating is done automatically for the following grating types:

- UA for 200-1100 nm, DUV400, only first 400 pixels coated
- UB for 200-700 nm, DUV800, only first 800 pixels coated

**Table 6 Filters installed in AvaSpec spectrometer series**

<b>OSF-305-3</b>	Permanently installed 3 mm order-sorting filter @ 305 nm
<b>OSF-385-3</b>	Permanently installed 3 mm order-sorting filter @ 385 nm
<b>OSF-475-3</b>	Permanently installed 3 mm order-sorting filter @ 475 nm
<b>OSF-515-3</b>	Permanently installed 3 mm order-sorting filter @ 515 nm
<b>OSF-550-3</b>	Permanently installed 3 mm order-sorting filter @ 550 nm
<b>OSF-600-3</b>	Permanently installed 3 mm order-sorting filter @ 600 nm
<b>OSF-850-3</b>	Permanently installed 3 mm order-sorting filter @ 850 nm
<b>OSC</b>	Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-ULS2048(L)/3648/2048XL
<b>OSC-UA</b>	Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS2048(L)/3648/2048XL
<b>OSC-UB</b>	Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS2048(L)/3648/2048XL
<b>OSC-HS500</b>	Order-sorting coating with 350 and 600 nm long-pass filter for HS500 gratings in AvaSpec-HS
<b>OSC-HS900</b>	Order-sorting coating with 600 nm long-pass filter for HS900 gratings in AvaSpec-HS
<b>OSC-HS1000</b>	Order-sorting coating with 350 nm long-pass filter for HS1000 gratings in AvaSpec-HS
<b>OSC-NIR</b>	Order-sorting coating with 1400 nm long-pass filter for NIR100-2.5 and NIR150-2.0 gratings in AvaSpec-NIR256/512-2.2/2.5TEC

# Spectrometer platforms

## AvaSpec StarLine

The AvaSpec StarLine family of instruments is comprised of high-performance spectrometers which exceed the demands of most general spectroscopy applications. The StarLine includes high-speed instruments for process control (AvaSpec-128 and AvaSpec-FAST-series), high-resolution instruments for demanding measurements like atomic emission (AvaSpec-3648) and versatile instruments for common applications such as irradiance and absorbance chemistry (AvaSpec-2048 & AvaSpec-2048L). This instrument line offers an array of solutions for varied uses, while providing excellent price-to-performance ratios.

The AvaSpec-2048/2048L and AvaSpec-3648 are based on front illuminated linear CCD arrays and thanks to Avantes' DUV coating can measure wavelengths from 200-1100 nm. The AvaSpec-FAST series of instruments is specially designed for high-speed acquisitions such as pulsed light source and laser measurements. The AvaSpec-128 is an ultrafast photo-diode array-based instrument for visible and near-infrared applications.

Instruments in the AvaSpec StarLine family are designed to perform in a variety of applications such as:

- Reflection and transmission measurements for optics, coatings, color measurement
- Irradiance and emission measurements for environmental, light characterization, and optical emission spectroscopy
- High-speed measurements for process control, LIBS or laser/pulsed source characterization
- Absorbance chemistry



AvaSpec StarLine instruments are fully integrated with Avantes' modular platform, allowing them to function stand-alone, or as multi-channel instruments. These products are fully compatible with other AvaSpec instruments in our AvaSpec SensLine and NIRLine. The entire AvaSpec StarLine is available as an individual lab instrument or an OEM module for integration into a customers' existing system.

The StarLine instruments are available with our standard AvaBench-45 optical bench (45 mm focal length) or the ultra-low stray-light (ULS) optical bench (75 mm focal length). The AvaSpec StarLine instruments are also available with a number of premium options such as irradiance/intensity calibration and non-linearity calibration.

For external triggering Avantes offers the AvaTrigger, featuring optical triggering, external TTL or manually through the pushbutton.



## AvaSpec SensLine

The AvaSpec SensLine family of products is Avantes' response to customers who require higher performance for demanding spectroscopy applications such as fluorescence, luminescence and Raman. The AvaSpec SensLine product line includes five high-sensitivity, low-noise spectrometers. Three of the instruments are based on back-thinned detector technology, of which two feature high-performance thermoelectrically cooled detectors. The other two models are based on standard CCDs, upgraded to high-performing instruments as a result of Avantes' unique and recently improved detector cooling technology. The back-thinned CCD detectors featured in the AvaSpec SensLine product family are high quantum efficiency detectors with excellent response in the UV, VIS and NIR from 200-1160 nm.

AvaSpec SensLine instruments are fully integrated with Avantes' modular platform, allowing them to function standalone, or as multi-channel instruments. These products are fully compatible with other

AvaSpec instruments in our AvaSpec StarLine and AvaSpec NIRLine product families. The entire AvaSpec SensLine is available as a lab instrument or an OEM module for integration into a customers' existing system.

Avantes' innovative ultra-low stray-light (ULS) and revolutionary new High-Sensitivity (HS) optical benches are the core optical technologies in the AvaSpec SensLine. These highly stable optical benches combined with our high-performance AS5216 USB2 electronics board deliver high-performance instruments at affordable prices.

All members of the AvaSpec SensLine are designed to provide performance features such as:

- High-stability
- High-sensitivity
- High-speed acquisition
- Low-noise



## AvaSpec NIRLine

The AvaSpec NIRLine instruments are high-performance, near-infrared spectrometers that are optimized for the demands of measuring long wavelengths. This line provides leading-edge performance for dispersive NIR instruments with toroidal focusing mirrors and dynamic dark correction for enhanced stability. The NIRLine is comprised of both thermo-electrically cooled and un-cooled instruments. AvaSpec-NIR256-1.7 features an uncooled 256 pixel InGaAs detector. All other instruments in the NIRLine have thermo-electric, peltier-cooled InGaAs detectors which support cooling down to -25°C against ambient.

AvaSpec NIRLine instruments are fully compatible with our AvaSpec StarLine and SensLine spectrometers. Avantes' AvaSpec NIRLine instruments are available as laboratory instruments or OEM modules.

AvaSpec NIRLine instruments are available with a number of premium options such as irradiance/intensity calibration and non-linearity calibration.

The AvaSpec NIRLine of instruments are designed to perform in a variety of applications such as:

- Moisture content measurement of liquids, solids and powders for inline and quality control purposes
- Quantitative and qualitative measurement of volatile organics such as ethanol, and methanol
- Plastic characterization and material identification
- Irradiance measurements, such as solar monitoring
- Qualitative measurements of feed and food



For the latest information,  
go to [www.avantes.com](http://www.avantes.com)

# AvaSpec Pre-configured Fiber-optic Spectrometers (In stock, ready to ship)

For customers with urgent needs and general flexibility in their specifications, Avantes offers a variety of pre-configured spectrometers, which are ready to ship. Three of the instruments are configured for UV-VIS-NIR measurements (200-1100 nm), one for VIS-NIR (360-1100 nm), and one for the visible range (360-880 nm). All configurations are priced at a discount off of list pricing and include an upgrade to AvaSoft-Full.

Of course a USB2-cable and an extensive manual are included. Everything you need to start your experiments is included. These spectrometers are off the shelf and ready to ship.



## Technical Data

Name	AvaSpec-ULS3648-USB2-UA-25	AvaSpec-ULS2048-USB2-UA-50	AvaSpec-ULS2048-USB2-VA-50	AvaSpec-ULS2048L-USB2-BB-50	AvaSpec-ULS2048XL-USB2-UA-50
Uses	UV/VIS/NIR	UV/VIS/NIR	VIS/NIR	VIS	UV/VIS/NIR
Range	200-1100 nm	200-1100 nm	360-1100 nm	360-880 nm	200-1150 nm
Slit/Connector	25 µm SMA-905 connector	50 µm SMA-905 connector	50 µm SMA-905 connector	50 µm SMA-905 connector	50 µm SMA-905 connector
Resolution (FWHM)	1.4 nm	2.4 nm	2.4 nm	1.2 nm	2.4 nm
A/D Convertor	16-bit	16-bit	16-bit	16-bit	16-bit
Interface	USB 2.0	USB 2.0	USB 2.0	USB 2.0	USB 2.0
Included options	Deep-UV Coating Order-sorting coating	Detector collection lens Deep-UV Coating Order-sorting coating	Detector collection lens Order-sorting coating	Detector collection lens Order-sorting coating	Detector collection lens Order-sorting coating
Applications	High-resolution measurements from high intensity sources (lasers, powerful light sources, plasma)	Highly versatile broadband spectrometer. Ideal for absorbance, emission, irradiance measurements	Color measurements, visible irradiance measurements	Color measurements, visible irradiance measurements	Highly sensitivity applications such as fluorescence or irradiance from very low intensity sources
AvaSoft-Full	Included	Included	Included	Included	Included

## Ordering Information

<b>AvaSpec-ULS3648-USB2-UA-25</b>	<ul style="list-style-type: none"> <li>UV/VIS/NIR spectrometer, 3648 pixel CCD detector, grating UA (200-1100 nm), slit-25, OSC-UA, DUV3648, USB2 high-speed interface, including USB interface cable and AvaSoft-Full.</li> </ul>
<b>AvaSpec-ULS2048-USB2-UA-50</b>	<ul style="list-style-type: none"> <li>UV/VIS/NIR spectrometer, 2048 pixel CCD detector, grating UA (200-1100 nm), slit-50, OSC-UA, DCL-UV/VIS, DUV400, USB2 high-speed interface, including USB interface cable and AvaSoft-Full.</li> </ul>
<b>AvaSpec-ULS2048-USB2-VA-50</b>	<ul style="list-style-type: none"> <li>VIS/NIR spectrometer, 2048 pixel CCD detector, grating VA (360-1100 nm), slit-50, OSC, DCL-UV/VIS, USB2 high-speed interface, including USB interface cable and AvaSoft-Full.</li> </ul>
<b>AvaSpec-ULS2048L-USB2-BB-50</b>	<ul style="list-style-type: none"> <li>VIS spectrometer, 2048 pixel CCD detector, grating BB (360-880 nm), slit-50, OSC, DCL-UV/VIS-200, USB2 high-speed interface, including USB interface cable and AvaSoft-Full.</li> </ul>
<b>AvaSpec-ULS2048XL-USB2-UA-50</b>	<ul style="list-style-type: none"> <li>UV/VIS/NIR spectrometer, 2048 pixel backthinned CCD detector, grating UA (200-1150 nm), slit-50, OSC-UA, DCL-UV/VIS-200, USB2 high-speed interface, including USB interface cable and AvaSoft-Full.</li> </ul>

# AvaSpec-128 StarLine Ultrafast Fiber-optic Spectrometer

## AvaSpec-128



The AvaSpec-128 is blazingly fast, supporting integration times as short as 60  $\mu$ s. The affordable price and range from 360-1100 nm make it an ideal instrument for inline process control measurements.

The AvaSpec-128 has a USB2-port to connect to your computer and transfers data at 1.1 ms per scan. Data sampling is done at a rate of 8000 scans per second. It comes complete with AvaSoft-basic software, an extensive manual and USB-cable. It's also available in dual-channel or multi-channel configurations (up to 10, built into a 19" rackmount), where all spectra are stored simultaneously. The resolution (FWHM) capability is between 1.7 and 64 nm, depending on slit and grating configurations.

For the fiber-optic entrance connector you can choose between SMA (default) and FC/PC. Furthermore you can select from a wide range of gratings, slit sizes, and second-order sorting filters. Other options are a detector collection lens for enhanced sensitivity and a switch to select between USB or external power.

### Technical Data

<b>Optical Bench</b>	Symmetrical Czerny-Turner, 45 mm focal length
<b>Wavelength range</b>	360-1100 nm
<b>Resolution</b>	1.7 – 64 nm, depending on configuration (see table)
<b>Stray-light</b>	< 0.3%
<b>Sensitivity</b>	430,000 counts/ $\mu$ W per ms integration time
<b>Detector</b>	Photo-diode array, 128 pixels
<b>Signal/Noise</b>	500:1
<b>AD converter</b>	16-bit, 2 MHz
<b>Integration time</b>	0.06 ms – 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	0.12 ms
<b>Data transfer speed</b>	1.1 ms / scan (USB2) 30 ms / scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
<b>Power supply</b>	Default USB power, 350 mA Or with SPU2 external 12VDC, 150 mA
<b>Dimensions, weight</b>	175 x 110 x 44 mm (1 channel), 716 grams

## Grating selection table for AvaSpec-128

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
VIS/NIR	360-1100	500	300	300	UA
VIS	360-750	100	1200	250	UC
VIS	360-850	240	600	400	BB
VIS/NIR	360-1100*	740*	150	500	VZ
VIS/NIR	360-1100	500	300	500	VA
VIS	360-850	235	600	500	VB
VIS	400-980	100	1200	500	VC
NIR	500-935	215	600	750	NB
NIR	500-1000	100	1200	750	NC
NIR	600-1100	475	300	1000	IA
NIR	600-1100	200	600	1000	IB

\* please note that not all 128 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-128

Grating (lines/mm)	Slit size (μm)			
	50	100	200	500
150	13.0	14.0	28.0	64.0
300	6.4	7.2	15.0	32.0
600	2.6	3.5	7.2	16.0
1200	1.7	2.1	4.0	8.0

## Ordering Information

### AvaSpec-128-USB2

- Fiber-optic Spectrometer, 45 mm AvaBench, 128 pixel PDA detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating, wavelength range and options

## Options

- SPU2** • incl. switch for USB powered USB2 or external power for RS-232
- FCPC** • FC/PC fiber-optic entrance
- DCL-VIS** • Detector collection lens to enhance sensitivity, BK7, 360-1100 nm
- SLIT-XX** • Slit size, please specify XX = 50, 100, 200 or 500 μm
- OSF-YYY-3** • Order-sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550 or 600 nm

AvaLight-LDXE:  
high-brightness laser-driven  
Xenon light source

# AvaSpec-ULS2048 StarLine

## Versatile Fiber-optic Spectrometer

### AvaSpec-ULS2048



It's the workhorse of our spectrometer line-up, the AvaSpec-ULS2048. Used in many applications in the UV/VIS-range, it is particularly useful in time-critical situations thanks to its exceptional response speed. Priced affordably, the AvaSpec-ULS2048 is the choice of many of our most demanding customers.

