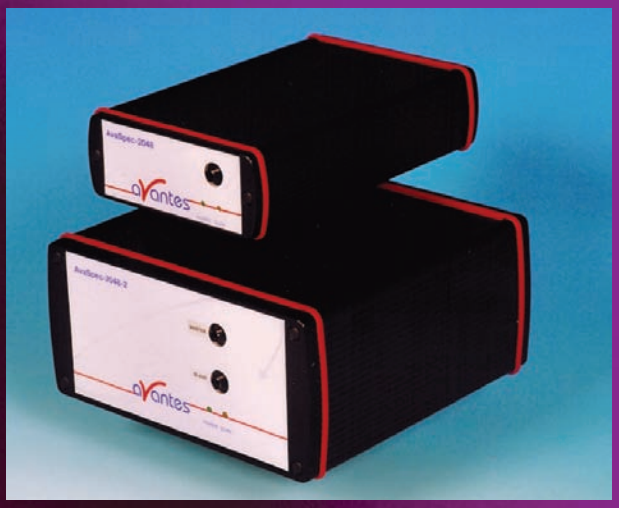
Spectrometers



Introduction Fiber Optic Spectroscopy

Optical spectroscopy is a technique for measuring light intensity in the UV-, VIS-, NIR- and IR-region. Spectroscopic measurements are being used in many different applications, such as color measurement, concentration determination of chemical components or electromagnetic radiation analysis. For more elaborate application information and setups, please see the Application chapter at the end of this catalog.

A spectroscopic instrument 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.

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. The same CCD and PDA detectors are now used in the Avantes line of spectrometers, enabling fast scanning of the spectrum, without the need of 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 a light source, sampling accessories and a fiber optic spectrometer.

Advantages of fiber optic spectroscopy are the modularity and flexibility of the system. The speed of measurement allows in-line analysis, and the use of low-cost commonly used detectors enable a complete low cost Avantes spectrometer system.

Optical Bench Design

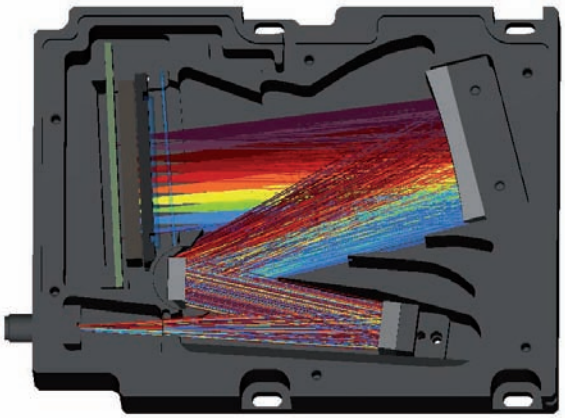


Figure 1 Optical bench design

The heart of the AvaSpec fiber optic spectrometer is an optical bench with 45, 50 or 75 mm focal length, developed in a symmetrical Czerny-Turner design (figure 1).

Light enters the optical bench through a standard SMA905 connector and is collimated by a spherical mirror. A plane 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.

The optical bench has 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. Sensitivity, resolution, bandwidth and stray light are further discussed in the following paragraphs.

How to configure a Spectrometer for your Application?

In the modular AvaSpec design a number of choices have to be made on several optical components and options, depending on the application you want to use the spectrometer for. This section should give you some guidance on how to choose the right grating, slit, detector and other options, installed in the AvaSpec.

1. Wavelength Range

In the determination for the optimal configuration of a spectrometer system the wavelength range is the first important parameter that defines the grating choice. If you are looking for a wide wavelength range, we recommend to take an A-type (300 lines/mm) or B-type (600 lines/mm) grating (see Grating selection table in the spectrometer product section). The other important component is the detector choice, Avantes offers 11 different detector types with each different sensitivity curves (see figure 5). For UV/VIS applications the 2048x14 pixel back-thinned CCD detector, the 256/1024 pixel CMOS detectors or DUV- enhanced 2048(L) or 3648 pixel CCD detectors may be selected. For the NIR range 4 different InGaAs detectors are available.
If you want to combine a wide range with a high resolution, a multiple channel spectrometer may be the best choice.

2. Optical Resolution

If you desire a high optical resolution we recommend to choose a grating that has 1200 or more lines/mm (C,D,E or F types) in combination with a narrow slit and a detector with 2048 or 3648 pixels, for example 10 µm slit for the best resolution on the AvaSpec-2048 (see Resolution table in the spectrometer product section)

3. Sensitivity

Talking about 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

In order to achieve the most sensitive spectrometer in for example Fluorescence or Raman applications we recommend the 2048 pixel CCD detector, as in the AvaSpec-2048. Further we recommend the use of a DCL-UV/VIS detector collection lens, a relatively wide slit (100µm or wider) or no slit and an A-type grating. For an A-type grating (300 lines/mm) the light dispersion is minimal, so it has the highest sensitivity of the grating types. Optionally the Thermo-electric cooling of the CCD detector (see product section AvaSpec-2048-TEC, page 39) may be chosen to minimize noise and increase dynamic range at long integration times (60 seconds).
For optimal UV sensitivity we recommend the back-thinned UV sensitive CCD detector, as implemented in the AvaSpec-2048x14.
For the different detector types the photometric sensitivity is given in table 4, the spectral sensitivity for each detector is depicted in figure 5.

b. Chemometric Sensitivity

To detect two absorbance values, close to each other with maximum sensitivity, you need a high Signal to Noise (S/N) performance. The detector with best S/N performance is the 2048x14 pixel back-thinned CCD detector, next to the 256/1024 CMOS detector in the AvaSpec-256/1024. The S/N performance can also be enhanced by averaging over multiple spectra.

4. Timing and Speed

The data capture process is inherently fast with detector arrays and no moving parts. However there is an optimal detector for each application. For fast response applications, we recommend to use the AvaSpec- USB2 platform spectrometers. When datatransfer time is critical we recommend to select a small amount of pixels to be transferred with the UBS2 interface. Data transfer time can be enhanced by selecting the pixel range of interest to be transmitted to the PC; in general the AvaSpec-128 may be considered as the fastest spectrometer with more than 8000 scans per second.

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. On the next page you will find a quick reference table 1 for most common applications, for a more elaborate explanation and configurations, please refer to the applications section in the back of this catalog.

In addition we have introduced in this catalog application icons, that will help you to find the right products and accessories for your applications.


Biomedical Technology


Chemistry


Colorimetry


Food Technology


Inline Process Control


Radiometry


Thinfilm Analysis

Table 1 Quick reference guide for spectrometer configuration

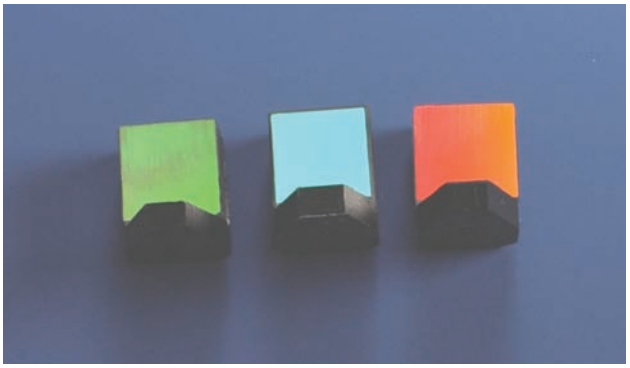
Application	AvaSpec-type	Grating	WL range (nm)	Coating	Slit	FWHM Resolution (nm)	DCL	OSF	OSC
Biomedical	2048	NB	500-1000	-	50	1.2	-	475	-
Chemometry	1024	UA	200-1100	-	50	2.0	-	-	OSC-UA
Color	128	VA	360-780	-	100	6.4	X/-	-	-
	256	VA	360-780	-	50	3.2	-	-	-
	2048	BB	360-780	-	200	4.1	X/-	-	-
Fluorescence	2048	VA	350-1100	-	200	8.0	X	-	OSC
Fruit-sugar	128	IA	800-1100	-	50	5.4	X	600	-
Gemology	2048	VA	350-1100	-	25	1.4	X	-	OSC
High resolution	2048	VD	600-700	-	10	0.07	-	550	-
	3648	VD	600-700	-	10	0.05	-	550	-
High UV-Sensitivity	2048x14	UC	200-450	-	200	2.0	-	-	-
Irradiance	2048	UA	200-1100	DUV	50	2.8	X/-	-	OSC-UA
Laserdiode	2048	NC	700-800	-	10	0.1	-	600	-
LED	2048	VA	350-1100	-	25	1.4	X/-	-	OSC
LIBS	2048-USB2	UE	200-300	DUV	10	0.09	-	-	-
Raman	2048TEC	NC	780-930	-	25	0.2	X	600	-
Thin Films	2048	UA	200-1100	DUV	-	4.1	X	-	OSC-UA
UV/VIS/NIR	2048	UA	200-1100	DUV	25	1.4	X/-	-	OSC-UA
	2048x14	UA	200-1100	-	25	1.4	-	-	OSC-UA
NIR	NIR256-1.7	NIR200-1.5	1000-1750	-	50	5.0	-	1000	-
	NIR256-2.0	NIR150-2.0	1000-2000	-	50	10.0	-	1000	-
	NIR256-2.2	NIR150-2.0	1200-2200	-	50	10.0	-	1000	OSC-NIR
	NIR256-2.5	NIR100-2.5	1000-2500	-	50	15.0	-	1000	OSC-NIR

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 into 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. In the Avaspec Spectrometers both ruled and holographic gratings are used.

The fiber optic spectrometer comes with a permanently installed grating that must be specified by the user. Further 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 triple beam spectrometer can be chosen. Then master and slave(s) have different gratings. Similarly, a higher resolution over a wide range can be achieved by using a dual or triple spectrometer.



For each spectrometer type, a grating selection table is shown in the Spectrometer Platforms 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 2 their 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 and coatings sensitivities. In Figure 3 the grating dispersion curves are shown for the AvaSpec-2048.