Options include deep-UV detector coating for better performance in the deep-UV-range, a detector collection lens to enhance sensitivity in the 200-1100 nm range and order-sorting filters to reduce 2<sup>nd</sup> order effects. Furthermore, the AvaSpec-ULS2048 is available with a wide range of slit sizes, gratings and fiber-optic entrance connectors.

The AvaSpec-ULS2048 is also available in dual or multi-channel versions (up to 10 spectrometers in a 19" rack), where all spectra are taken simultaneously.

Connection with your PC is done via USB2-connection, delivering a scan every 1.8 milliseconds. Integration time can be as short as 1.1 milliseconds up to a maximum of 10 minutes. It comes complete with AvaSoft-Basic software, USB cable and an extensive manual, including a quick start guide in four languages.

### Technical Data

<b>Optical Bench</b>	ULS Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200-1100 nm
<b>Resolution</b>	0.05 -20 nm, depending on configuration (see table)
<b>Stray-light</b>	0.04-0.1%, depending on the grating
<b>Sensitivity</b>	310,000 counts/μW per ms integration time
<b>Detector</b>	CCD linear array, 2048 pixels
<b>Signal/Noise</b>	200:1
<b>AD converter</b>	16-bit, 2 MHz
<b>Integration time</b>	1.11 ms - 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	1.1 ms /scan
<b>Data transfer speed</b>	1.8 ms /scan (USB2) 430 ms/scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
<b>Power supply</b>	Default USB power, 350 mA Or with SPU2 external 12VDC, 150 mA
<b>Dimensions, weight</b>	175 x 110 x 44 mm (1 channel), 716 grams

Pre-configured  
spectrometers can be shipped  
within 24 hours



## Grating selection table for AvaSpec-ULS2048

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**	800**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-90*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1100**	500**	300	1000	IA
NIR	600-1100	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 2048 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-ULS2048

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
<b>300</b>	0.80 – 0.90*	1.10-1.20*	2.30	4.60	9.00	20.0
<b>600</b>	0.40 – 0.50*	0.63	1.15	2.31	4.50	10.0
<b>830</b>	0.28	0.40	0.80	1.60	3.20	8.0
<b>1200</b>	0.18 – 0.22*	0.29	0.61	1.18	2.20	5.4
<b>1800</b>	0.10 – 0.16*	0.19	0.35-0.42*	0.80	1.60	3.6
<b>2400</b>	0.08 – 0.11*	0.10 – 0.15*	0.28	0.55	1.10	2.7
<b>3600</b>	0.05 – 0.08*	0.10	0.18	0.38	0.75	1.8

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS2048-USB2

- Fiber-optic Spectrometer, 75 mm AvaBench, 2048 pixel CCD detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating, wavelength range and options

## Options

<b>-SPU2</b>	• incl. switch for USB powered USB2 or external power for RS-232
<b>-RS</b>	• Replaceable slit, see page 58
<b>DUV</b>	• Deep-UV detector coating >150 nm
<b>DCL-UV/VIS</b>	• Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 µm
<b>SLIT-XX-RS</b>	• Replaceable slit with SMA connector, specify slit size XX=25, 50, 100 or 200 µm. Only in combination with AvaSpec-ULS2048-USB2-RS
<b>SLIT-XX-RS-FCPC</b>	• as SLIT-XX-RS, but with FC/PC connector
<b>OSF-YYY-3</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-ULS2048
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS2048
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS2048
<b>-FCPC</b>	• FC/PC fiber-optic connector

To calibrate your spectrometer,  
take a look at the AvaLight-CAL calibration light source.  
Alternatively Avantes has in-house calibration possibilities.  
Contact an application specialist for more information.

# AvaSpec-ULS3648 StarLine

## High-resolution Fiber-optic Spectrometer

When you're looking for high-resolution, then take a look at the AvaSpec-ULS3648. Featuring an electronic shutter, it can support integration times as short as 10 microseconds, making it also ideal for CW laser measurements.

Options include order-sorting filters to prevent 2<sup>nd</sup> order effects, deep-UV detector coating for better sensitivity in the deep-UV-range, and a detector collection lens to enhance overall sensitivity. Also, a wide range of slit sizes, gratings and fiber-optic entrance connectors are available.

Configurations with two to ten channel spectrometers are available. These give you the possibility of multiple simultane-

ous readouts or higher optical resolution in which several spectrometers are arrayed with each covering a short range with high-resolution. For more information, see pages 53 and 54.

The connection to your computer is done through USB2 at 480 Mbps. This translates into 3.7 ms per scan data transfer speed. Of course it's supplied with AvaSoft-Basic, USB cable and an extensive manual, including a quick start guide in four languages.

### AvaSpec-ULS3648



### Technical Data

<b>Optical Bench</b>	ULS Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200 - 1100 nm
<b>Resolution</b>	0.05 - 20 nm, depending on configuration (see table)
<b>Stray-light</b>	0.04-0.1%, depending on the grating
<b>Sensitivity</b>	160,000 counts/μW per ms integration time
<b>Detector</b>	CCD linear array, 3648 pixels
<b>Signal/Noise</b>	350:1
<b>AD converter</b>	16-bit, 1 MHz
<b>Integration time</b>	10 μs - 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	3.7 ms /scan
<b>Data transfer speed</b>	3.7 ms /scan (USB2) 750 ms/scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization
<b>Power supply</b>	Default USB power, 350 mA Or with SPU2 external 12VDC, 150 mA
<b>Dimensions, weight</b>	175 x 110 x 44 mm (1 channel), 716 grams

## Grating selection table for AvaSpec-ULS3648

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**	800**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-100*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1100**	500**	300	1000	IA
NIR	600-1100	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 3648 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-ULS3648

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
<b>300</b>	0.60 – 0.70*	1.10-1.30*	2.20-2.40*	4.60	9.00	20.0
<b>600</b>	0.30 – 0.36*	0.58-0.68*	1.17	2.20	4.50	10.0
<b>830</b>	0.25	0.48	0.93	1.70	3.40	8.0
<b>1200</b>	0.14 – 0.18*	0.30	0.62	1.08	2.20	5.0
<b>1800</b>	0.09 – 0.11*	0.18	0.36-0.40*	0.78	1.50	3.7
<b>2400</b>	0.07 – 0.09*	0.13 – 0.15*	0.26-0.32*	0.40-0.64*	1.10	2.7
<b>3600</b>	0.05 – 0.06*	0.10	0.19	0.40	0.80	2.0

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS3648-USB2

- Fiber-optic Spectrometer, 75 mm AvaBench, 3648 pixel CCD detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating, wavelength range and options

## Options

<b>-SPU2</b>	• incl. switch for USB powered or external power for RS-232
<b>-RS</b>	• Replaceable slit, see page 58
<b>DUV</b>	• Deep-UV detector coating >150 nm
<b>DCL-UV/VIS-200</b>	• Quartz Detector Collection Lens (200-1100 nm)
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 $\mu\text{m}$
<b>SLIT-XX-RS</b>	• Replaceable slit with SMA connector , specify slit size XX=25, 50, 100 or 200 $\mu\text{m}$ . Only in combination with AvaSpec-ULS3648-USB2-RS
<b>SLIT-XX-RS-FCPC</b>	• as SLIT-XX-RS, but with FC/PC connector
<b>OSF-YYY-3</b>	• Order-sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>305 nm) and VB gratings in AvaSpec-ULS3648
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS3648
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS3648
<b>-FCPC</b>	• FC/PC fiber-optic connector

The grating can only be changed by Avantes.

Therefore, choose your grating wisely.

Our application specialists are available to support you with your choice.

In general, a higher resolution means a lower bandwidth.

By combining multiple spectrometers  
in our AvaSpec-Dual or rack-mountable versions,  
you can create one virtual spectrometer with high-resolution  
and high bandwidth.



## AvaSpec-ULS2048L StarLine Versatile Fiber-optic Spectrometer

### AvaSpec-ULS2048L



A close cousin to the AvaSpec-ULS2048 but with larger pixels is the AvaSpec-ULS2048L. It provides enhanced sensitivity at an affordable price. The AvaSpec-ULS2048L has pixels that are almost four times higher than those in the AvaSpec-ULS2048. It gives you twice the signal to noise ratio and 40% less dark noise.

Options include a deep-UV detector coating, for better performance in the deep-UV range, a detector collection lens to enhance sensitivity in the 200-1100 nm range and order-sorting filter to reduce 2<sup>nd</sup> order effects. Furthermore, the AvaSpec-2048L is available with a wide range of slit sizes, gratings and fiber-optic entrance connectors.

The AvaSpec-2048L is also available in dual or multi-channel versions (up to 10 spectrometers), where all spectra are taken simultaneously.

Connection to your PC is handled via USB2-connection, delivering a scan every 1.8 milliseconds. Integration time can be as short as 1.11 milliseconds up to a maximum of 10 minutes. It comes complete with AvaSoft-Basic software, USB cable and an extensive manual, including a quick start guide in four languages.

### Technical Data

<b>Optical Bench</b>	ULS Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200-1100 nm
<b>Resolution</b>	0.06 –20 nm, depending on configuration (see table)
<b>Stray-light</b>	0.04-0.1%, depending on the grating
<b>Sensitivity</b>	470,000 counts/μW per ms integration time
<b>Detector</b>	CCD linear array, 2048 pixels
<b>Signal/Noise</b>	300:1
<b>AD converter</b>	16-bit, 2 MHz
<b>Integration time</b>	1.11 ms – 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	1.1 ms /scan
<b>Data transfer speed</b>	1.8 ms/scan (USB2) 430 ms/scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
<b>Power supply</b>	Default USB power, 350 mA Or with SPU2 external 12VDC, 150 mA
<b>Dimensions, weight</b>	175 x 110 x 44 mm (1 channel), 716 grams

Add flexibility  
to your spectrometer with  
the Replaceable Slit (-RS) option

## Grating selection table for AvaSpec-ULS2048L

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**	800**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-90*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1100**	500**	300	1000	IA
NIR	600-1100	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 2048 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-ULS2048L

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
<b>300</b>	1.0	1.4	2.5	4.8	9.2	21.3
<b>600</b>	0.40-0.53*	0.7	1.2	2.4	4.6	10.8
<b>830</b>	0.32	0.48	0.93	1.7	3.4	8.5
<b>1200</b>	0.20-0.28*	0.27-0.38*	0.52-0.66*	1.1	2.3	5.4
<b>1800</b>	0.10-0.18*	0.20-0.29*	0.34-0.42*	0.8	1.6	3.6
<b>2400</b>	0.09-0.13*	0.13-0.17*	0.26-0.34*	0.44-0.64*	1.1	2.7
<b>3600</b>	0.06-0.08*	0.10	0.19	0.4	0.8	1.8

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS2048L-USB2

- Fiber-optic Spectrometer, 75 mm AvaBench, 2048 pixel CCD detector 14 x 200 μm, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating, wavelength range and options

We can also calibrate  
your AvaSpec series  
spectrometer

## Options

<b>-SPU2</b>	• incl. switch for USB powered USB2 or external power for RS-232
<b>-RS</b>	• Replaceable slit, see page 58
<b>DUV</b>	• Deep-UV detector coating >150 nm
<b>DCL-UV/VIS-200</b>	• Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 µm
<b>SLIT-XX-RS</b>	• Replaceable slit with SMA connector , specify slit size XX=25, 50, 100 or 200 µm. Only in combination with AvaSpec-ULS2048L-USB2-RS
<b>SLIT-XX-RS-FCPC</b>	• as SLIT-XX-RS, but with FC/PC connector
<b>OSF-YYY-3</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 3 mm thick, please specify YYY= 305, 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-ULS2048L
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS2048L
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS2048L
<b>-FCPC</b>	• FC/PC fiber-optic connector

For extra sensitivity:  
take a look at the  
AvaSpec-ULS2048XL

# AvaSpec-Fast StarLine

## Ultra-fast Spectrometer for High-speed Applications

For ultra-fast spectral acquisition the AvaSpec-Fast offers the best solution. Up to 5637 spectra can be stored at 0.20 ms per scan using Avantes unique store-to-RAM functionality. Depending on the configuration chosen, between 1254 and 5637 spectra can be stored during one burst.