Table 2 Example of spectral range and gratings

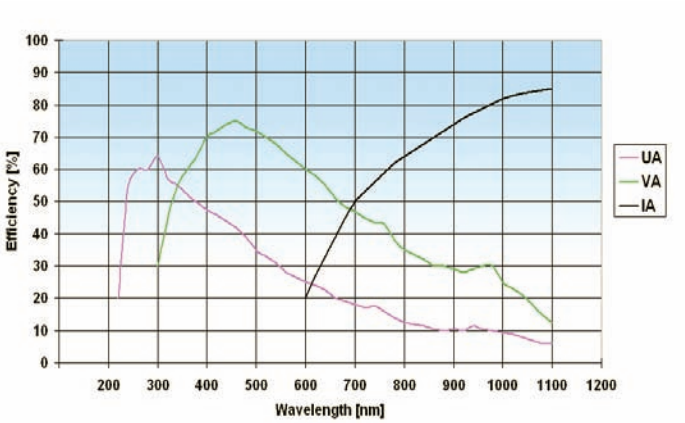
Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100**	900**	300	300	UA
UV/VIS	200-850	520	600	300	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	UV	UD
UV	200-580	115-70*	2400	UV	UE
UV	220-400	70-45*	3600	UV	UF
UV/VIS	250-850	520	600	400	BB
VIS/NIR	300-1100**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

Please select Spectral range band-width from the useable Wavelength range, for example: grating UE (200-315nm)
***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)

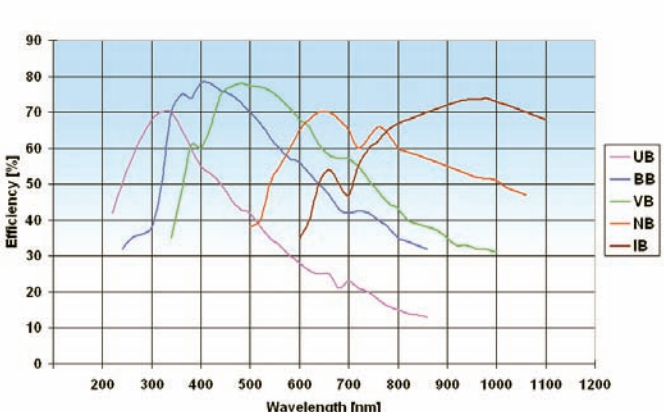
The order code is defined by 2 letters: the first is the Blaze (U= 250/300nm or UV for holographic, B=400nm, V=500nm or VIS for holographic, N=750nm, I=1000nm) and the second the nr of lines/mm (Z=150, A=300, B=600, C=1200, D=1800, E=2400, F=3600 lines/mm)

Figure 2 Grating Efficiency Curves

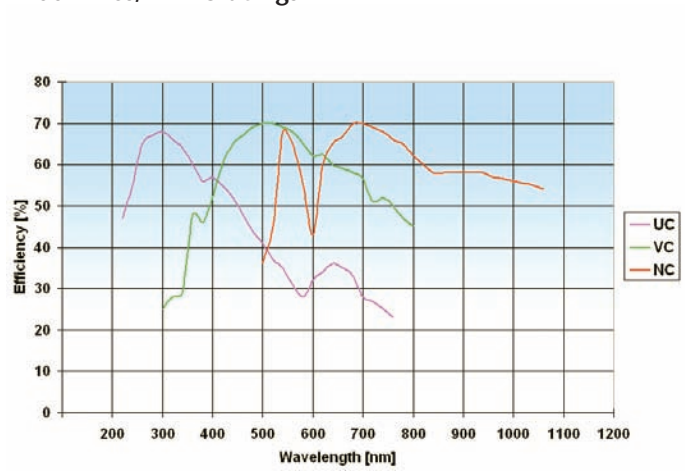
300 Lines/mm Gratings



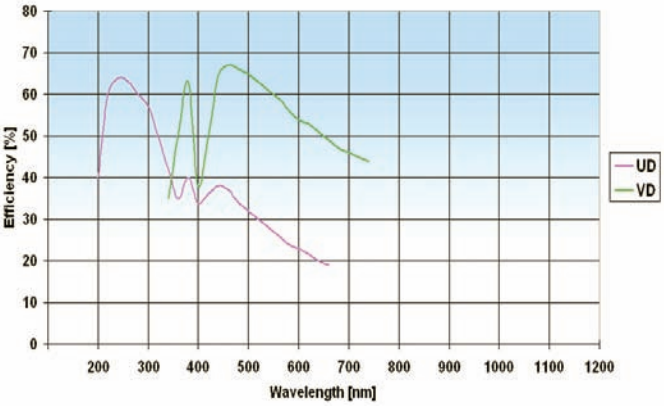
600 Lines/mm Gratings



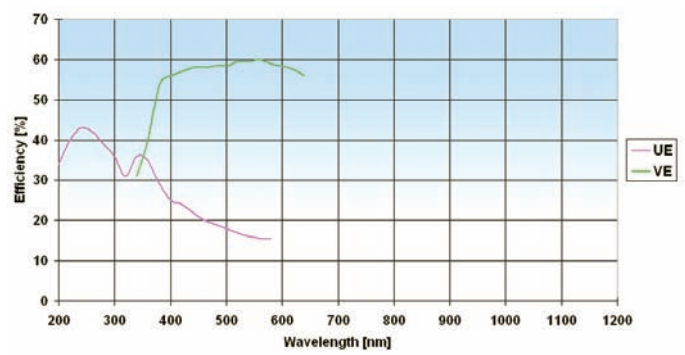
1200 Lines/mm Gratings



1800 Lines/mm Gratings



2400 Lines/mm Gratings



3600 Lines/mm Gratings

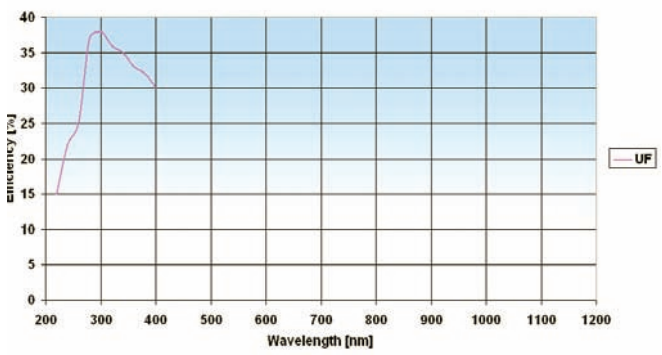
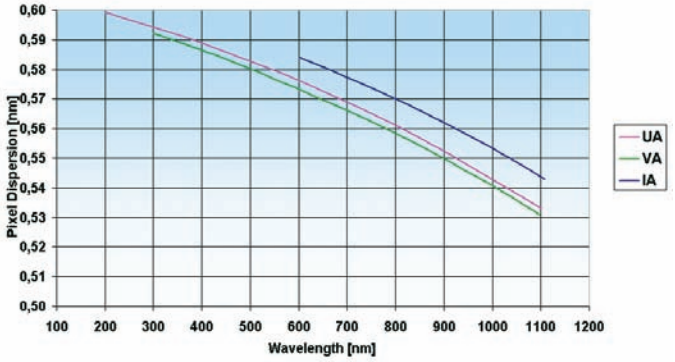
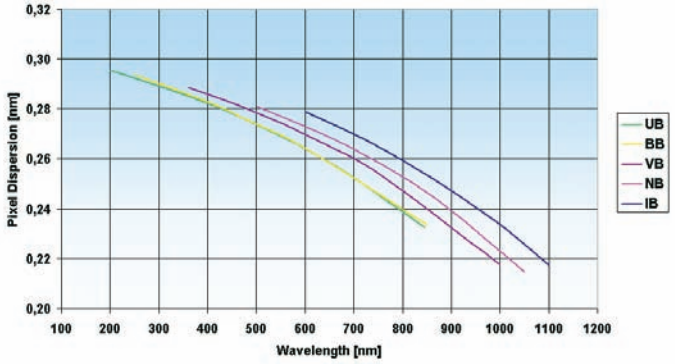


Figure 3 Grating Dispersion Curves

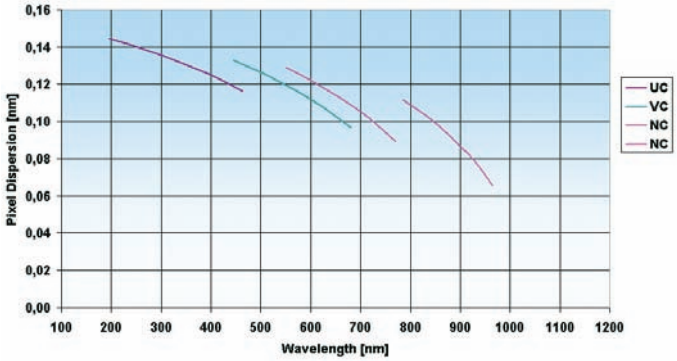
300 Lines/mm Gratings



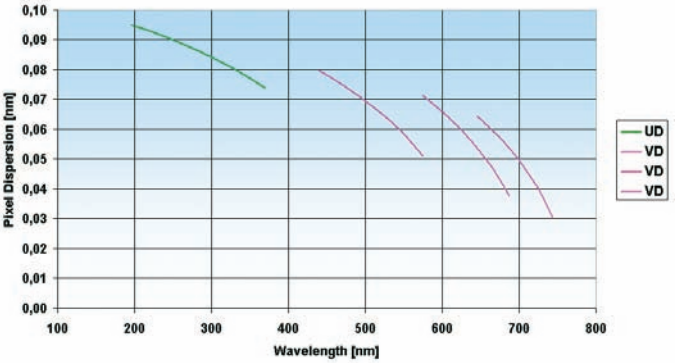
600 Lines/mm Gratings



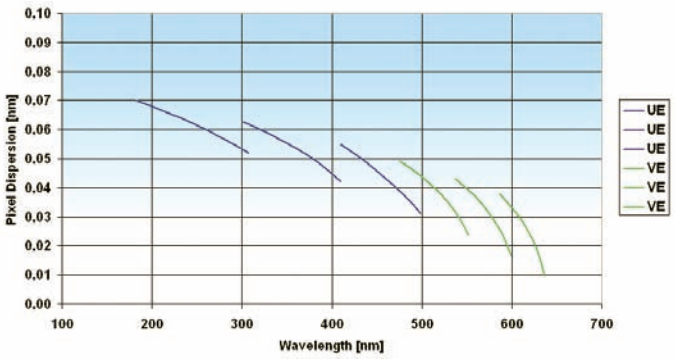
1200 Lines/mm Gratings



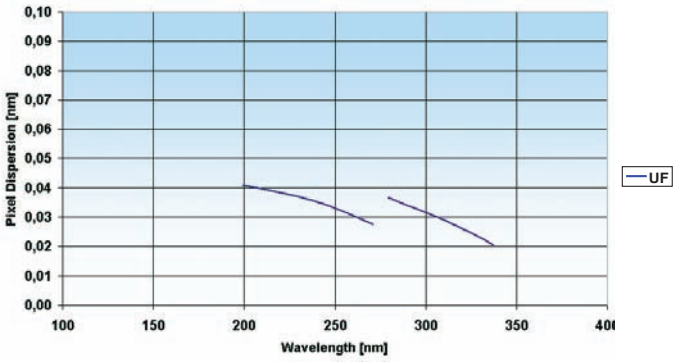
1800 Lines/mm Gratings



2400 Lines/mm Gratings



3600 Lines/mm Gratings

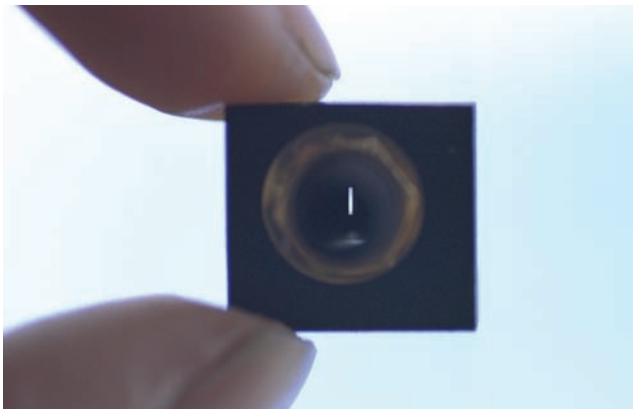


How to select optimal Optical Resolution?

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 2 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 diameter when no slit is installed.
The slits can be installed with following dimensions: 10, 25, 50, 100 or 200 x 1000 µm high or 500 µm x 2000 µm high. Its image on the detector array for a given wavelength will cover a number of pixels. For two spectral lines to be separated, it is now 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 entering light beam.