The AvaSpec-FAST series is available in five different configurations; the difference being the number of active pixels. More pixels provide higher resolution or more bandwidth, but slower minimum integration time. For all models, start/stop pixels can be set in our software to increase the number of scans stored on board over a shorter wavelength range.

The AvaSpec-FAST can be configured in CR or SS mode. CR, or continuous run, mode means a single external trigger (through the DB26-connector) results in a customer-set number of scans automatically to be measured. SS-mode, for single scan, means a single spectrum is acquired at every external trigger. CR or SS mode must be specified at the time of order.

Possible configurations are single or dual channel, desktop or Rack-mounted. The instrument is available with all the options and gratings of the AvaSpec-ULS2048.

### AvaSpec-Fast



### Technical Data

FAST Series Model	Min Integration Time	Pixels	Max. Frequency (Hz) in CR-Store to RAM	Max amount of spectra Store to RAM
<b>AvaSpec-ULS350F-USB2</b>	0.20 ms	350	5000	5637
<b>AvaSpec-ULS750F-USB2</b>	0.40 ms	750	2500	2716
<b>AvaSpec-ULS950F-USB2</b>	0.50 ms	950	2000	2157
<b>AvaSpec-ULS1350F-USB2</b>	0.70 ms	1350	1400	1528
<b>AvaSpec-ULS1650F-USB2</b>	0.85 ms	1650	1100	1254

### Grating selection table for AvaSpec-FAST

Grating	Lines/mm	Spectral range AvaSpec-ULS350F (nm)	Spectral range AvaSpec-ULS750F (nm)	Spectral range AvaSpec-ULS950F (nm)	Spectral range AvaSpec-ULS1350F (nm)	Spectral range AvaSpec-ULS1650F (nm)
Z	150	400	850	900	n.a.	n.a.
A	300	190	400	520	750	900
B	600	90	200	250	360	450
C	1200	45	100	120	180	210
D	1800	30	60	80	110	140
E	2400	20	45	50	80	100
F	3600	10	27	30	50	60

### Ordering Information

<b>AvaSpec-350F-USB2</b>	<ul style="list-style-type: none"> <li>Ultra-fast Fiber-optic Spectrometer, 75 mm low stray-light AvaBench, 350 pixel CCD detector, USB/RS-232 interface, incl. AvaSoft-Basic, USB2 cable. Specify grating, wavelength range and options</li> </ul>
<b>AvaSpec-750F-USB2</b>	<ul style="list-style-type: none"> <li>As AvaSpec-350F-USB2, but 750 pixel CCD detector</li> </ul>
<b>AvaSpec-950F-USB2</b>	<ul style="list-style-type: none"> <li>As AvaSpec-350F-USB2, but 550 pixel CCD detector</li> </ul>
<b>AvaSpec-1350F-USB2</b>	<ul style="list-style-type: none"> <li>As AvaSpec-350F-USB2, but 1350 pixel CCD detector</li> </ul>
<b>AvaSpec-1650F-USB2</b>	<ul style="list-style-type: none"> <li>As AvaSpec-350F-USB2, but 1650 pixel CCD detector</li> </ul>

### Options

- See AvaSpec-ULS2048-USB2

# AvaSpec-ULS2048XL SensLine

## High UV- and NIR-sensitivity back-thinned CCD Spectrometer



Combining exceptional quantum efficiency with high-speed is the value proposition of the AvaSpec-ULS2048XL spectrometer. Unlike many back-thinned CCD spectrometers, which have two dimensional arrays the ULS2048XL has large monolithic pixels of 14x500 microns with exceptional efficiency in the UV from 200-400 nm and the NIR from 950-1160 nm. The instrument also has an electronic shutter, which enables integration times as low as 2 microseconds. To further enhance sensitivity a detector collection lens is available which improves sensitivity up to 60% when combined with larger core fibers.

Options include order-sorting filter to reduce 2<sup>nd</sup> order effects, purge ports for deep-UV measurements. The AvaSpec-ULS2048XL comes with a wide range of slit sizes, gratings and may be configured with SMA or FC/PC fiber-optic entrance connectors.

The AvaSpec-2048XL is also available in dual or multi-channel versions (up to 10 spectrometers), where all spectra are acquired simultaneously.

Connection to your PC is handled via a USB2-connection, delivering a scan every 2 milliseconds. The instrument comes complete with AvaSoft-basic software, USB cable and an extensive manual, including a quick start guide in four languages.

### Technical Data

<b>Optical Bench</b>	ULS, Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200 - 1160 nm
<b>Resolution</b>	0.09 - 20 nm, depending on configuration (see table)
<b>Stray-light</b>	< 0.3%
<b>Sensitivity</b>	460,000 counts/μW per ms int. time
<b>UV Quantum efficiency</b>	60% (200-300 nm)
<b>Detector</b>	Back-thinned CCD image sensor 2048 pixels
<b>Signal/Noise</b>	450:1
<b>AD converter</b>	16-bit, 1 MHz
<b>Integration time</b>	2 μs - 20 seconds
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	2.09 ms /scan
<b>Data transfer speed</b>	2.09 ms /scan (USB2) 432 ms / scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization
<b>Power supply</b>	Default USB power, 450 mA. Or with SPU2 external 12VDC, 200 mA
<b>Dimensions, weight</b>	175 x 110 x 44 mm (1 channel), 855 grams



## Grating selection table for AvaSpec-2048XL

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1160**	960**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1160**	860**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-100*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1160**	560**	300	1000	IA
NIR	600-1160	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 2048 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-2048XL

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
300	1.40	1.50	2.5	4.8	9.2	21.3
600	0.70 - 0.80*	0.75-0.85*	1.2	2.4	4.6	10.8
830	0.42 - 0.48*	0.50-0.58*	0.93	1.7	3.4	8.5
1200	0.25 - 0.31*	0.37 - 0.43*	0.52-0.66*	1.1	2.3	5.4
1800	0.17 - 0.21*	0.26 - 0.32*	0.34-0.42*	0.8	1.6	3.6
2400	0.12 - 0.18*	0.18 - 0.24*	0.26-0.34*	0.44-0.64*	1.1	2.7
3600	0.09 - 0.12*	0.11 - 0.15*	0.19	0.4	0.8	1.8

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS2048XL-USB2

- Ultra-low Stray-light Fiber-optic Spectrometer, 75 mm AvaBench, 2048 large 500 μm pixel back-thinned CCD detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable.
- Specify grating, wavelength range and options

Why is the XL so sensitive?  
We're using back-illuminated detectors.  
They have the electronics on the backside of the detector,  
allowing more light to be caught by the front side.

## Options

<b>-SPU2</b>	• incl. switch for USB power or external power for RS-232
<b>-RS</b>	• Replaceable slit, see page 58
<b>DCL-UV/VIS-200</b>	• Quartz Detector Collection Lens (200-1100 nm)
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 µm
<b>SLIT-XX-RS</b>	• Replaceable slit with SMA connector, specify slit size XX=25, 50, 100 or 200 µm. Only in combination with AvaSpec-ULS2048XL-USB2-RS
<b>SLIT-XX-RS-FCPC</b>	• as SLIT-XX-RS, but with FC/PC connector
<b>OSF-YYY</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 1 mm thick, please specify YYY= 305, 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-2048XL, recommended with OSF-305
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS2048XL
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS2048XL
<b>-FCPC</b>	• FC/PC fiber-optic connector

The grating can only be changed by Avantes.  
Therefore, choose your grating wisely.  
Our application specialists are available to support you with your choice.  
In general, a higher resolution means a lower bandwidth.  
By combining multiple spectrometers  
in our AvaSpec-Dual or rack-mountable versions,  
you can create one virtual spectrometer with high-resolution  
and high bandwidth.

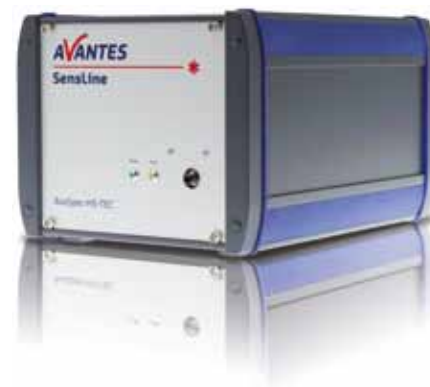
# AvaSpec-HS1024x58/122 SensLine High UV- and NIR-sensitivity TE-cooled CCD Spectrometer

AvaSpec-HS1024x58 and HS1024x122 High-sensitivity Fiber-optic Spectrometers are top performing instruments in the SensLine High-sensitivity spectrometer family with high quantum efficiency in the UV and near infrared spectral regions. The detector pixels in the AvaSpec-HS1024x58 measure 1392  $\mu\text{m}$  high and for the AvaSpec-HS1024x122 they measure 2928  $\mu\text{m}$  high. The instrument's optical bench design is based on a revolutionary concept with high numerical (0.22) aperture and throughput. TE-cooled backthinned CCD detectors are used as a linear array of 1024 pixels binning the vertical 58 or 122 pixels for optimal efficiency. The spectrometers have a fiber-optic entrance connector (standard SMA, other options available), toroid collimating and focusing mirrors and are available with choice of 7 different standard diffraction gratings to enable

applications in the 200-1160 nm range. The AvaSpec-HS1024x58/122 include a 16-bit AD converter, and USB2.0 high-speed interface. These instruments are especially suitable for measuring low light, fluorescence and UV applications and also have superior NIR sensitivity relative to front illuminated CCDs. Digital IO ports enable external triggering, control of shutters, and pulsed light sources from the Avantes line of instruments.

AvaSpec-HS1024x58/122 have TE-cooled detectors with lower dark noise, better signal to noise, and enhanced sensitivity that is even 3 times more sensitive than the nearest spectrometer in our Sensline. The AvaSpec-HS-1024x58/122 runs on 100-240VAC power and comes with AvaSoft-Basic, a manual and USB interface cable.

## AvaSpec-HS1024x58/122TEC



### Technical Data

Spectrometer Type	AvaSpec-HS1024x58TEC	AvaSpec-HS1024x122TEC
Optical Bench	High-sensitivity asymmetrical design 37.5 mm focal length, N.A. 0.22, f/2.27	
Wavelength range	200 - 1160 nm	
Resolution	1.2 - 20 nm, depending on configuration (see table)	
Stray-light	< 1%	< 1%
Sensitivity (counts/ $\mu\text{W}$ per ms int. time)	850,000	1,270,000
UV Quantum efficiency	80% (200-250 nm), >90% (550-750 nm)	
Detector	Back-thinned TE-cooled CCD image sensor 1024x58 pixels	Back-thinned TE-cooled CCD image sensor 1024x122 pixels
Signal/Noise	1000:1	
AD converter	16-bit, 250 KHz	
Integration time	5.22 ms - 60 seconds	6.24 ms - 60 seconds
Interface	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps	
Sample speed with on-board averaging	5.22 ms /scan	6.24 ms /scan
Data transfer speed	5.22 ms /scan (USB2) 220 ms / scan (RS-232)	6.24 ms /scan (USB2) 220 ms / scan (RS-232)
Digital IO	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization	
Power supply	100-240 VAC, 50-60 Hz, 35W	
Dimensions, weight	245 x 175 x 140 mm, 3.9 kg	

## Grating selection table for AvaSpec-HS1024x58/122TEC

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100	900	500	330	HS500-0.33
UV/VIS	200-660	440	1000	250	HS1000-0.25
VIS/NIR	300-1160	860	500	560	HS500-0.56
VIS	350-850	460	900	550	HS900-0.55
VIS	400-722	322	1200	500	HS1200-0.5
NIR	600-1160	350	830	900	HS830-0.9
NIR	750-990	240	1200	1000	HS1200-1.0

## Resolution table (FWHM in nm) for AvaSpec-HS1024x58/122TEC

Grating (lines/mm)	Slit size (μm)				
	25	50	100	200	500
<b>500</b>	3.0	3.2-4.5*	5.8-9.5*	10.5	21.0
<b>830</b>	2.5	5.0	5.5	8.0	15.0
<b>900</b>	1.3-1.9*	4.5	3.6-8.0*	7.2	13.5
<b>1000</b>	1.3	4.0	4.5	6.5	11.0
<b>1200</b>	1.2	3.0	3.7	5.0	10.0

\* Best resolution in the center of the range

## Ordering Information

### AvaSpec-HS1024x58TEC-USB2

- High-sensitivity Fiber-optic Spectrometer, 1024x58 pixel back-thinned TE-cooled CCD detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable.

Specify grating, wavelength range and options

### AvaSpec-ULS1024x122-USB2

- High-sensitivity Fiber-optic Spectrometer, 1024x122 pixel back-thinned TE-cooled CCD detector, USB powered, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable.

Specify grating, wavelength range and options

## Options

<b>SLIT-XX</b>	• Slit size, please specify XX = 25, 50, 100, 200 or 500 μm
<b>OSF-YYY</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 1 mm thick, please specify YYY= 305, 385, 475, 515, 550 or 600 nm
<b>OSC-HS500</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for HS500 gratings in AvaSpec-HS
<b>OSC-HS900</b>	• Order-sorting coating with 600 nm long-pass filter for HS900 gratings in AvaSpec-HS
<b>OSC-HS1000</b>	• Order-sorting coating with 350 nm long-pass filter for HS1000 gratings in AvaSpec-HS

Download the latest software for your AvaSpec at [www.avantes.com](http://www.avantes.com)

# AvaSpec-ULS2048LTEC SensLine

## Thermo-Electric Cooled

## Fiber-optic Spectrometer

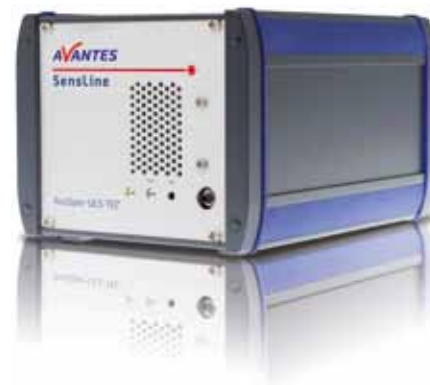
Long integration times in general are equivalent to higher dark noise. Avantes Thermo-Electric Cooled (TEC) spectrometers systems overcome this problem by cooling the detector. These recently re-designed instruments are equipped with triple stage cooling, keeping your detector at a optimal 5 degrees Celsius (maximum -35°C difference from ambient temperature).

The detector cooling provides a significantly lower and more stable dark baseline and PRNU level. Dark noise is reduced by a fac-

tor of 2-3. This allows the ULS2048LTEC to be used in very low light conditions, such as fluorescence and Raman measurements. If needed, integration times of more than 5 seconds are possible.

The AvaSpec-ULS2048LTEC has an integrated temperature regulator, USB2.0 high-speed interface and two cooling fans to actively ventilate the heat sink of the Peltier cooling elements. The spectrometer power supply is integrated into the housing.

### AvaSpec-ULS2048LTEC



### Technical Data

<b>Optical Bench</b>	ULS Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200-1100 nm
<b>Resolution</b>	0.06 -20 nm, depending on configuration (see table)
<b>Stray-light</b>	0.04-0.1%, depending on the grating
<b>Sensitivity</b>	470,000 counts/μW per ms integration time
<b>Detector</b>	CCD linear array, 2048 pixels
<b>Temperature cooled CCD</b>	Max. ΔT = -35 °C versus ambient
<b>Time to stabilize</b>	4 minutes
<b>Dark baseline improvement @ ΔT=-35°C and it&gt;5 sec</b>	> Factor 6
<b>PRNU improvement @ ΔT=-35°C and it&gt;5 sec</b>	> Factor 8
<b>3-stage Peltier cooling internal Power supply @ ΔT=-35°C</b>	5VDC, 3.0A
<b>Signal/Noise</b>	300:1
<b>AD converter</b>	16-bit, 2 MHz
<b>Integration time</b>	1.11 ms - 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	1.1 ms /scan
<b>Data transfer speed</b>	1.8 ms /scan (USB2) 430 ms/scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
<b>Power supply</b>	100-240 VAC, 50W
<b>Dimensions, weight</b>	250 x 179 x 144 mm, 3.6 kg

Our TEC-spectrometers  
are kept at a steady 5°C  
for maximum precision



## Grating selection table for AvaSpec-ULS2048LTEC

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**	800**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-90*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1100**	500**	300	1000	IA
NIR	600-1100	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 2048 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-ULS2048LTEC

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
<b>300</b>	1.0	1.4	2.5	4.8	9.2	21.3
<b>600</b>	0.40-0.53*	0.7	1.2	2.4	4.6	10.8
<b>830</b>	0.32	0.48	0.93	1.7	3.4	8.5
<b>1200</b>	0.20-0.28*	0.27-0.38*	0.52-0.66*	1.1	2.3	5.4
<b>1800</b>	0.10-0.18*	0.20-0.29*	0.34-0.42*	0.8	1.6	3.6
<b>2400</b>	0.09-0.13*	0.13-0.17*	0.26-0.34*	0.44-0.64*	1.1	2.7
<b>3600</b>	0.06-0.08*	0.10	0.19	0.4	0.8	1.8

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS2048LTEC-USB2

- Thermo-Electric Cooled Fiber-optic Spectrometer, 75 mm Ultra-Low Stray-light AvaBench, 2048L pixel 3-stage TE-cooled and regulated CCD detector, USB2 high-speed interface, incl. AvaSoft-Basic, USB cable, desktop housing.
- Specify grating, wavelength range and options

## Options

<b>DUV</b>	• Deep-UV detector coating >150 nm
<b>DCL-UV/VIS-200</b>	• Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 μm
<b>OSF-YYY-3</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings
<b>-FCPC</b>	• FC/PC fiber optic connector

# AvaSpec-ULS3648TEC SensLine

## Thermo-Electric Cooled

## Fiber-optic Spectrometer

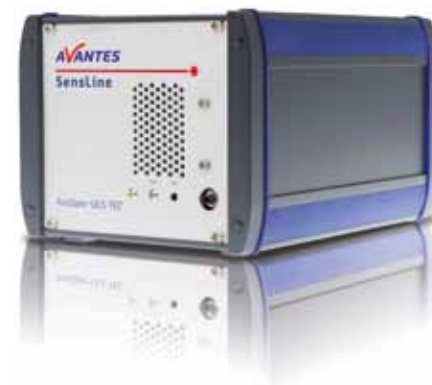
The AvaSpec-ULS3648TEC spectrometer is one of the newest spectrometers in the SensLine. The instrument features our re-designed three-stage Peltier cooling device integrated into our exclusive ultra-low stray-light optical bench, which can reduce the temperature of the CCD chip by -35 °C against ambient, improving the dark baseline and PRNU level by a significant factor. The detector cooling also reduces the dark noise by a factor of 2-3.

The size of the ULS3648TEC is reduced by more than 35% compared with Avantes previous TEC spectrometers.

The above features make the AvaSpec-ULS3648TEC an excellent choice for low light-level applications, such as fluorescence and Raman measurements, where integration times of more than 5 seconds may be needed. The AvaSpec-ULS3648TEC can be delivered as 1- or 2-channel instrument and has all the standard options, gratings and specifications of the standard AvaSpec-ULS3648.

The AvaSpec-ULS3648TEC is built into a newly designed housing with an integrated temperature regulator, USB2 high-speed communication, dual cooling fans and an integrated power supply.

### AvaSpec-ULS 3648TEC



### Technical Data

<b>Optical Bench</b>	ULS Symmetrical Czerny-Turner, 75 mm focal length
<b>Wavelength range</b>	200-1100 nm
<b>Resolution</b>	0.05 -20 nm, depending on configuration (see table)
<b>Stray-light</b>	0.04-0.1%, depending on the grating
<b>Sensitivity</b>	160,000 counts/μW per ms integration time
<b>Detector</b>	CCD linear array, 3648 pixels
<b>Temperature cooled CCD</b>	Max. ΔT = -35 °C versus ambient
<b>Time to stabilize</b>	4 minutes
<b>Dark baseline improvement @ ΔT=-35°C and it&gt;5 sec</b>	> Factor 6
<b>PRNU improvement @ ΔT=-35°C and it&gt;5 sec</b>	> Factor 8
<b>3-stage Peltier cooling internal Power supply @ ΔT=-35°C</b>	5VDC, 3.0A
<b>Signal/Noise</b>	350:1
<b>AD converter</b>	16-bit, 1 MHz
<b>Integration time</b>	10 μs - 10 minutes
<b>Interface</b>	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps
<b>Sample speed with on-board averaging</b>	3.7 ms /scan
<b>Data transfer speed</b>	3.7 ms /scan (USB2) 750 ms/scan (RS-232)
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
<b>Power supply</b>	100-240 VAC, 50W
<b>Dimensions, weight</b>	250 x 179 x 144 mm, 3.6 kg

AvaLight-LDXE:  
high-brightness laser-driven  
Xenon light source

## Grating selection table for AvaSpec-ULS3648TEC

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS/NIR	200-1100**	900**	300	300/1000	UNA-DB
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	200-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**	800**	300	500	VA
VIS	360-1000	500	600	500	VB
VIS	300-800	250-200*	1200	500	VC
VIS	350-750	145-90*	1800	500	VD
VIS	350-640	75-50*	2400	VIS	VE
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	750	NC
NIR	600-1160	350-300	830	800	SI
NIR	600-1100**	500**	300	1000	IA
NIR	600-1100	500	600	1000	IB

\* depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.

\*\* please note that not all 3648 pixels will be used for the useable range

## Resolution table (FWHM in nm) for AvaSpec-ULS3648TEC

Grating (lines/mm)	Slit size (μm)					
	10	25	50	100	200	500
<b>300</b>	0.60 – 0.70*	1.10-1.30*	2.20-2.40*	4.60	9.00	20.0
<b>600</b>	0.30 – 0.36*	0.58-0.68*	1.17	2.20	4.50	10.0
<b>830</b>	0.25	0.48	0.93	1.70	3.40	8.0
<b>1200</b>	0.14 – 0.18*	0.30	0.62	1.08	2.20	5.0
<b>1800</b>	0.09 – 0.11*	0.18	0.36-0.40*	0.78	1.50	3.7
<b>2400</b>	0.07 – 0.09*	0.13 – 0.15*	0.26-0.32*	0.40-0.64*	1.10	2.7
<b>3600</b>	0.05 – 0.06*	0.10	0.19	0.40	0.80	2.0

\*depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the better the resolution

## Ordering Information

### AvaSpec-ULS3648TEC-USB2

- Thermo-Electric Cooled Fiber-optic Spectrometer, 75 mm Ultra-Low Stray-light AvaBench, 3648 pixel 3-stage TE-cooled and regulated CCD detector, USB2 high-speed interface, incl. AvaSoft-Basic, USB cable, desktop housing.
- Specify grating, wavelength range and options

## Options

<b>DUV</b>	• Deep-UV detector coating >150 nm
<b>DCL-UV/VIS-200</b>	• Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
<b>SLIT-XX</b>	• Slit size, please specify XX = 10, 25, 50, 100, 200 or 500 μm
<b>OSF-YYY-3</b>	• Order-sorting filter for reduction of 2 <sup>nd</sup> order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550 or 600 nm
<b>OSC</b>	• Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings
<b>OSC-UA</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings
<b>OSC-UB</b>	• Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings
<b>-FCPC</b>	• FC/PC fiber optic connector

# AvaSpec-NIR256/512-1.7(TEC)

## NIRLine Near-Infrared Fiber-optic Spectrometer

For measurements in the near infrared range out to 1.7  $\mu\text{m}$  or 1700 nm, Avantes offers three spectrometer configurations. The AvaSpec-NIR256-1.7 is the most economical in the NIR-range of spectrometers made by Avantes, but offers exceptional performance specifications such as a sample speed of only 1.06 ms/scan and integration times as fast as 10  $\mu\text{s}$ . This instrument is also available in RS-version meaning you can easily change the slit in a matter of seconds.

The AvaSpec-NIR256/512-1.7 TEC spectrometers are also affordably priced and can be operated in two distinct gain-setting modes, the high-sensitivity mode (HS,

default) and the low-noise (LN) mode. Setting of the different gain modes can be done via a software option.

All NIR-1.7 instruments are available with a choice of four different gratings, making it possible to choose the bandwidth fitting your application. Digital and analog I/O ports enable external triggering and control over the shutter and pulsed light sources from the Avantes line of products. The uncooled AvaSpec-NIR256-1.7 is USB2 powered, while the TEC cooled instruments require external power.