The influence of the chosen grating and the effective width of the light beam (fiber core or entrance slit) are shown in the tables at the product information. 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 best resolution can always be found for the longest wavelengths. The resolution in this table is defined as F(ull) W(idth) H(alf) M(aximum), 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.

Installed Slit in SMA Adapter



In combination with a DCL-detector collection lens or thick fibers the actual FWHM value can be 10-20% higher than the value in the table. For best resolution small fibers and no DCL is recommended.

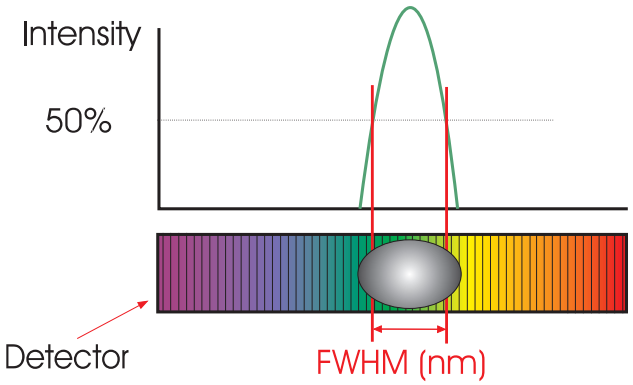


Figure 4 Full Width Half Maximum

Table 3 Resolution (FWHM in nm) for the AvaSpec-2048

	Slit size (µm)					
Grating (lines/mm)	**10**	**25**	**50**	**100**	**200**	**500**
300	0.8	1.4	2.4	4.3	8.0	20.0
600	0.4	0.7	1.2	2.1	4.1	10.0
1200	0.1-0.2*	0.2-0.3*	0.4-0.6*	0.7-1.0*	1.4-2.0*	3.3-4.8*
1800	0.07-0.12*	0.12-0.21*	0.2-0.36*	0.4-0.7*	0.7-1.4*	1.7-3.3*
2400	0.05-0.09*	0.08-0.15*	0.14-0.25*	0.3-0.5*	0.5-0.9*	1.2-2.2*
3600	0.04-0.06*	0.07-0.10*	0.11-0.16*	0.2-0.3*	0.4-0.6*	0.9-1.4*

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

Detector Arrays

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

CCD Detectors (AvaSpec-2048/2048L/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 an 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 10µs can be achieved.

+ Advantages for the CCD detectors are many pixels (2048 or 3648), high sensitivity and high speed.
- Main disadvantage is the lower S/N ratio.

UV enhancement

For applications below 350 nm with the AvaSpec-2048(L)/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 150-350nm. The DUV coating has a very fast decay time, typ. in ns range and is therefore useful for fast trigger LIBS applications.

Back-thinned CCD Detectors (AvaSpec-2048x14)

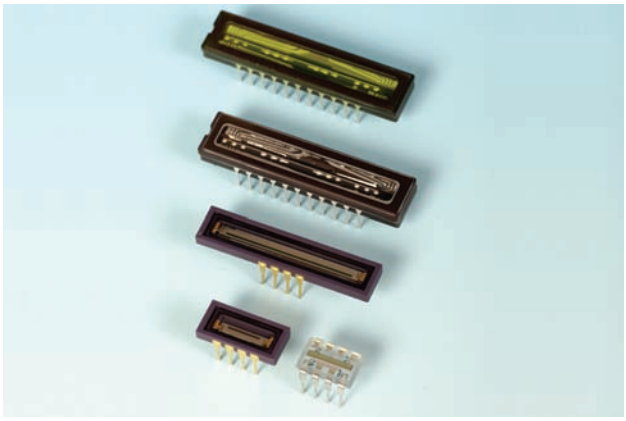
For applications requiring high quantum efficiency in the UV (200-350nm) and NIR (900-1160nm) range, combined with good S/N and a wide dynamic range, a back-thinned CCD detector may be the right choice. The detector is an area detector of 2048x14 pixels, for which the vertical 14 pixels are binned (electronically added together) to have more sensitivity and a better S/N performance.

+ 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 relative high cost

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 output an electrical signal. Most photodiode arrays have an integrated signal processing circuit with readout/integration amplifier on the same chip.

Different Detector Arrays



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

CMOS linear image sensors (AvaSpec-256/1024)

These so called CMOS linear image sensors have a lower charge to voltage conversion efficiency than CCD array sensors and are therefore less light sensitive, but have a much better signal to noise ratio.

The CMOS detectors have a higher conversion gain than NMOS detectors and also have a clamp circuit added to the internal readout circuit to suppress noise to a low level.

+ Advantages for the CMOS detectors are good S/N ratio and good UV sensitivity.
- Disadvantages are the low readout speed, low sensitivity, and relative high cost (1024 pixels).

InGaAs linear image sensors (AvaSpec-NIR256)

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 1.75µm no cooling is required, but for the extended range 2.0-2.5µm a 2 stage TE cooling is required to reduce dark noise.

4 versions of detectors are available:

- 256 pixel non-cooled InGaAs detector for the 900-1750nm useable range
- 256 pixel 2-stage cooled Extended InGaAs detector for the 1000-2000nm range
- 256 pixel 2-stage cooled Extended InGaAs detector for the 1000-2200nm range
- 256 pixel 2-stage cooled Extended InGaAs detector for the 1000-2500nm 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 cylindrical Detector Collection Lens (DCL) 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 new DCL-UV/VIS-200 can be used for the AvaSpec-2048L/3648/2048x14 to have a better vertically distributed light focusing for fiber diameters larger than 200µm and round to linear assemblies.

In Table 4 the overall sensitivity is given 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 assumed an optical bench with 600 lines/mm grating and no DCL. The entrance of the bench is an 8 µm core diameter fiber, connected to a standard AvaLight-HAL halogen light source. This is equivalent to ca. 1 µWatt light energy input.

In table 5 the specification is given for the NIR spectrometers, in figure 5 and figure 6 the spectral response curve for the different detector types are depicted.

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

Detector	**TAOS 128**	**HAM256**	**HAM1024**	**SONY2048**	**SONY2048L**	**TOSHIBA3648**	**HAM2048x14**
Type	Photo diode Array	CMOS linear Array	CMOS linear Array	CCD linear Array	CCD linear Array	CCD linear Array	Back-thinned CCD Array
# Pixels, pitch	128, 63.5 µm	256, 25 µm	1024, 25 µm	2048, 14 µm	2048, 14 µm	3648, 8 µm	2048x14, 14 µm
Pixel width x height (µm)	55.5 x 63.5	25 x 500	25 x 500	14 x 56	14 x 200	8 x 200	14x14 (total height 196 µm)
Pixel well depth (electrons)	250,000	50,000	50,000	40,000	90,000	120,000	250,000
Sensitivity V/lx.s	10	22	22	240	200	160	200
Sensitivity Photons/count @600nm	1000	440	440	40	50	60	50
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts/µW per ms integration time	400 (AvaSpec-128)	120 (AvaSpec-256)	120 (AvaSpec-1024)	20,000 (AvaSpec-2048)	20,000 (AvaSpec-2048L)	14,000 (AvaSpec-3648)	16,000 (Avaspec 2048x14)
Peak wavelength	750 nm	500 nm	500 nm	550 nm	450 nm	550 nm	650 nm
Signal/Noise	500:1	700:1	700:1	200 :1	350:1	350 :1	500:1
Dark noise (counts RMS)	60	28	80	40	24	40	50
Dynamic Range	1000	2500	1000	1700	2700	2000	1300
PRNU**	± 4%	± 3%	±3%	± 5%	± 5%	± 5%	± 3%
Wavelength range (nm)	360-1100	200-1000	200-1000	200*-1100	200*-1100	200*-1100	200-1160
Frequency	2 MHz	500 kHz	500 kHz	2 MHz	2 MHz	1 MHz	1.5 MHz

** DUV coated*

*** Photo Response Non-Uniformity = max difference between output of pixels when uniformly illuminated, divided by average signal*

Figure 5 Detector Spectral sensitivity curves

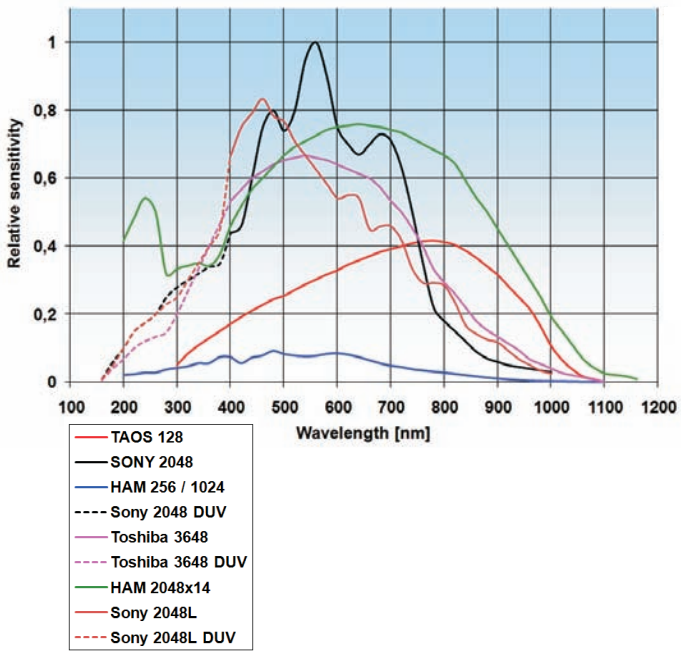


Figure 6 NIR Detector Sensitivity Curves

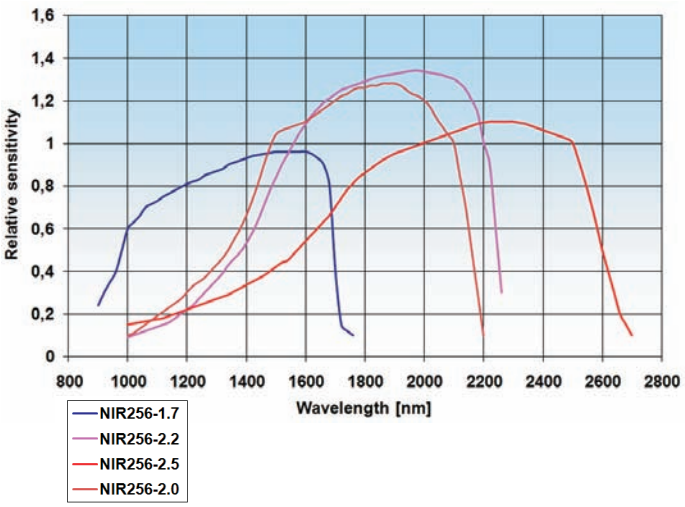


Table 5 NIR Detector Specifications

Detector	NIR256-1.7	NIR256-2.0	NIR256-2.2	NIR256-2.5
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
# Pixels, pitch	256, 50 µm	256, 50 µm	256, 50 µm	256, 50 µm
pixel width x height (µm)	50 x 500	50 x 250	50 x 250	50 x 250
Pixel well depth (electrons)	4,000,000	1,500,000	1,500,000	1,500,000
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts/µW per ms integration time	350	220	250	200
Peak wavelength	1550 nm	1950 nm	2050 nm	2300 nm
Signal/Noise	2000:1	1500:1	1500 :1	1500 :1
Dark noise (counts RMS)	12	25	25	25
Dynamic Range	5000	2500	2500	2500
PRNU**	± 5%	± 5%	± 5%	± 5%
Defective pixels (max)	0	12	12	12
Wavelength range (nm)	900-1750	1000-2000	1000-2200	1000-2500
Frequency	500 kHz	500 kHz	500 kHz	500 kHz

*** Photo Response Non-Uniformity = max difference between output of pixels when uniformly illuminated, divided by average signal*

Stray Light and Second Order Effects

Stray light is radiation of the wrong wavelength 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

The newly designed Ultra Low Straylight (AvaSpec-ULS) series have a number of internal measures to further reduce stray-light from zero order and backscattering. When straylight is an important parameter we strongly recommend to use the AvaSpec-ULS series.