### AvaSpec-NIR256-1.7TEC



### Technical Data

	Spectrometer	AvaSpec-NIR256-1.7	AvaSpec-NIR256-1.7TEC	AvaSpec-NIR512-1.7TEC
	Optical Bench	Symmetrical Czerny-Turner, 50 mm focal length	Symmetrical Czerny-Turner, 50 mm focal length, TE-cooled	
	Wavelength range	900 - 1750 nm		
	Resolution (slit & grating dependent)	2.0 - 50 nm		1.5 - 50 nm
	Stray-light	< 1%	<0.5%	<0.5%
	Sensitivity HS in counts / $\mu\text{W}$ per $\mu\text{s}$	167,000 (integral 1000-1750 nm)	1,320,000 (integral 1000-1750 nm)	610,000 (integral 1000-1750 nm)
	Signal/Noise HS	2000:1	1700:1	1700:1
	Integration time HS	10 $\mu\text{s}$ – 750 ms	20 $\mu\text{s}$ – 1 seconds	20 $\mu\text{s}$ – 1 seconds
	Sensitivity LN in counts / $\mu\text{W}$ per $\mu\text{s}$	9,000 (integral 1000-1750 nm)	4,400 (integral 1000-1750 nm)	2,200 (integral 1000-1750 nm)
	Signal/Noise LN	6000:1	3600:1	3600:1
	Integration time LN	10 $\mu\text{s}$ – 8 seconds	20 $\mu\text{s}$ – 35 seconds	20 $\mu\text{s}$ – 35 seconds
	Detector	InGaAs linear array, 256 pixels, 50 $\mu\text{m}$ x 500 $\mu\text{m}$	TE-cooled InGaAs linear array, 256 pixels, 50 $\mu\text{m}$ x 500 $\mu\text{m}$	TE-cooled InGaAs linear array, 512 pixels, 25 $\mu\text{m}$ x 500 $\mu\text{m}$
	AD converter	16-bit, 500kHz	16-bit, 2.4 MHz	16-bit, 2.4 MHz
	Interface	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps		
	Sample speed with on-board averaging	1.06 ms /scan	0.19 ms /scan @ 0.08 ms int. time	0.31 ms /scan @ 0.09 ms int. time
	Data transfer speed	1.56 ms /scan (USB2) 60 ms /scan (RS-232)	1.0 ms /scan (USB2) 60 ms /scan (RS-232)	1.2 ms /scan (USB2) 120 ms /scan (RS-232)
	Digital IO	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization		
	Power supply	Default USB power, 350 mA or with SPU2 external 12VDC, 150 mA	100-240 VAC, 50-60 Hz, 35W	
	Dimensions, weight	175 x 165 x 85 mm, 2.2 kg	244 x 144 x 254 mm, 5.1 kg	

## Grating selection table for AvaSpec-NIR256/512-1.7

Use	Useable range (nm)	Spectral range (nm)		Lines/mm	Blaze (nm)	Order code
		256	256/512TEC			
NIR	900-1750	850	650	200	1500	NIR200-1.5
NIR	1000-1700	340	250	400	1600	NIR400-1.6
NIR	900-1400	200	n.a.	600	1200	NIR600-1.2
NIR	1300-1600	170	n.a.	600	1600	NIR600-1.6

## Resolution table (FWHM in nm) for AvaSpec-NIR256/512-1.7

Grating (lines/mm)	Slit size (μm)				
	25*	50	100	200	500
200	5	6	12	24	50
400	2.5	3	6	12	25
600	n.a.	2	4	8	18

\* only for AvaSpec-NIR512TEC

## Ordering Information

<b>AvaSpec-NIR256-1.7</b>	<ul style="list-style-type: none"> <li>Fiber-optic Spectrometer, 50 mm AvaBench, 256 pixel InGaAs detector, USB powered high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, OSF-850/1000-3. Specify grating, wavelength range and slit</li> </ul>
<b>AvaSpec-NIR256-1.7TEC</b>	<ul style="list-style-type: none"> <li>Fiber-optic Spectrometer, 50 mm AvaBench, 256 pixel InGaAs detector with 2-stage TE cooling, USB powered high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, OSF-850/1000-3. Specify grating, wavelength range and slit</li> </ul>
<b>AvaSpec-NIR512-1.7TEC</b>	<ul style="list-style-type: none"> <li>Fiber-optic Spectrometer, 50 mm AvaBench, 512 pixel InGaAs detector with 2-stage TE cooling, USB powered high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, OSF-850/1000-3. Specify grating, wavelength range and slit</li> </ul>

## Options

<b>-RS</b>	<ul style="list-style-type: none"> <li>Replaceable slit for the AvaSpec-NIR256-1.7 only, see page 58</li> </ul>
<b>SLIT-XX-RS</b>	<ul style="list-style-type: none"> <li>Replaceable slit with SMA connector, specify slit size XX=25, 50, 100 or 200 μm, only in combination with the AvaSpec-NIR256-1.7-RS</li> </ul>
<b>SLIT-XX-RS-FCPC</b>	<ul style="list-style-type: none"> <li>as SLIT-XX-RS, but with FC/PC connector</li> </ul>
<b>SLIT-XX</b>	<ul style="list-style-type: none"> <li>Slit size, please specify XX = 25*, 50, 100, 200 or 500 μm</li> </ul>

\* only for AvaSpec-NIR512TEC

For external triggering Avantes offers the AvaTrigger featuring optical triggering, external TTL or manually through the pushbutton.



# AvaSpec-NIR256/512-2.0/2.2/2.5TEC

## NIRLine Near-Infrared Fiber-optic Spectrometer

Avantes offers a wide range of NIR spectrometers. The 2.x-series extended InGaAs instruments feature 256 or 512 pixel detectors and are available in configurations enabling measurements up to 2000, 2200 and 2500 nm. Resolution can be as high as 4 nm (on the 512 pixel version) or 10 nm (256 pixel). Integration times can go as low as 10 microseconds. Four different gratings are possible.

A new feature of the NIR-series is the user-selectable gain setting mode: LN (low-noise, standard setting), which gives you a longer integration time and higher signal to noise ratio, or HS (high-sensitivity) for

measuring in low-light conditions. Analog and digital IO ports enable external triggering and control of shuttered and pulsed light sources from the AvaLight series of illumination sources.

All instrument feature a dual stage thermo-electrical Peltier-cooled InGaAs detector, especially designed for measuring in the NIR range. Connection to the computer is managed through the USB2.0 interface. Data is transferred in 1.0 ms. All instruments are supplied with AvaSoft-Basic, a manual and USB/power cable.

### AaSpec-NIR256-2.5TEC



### Technical Data

Spectrometer platform	AvaSpec- NIR256-2.0TEC	AvaSpec- NIR256-2.2TEC	AvaSpec- NIR512-2.2TEC	AvaSpec- NIR256-2.5TEC
Optical Bench	TE-cooled Symmetrical Czerny-Turner, 50 mm focal length			
Wavelength range	1000 - 2000 nm	1000 - 2200 nm		1000 - 2500 nm
Resolution (slit & grating dependent)	6 - 60 nm	6 - 60 nm	4 - 60 nm	6 - 90 nm
Stray-light	< 1%			
Sensitivity HS in counts / $\mu$ W per $\mu$ s	70,000 (integral 1000-2000 nm)	77,000 (integral 1200-2200 nm)	38,500 (integral 1200-2200 nm)	70,000 (integral 1000-2500 nm)
Signal/Noise HS	1500:1	1200:1		1200:1
Integration time HS	10 $\mu$ s - 350 ms	20 $\mu$ s - 1 ms		10 $\mu$ s - 5 ms
Sensitivity LN in counts / $\mu$ W per $\mu$ s	4,000 (integral 1000-2000 nm)	2,750 (integral 1200-2200 nm)	1,375 (integral 1200-2200 nm)	4,000 (integral 1000-2500 nm)
Signal/Noise LN	4000:1	4100:1		2700:1
Integration time LN	10 $\mu$ s - 6 seconds	20 $\mu$ s - 50 ms		10 $\mu$ s - 100 ms
Detector	InGaAs linear array with 2-stage TE-cooling, 256 pixels	InGaAs linear array with 2-stage TE-cooling, 256 pixels	InGaAs linear array with 2-stage TE-cooling, 512 pixels	InGaAs linear array with 2-stage TE-cooling, 256 pixels
Pixel size (WxH)	50 $\mu$ m x 250 $\mu$ m	50 $\mu$ m x 500 $\mu$ m	25 $\mu$ m x 500 $\mu$ m	50 $\mu$ m x 250 $\mu$ m
AD converter	16-bit, 500kHz	16-bit, 2.4 MHz		16-bit, 500kHz
Interface	USB 2.0 high-speed, 480 Mbps RS-232, 115.200 bps			
Sample speed with on-board averaging	0.54 ms /scan	0.19 ms / scan @ 0.08 ms int.time	0.31 ms / scan @ 0.09 ms int.time	0.54 ms /scan
Data transfer speed	1.0 msec /scan (USB2) 60 ms / scan (RS-232)		1.2 msec /scan (USB2) 120 ms / scan (RS-232)	1.0 msec /scan (USB2) 60 ms / scan (RS-232)
Digital IO	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization			
Power supply	100-240 VAC, 50/60Hz, 35 W			
Dimensions, weight	315 x 235 x 135 mm, 5.1 kg			

### Grating selection table for AvaSpec-NIR256/512-2.0/2.2/2.5

Use	Useable range (nm)	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
NIR	1000-2500	1500	100	2500	NIR100-2.5
NIR	1000-2200	1000	150	2000	NIR150-2.0
NIR	900-1750	750	200	1500	NIR200-1.5
NIR	1700-2500	650	200	2600	NIR200-2.6

### Resolution table (FWHM in nm) for AvaSpec-NIR256/512-2.0/2.2/2.5

Grating (lines/mm)	Slit size (μm)				
	25*	50	100	200	500
100	10	15	25	50	90
150	6	10	15	30	60
200	4	6-8	12	24	50

\* only for AvaSpec-NIR512TEC

### Ordering Information

#### AvaSpec-NIR256-2.0TEC

- Fiber-optic Spectrometer, 50 mm AvaBench, 256 pixel InGaAs detector with 2-stage TEC, USB powered high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating and wavelength range, OSF-1000, slit

#### AvaSpec-NIR256-2.2TEC

- Fiber-optic Spectrometer, 50 mm AvaBench, 256 pixel InGaAs detector with 2-stage TEC, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating and wavelength range, OSF-1000, slit

#### AvaSpec-NIR512-2.2TEC

- Fiber-optic Spectrometer, 50 mm AvaBench, 512 pixel InGaAs detector with 2-stage TEC, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating and wavelength range, OSF-1000, slit

#### AvaSpec-NIR256-2.5TEC

- Fiber-optic Spectrometer, 50 mm AvaBench, 256 pixel InGaAs detector with 2-stage TEC, high-speed USB2 interface, incl. AvaSoft-Basic, USB interface cable. Specify grating and wavelength range, OSF-1000, slit

### Options

#### SLIT-XX

- Slit size, please specify XX = 25\*, 50, 100, 200 or 500 μm

\* only for AvaSpec-NIR512TEC

The low-noise/high-sensitivity setting makes your instrument even more versatile

# AvaSpec Dual-Channel Fiber-optic Spectrometer

Sometimes a single channel spectrometer is not enough, for example when you want higher resolution or to do two redundant measurements at the same time. The AvaSpec dual channel spectrometers are designed specifically for this purpose. Each spectrometer can be configured independently. It is also possible to have different detector types in each channel.

Please contact one of our application specialists to configure the perfect solution for your application.

AvaSpec-ULS3648-2-USB2



### Technical Data

Connections	2 x USB2.0
	2 x DB26 (DIO/RS232)
Dimensions, weight	2 x SMB (synch)
	2 x power connector
175 x 165 x 85 mm, 1800 grams	

### Ordering Information

AvaSpec-DDDD-2-USB2	<ul style="list-style-type: none"><li>Dual-channel AvaSpec-USB2 Fiber-optic Spectrometer with 2 channels with the same detector in one housing, including synchronization cable. For both channels specify Detector type DDDD (128/ULS2048/ULS3648/ULS2048L/2048XL), grating, wavelength range and options.</li></ul>
AvaSpec-MMMM/SSSS-2-USB2	<ul style="list-style-type: none"><li>Dual-channel AvaSpec-USB2 Fiber-optic Spectrometer with 2 channels with different detectors in one housing, including synchronization cable. For both channels specify Detector type MMMM and SSSS (128/ULS2048/ULS3648/ULS2048L/ULS2048XL), grating, wavelength range and options.</li></ul>

Pre-configured spectrometers can be shipped within 24 hours

# AvaSpec Multi-Channel Spectrometer



Do you need more precise measurements over a broad range? Or multiple measurements at the same moment for process control? AvaSpec multi-channel spectrometers fulfill your every need. You can select from our range of spectrometer detectors, choose different slits or gratings: anything is possible.

Two enclosure options are available: the 9" desktop housing for up to 4 channels and the 19" rack-mountable which holds a maximum of 10 spectrometers. All channels are connected to the computer through one single USB 2.0-cable.