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 being carried out with a halogen light source and long pass- or band pass filters.

Typical stray light performance for the ULS series 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 grating 2nd order diffracted beam. The effects of these higher orders can often be ignored, but sometimes need to be taken care of. 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

Order Sorting Window in holder

in the SMA entrance connector 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 (590nm) or 2 long pass filters (350 nm and 590 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 new filter types are 3mm thick and give much better 2nd 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.

In addition to the order sorting coatings we implement partial DUV coatings on the Sony 2048 detector 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

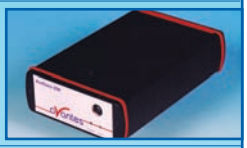
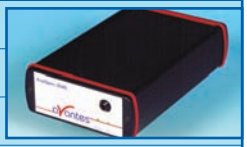
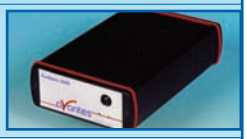
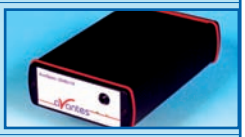
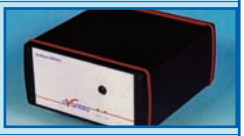
Table 6 Filters installed in the AvaSpec spectrometer series

OSF-385-3	Permanently installed 3 mm order sorting filter @ 385 nm
OSF-475-3	Permanently installed 3 mm order sorting filter @ 475 nm
OSF-515-3	Permanently installed 3 mm order sorting filter @ 515 nm
OSF-550-3	Permanently installed 3 mm order sorting filter @ 550 nm
OSF-600-3	Permanently installed 3 mm order sorting filter @ 600 nm
OSC	Order sorting coating with 590nm long pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-1024/2048(L)/3648/2048x14
OSC-UA	Order sorting coating with 350 and 590nm longpass filter for UA gratings in AvaSpec-1024/2048(L)/3648/2048x14
OSC-UB	Order sorting coating with 350 and 590nm longpass filter for UB or BB (<350 nm) gratings in AvaSpec-1024/2048(L)/3648/2048x14
OSC-NIR	Order sorting coating with 1400 nm long pass filter for NIR100-2.5 and NIR150-2.0 gratings in AvaSpec-NIR256-2.2/2.5

Spectrometer Platforms

The AvaSpec Spectrometer System comes in different platforms, consisting of different electronics, optical benches and detectors. This document gives an overview of the different platforms, the nomenclature and technical specifications.
The AvaSpec spectrometer platform was designed to enable applications in the various fields. The concept in the R&D phase was to design a platform, based on a powerfull microprocessor system, with stand-alone capability, multi-channel simultaneous readout, digital in- and outputs as well as USB and RS-232 to allow easy interfacing with or without computer environment.

Table 7 Fast selection guide

Product name	Electronics	Optical bench	Detector	Housing
AvaSpec-128	AS-161 with USB	AvaBench-45, all gratings 360-1100 nm	TAOS 128	
AvaSpec-128-USB2	AS-5216 with USB2			
AvaSpec-256	AS-161 with USB	AvaBench-45, all gratings 200-1100 nm	HAM 256	
AvaSpec-256-USB2	AS-5216 with USB2			
AvaSpec-1024	AS-161 with USB	AvaBench-75, all gratings 200-1100 nm	HAM 1024	
AvaSpec-1024-USB2	AS-5216 with USB2			
AvaSpec-2048	AS-161 with USB	AvaBench-75, all gratings 200-1100 nm	Sony 2048	
AvaSpec-2048-USB2	AS-5216 with USB2		Sony 2048	
AvaSpec-2048L-USB2	AS-5216 with USB2		Sony 2048L	
AvaSpec-3648-USB2	AS-5216 with USB2	AvaBench-75, all gratings 200-1100 nm	Toshiba 3648	
AvaSpec-2048x14-USB2	AS-5216 with USB2	AvaBench-75, all gratings 200-1160 nm	HAM 2048x14	
AvaSpec-NIR256-1.7	AS-5216 with USB2	AvaBench-50, grating 900-1750 nm	HAM NIR256-1.7	
AvaSpec-NIR256-2.0	AS-5216 with USB2	AvaBench-50, all gratings 1000-2500 nm	HAM NIR256-2.0	
AvaSpec-NIR256-2.2	AS-5216 with USB2		HAM NIR256-2.2	
AvaSpec-NIR256-2.5	AS-5216 with USB2		HAM NIR256-2.5	
AvaSpec-xxx-2 xxx=128/256/ 1024/2048	AS-161 with USB, 2 channels	AvaBench-45/75, all gratings 200-1100 nm	TAOS 128 HAM 256/1024 or Sony 2048	
AvaSpec-xxx-USB2-2 xxx=128/256/1024/ 2048(L)/3648/2048x14	2 * AS-5216		All detectors	
AvaSpec Multichannel as Desktop or Rackmount	AS-161 with USB1 or AS-5216 with USB2	AvaBench-45/75, all gratings 200-1100 nm	All detectors	 

AvaSpec-128 Ultrafast Fiber Optic Spectrometer

The AvaSpec-128 Fiber Optic Spectrometer is based on the AvaBench-45 symmetrical Czerny-Turner design with 128 pixel Photo Diode Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 11 different gratings with different dispersion and blaze angles enable applications in the 360-1100nm range. The AvaSpec-128 can be delivered with 2 platforms of electronics; either with USB1.1 with 14 bit AD converter or USB2.0 interface with 16 bit AD converter. Applications for this instrument are low cost color measurements. Digital IO ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-128 is also available as dual channel or multiple channel instrument (up to 8 channels), where all spectra are taken simultaneously.
The AvaSpec-128 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12V/1.0A power supply. AvaSoft-full and application software can be ordered separately.
Alternatively the AvaSpec-128-SPU has a switch to run on USB power or external power.
The AvaSpec-128-USB2 has a USB2 interface with ultrafast datasampling of 8000 spectra per second (with on-board averaging) and datatransfer in 1.1ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-128-USB2 runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detectors can be externally coupled (see section multichannel spectrometers, page 37).

AvaSpec-128

Technical Data

Spectrometer Platform	AvaSpec-128	AvaSpec-128-USB2
Optical Bench	Symmetrical Czerny-Turner, 45 mm focal length	
Wavelength range	360-1100 nm	
Resolution	1.5-64 nm, depending on configuration (see table)	
Stray light	< 0.3%	
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts/µw -per ms integration time	100 (14-bit AD)	400 (16-bit AD)
Detector	Photo diode array, 128 pixels	
Signal/Noise	500:1	
AD converter	14 bit, 1.33 MHz	16 bit, 2 MHz
Integration time	1 ms – 60 seconds	0.06 ms - 10 minutes
Interface	USB 1.1, 12 Mbps RS-232, 115.200 bps	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps
Sample speed with on-board averaging	3 ms	0.12 ms
Data transfer speed	6-7 ms / scan (depending on # pixels transferred)	1.1 ms / scan (USB2) 30 ms / scan (RS-232)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.0A) or 5VDC USB power	Default USB power, 350 mA. Or with SPU2 external 12VDC, 350 mA
Dimensions, weight	175 x 110 x 44 mm(1 channel), 716 grams	

Grating selection table for AvaSpec-128

Use	Useable range	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) for AvaSpec-128

	Slit size (µm)			
Grating (lines/mm)	**50**	**100**	**200**	**500**
150	13.0	13.0	26.0	64.0
300	6.4	6.4	13.0	32.0
600	3.0	3.0	6.0	16.0
1200	1.5	1.5	3.0	8.0

ORDERING INFORMATION	
AvaSpec-128	Fiber Optic Spectrometer, 45 mm Avabench, 128 pixel PDA detector, USB1.1/RS-232 interface, incl. AvaSoft-Basic, USB interface cable and a PS-12V/1.0A power supply, specify grating, wavelength range and options
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	
-SPU	incl. switch for USB powered USB1 or external power for RS-232
-SPU2	incl. switch for USB powered USB2 or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on-board data saving, for USB2 platform only
DCL-VIS	Detector collection lens to enhance sensitivity, BK7, 360-1100nm
SLIT-XX	Slit size, please specify XX = 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3mm thick, please specify YYY= 385, 475, 515, 550, 600 nm

AvaSpec-256 Low Noise Fiber Optic Spectrometer

The AvaSpec-256 Fiber Optic Spectrometer is based on the AvaBench-45 symmetrical Czerny-Turner design with 256 pixel CMOS Detector Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 13 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The AvaSpec-256 can be delivered with 2 platforms of electronics; either with USB1.1 with 14 bit AD converter or USB2.0 interface with 16 bit AD converter.

The AvaSpec-256 is especially suitable for low noise applications. Digital I/O ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-256 is also available as dual channel or multiple channel instrument (up to 8 channels), where all spectra are taken simultaneously.

The AvaSpec-256 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12V/1.0A power supply. AvaSoft-full and application software can be ordered separately. Alternatively the AvaSpec-256-SPU has a switch to run on USB power or external power.

The AvaSpec-USB2 has a USB2 interface with ultrafast datasampling of 1500 spectra per second (with on-board averaging) and datatransfer in 1.5ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-256-USB2 runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detectors can be externally coupled (see section multichannel spectrometers, page 37).