## Benefits:

- Combine up to 10 channels in one enclosure
- Any channel fully configurable to your needs
- Different integration times and averaging settings for each channel
- Ideal for process control

## Technical Data

Housing	Desktop	Rack-mount
Max nr. Channels	4	10 (UV/VIS)
Dimensions	315 x 235 x 135 mm	315 x 445 x 135 mm

## Ordering Information

<b>AVS-DESKTOP-USB2</b>	<ul style="list-style-type: none"> <li>• Desktop for USB2 platform multichannel AvaSpec, incl. channel synchronization, USB2-hub and 100-240VAC power supply, supports max. 4 Rack-mount spectrometer units.</li> </ul>
<b>AVS-RACKMOUNT-USB2</b>	<ul style="list-style-type: none"> <li>• 19" Rack-mount for USB2 platform multichannel AvaSpec, incl. channel synchronization, USB2-hub and 100-240VAC power supply, supports max. 10 Rack-mount spectrometer units.</li> </ul>
<b>AvaSpec-DDDD-USB2-RM</b>	<ul style="list-style-type: none"> <li>• Rack-mount Unit USB2 Fiber-optic Spectrometer, self powered high-speed USB2 interface, incl. AvaSoft-Basic software, USB cable and sync cable, specify detector type DDDD (128/ULS2048/ULS3648/ULS2048L/ULS2048XL/NIR256/512), grating, wavelength range and options. Desktop/Rack-mount needs to be ordered separately</li> </ul>

Synchronize all channels  
easily with  
internal sync cables

# AvaRaman Fiber-optic Raman System

Raman spectroscopy is especially useful for reaction monitoring, product identification, remote sensing and the characterization of highly scattering particulate matter in aqueous solutions. Based on the principle discovered by Prof. Chandrasekhara Venkata Raman, it measures the result of the inelastic scattering of photons.

Avantes uses the high-sensitivity AvaSpec spectrometers in combination with a 532 nm, 633 nm or 785 nm laser to give you the best result for your Raman measurements. The spectrometers are appropriately configured according to the wavelength of the laser.

AvaRaman-TEC series spectrometers have a

three-stage Peltier cooling systems, which provides  $\Delta T$  down to  $-30^{\circ}\text{C}$  cooling to ambient for superior dark noise reduction, keeping the detector at a steady  $5^{\circ}\text{C}$ . Thanks to the PID controller, this temperature is stable within a  $0.1^{\circ}\text{C}$  bandwidth. All AvaRaman systems are delivered with special AvaSoft-Raman software. Complementary Panorama-Pro software is available for Raman interpretation and functional group assignment.

A selection of different probes is available to select the right one for your application. For more information on our software solutions including AvaSoft-Raman and Panorama-Pro, please refer to the software pages in this catalog.



## Technical Data

	AvaRaman-532	AvaRaman-532TEC	AvaRaman-785	AvaRaman-785TEC
	Non-cooled	Cooled	Non-cooled	Cooled
<b>Signal to noise Ratio</b>	200:1 for Benzene	200:1 for Benzene	200:1 for Benzene	300:1 for Benzene
<b>Resolution*</b>	$\pm 10 \text{ cm}^{-1}$	$\pm 6 \text{ cm}^{-1}$	$\pm 10 \text{ cm}^{-1}$	$\pm 6 \text{ cm}^{-1}$
<b>Spectrometer</b>	AvaSpec-ULS2048 with grating NC (535-752 nm), slit-50, DCL-UV/VIS	AvaSpec-ULS2048L-TEC with grating NC (535-752 nm), slit-25, DCL-UV/VIS TE-cooled	AvaSpec-ULS2048 with grating SI (785-1080 nm), slit-50, DCL-UV/VIS	AvaSpec-ULS2048L-TEC with grating SI (785-1080 nm), slit-25, DCL-UV/VIS-200 TE-cooled
<b>Raman Shift</b>	100-5400 $\text{cm}^{-1}$	100-5400 $\text{cm}^{-1}$	100-3500 $\text{cm}^{-1}$	100-3500 $\text{cm}^{-1}$
<b>Laser output</b>	532 nm, 50 mW	532 nm, 50 mW	785 nm, 500 mW, Class 3b	785 nm, 500 mW, Class 3b
<b>Laser Wavelength</b>	532 nm	532 nm	785 nm	785 nm
<b>Laser Bandwidth</b>	< 0.1 nm	< 0.1 nm	< 0.2 nm	< 0.2 nm
<b>Dimensions housing</b>	240 (L) x 140 (W) x 250 (H) mm			

\* typical resolution: higher resolution possible on request

Pre-configured spectrometers can be shipped within 24 hours



## AvaRaman probes

### AvaRaman-PRB-XXX

3/8" SS low-cost focusing probe with a 100  $\mu\text{m}$  excitation fiber and 200  $\mu\text{m}$  read fiber. Multiple focal lengths available (5 mm, 7.5 mm (standard), 10 mm). It can withstand 80°C. Manual shutter included, 1.5 m fibers. Specify XXX=excitation wavelength

### AvaRaman-PRB-FP-XXX

1/2" SS focusing probe with a 100  $\mu\text{m}$  excitation fiber and 200  $\mu\text{m}$  read fiber. Multiple focal lengths available (5 mm (standard), 7.5 mm, 10 mm). It can withstand 80°C. Specify XXX=excitation wavelength

### AvaRaman-PRB-FIP-XXX

5/8" SS immersible probe for in-situ measurements with a 100  $\mu\text{m}$  excitation fiber and 200  $\mu\text{m}$  read fiber. It can withstand 200°C. Specify XXX=excitation wavelength

### AvaRaman-PRB-FC-XXX

3/8" SS immersible process probe for in-situ measurements with a 100  $\mu\text{m}$  excitation fiber and 200  $\mu\text{m}$  read fiber. It can withstand 500°C and 3000psi, the probe optics provide complete background filtering. Specify XXX=excitation wavelength

## Ordering Information

### AvaRaman-532-USB2

Consisting of following elements:

- Solid state 500 mW laser 532 nm, FWHM 0.2 nm
- AvaSpec-ULS2048-USB2 Spectrometer with 1200 lines/mm grating set 535-752 nm, 50  $\mu\text{m}$  slit, DCL-UV/VIS
- AvaSoft-Raman stand-alone software for the AvaRaman system, AvaRaman-GL-532 laser safety goggles

### AvaRaman-532-TEC-USB2

Consisting of following elements:

- Solid state 500 mW laser 532 nm, FWHM 0.2 nm
- TE-cooled AvaSpec-ULS2048L-TEC-USB2 Spectrometer with 1200 lines/mm grating set 535-752 nm, 25  $\mu\text{m}$  slit, DCL-UV/VIS
- AvaSoft-Raman stand-alone software for the AvaRaman system, AvaRaman-GL-532 laser safety goggles

### AvaRaman-785-USB2

Consisting of following elements:

- Solid state 500 mW laser 785 nm, FWHM 2.5 nm
- AvaSpec-ULS2048-USB2 Spectrometer with 830 lines/mm grating set 785-1080 nm, 50  $\mu\text{m}$  slit, DCL-UV/VIS
- AvaSoft-Raman stand-alone software for the AvaRaman system, AvaRaman-GL-785 laser safety goggles

### AvaRaman-785TEC-USB2

Consisting of following elements:

- Solid state 500 mW laser 785 nm, FWHM 0.2 nm
- TE-cooled AvaSpec-ULS2048L-TEC-USB2 Spectrometer with 830 lines/mm grating set 785-1080 nm, 25  $\mu\text{m}$  slit, DCL-UV/VIS-200
- AvaSoft-Raman stand-alone software for the AvaRaman system, AvaRaman-GL-785 laser safety goggles

*Different Raman probes available, please see table above*

## Other accessories

### AvaRaman-SH-3/8"

- Rugged sample holder for secure positioning of 3/8" Raman probes

### AvaRaman-SH-1/2"

- Rugged sample holder for secure positioning of 1/2" Raman probes

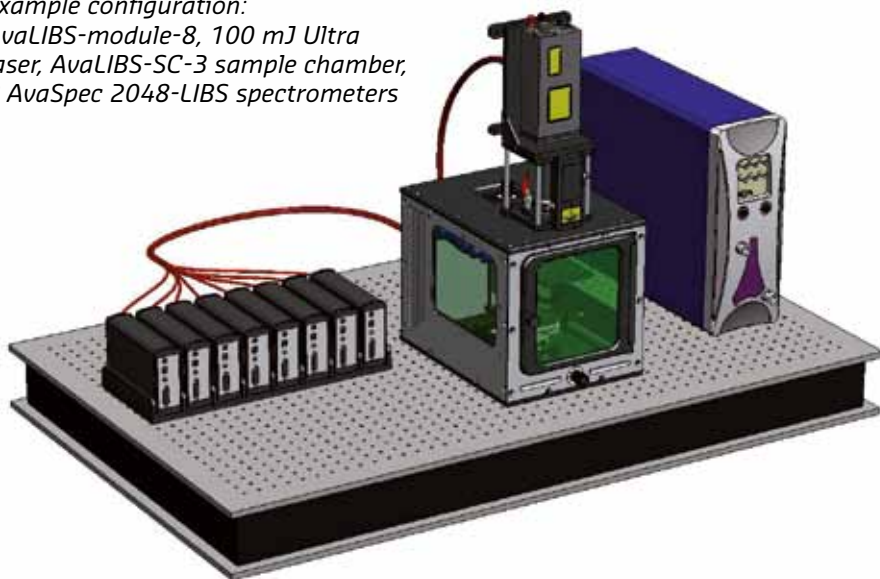
### AvaRaman-Calibrationtile

- PTFE White tile in holder for 3/8" Raman probe



# AvaLIBS Modules – an alternative method of configuring a LIBS system

Example configuration:  
AvaLIBS-module-8, 100 mJ Ultra laser, AvaLIBS-SC-3 sample chamber, 8 AvaSpec 2048-LIBS spectrometers



For full flexibility, Avantes offers the AvaLIBS modules. You choose the number of AvaSpec spectrometers (up to 8), the number of axis in your sample chamber and the layout. You can even connect your own laser to the system or order one of the high-quality, affordable YAG-lasers that Avantes offers.

In addition to the 50 mJ and 100 mJ lasers described below, the AvaLIBS modules may be used with a variety of other lasers using an available adaptor plate (contact us for further details).

**Configuration table**

AvaLIBS Module configurations	50 mJ 1-6 channels	100 mJ 1-6 channels	50 mJ 1-8 channels	100 mJ 1-8 channels
	AvaLIBS-module-6		AvaLIBS-module-8	
<b>AvaLIBS Module</b>	AvaLIBS-module-6		AvaLIBS-module-8	
<b>Laser</b>	YAG-LASER-50	YAG-LASER-100	YAG-LASER-50	YAG-LASER-100
<b>Sample chambers</b>	Fully compatible with AvaLIBS-SC-1, AvaLIBS-SC-2 and AvaLIBS-SC-3 modular sample chambers		Fully compatible with AvaLIBS-SC-1, AvaLIBS-SC-2 and AvaLIBS-SC-3 modular sample chambers	
<b>Fiberoptics</b>	N* x FC-UV200-2		N* x FC-UV200-2	
<b>Spectrometers</b>	Up to 6 spectrometers - as specified by user		Up to 8 spectrometers - as specified by user	
<b>Cable set</b>	IC-LIBS-SET-N*		IC-LIBS-SET-N*	

N\* = number of channels

## Ordering Information

<b>AvaLIBS-module-6</b>	<ul style="list-style-type: none"> <li>Six-channel LIBS module, including laser beam expander, plasma light collection optics (6 channels), requires a single-core optical fiber cable to connect each channel to a spectrometer (i.e. 6 fibers required for 6 spectrometers)</li> </ul>
<b>Adaptor plate for Ultra laser</b>	<ul style="list-style-type: none"> <li>For attaching AvaLIBS modules to Ultra laser head (50 mJ or 100 mJ)</li> </ul>
<b>Imaging kit (optional)</b>	<ul style="list-style-type: none"> <li>Miniature CCD colour camera, camera mount, IR blocking filter, plug-in power adaptor, 5.6" LCD colour monitor, USB 2.0 video grabber</li> </ul>
<b>Vertical support stand (optional)</b>	<ul style="list-style-type: none"> <li>Adjustable height vertical support stand for AvaLIBS-module-6 and AvaLIBS-module-8</li> </ul>
<b>FC-UV200-2</b>	<ul style="list-style-type: none"> <li>Fiber Cable, UV/VIS, 2 m, SMA terminated (6 or 8 pcs needed)</li> </ul>
<b>AvaLIBS-module-8</b>	<ul style="list-style-type: none"> <li>Eight-channel LIBS module, including laser beam expander, plasma light collection optics (6 channels), requires a single-core optical fiber cable to connect each channel to a spectrometer (i.e. 8 fibers required for 8 spectrometers)</li> </ul>
<b>AvaSpec-ULS2048-LIBS</b>	<ul style="list-style-type: none"> <li>AvaLIBS Spectrometer channel, Avaspec-ULS2048-USB2, 2048 CCD detector. Specify grating, wavelength range and options. AvaSoft-Full and Ava-LIBS included.</li> </ul>

## AvaSpec-RS Replaceable-Slit Spectrometer

### AvaSpec-RS



For most customers the choice between throughput and resolution is not an easy one. Avantes now offers the possibility for end-users to easily replace a slit through the introduction of our replaceable-slit feature. The replaceable slit option is only available on ULS Ultra-low Stray-light AvaSpecs and the NIR256-1.7 spectrometer. The slit sets contain 25, 50, 100

and 200  $\mu\text{m}$  slits along with a screwdriver tool to facilitate the change. Slit kits are available with SMA-905 connector, as well as FC/PC connectors. Slit sets can be ordered separately for the -RS spectrometer.