AvaSpec-256

Technical Data

Spectrometer platform	AvaSpec-256	AvaSpec-256-USB2
Optical Bench	Symmetrical Czerny-Turner, 45 mm focal length	
Wavelength range	200-1100 nm	
Resolution	0.5 -79 nm, depending on configuration (see table)	
Stray light	< 0.2%	
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts/µW -per ms integration time	30 (14-bit AD)	120 (16-bit AD)
Detector	CMOS linear array, 256 pixels	
Signal/Noise	700:1	
AD converter	14 bit, 330 kHz	16 bit, 500 kHz
Integration time	1 ms – 60 seconds	0.6 ms – 10 minutes
Interface	USB 1.1, 12 Mbps RS-232, 115.200 bps	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps
Sample speed with on-board averaging	4 ms / scan	0.6 ms /scan
Data transfer speed	7-9 ms / scan (depending on # pixels transferred)	1.5 ms / scan (USB2) 60 ms / scan (RS-232)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.0A) or 5VDC USB power	Default USB power, 350 mA. Or with SPU2 external 12VDC, 350 mA
Dimensions, weight	175 x 110 x 44 mm (1 channel), 716 grams	

Grating selection table for AvaSpec-256

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100*	900*	122	UV	UZ
UV/VIS/NIR	200-1100	400	300	300	UA
UV/VIS	200-850	200	600	300	UB
UV	200-750	100	1200	250	UC
UV/VIS	250-850	200	600	400	BB
VIS/NIR	300-1100*	800*	150	500	VZ
VIS/NIR	300-1100	400	300	500	VA
VIS	360-1000	200	600	500	VB
VIS	300-800	100	1200	500	VC
NIR	500-1050	200	600	750	NB
NIR	500-1050	100	1200	750	NC
NIR	600-1100	400	300	1000	IA
NIR	600-1100	200	600	1000	IB

** please note that not all 256 pixels will be used for the useable range*

Resolution table (FWHM) for AvaSpec-256

	Slit size (µm)				
Grating (lines/mm)	**25**	**50**	**100**	**200**	**500**
122	5.5	7.9	15.7	32.0	79.0
150	4.5	6.4	12.8	26.0	64.0
300	2.5	3.2	6.4	13.0	32.0
600	1.0	1.5	3.0	6.0	16.0
1200	0.5	0.8	1.5	3.0	8.0

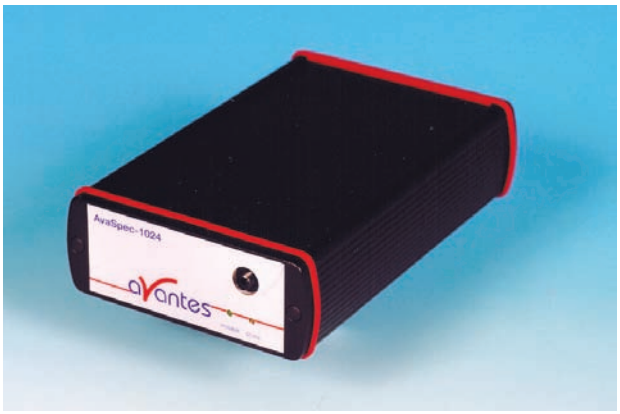
ORDERING INFORMATION	
AvaSpec-256	Fiber Optic Spectrometer, 45 mm Avabench, 256 pixel CMOS detector, USB1.1/RS-232 interface, incl. AvaSoft-Basic, USB cable and PS-12V/1.0A power supply, specify grating, wavelength range and options
AvaSpec-256-USB2	Fiber Optic Spectrometer, 45 mm Avabench, 256 CMOS detector, USB powered high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating, wavelength range and options
Options	
-SPU	incl. switch for USB powered USB1 or external power for RS-232
-SPU2	incl. switch for USB powered USB2 or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on-board data saving, for USB2 platform only
SLIT-XX	Slit size, please specify XX = 25, 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550, 600 nm

AvaSpec-1024 Low Noise Fiber Optic Spectrometer

The AvaSpec-1024 Fiber Optic Spectrometer is based on the AvaBench-75 symmetrical Czerny-Turner design with 1024 pixel CMOS Detector Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 16 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The AvaSpec-1024 can be delivered with 2 platforms of electronics; either with USB1.1 with 14 bit AD converter or USB2.0 interface with 16 bit AD converter.

The AvaSpec-1024 is especially suitable for low noise applications with good resolution. Digital I/O ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.
The AvaSpec-1024 is also available as dual channel or multiple channel instrument (up to 8 channels), where all spectra are taken simultaneously.
The AvaSpec-1024 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12V/1.0A power supply. AvaSoft-full and application software can be ordered separately. Alternatively the AvaSpec-1024-SPU has a switch to run on USB power or external power.
The AvaSpec1024-USB2 has a USB2 interface with fast

AvaSpec-1024



datasampling of 450 spectra per second and datatransfer in 2.2 ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-1024-USB2 runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detectors can be externally coupled (see section multichannel spectrometers, page 37).

Technical Data

Spectrometer platform	AvaSpec-1024	AvaSpec-1024-USB2
Optical Bench	Symmetrical Czerny-Turner, 75 mm focal length	
Wavelength range	200-1100 nm	
Resolution	0.15 - 20 nm, depending on configuration (see table)	
Stray light	< 0.1%	
Sensitivity (AvaLight-HAL, 8 µm fiber) counts/µW -per ms integration time	30 (14-bit AD)	120 (16-bit AD)
Detector	CMOS linear array, 1024 pixels	
Signal/Noise	700:1	
AD converter	14 bit, 330 kHz	16 bit, 500 kHz
Integration time	4 ms – 60 seconds	2.2 ms – 10 minutes
Interface	USB 1.1, 12 Mbps RS-232, 115.200 bps	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps
Sample speed with on-board averaging	12 ms / scan	2.2 ms /scan
Data transfer speed	12-20 ms / scan (depending on # pixels transferred)	2.2 ms / scan (USB2) 220 ms / scan (RS-232)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.0A) or 5VDC USB power	Default USB power, 350 mA. Or with SPU2 external 12VDC, 350 mA
Dimensions, weight	175 x 110 x 44 mm (1 channel), 716 grams	

Grating selection table for AvaSpec-1024

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1100*	900*	300	300	UA
UV/VIS	200-850	450	600	300	UB
UV	200-750	220	1200	250	UC
UV	200-650	160	1800	UV	UD
UV	200-580	100	2400	UV	UE
UV	220-400	50	3600	UV	UF
UV/VIS	250-850	450	600	400	BB
VIS/NIR	300-1100*	800*	300	500	VA
VIS	360-1000	450	600	500	VB
VIS	300-800	220	1200	500	VC
VIS	350-750	160	1800	500	VD
VIS	350-640	75	2400	VIS	VE
NIR	500-1050	450	600	750	NB
NIR	500-1000	200	1200	750	NC
NIR	600-1100*	500*	300	1000	IA
NIR	600-1100	450	600	1000	IB

** please note that not all 1024 pixels will be used for the useable range*

Resolution table (FWHM) for AvaSpec-1024

	Slit size (µm)				
Grating (lines/mm)	**25**	**50**	**100**	**200**	**500**
300	1.2	2.4	4.3	8.0	20.0
600	0.8	1.2	2.1	4.1	10.0
1200	0.4	0.5	1.0	2.0	5.0
1800	0.3	0.4	0.8	1.4	3.5
2400	0.2	0.25	0.5	1.0	2.5
3600	0.15	0.20	0.4	0.6	1.5

ORDERING INFORMATION	
AvaSpec-1024	Fiber Optic Spectrometer, 75 mm Avabench, 1024 pixel CMOS detector, USB1.1/RS-232 interface, incl. AvaSoft-Basic, USB cable and PS-12V/1.0A power supply, specify grating, wavelength range and options
AvaSpec-1024-USB2	Fiber Optic Spectrometer, 75 mm Avabench, 1024 CMOS detector, USB powered high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating, wavelength range and options
Options	
-SPU	incl. switch for USB powered USB1 or external power for RS-232
-SPU2	incl. switch for USB powered USB2 or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on-board data saving, for USB2 platform only
SLIT-XX	Slit size, please specify XX = 25, 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550, 600 nm
OSC	Order sorting coating with 590nm long pass filter for VA, BB (>350nm) and VB gratings in AvaSpec-1024
OSC-UA	Order sorting coating with 350 and 590nm longpass filter for UA gratings in AvaSpec-1024
OSC-UB	Order sorting coating with 350 and 590nm longpass filter for UB or BB (<350nm) gratings in AvaSpec-1024

AvaSpec-2048 Standard Fiber Optic Spectrometer

The AvaSpec-2048 Fiber Optic Spectrometer is based on the AvaBench-75 symmetrical Czerny-Turner design with 2048 pixel CCD Detector Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 16 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The AvaSpec-2048 can be delivered with 2 platforms of electronics; either with USB1.1 with 14 bit AD converter or USB2.0 interface with 16 bit AD converter. The AvaSpec-2048 is especially suitable for low light level and high resolution applications. An optional detector coating enhances the CCD performance for the UV range and a detector collection lens offers high sensitivity. Digital I/O ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-2048 is also available as dual channel or multiple channel instrument (up to 8 channels), where all spectra are taken simultaneously.

The AvaSpec-2048 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12V/1.0A power supply. AvaSoft-full and application software can be ordered separately. Alternatively the AvaSpec-2048-SPU has a switch to run on USB power or external power.

AvaSpec-2048

The AvaSpec2048-USB2 has a USB2 interface with ultrafast datasampling of 900 spectra per second and datatransfer in 1.8ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-2048-USB2 runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detectors can be externally coupled (see section multichannel spectrometers, page 37).

Technical Data

Spectrometer platform	**AvaSpec-2048**	**AvaSpec-2048-USB2**
Optical Bench	Symmetrical Czerny-Turner, 75 mm focal length	
Wavelength range	200-1100 nm	
Resolution	0.04 –20 nm, depending on configuration (see table)	
Stray light	< 0.1%	
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts/µW -per ms integration time	5,000 (14-bit AD)	20,000 (16-bit AD)
Detector	CCD linear array, 2048 pixels	
Signal/Noise	200:1	
AD converter	14 bit, 1.33 MHz	16 bit, 2 MHz
Integration time	2 ms – 60 seconds	1.1 ms – 10 minutes
Interface	USB 1.1, 12 Mbps RS-232, 115.200 bps	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps
Sample speed with on-board averaging	17 ms / scan	1.11 ms /scan
Data transfer speed	14-31 ms / scan (depending on # pixels transferred)	1.8 ms / scan (USB2) 430 ms / scan (RS-232)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, sync.
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.0A) or 5VDC USB power	Default USB power, 350 mA. Or with SPU2 external 12VDC, 350 mA
Dimensions, weight	175 x 110 x 44 mm (1 channel), 716 grams	

Grating selection table for AvaSpec-2048

Use	Useable range	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
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	600-1100**	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) for AvaSpec-2048

	Slit size (µm)					
Grating (lines/mm)	**10**	**25**	**50**	**100**	**200**	**500**
300	0.8	1.4	2.4	4.3	8.0	20.0
600	0.4	0.7	1.2	2.1	4.1	10.0
1200	0.1-0.2*	0.2-0.3*	0.4-0.6*	0.7-1.0*	1.4-2.0*	3.3-4.8*
1800	0.07-0.12*	0.12-0.21*	0.2-0.36*	0.4-0.7*	0.7-1.4*	1.7-3.3*
2400	0.05-0.09*	0.08-0.15*	0.14-0.25*	0.3-0.5*	0.5-0.9*	1.2-2.2*
3600	0.04-0.06*	0.07-0.10*	0.11-0.16*	0.2-0.3*	0.4-0.6*	0.9-1.4*

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

ORDERING INFORMATION	
AvaSpec-2048	Fiber Optic Spectrometer, 75 mm Avabench, 2048 pixel CCD detector, USB1.1/RS-232 interface, incl. AvaSoft-Basic, USB cable and PS-12V/1.0A power supply, specify grating, wavelength range and options
AvaSpec-2048-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	
-SPU	incl. switch for USB powered USB1 or external power for RS-232
-SPU2	incl. switch for USB powered USB2 or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on board data saving, for USB2 platform only
DUV	Deep UV detector coating >150 nm
DCL-UV/VIS	Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
SLIT-XX	Slit size, please specify XX = 10, 25, 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550, 600 nm
OSC	Order sorting coating with 590nm long pass filter for VA, BB (>350nm) and VB gratings in AvaSpec-2048
OSC-UA	Order sorting coating with 350 and 590nm longpass filter for UA gratings in AvaSpec-2048
OSC-UB	Order sorting coating with 350 and 590nm longpass filter for UB or BB (<350nm) gratings in AvaSpec-2048

AvaSpec-3648 High Resolution Fiber Optic Spectrometer

The AvaSpec-3648 Fiber Optic Spectrometers is based on the AvaBench-75 symmetrical Czerny-Turner design with 3648 pixel CCD Detector Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 16 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The AvaSpec-3648 comes with a 16 bit AD converter, and USB2.0 high speed interface.

The AvaSpec- 3648 is especially suitable for measuring high resolution applications and, thanks to the 10µs electronic shutter, has a wide dynamic range. An optional detector coating enhances the CCD performance for the UV range and a detector collection lens offers high sensitivity.
Digital IO ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.
The AvaSpec-3648 has a USB2 interface with fast data sampling of 270 spectra per second and data transfer in 3.7 ms. It supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-3648-USB2 runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detectors can be externally coupled (see section multichannel spectrometers, page 37).

AvaSpec-3648

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 75 mm focal length
Wavelength range	200-1100 nm
Resolution	0.025 –20 nm, depending on configuration (see table)
Stray light	< 0.1%
Sensitivity (AvaLight-HAL, 8 µm fiber)	14,000 counts (16-bit AD)/µW -per ms integration time
Detector	CCD linear array, 3648 pixels
Signal/Noise	350:1
AD converter	16 bit, 1MHz
Integration time	10 µs – 10 minutes
Interface	USB 2.0 high speed, 480 Mbps or RS-232, 115.200 bps
Sample speed with on-board averaging	3.7 ms / scan
Data transfer speed	3.7 ms / scan (USB2) 750 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, 350 mA
Dimensions, weight	175 x 110 x 44 mm (1 channel), 716 grams

Grating selection table for AvaSpec-3648

Use	Useable range	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
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	600-1100**	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) for AvaSpec-3648

	Slit size (µm)					
Grating (lines/mm)	**10**	**25**	**50**	**100**	**200**	**500**
300	0.5	1.4	2.4	4.3	8.0	20.0
600	0.32	0.7	1.2	2.1	4.1	10.0
1200	0.07-0.13*	0.2-0.3*	0.4-0.6*	0.7-1.0*	1.4-2.0*	3.3-4.8*
1800	0.05-0.08*	0.12-0.21*	0.2-0.36*	0.4-0.7*	0.7-1.4*	1.7-3.3*
2400	0.04-0.07*	0.08-0.15*	0.14-0.25*	0.3-0.5*	0.5-0.9*	1.2-2.2*
3600	0.025-0.04*	0.07-0.10*	0.11-0.16*	0.2-0.3*	0.4-0.6*	0.9-1.4*

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

ORDERING INFORMATION	
AvaSpec-3648-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	
-SPU2	incl. switch for USB powered or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on board data saving, for USB2 platform only
DUV	Deep UV detector coating >150 nm
DCL-UV/VIS	Detector Collection Lens to enhance sensitivity, Quartz, 200-1100 nm
DCL-UV/VIS-200	Quarz Detector Collection Lens (200-1100nm) for >200µm fibers
SLIT-XX	Slit size, please specify XX = 10, 25, 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550, 600 nm
OSC	Order sorting coating with 590nm long pass filter for VA, BB (>350nm) and VB gratings in AvaSpec-3648
OSC-UA	Order sorting coating with 350 and 590nm longpass filter for UA gratings in AvaSpec-3648
OSC-UB	Order sorting coating with 350 and 590nm longpass filter for UB or BB (<350nm) gratings in AvaSpec-3648

AvaSpec-2048x14 High UV-sensitivity back-thinned CCD Spectrometer

The AvaSpec-2048x14 Fiber Optic Spectrometer is a back-thinned type CCD spectrometer with high quantum efficiency and high UV sensitivity. The optical design is based on the AvaBench-75 symmetrical Czerny-Turner design with a 2048x14 pixels high UV sensitive CCD image sensor. The image sensor is used as a linear array of 2048 pixels binning the vertical 14 pixels to optimize efficiency. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and a diffractional grating. A choice of 16 different gratings with different dispersion and blaze angles enable applications in the 200-1160nm range. The AvaSpec-2048x14 comes with a 16 bit AD converter, and USB2.0 high speed interface. The AvaSpec-2048x14 is especially suitable for measuring low light, fluorescence and UV-applications. Digital IO ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-2048x14 has a USB2 interface with fast data sampling of 450 spectra per second and data transfer in 2.24 ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-2048x14-USB2

AvaSpec-2048x14

runs on USB power and comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detector types can be externally coupled (see section multi-channel spectrometers, page 37).

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 75 mm focal length
Wavelength range	200-1160 nm
Resolution	0.04 –20 nm, depending on configuration (see table)
Stray light	< 0.1%
Sensitivity (AvaLight-HAL, 8 µm fiber)	16,000 counts (16-bit AD)/µW -per ms integration time
UV Quantum efficiency	35-65% (200-300nm)
Detector	Back-thinned CCD image sensor 2048x14 pixels
Signal/Noise	500:1
AD converter	16 bit, 1.5MHz
Integration time	2.24 ms – 10 minutes
Interface	USB 2.0 high speed, 480 Mbps or RS-232, 115.200 bps
Sample speed with on-board averaging	2.24 ms / scan
Data transfer speed	2.24 ms / scan (USB2) 432 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, 350 mA
Dimensions, weight	175 x 110 x 44 mm (1 channel), 716 grams

Grating selection table for AvaSpec-2048x14

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
UV/VIS/NIR	200-1160**	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
VIS/NIR	300-1160**	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**	500**	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) for AvaSpec-2048x14

	Slit size (µm)					
Grating (lines/mm)	**10**	**25**	**50**	**100**	**200**	**500**
300	0.8	1.4	2.4	4.3	8.0	20.0
600	0.4	0.7	1.2	2.1	4.1	10.0
1200	0.1-0.2*	0.2-0.3*	0.4-0.6*	0.7-1.0*	1.4-2.0*	3.3-4.8*
1800	0.07-0.12*	0.12-0.21*	0.2-0.36*	0.4-0.7*	0.7-1.4*	1.7-3.3*
2400	0.05-0.09*	0.08-0.15*	0.14-0.25*	0.3-0.5*	0.5-0.9*	1.2-2.2*
3600	0.04-0.06*	0.07-0.10*	0.11-0.16*	0.2-0.3*	0.4-0.6*	0.9-1.4*

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

ORDERING INFORMATION	
AvaSpec-2048x14-USB2	Fiber Optic Spectrometer, 75 mm Avabench, 2048x14 pixel back-thinned CCD 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 power or external power for RS-232/BT
-SPU2-BT	Bluetooth® interface for USB2 platform only, including antenna and switch
SDXXX	Internal XXX MB SD card for on-board data saving
DCL-UV/VIS-200	Quarz Detector Collection Lens (200-1100nm)
SLIT-XX	Slit size, please specify XX = 10, 25, 50, 100, 200, 500 µm
OSF-YYY-3	Order sorting filter for reduction of 2nd order effects, 3 mm thick, please specify YYY= 385, 475, 515, 550, 600 nm
OSC	Order sorting coating with 590nm long pass filter for VA, BB (>350nm) and VB gratings in AvaSpec-2048x14
OSC-UA	Order sorting coating with 350 and 590nm longpass filter for UA gratings in AvaSpec-2048x14
OSC-UB	Order sorting coating with 350 and 590nm longpass filter for UB or BB (<350nm) gratings in AvaSpec-2048x14

AvaSpec-2048L Fiber Optic Spectrometer with larger pixels

The new AvaSpec-2048L Fiber Optic Spectrometer has been recently added to the Avantes product line and has many technical specifications comparable to the standard AvaSpec-2048.

The difference is the CCD detector, the AvaSpec-2048L uses the Sony ILX511 detector whereas the AvaSpec-2048 uses the ILX554B detector.

The AvaSpec-2048L is very useful for applications where larger fiber entrance diameter needs to be projected on the larger CCD detector pixels of 200µm height.

The AvaSpec-2048L also has a better signal to noise performance and shows no peak inversion and dark increase at the end of the detector array at longer integration times. The FWHM resolution of the 2048L is ca 20% less good than for the standard 2048. Non-linearity is also a little less, so a NL-calibration per channel is recommended.

AvaSpec-2048L

NEW

All options for the AvaSpec-2048 are also available on the AvaSpec-2048L, the DCL-UV/VIS-200 has been added to optimize sensitivity for fiber diameters larger than 200µm.

Technical Data

Spectrometer	AvaSpec-2048-USB2	AvaSpec-2048L-USB2
Detector	Sony ILX-554B	Sony ILX-511
Pixel size	14 X 56 µm	14 x 200µm
Sensitivity (V/lx.s)	240	200
Sensitivity (AvaLight-HAL, 8 µm fiber) counts/µW per ms integration time	20,000	20,000
Peak Wavelength	550 nm	450 nm
Signal/Noise	160:1	350:1
Dark Noise	40	24
Ext trigger delay	1.3µs	3.0µs

ORDERING INFORMATION	
AvaSpec-2048L-USB2	Fiber Optic Spectrometer, 75 mm Avabench, 2048 pixel 14x200µm CCD detector, USB powered high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating, wavelength range and options
Options	All options of the AvaSpec-2048-USB2
extra Options:	
DCL-UV/VIS-200	Quarz Detector Collection Lens (200-1100nm)

AvaSpec-ULS Ultra Low Straylight Fiber Optic Spectrometer

The AvaSpec-ULS family consists of a revolutionary new optical bench optimized to reduce straylight and increase both mechanical and temperature stability. The new optical bench has a dual internal modestripper along with multiple CPC's (Compound Parabolic Concentrators) to further reduce straylight levels down to 0.04%, an improvement of a factor of 2.5 over the standard AvaSpec-2048. Along with the straylight improvement the new optical bench design features a much higher rigidity resulting in a factor of 10 decrease in strain sensitivity caused by microbending and temperature fluctuations.

The ULS optical bench is available for the following detector types 1024, 2048, 2048L, 3648 and 2048x14 and has the same dimensions as the standard 75 mm Avabench.

The low straylight performance of the AvaSpec-ULS is extremely useful in applications where high absorbance parameters need to be measured, such as those associated with high chemical concentrations, high optical density optics or long optical path lengths. The new optical bench and spectrometer are available for OEM integration as well as for individual instruments.