No recalibration of the spectrometer is needed when changing slit because of the high-precision slit positioning.

### Technical Data

<b>Slit set connectors</b>	SMA-905 or FC/PC
<b>Slit sizes</b>	25, 50, 100, 200 $\mu\text{m}$ (width) x 1 mm (height)
<b>Material</b>	Stainless steel
<b>Fixing screws</b>	Torx (included)

### Ordering Information

<b>-RS</b>	<ul style="list-style-type: none"> <li>Replaceable slit, to be added to the product code of the AvaSpec-ULS or AvaSpec-NIR256-1.7</li> </ul>
<b>SLIT-XX-RS</b>	<ul style="list-style-type: none"> <li>Replaceable slit with SMA connector. Specify slit size XX=25, 50, 100 or 200 <math>\mu\text{m}</math>, only in combination with AvaSpec-ULS-RS spectrometers and AvaSpec-NIR256-1.7-RS</li> </ul>
<b>SLIT-XX-RS-FCPC</b>	<ul style="list-style-type: none"> <li>as SLIT-XX-RS, but with FC/PC connector</li> </ul>



### Slit Kit

To fully utilize your AvaSpec-RS series spectrometer with replaceable slit, the Slit Kit is available. It features a complete set with four slits, of 25, 50, 100 and 200  $\mu\text{m}$ . Also included in the kit are the tools to easily change the slit in the spectrometer.

The Slit Kit is available in SMA and FC/PC versions. Both kits can be used on any spectrometer with the replaceable slit option installed.

### Ordering information

<b>SLITKIT-SMA</b>	<ul style="list-style-type: none"> <li>Slit kit containing 25, 50, 100 and 200 <math>\mu\text{m}</math> slits, and the tools to replace the slit. SMA-connectors</li> </ul>
<b>SLITKIT-FCPC</b>	<ul style="list-style-type: none"> <li>As SLITKIT-SMA, but with FC/PC connectors</li> </ul>

Don't forget to order  
a fiber cable

# AvaSpec Spectrometer Interface Cables

Avantes offers a wide range of cables to connect your AvaSpec spectrometer to an AvaLight series light source or one of our many accessories (Fiber-optic switches, AvaTrigger, etc).

In the table below, the cable options for your light source or accessory application can be found. Please note that the cables generally are 2 meters long, but custom lengths are available on request.

## Interface cables



### USB2 platform spectrometers (dB26 / SMB connector)

Connect to	Product code	Description
<b>RS-232</b>	IC-DB26/DB9-2	Interface cable AvaSpec-USB2 platform DB26 male to RS232 DB9 female cable, 2 m
<b>USB2</b>	IC-USB2-2	Interface cable AvaSpec to USB port on PC, 2 m
<b>AvaLight-S / AvaLight-XE</b>	IC-DB26-2	Interface cable AvaSpec-USB2 platform to DB15 for AvaLight-S with shutter for auto-save dark/ lamp off, AvaLight-XE control
<b>BNC-Ext. hardware trigger</b>	IC-DB26-EXTRIG-BNC-2	Interface cable AvaSpec-USB2 platform to BNC plug External trigger, 2 m
<b>External Hardware Trigger</b>	IC-Extrig-USB2	Interface cable AvaSpec-USB2 to External trigger pushbutton, 2 m
<b>RS-232 Avalight-S / Avalight-XE</b>	IC-DB26/DB9/DB15-2	Interface Y cable AvaSpec-USB2 platform to RS-232 (DB9) and AvaLight-S (DB15) with shutter for auto save dark/ lamp off, AvaLight-XE control
<b>Avalight-S / Avalight-XE External Hardware Trigger</b>	IC-DB26-Extrig-USB2	Interface Y-cable AvaSpec-USB2 to External trigger pushbutton and AvaLight-S with shutter, 2 m
<b>Avalight-S FOS-2</b>	IC-DB26-FOS2-2	Interface Y-cable AvaSpec-USB1 platform to FOS-2 and AvaLight-S with shutter, 2 m
<b>Other USB2 spectrometer</b>	IC-COAX-SMB-0.25	Synchronization coax cable with 2 SMB connectors 0.25 m for AvaSpec USB2 platform

# AvaSpec Services and Calibrations



## Wavelength Calibration

All AvaSpec spectrometers come standard with a wavelength calibration and coefficients, to calculate wavelength from pixel number. This information is installed on-board, on the AvaSpec's EEPROM.

Under normal conditions the wavelength calibration does not need to be redone, since the spectrometers have no moving elements inside. If a wavelength shift is measured versus the original wavelength calibration, the spectrometer can be recalibrated by the end-user, using the Avalight-CAL using the auto-calibration software routine in AvaSoft-Full.

As an option the spectrometer can also be returned to Avantes for recalibration, (Spectral-cal-service). Before returning the spectrometer an RMA authorization number needs to be obtained.

## Non-linearity Calibration

Most detectors of the AvaSpec spectrometers have a good linear behavior in their detector response, which means that there is a better than 95% correlation between raw signal in A/D counts and the light intensity at the spectrometer entrance. However for some applications, which

require a wide dynamic range, such as highly absorbing substances or low light level applications, combined with a need for high accuracy, a non-linearity calibration of the detector is recommended. This NL-calibration is performed on the detector array and the output signal is linearized to better than 99%. A complete calibration report and the calculated NL calibration coefficients are delivered with the spectrometer. For irradiance calibrations the NL-calibration is automatically included.

## Irradiance Calibration

Applications that use spectrometers to measure the light energy of radiant sources require an irradiance-calibrated spectrometer. For all AvaSpec spectrometers both irradiance and radiance NIST traceable calibrations can be offered. Irradiance calibrations ( $\mu\text{W}/\text{cm}^2$ ) are normally performed on a system with a fiber-optic cable and a cosine corrector or integrating sphere. Radiance calibrations ( $\mu\text{W}/\text{cm}^2/\text{sr}$ ) can be performed on a spectrometer and a bare fiber or fiber with collimating lens looking at a diffuse illuminated surface. The (ir)radiance calibrations can be performed over 3 different wavelength ranges, UV (200-400 nm), VIS (360-1100 nm) and NIR (1100-2500 nm). All systems are calibrated against a NIST traceable irradiance calibration standard and come with a complete report and calibration files, which are stored on the EEPROM of the spectrometer and can be loaded directly into the AvaSoft-IRRAD software module to obtain irradiance parametric measurements.

More information on irradiance can be found in the software section (AvaSoft-IRRAD) and the section Applications - Irradiance Measurements.

As an alternative to Avantes irradiance calibration services, irradiance calibrated light sources, such as AvaLight-DHS-CAL and AvaLight-HAL-CAL are available to perform your own irradiance calibration.

## Ordering Information

<b>Spectral-cal-service</b>	• Spectral calibration service for an AvaSpec, incl. calibration sheet
<b>NL-calibration</b>	• Non-linearity calibration service (per channel)
<b>IRRAD-CAL-UV</b>	• Irradiance calibration service UV range (200-400 nm) per channel, incl. NL-calibration, needs AvaSoft-Full, AvaSoft-IRRAD and -SR fibers
<b>IRRAD-CAL-VIS</b>	• Irradiance calibration service VIS range (360-1100 nm) per channel, incl. NL-calibration, needs AvaSoft-Full and AvaSoft-IRRAD
<b>IRRAD-CAL-NIR</b>	• Irradiance calibration service NIR range (1100-2500 nm) per channel, incl. NL-calibration, needs AvaSoft-Full and AvaSoft-IRRAD
<b>IRRAD-CAL-UV/VIS</b>	• Irradiance calibration service UV/VIS range (200-1100 nm) per channel, incl. NL-calibration, needs AvaSoft-Full, AvaSoft-IRRAD and -SR fibers

# OEM Spectrometer: AS-5216 Microprocessor board

The AS-5216 microprocessor board provides both flexibility and ease of integration. It features high-speed USB 2.0 communication and can be used in combination with the following detectors:

- Sony ILX554B and ILX511B
- TAOS 1401
- Toshiba 1304
- Hamamatsu S11155/S7031 and G92xx series with/without TEC
- Sensors Unlimited 256 and 512

The board is equipped with an HD26 digital I/O connector with 13 programmable I/O port (3 digital in, 10 digital out), 2 analog out ports

and 2 analog in ports. One digital out port is generally used to control the flash rate of an AvaLight-XE pulsed Xenon light source, another digital out it used to control external TTL-shutter devices and a third is reserved for external control for flashing a laser source in LIBS applications. A digital in may be used for external hardware triggering.

A maximum of 127 AS-5216s can be coupled and synchronized through the USB 2.0 interface. This means easy and simultaneous sampling of 2-127 channels. The AS-5216 board can be synchronized with other AS-5216 boards to control the simultaneous data-sampling of multiple channels, all con-



nected to USB2.0 high-speed interface. On-board signal processing allows data reduction to speed up scan transfer time. Data reduction can be achieved by defining a start and stop pixel and On-Board Averaging.

This board is compatible with the extensive AS-5216-DLL software development kit, enabling full control over the spectrometer in customer-designed software.

## Technical specifications AS5216

<b>Microprocessor</b>	Coldfire® 5216, 32-bit, 64 MHz
<b>Memory</b>	512 KB Flash Memory, 64KB RAM
<b>A/D converter</b>	16-bit, 2 channels for video signal
<b>Integration time</b>	2 µs – 10 minutes (detector dependent)
<b>Data Transfer speed</b>	1.8 ms/scan for Sony ILX554 2048 pixels, 2 MHz
	1.8 ms /scan for Sony ILX511 2048 pixels, 2 MHz
	1.1 ms/scan for TAOS 1401 2 MHz
	3.7 ms /scan for Toshiba TCD1304, 1 MHz
	2.09 ms/scan for Hamamatsu S11155, 1 MHz
	5.22 ms/scan for Hamamatsu S7031, 250 kHz
	1.56 ms/scan for Hamamatsu 92XX, 500 kHz
<b>USB interface</b>	2.0 high-speed, 480 Mbps
<b>RS-232 interface</b>	Baudrate 115200 bps, HD-26 female connector
<b>Digital IO</b>	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synchronization
<b>Power supply</b>	Default USB power, 350 mA 12 VDC, reverse polarity protection, 150 mA
<b>Temperature range</b>	0- 55 °C
<b>Dimensions, weight</b>	162,5 x 100 mm, 97 grams

## Ordering Information

<b>AS-5216</b>	<ul style="list-style-type: none"> <li>• Microprocessor board 16-bit AD and USB2.0/RS-232 interface.</li> <li>Specify detector type, see below</li> </ul>
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## For all boards, specify detector type

<b>- ILX</b>	for Sony ILX554B detectors (AvaSpec-ULS2048-USB2)
<b>-ILX511</b>	for Sony ILX511B detectors (AvaSpec-ULS2048L-USB2)
<b>- TAOS128</b>	for TAOS 1401 detectors (AvaSpec-128-USB2)
<b>- TOS3648</b>	for Toshiba 1304 detectors (AvaSpec-3648-USB2)
<b>- HAM2048XL</b>	for Hamamatsu S11155 detectors (AvaSpec-ULS2048XL-USB2), extra pcb incl.
<b>HAM1024x58/122</b>	for Hamamatsu S7031 detectors (AvaSpec-HS1024x58/122-USB2), extra pcb incl.
<b>- NIR256</b>	Hamamatsu G92xx series InGaAs NIR detectors (AvaSpec-NIR256-1.7)
<b>- NIR256TEC</b>	Hamamatsu G92xx series with TEC InGaAs NIR detectors (AvaSpec-NIR256-2.0/2.5TEC), extra pcb incl.
<b>-NIRSU256</b>	Sensors Unlimited 256 InGaAs NIR detectors (AvaSpec-NIR256-1.7/2.2TEC)
<b>-NIRSU512</b>	Sensors Unlimited 512 InGaAs NIR detectors (AvaSpec-NIR512-1.7/2.2TEC)



## OEM Spectrometer: ASM-5216 Microprocessor board



The ASM-5216 is the smaller version of our AS-5216 board with more than 25% reduction in size and a lower price. The board also provides additional interfaces for optimal coupling with other devices. The ASM-5216 supports all Avantes USB2 optical Benches with a wide range of new detectors and high-speed (USB2.0) communication. The ASM-5216 board is based on a powerful 5216 Coldfire® processor, running at 64 Mhz, 16-bit AD converter and USB2.0/RS232-interface. Different detector types can be connected to the electronics board, such as TAOS Photo-Diode Arrays

(TSL1401), Sony CCD detectors (ILX511, ILX554B), Toshiba CCD detectors (TCD-1304), Hamamatsu back-thinned CCD detectors (C11155, S7031), Hamamatsu (G92xx series) and Sensors Unlimited InGaAs NIR detectors. For the Hamamatsu back-thinned detector a separate power converter board is needed, and for the detectors with TE cooling a separate TE controller board is required.