AvaSpec-ULS2048

NEW

Technical Data

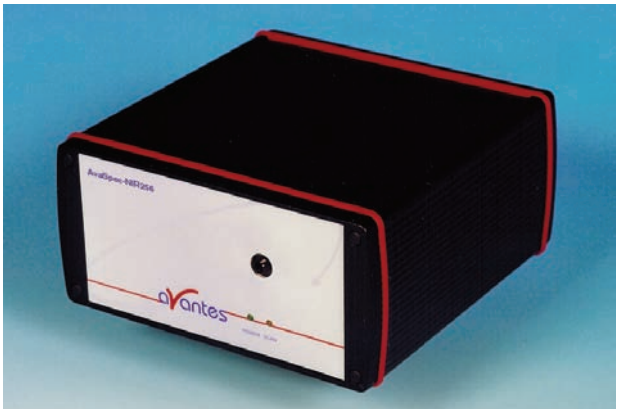
Spectrometer	AvaSpec-2048-USB2	AvaSpec-ULS2048-USB2
Typ. Straylight for UA, VA, IA gratings	0.5%	0.1%
Typ. Straylight for UB, VB, IB gratings	0.1%	0.04%
Typ. Straylight for UC, VC, IC gratings	0.1%	0.04%
Typ. Straylight for D, E, F gratings	0.1%	0.02-0.07%
Typ. Temp wavelength shift	0.15 Pixel/°C	0.1 Pixel/°C
Typ. Temp intensity change (CDD on)	1 %/°C	0.5 %/°C
Typ. Microbending* Sensitivity	3 %/N	0.3 %/N
Weight	716 grams	855 grams

** Microbending is defined as the signal change due to the average external force in vertical direction applied to the SMA connector.*

ORDERING INFORMATION	
AvaSpec-ULS1024-USB2	Ultra Low Straylight Fiber Optic Spectrometer, 1024 pixel CMOS detector, specify grating, wavelength range and options
AvaSpec-ULS2048-USB2	Ultra Low Straylight Fiber Optic Spectrometer, 2048 pixel 14x56µm CCD detector, specify grating, wavelength range and options
AvaSpec-ULS2048L-USB2	Ultra Low Straylight Fiber Optic Spectrometer, 2048 pixel 14x200µm CCD detector, specify grating, wavelength range and options
AvaSpec-ULS3648-USB2	Ultra Low Straylight Fiber Optic Spectrometer, 3648 pixel CCD detector, specify grating, wavelength range and options
AvaSpec-ULS2048x14-USB2	Ultra Low Straylight Fiber Optic Spectrometer, 2048x14 pixel backthinned CCD detector, specify grating, wavelength range and options

AvaSpec-NIR256-1.7 Near-Infrared Fiber Optic Spectrometer

AvaSpec-NIR256-1.7



The AvaSpec-NIR256-1.7 Fiber Optic Spectrometer is based on the AvaBench-50 symmetrical Czerny-Turner design with 256 pixel InGaAs Detector Array. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating.

A choice of 4 gratings with different dispersion and blaze angles enable applications in the 900-1700nm range. The AvaSpec-NIR256 includes a 16 bit AD converter, and USB2.0 high speed interface. The AvaSpec- NIR256-1.7 is especially suitable for measuring in the NIR range from 900-1750nm applications, e.g. plastics and water absorbance.
Digital IO ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-NIR256 series have a USB2 interface with fast datasampling of 940 spectra per second and datatransfer in 1.56 ms and supports analog in- and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-NIR-256-1.7 runs on USB power. The spectrometer comes with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detector types can be externally coupled (see section multi-channel spectrometers).

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 50 mm focal length
Wavelength range	900 - 1750nm
Resolution	2.0 - 50 nm
Stray light	< 0.1%
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts (16-bit A/D)/µW per ms integration time	350
Detector	InGaAs linear array, 256 pixels
Signal/Noise	2000:1
AD converter	16 bit, 500kHz
Integration time	0.52 ms – 8 seconds
Interface	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps
Sample speed with on-board averaging	1.06 ms /scan
Data transfer speed	1.56 ms /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	Default USB power, 350 mA or with SPU2 external 12VDC, 350 mA
Dimensions, weight	175 x 165 x 85 mm, 2.2 Kg

Grating selection table for AvaSpec-NIR256-1.7

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
NIR	900-1750	750	200	1500	NIR200-1.5
NIR	1000-1700	340	400	1600	NIR400-1.6
NIR	900-1400	200	600	1200	NIR600-1.2
NIR	1300-1600	170	600	1600	NIR600-1.6

Resolution table (FWHM) for AvaSpec-NIR256-1.7

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

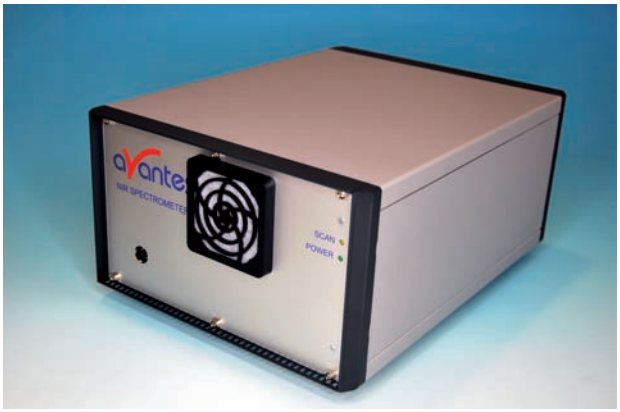
ORDERING INFORMATION	
AvaSpec-NIR256-1.7	Fiber Optic Spectrometer, 50 mm Avabench, 256 pixel InGaAs detector, USB powered high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, OSF-1000-3, specify grating, wavelength range and slit
Options	
BT	Bluetooth® interface for USB2 platform only, including antenna
SDXXX	Internal XXX MB SD card for on-board data saving, for USB2 platform only
SLIT-XX	Slit size, please specify XX = 50, 100, 200, 500 µm

AvaSpec-NIR256-2.0/2.2/2.5 Near-Infrared Fiber Optic Spectrometers

The AvaSpec-NIR256-2.0/2.2/2.5 Fiber Optic Spectrometers are based on the AvaBench-50 symmetrical Czerny-Turner design with 256 pixel TE Cooled extended InGaAs Detector Arrays. The spectrometer has a fiber optic entrance connector (standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of 4 gratings with different dispersion and blaze angles enables applications in the 900-2500nm range. The AvaSpec-NIR256-2.0/2.2/2.5 includes a 16 bit AD converter, and USB2.0 high speed interface. The AvaSpec- NIR256-2.0/2.2/2.5 have a 2-stage Thermo-electrical Peltier-cooled InGaAs detector, specially suitable for measuring in the NIR range from 1000-2000/2200/2500nm. The newly added AvaSpec-NIR256-2.0 has a very low dark noise level and therefore a much longer integration time can be used for low light level applications. Digital IO ports enable external triggering and control of shutter and pulsed light sources from the Avantes line of instruments.

The AvaSpec-NIR256 series have a USB2 interface with fast datasampling of 940 spectra per second and datatransfer in 1.56 ms and supports analog in-and outputs as well. Optional Bluetooth® (-BT) communication and an SD card for on-board saving of spectra can be added. The AvaSpec-NIR-256-2.0/2.2/2.5 come in a desktop housing and run on 100-240VAC. They come with AvaSoft-basic, a complete manual and USB interface cable. Multiple (up to 127) USB2 spectrometers with different detector types can be externally coupled (see section multi-channel spectrometers, page 37).

AvaSpec-NIR256-2.5



Technical Data

NEW

Spectrometer platform	AvaSpec-NIR256-2.0	AvaSpec-NIR256-2.2	AvaSpec-NIR256-2.5
Optical Bench	Symmetrical Czerny-Turner, 50 mm focal length		
Wavelength range	1000 - 2000nm	1000 - 2200nm	1000 - 2500nm
Resolution	6.0 - 60 nm	6.0 - 60 nm	6.0 - 90 nm
Stray light	< 0.1%		
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts (16-bit A/D)/µW per ms integration time	250	250	200
Detector	InGaAs linear array with 2 stage TE-cooling, 256 pixels		
Signal/Noise	1500:1		
AD converter	16 bit, 500kHzHz		
Integration time*	0.52 ms- 6 seconds	0.52-350 ms	0.52-100 ms
Interface	USB 2.0 high speed, 480 Mbps RS-232, 115.200 bps		
Sample speed with on-board averaging	1.06 ms /scan		
Data transfer speed	1.56 ms / 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		

* *Integrating time with TE cooling set to -20°C*

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

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
NIR	1000-2500	1470	100	2500	NIR100-2.5
NIR	1000-2200	980	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) for AvaSpec-NIR256-2.0/2.2/2.5

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

ORDERING INFORMATION	
AvaSpec-NIR256-2.0	Fiber Optic Spectrometer, 50 mm Avabench, 256 pixel InGaAs detector with 2stage TEC, USB powered high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating and wavelength range, OSF-1000, specify slit
AvaSpec-NIR256-2.2	Fiber Optic Spectrometer, 50 mm Avabench, 256 pixel InGaAs detector with 2stage TEC, high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating and wavelength range, OSF-1000, specify slit
AvaSpec-NIR256-2.5	Fiber Optic Spectrometer, 50 mm Avabench, 256 pixel InGaAs detector with 2stage TEC, high speed USB2 interface, incl. AvaSoft-Basic, USB interface cable, specify grating and wavelength range, OSF-1000, specify slit
Options	
BT	Bluetooth® interface for USB2 platform only, including antenna
SDXXX	Internal XXX MB SD card for on-board data saving, for USB2 platform only
SLIT-XX	Slit size, please specify XX = 50, 100, 200, 500 µm

AvaSpec Dual-channel Fiber Optic Spectrometers

AvaSpec –USB1.1 platform

The AvaSpec USB1.1 platform Dual Channel Fiber Optic Spectrometers all read out simultaneously, controlled by a master´s board microprocessor.

The simultaneous data-sampling allows fast read-out and enables monitoring of pulsed light sources with different channels looking at the same pulse.

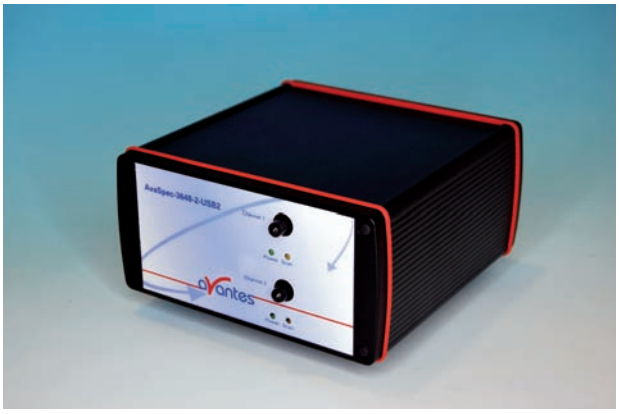
Dual-channel spectrometers need to have the same detector type for both channels (128, 256 or 1024 or 2048 pixels), the spectrometer channels can cover different wavelength ranges or have different resolution specifications. For each channel grating, wavelength range and options need to be specified.

The dual-channel spectrometers all run with one USB interface and work with AvaSoft software.

AvaSpec –USB2.0 platform – maximum modularity

The AvaSpec-USB2.0 platform offers maximum modularity for dual-channel applications. For each channel a different wavelength range, detector and integration time can be selected, without losing the advantage of synchronization between the different channels. The AvaSpec-USB2.0 platform uses 2 USB2.0 ports to connect the different channels to the PC platform. To synchronize both channels a separate synchronization cable needs to be ordered.