The board is equipped with a Samtec 60-pin Card edge connector with 12 programmable IO ports (3 DI, 9 DO), 2 analog

out ports and 2 analog in ports. One digital out port is used for controlling the flash rate of an external Xenon strobe (AvaLight-XE), one digital out port is used to control external TTL-shutter devices, one digital output is reserved for external control for flashing a laser source in LIBS applications. One digital in is used for external hardware triggering.

The ASM-5216 board can be synchronized with other ASM-5216 boards to control the simultaneous data sampling of multiple channels, all connected to USB2.0 high-speed interface.

On-board signal processing allows data reduction to speed up scan transfer time. Data reduction can be achieved by defining a start and stop pixel and On-Board Averaging. The board can be operated by the extensive AS-5216-DLL software development kit with many functions to control the electronics board and data sampling parameters (see software section).

### Technical specifications ASM-5216

<b>Microprocessor</b>	Coldfire® 5216, 32-bit, 64 MHz
<b>Memory</b>	512 KB Flash Memory, 64KB RAM
<b>A/D converter</b>	16-bit, 2 channels for video signal
<b>Integration time</b>	10 µs – 10 minutes (detector dependent)
<b>Data Transfer speed</b>	Detector dependent 1-5 ms
<b>USB interface</b>	2.0 high-speed, 480 Mbps
<b>RS-232 interface</b>	Baudrate 115200 bps,
<b>Digital IO</b>	60 pole Samtec connector, 2 Analog in, 2 Analog out, 3 Digital in, 9 Digital out, trigger, synchronization
<b>Power supply</b>	Default USB power, 350 mA 12 VDC, reverse polarity protection, 350 mA
<b>Temperature range</b>	0 - 55 °C
<b>Dimensions, weight</b>	119.5 x 100 mm, 90 grams

### Ordering Information

<b>ASM-5216</b>	• Microprocessor board 16-bit AD and USB2.0/RS-232 interface. Specify detector type, see AS-5216
<b>IC-USB2-ASM5216</b>	• Interface cable ASM-5216 to USB2, shielded



# AvaSpec Stand-alone Fiber-optic Spectrometer

Any Avantes AvaSpec spectrometer can operate in stand-alone mode in which the spectrometer is not connected to a computer. The stand-alone mode is developed for process control applications, in which the spectrometer must output analog or digital signals that can be directly coupled to Programmable Logical Controllers (PLC) in a process control environment.

In order to get the desired stand-alone functionality of a spectrometer, it is important to define functions in which the parameters that need to be controlled can be measured.

These functions can be defined as (max. 8) History Channel Functions and the output values as 8 digital TTL-functions for which thresholds can be set using the AvaSoft-PROC process control software. Two functions can also be used to output an 8-bit analog value in the 0-5V Voltage range. After a successful implementation using a PC connected spectrometer, Avantes can be contacted to implement the desired functions into the firmware on-board of the USB2 platform spectrometer. Since most of this functionality is customer-specific, please contact our Technical Sales-Department for more information on this.



## Technical Data Stand-alone mode

<b>Spectrometer</b>	All AvaSpec-USB2 platform spectrometers
<b>Power consumption</b>	5-12 VDC, 155 mA
<b>Measurement speed</b>	2 ms (spectrometer and function dependent)
<b>Analog in</b>	2 channel, 0-5 VDC, 10-bit
<b>Digital In</b>	3 Digital in (TTL level) 1 External hardware Trigger
<b>Analog out</b>	2 channel, 0-5VDC, 8-bit
<b>Digital out</b>	10 programmable Digital out TTL level, 0 or 5VDC, max 10 mA 1 external strobe digital out, 1 laser trigger digital out

## Ordering Information

<b>Stand-alone</b>	• One time NRE cost to implement desired functionality in AvaSpec-USB2 spectrometer
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For external triggering Avantes offers the AvaTrigger featuring optical triggering, external TTL or manually through the pushbutton.

## OEM spectrometer: AvaBench Optical Bench

### AvaBench-75-ULS



AvaSpec optical benches are available with or without one of our electronics boards for integration into customer's systems. Avantes has developed four types of UV/VIS optical benches, especially for OEM customers. The optical benches AvaBench-45 (StarLine), AvaBench-75-ULS (used in both StarLine and SensLine), AvaBench-75-ULSTEC (SensLine) and AvaBench-37.5-HS (SensLine) are Czerny-Turner designs with fiber-optic entrance connectors (Standard

SMA, others possible), collimating and focusing mirrors and a diffraction grating. A choice of different gratings with different dispersions and blaze angles enable applications in the 200-1100 nm range. The newly designed high numerical aperture AvaBench-37.5-HS has full mechanical compatibility for mounting holes with the AvaBench-75-ULS, so for OEM customers it is easy to upgrade to a higher-throughput optical bench.

Wavelength ranges, resolution tables, detector specifications and AvaBench options can be found in the instrument page corresponding to each spectrometer type. In the table below the key specification of the optical benches are detailed. All AvaBench optical benches are fully compatible with Avantes electronics board or may be interfaced to customer specific electronics. Video output is handled through a separate mini-coax cable.

### Technical Data

	AvaBench-45	AvaBench-75-ULS	AvaBench-75-ULSTEC	AvaBench-37.5-HS
<b>Implemented in</b>	AvaSpec-128	AvaSpec-ULS2048/ 3648/2048L/ 2048XL	AvaSpec- ULS2048LTEC/ ULS3648TEC	AvaSpec-HS1024x58 /122TEC
<b>Focal length</b>	45 mm	75 mm	75 mm	37.5 mm asym.
<b>Numerical aperture</b>	0.11	0.07	0.07	0.22
<b>Wavelength range</b>	350-1100 nm	200-1160 nm	200-1100 nm	200-1160 nm
<b>Resolution (FWHM)</b>	1.5 -64 nm	0.05 - 20 nm	0.05 - 20 nm	1.2 -20 nm
<b>Stray-light</b>	< 0.3%	0.04-0.1%	0.04-0.1%	<1%
<b>Gratings</b>	different	different	different	different
<b>Slits</b>	25, 50, 100, 200, 500 µm	10, 25, 50, 100, 250, 500 µm	10, 25, 50, 100, 250, 500 µm	25, 50, 100, 200, 500 µm
<b>Detector</b>	TAOS 128	SONY 2048(L) / TOSHIBA 3648 / HAM 2048XL	SONY 2048L / TOSHIBA 3648	HAM 1024x58/122
<b>Detector lens</b>	VIS, for TAOS only	UV/VIS	UV/VIS-200	n.a.
<b>Order-sorting filter</b>	See options	See options	See options	See options
<b>Dimensions, weight</b>	82 x 72 x 20 mm, 130 gr.	120 x 91 x 21 mm, 350 gr.	120 x 91 x 62 mm, 760 gr.	95 x 152 x 42 mm, 722 gr

Download the latest  
software for your AvaSpec  
at [www.avantes.com](http://www.avantes.com)

## Ordering Information

<b>AvaBench-45-128-U2</b>	<ul style="list-style-type: none"> <li>• OEM optical bench, 45 mm focal length, 128 pixel PDA detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS2048-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, 2048 pixel CCD detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS3648-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, 3648 pixel CCD detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS2048L-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, 2048 pixel CCD detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS2048XL-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, 2048XL pixel back-thinned CCD detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS2048LTEC-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, TE-cooled 2048 large pixel detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-75-ULS3648LTEC-U2</b>	<ul style="list-style-type: none"> <li>• OEM ultra-low stray-light optical bench, 75 mm focal length, TE-cooled 3648 large pixel detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-37.5-HS1024x58TEC-U2</b>	<ul style="list-style-type: none"> <li>• OEM High-sensitivity optical bench, 37.5 mm focal length, 1024x58 pixel TE-cooled back-thinned CCD detector. Specify grating, wavelength range and options.</li> </ul>
<b>AvaBench-37.5-HS1024x122TEC-U2</b>	<ul style="list-style-type: none"> <li>• OEM High-sensitivity optical bench, 37.5 mm focal length, 1024x122 pixel TE-cooled back-thinned CCD detector. Specify grating, wavelength range and options.</li> </ul>

The grating can only be changed by Avantes.  
Therefore, choose your grating wisely.  
Our application specialists are available to support you with your choice.  
In general, a higher resolution means a lower bandwidth.  
By combining multiple spectrometers  
in our AvaSpec-Dual or rack-mountable versions,  
you can create one virtual spectrometer with high-resolution  
and high bandwidth.

## OEM spectrometer: AvaBench NIR Optical Bench

For OEM applications in the NIR, Avantes offers our line of AvaBench NIR optical benches. The AvaBench-50 optical bench has undergone a redesign and is more compact and has higher throughput. It is available in the 1000-1750 nm range for uncooled detectors. The AvaBench-50TEC is developed for NIR range from 1000-2500 nm with thermo-electric cooling. The AvaBench-50TEC supports three different TE-cooled detectors with 256 pixels and two TE-cooled detectors with 512 pixels. All AvaBench NIR optical benches have symmetrical Czerny-Turner designs with a fiber-optic entrance connector (Standard SMA, others possible), collimating and a newly designed special toroid focussing mirror and diffraction grating. A choice of

different NIR gratings can be selected with the products.

Wavelength ranges, resolution tables, detector specifications and AvaBench options can be found in the instrument page corresponding to each spectrometer type. In the table below the key specifications of the NIR optical benches are listed.

The NIR AvaBenches are fully compatible with Avantes electronics boards or may be interfaced to customer specific electronics. The NIR optical benches have a separate video output through a mini-coax cable. The TEC NIR benches have a heatsink and additional electrical connections for both temperature sensor and power for the 2-stage Peltier cooling.

### AvaBench-50



### Technical Data

	AvaBench-50	AvaBench-50TEC
<b>Implemented in</b>	AvaSpec-NIR256-1.7	AvaSpec-NIR256-1.7TEC AvaSpec-NIR256-2.0/2.2/2.5TEC AvaSpec-NIR512-1.7/2.2TEC
<b>Focal length</b>	50 mm	50 mm
<b>Numerical aperture</b>	0.24	0.24
<b>Wavelength range</b>	1000-1750 nm	1000-2500 nm
<b>Resolution (FWHM)</b>	2-50 nm	1.5-90 nm
<b>Stray-light</b>	< 1%	< 0.5%
<b>Gratings</b>	different	different
<b>Slits</b>	50, 100, 200, 500 µm	50, 100, 250, 500 µm
<b>Detector</b>	HAM-NIR256-1.7	SU-NIR256/512-1.7 HAM-NIR256-2.0/2.5 SU-NIR256/512-2.2
<b>TE Cooling</b>	No	Yes
<b>Order-sorting filter</b>	OSF-850-3/OSF-1000-3	OSF-1000-3 and OSC-NIR for 2.2/2.5
<b>Dimensions, weight</b>	100 x 130 x 40 mm, 875 gr.	177 x 125 x 108 mm / 2.5 Kg

### Ordering Information

<b>AvaBench-50-NIR256-1.7</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel InGaAs detector. Specify grating, wavelength range and slit, OSF-850-3 or OSF-1000-3.
<b>AvaBench-50-NIR256-1.7TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE-cooled InGaAs detector. Specify grating, wavelength range and slit, OSF-850-3 or OSF-1000-3.
<b>AvaBench-50-NIR512-1.7TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 512 pixel TE-cooled InGaAs detector. Specify grating, wavelength range and slit, OSF-850-3 or OSF-1000-3.
<b>AvaBench-50-NIR256-2.0TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE-cooled InGaAs detector 2.0 µm. Specify grating, wavelength range and slit, OSF-1000-3.
<b>AvaBench-50-NIR256-2.2TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE-cooled InGaAs detector 2.2 µm. Specify grating, wavelength range and slit, OSF-1000-3, OSC-NIR.
<b>AvaBench-50-NIR512-2.2TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 512 pixel TE-cooled InGaAs detector 2.2 µm. Specify grating, wavelength range and slit, OSF-1000-3, OSC-NIR.
<b>AvaBench-50-NIR256-2.5TEC</b>	• OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE-cooled InGaAs detector 2.5 µm. Specify grating, wavelength range and slit, OSF-1000-3, OSC-NIR.

# OEM Spectrometer: Enclosure

For OEM customers Avantes offers a line of neutral black enclosures in which either 1 or 2 channel spectrometers can be integrated.

The black enclosures have mounting ears and are available in single and dual channel housing.

Both the AvaBench-45/75 and the AS-5216 electronic board fit into the 1-channel OEM housing. In 2-channel OEM housings 2 AvaBenches and 2 electronics boards will easily fit.



### Technical Data

Product	AVS-HOUSING-IND	AVS-HOUSING-DUAL-IND
Material	Black aluminum	
Size	203 x 106 x 50 mm	203 x 106 x 93 mm
Weight	40 grams	55 grams

### Ordering Information

AVS-HOUSING-IND	• Neutral black aluminum housing to fit AvaBench-45/75 and AS-5216 board with mounting ears
AVS-HOUSING-DUAL-IND	• 2-channel Neutral black aluminum housing to fit 2 AvaBench-45/75 and 2 AS-5216 board with mounting ears