AvaSpec-3648-2-USB2



Technical Data

Platform	USB1	USB2
Connections	1 x USB1.1 1 x DB15 (DIO) 1 x DB9 (RS-232) 1 x power connector	2 x USB2.0 2 x DB26 (DIO/RS-232) 2 x SMB (synch) 2 x power connector
Dimensions, weight	175 x 165 x 85 mm, 1700 grams	175 x 165 x 85 mm, 1800 grams

ORDERING INFORMATION	
USB1 platform	
AvaSpec-DDDD-2	Dual-channel AvaSpec-USB1 Fiber Optic Spectrometer with 2 channels in one housing, specify Detector type DDDD (128/256/1024/2048), for both channels specify grating, wavelength range and options
USB2 platform	
AvaSpec-DDDD-2-USB2	Dual-channel AvaSpec-USB2 Fiber Optic Spectrometer with 2 channels with the same detector in one housing, for both channels specify Detector type DDDD (128/256/1024/2048/3648/2048L/2048x14), grating, wavelength range and options
AvaSpec-MMMM/ SSSS-2-USB2	Dual-channel AvaSpec-USB2 Fiber Optic Spectrometer with 2 channels with different detectors in one housing, for both channels specify Detector type MMMM and SSSS (128/256/1024/2048/3648/2048L/ 2048x14), grating, wavelength range and options
IC-COAX-SMB-0,25	Synchronization coax cable with 2 SMB connectors, 0.25m long

AvaSpec Multichannel Fiber Optic Spectrometers

AvaSpec –USB1.1 platform

The AvaSpec USB 1.1. platform Fiber Optic Spectrometers can be configured as single, dual, triple, quadruple or multichannel instrument with up to 8 different spectrometer channels, all read out simultaneously, controlled by a master´s board microprocessor.

The simultaneous data-sampling allows fast read-out and enables for example monitoring of short duration events, i.e. pulsed lightsources with different channels looking at the same pulse.

Multichannel spectrometers all consist of the same detector type (128, 256 or 1024 or 2048 pixels), the spectrometer channels can cover different wavelength ranges or have different resolution specifications. For each channel grating, wavelength range and options need to be specified.

The multichannel spectrometers all run with one USB interface and work with AvaSoft software. Multichannel housing can be in 9.5" desktop (for 1-4 channels) or 19" rack mount housing (1-8 channels)

AvaSpec –USB2.0 platform – maximum modularity

The AvaSpec-USB2.0 platform offers maximum modularity for multi-channel applications. For each channel a different wavelength range, detector and integration time can be selected, without losing the advantage of synchronization between the different channels. The AvaSpec-USB2.0 platform uses the USB2.0 bus to connect the different channels to the PC platform and supports up to 127 channels. Applications

that can be realized with the AvaSpec-USB2.0 multi-channel platform:

- Different integration times or averaging settings per channel, still start each scan simultaneously for all synchronized channels
- Different detector types, such as UV/VIS and NIR detectors possible to cover a wide wavelength range with one spectrometer system
- More than 8 channels (even up to 127 channels) can be connected through USB2 hubs.

To order a USB2.0 multi-channel, please specify the different spectrometers (-RM) and options and the housing (up to 4 channels in desktop, up to 10 channels in rack mount).

Technical Data

Housing	Desktop	Rackmount
Max nr. Channels	4	8 (USB1), 10 (USB2)
Dimensions	315 x 235 x 135 mm	315 x 445 x 135 mm

ORDERING INFORMATION	
USB1 platform	
AvaSpec-DDDD-x-DT/-RM	Multichannel AvaSpec-USB1 Fiber Optic Spectrometer with x (max. 4) channels in desktop housing, (–DT) or with max. 8 channels in rack mount housing (-RM) for all channels specify Detector type DDDD (128/256/1024/2048) grating, wavelength range and options
USB2 platform	
AVS-DESKTOP-USB2	Desktop for USB2 platform multichannel AvaSpec, incl. channel synchronization, USB2-hub and 100-240VAC power supply, supports max. 4 rackmount unit spectrometer channels.
AVS-RACKMOUNT-USB2	19" Rackmount for USB2 platform multichannel AvaSpec, incl. channel synchronization, USB2-hub and 100-240VAC power supply, supports max. 10 rackmount unit spectrometer channels.
AvaSpec-DDDD-USB2-RM	Rackmount Unit USB2 Fiber Optic Spectrometer, self powered high speed USB2 interface, incl. AvaSoft-Basic software, USB cable and sync cable, specify detector type DDDD (128/256/1024/2048(L)/3648/2048x14/NIR256), grating, wavelength range and options. Desktop/Rackmount needs to be ordered separately

AvaSpec preconfigured Fiber Optic spectrometers from Stock

Avantes offers four pre-configured spectrometer instruments as stock items for our customers who are working on short deadlines and are in need of Avantes' superior instrumentation in a shorter timeframe.

The AvaSpec-3648-USB2-UA-25, AvaSpec-2048-USB2-UA-50, AvaSpec-2048-USB2-VA-50 and AvaSpec-USB2-VA-200 represent four of our most standard configurations for UV/VIS and NIR spectroscopy. Each configuration will be carried in inventory and is available for immediate shipment to our customers.

AvaSpec-2048-UA

NEW

Technical Data

Name	AvaSpec-3648-USB2-UA-25	AvaSpec-2048-USB2-UA-50	AvaSpec-2048-USB2-VA-50	AvaSpec-2048-USB2-VA-200
Uses	UV/VIS/NIR	UV/VIS/NIR	VIS/NIR	VIS/NIR
Range	200-1100 nm	200-1100 nm	360-1100 nm	360-1100 nm
Slit/Connector	25 µm SMA 905 connector	50 µm SMA 905 connector	50 µm SMA 905 connector	200 µm SMA 905 connector
Resolution (FWHM)	1.4 nm	2.4 nm	2.4 nm	8 nm
A/D Convertor	16 bit	16 bit	16 bit	16 bit
Interface	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
Applications	High resolution measurements from high intensity sources (lasers, powerful light sources, plasma)	Highly versatile broad-band spectrometer. Ideal for absorbance, emission, 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

ORDERING INFORMATION	
Avaspec-3648-USB2-UA-25	UV/VIS/NIR spectrometer, 3648 pixel CCD detector, grating UA (200-1100nm), slit-25, OSC-UA, DUV3648, USB2 high speed interface, including USB interface cable and AvaSoft-full.
Avaspec-2048-USB2-UA-50	UV/VIS/NIR spectrometer, 2048 pixel CCD detector, grating UA (200-1100nm), slit-50, OSC-UA, DCL-UV/VIS, DUV400, USB2 high speed interface, including USB interface cable and AvaSoft-full.
Avaspec-2048-USB2-VA-50	VIS/NIR spectrometer, 2048 pixel CCD detector, grating VA (360-1100nm), slit-50, OSC, DCL-UV/VIS, USB2 high speed interface, including USB interface cable and AvaSoft-full.
Avaspec-2048-USB2-VA-200	VIS/NIR spectrometer, 2048 pixel CCD detector, grating VA (360-1100nm), slit-200, OSC, DCL-UV/VIS, USB2 high speed interface, including USB interface cable and AvaSoft-full.

AvaSpec-TEC Thermo-Electric Cooled Fiber Optic Spectrometers

AvaSpec-2048TEC

The AvaSpec-TEC spectrometers are a special version of the standard AvaSpecs, where the CCD detector is mounted on a one-stage Peltier cooling device. This Peltier cooling element can reduce the temperature of the CCD chip by -20 °C, improving the dynamic range by at least a factor of 10. As an additional benefit from the cooling, the dark noise is reduced by a factor of 2-3.

The above features enable the AvaSpec-TEC to be implemented in low light-level applications, such as fluorescence and Raman measurements, where integration times of more than 5 seconds are needed. The AvaSpec-TEC can be delivered with 2 different TE cooled detector arrays with (2048/3648 pixels) as 1- or 2-channel instrument and has all the standard options, gratings and specifications the standard AvaSpec has.

The AvaSpec-TEC is built into a desktop housing, has a cooling fan to actively ventilate the heatsink of the Peltier cooling element and an internal power supply.

The AvaSpec-2048/3648TEC for the USB2 platform has an integrated temperature regulator.

Technical Data

Platform	**USB1**	**USB2**
Detector	Sony 2048 CCD	Sony 2048 CCD/ Toshiba 3648 CCD
Temperature cooled CCD	Max. ΔT = -20 °C versus ambient	Regulated ΔT = -20 °C versus ambient
Time to stabilize	1-2 Minutes	30-60 seconds
Dynamic Range improvement for it > 5 seconds	> Factor 10	
Dark Noise improvement for it > 5 seconds	Factor 2-3	
Peltier cooling internal Power supply	3.0 V, 4A	0-3V, 0-4A
External Power supply	100-240 VAC, 30W	
Dimensions , weight	310 x 235 x 135 mm Desktop, 4.1 Kg	

ORDERING INFORMATION	
AvaSpec-2048TEC	Thermo-Electric Cooled Fiber Optic Spectrometer, 75 mm Avabench, 2048 pixel TE cooled CCD detector, USB/RS-232 interface, incl. AvaSoft-Basic, USB cable, desktop housing. Specify grating, wavelength range and options.
AvaSpec-2048TEC-USB2	Thermo-Electric Cooled Fiber Optic Spectrometer, 75 mm Avabench, 2048 pixel TE cooled and regulated CCD detector, USB2 high speed interface, incl. AvaSoft-Basic, USB cable, desktop housing. Specify grating, wavelength range and options
AvaSpec-3648TEC-USB2	Thermo-Electric Cooled Fiber Optic Spectrometer, 75 mm Avabench, 3648 pixel TE cooled and regulated CCD detector, USB2 high speed interface, incl AvaSoft-Basic, USB cable, desktop housing. Specify grating, wavelength range and options
Options	See AvaSpec-2048/3648

AvaSpec Stand-alone Fiber Optic Spectrometers

AvaSpec Stand-alone

All AvaSpec spectrometers with USB2 platform can work in stand-alone mode. The stand-alone mode is developed for process control applications, in which the spectrometer should output analog or digital signals, that can be directly coupled to Programmable Logical Controlers (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. Also 2 functions can be used to output an 8-bit analog value in the 0-5V Voltage range.

After a successful implementation in 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 functionality is custom-specific, please contact our technical sales-department for more information on this.

Optionally an on-board SD card can be installed to save spectra on the card and download later to the PC.

Technical Data Stand-alone mode

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

ORDERING INFORMATION	
Stand-alone	One time NRE cost to implement desired functionality in AvaSpec-USB2 spectrometer

AvaSpec Bluetooth® Wireless Fiber Optic Spectrometers

All AvaSpec spectrometers with USB2 platform can be delivered with the optional Bluetooth® wireless interface. This interface enables wireless communication between PC and spectrometer over a distance of up to 100 meters.

Wireless spectrometers are extremely useful for portable applications or spectrometers to be used in environments, where no PC's can be installed.

Bluetooth® spectrometers are standard supplied with a dipole miniature size antenna and a Bluesoleil USB adapter for the PC to allow easy installation and configuration. The AvaSoft software automatically recognizes the Bluetooth® spectrometer the PC has been paired with.

Bluetooth® spectrometers also have an USB2 interface, but for wireless communication need an external 5-12VDC power supply and are therefore equipped with a switch (-SPU2) for either USB2 buspower or external power.

AvaSpec BT

For optimal portability we recommend to use the Bluetooth® spectrometer with a 12VDC Batterypack (page 114).

Technical Data

Bluetooth model	**-SPU2-BT**
Max. range	100m
Power consumption	3.3VDC, 1-70 mA (av. 17 mA)
Field Strength	+7 dBm
Interface	Serial UART
Baudrate	115.2 kbit/sec
Antenna	Dipole Comaer 100mm, 360° rotation, right angle adjustable 0-90°

ORDERING INFORMATION	
-SPU2-BT	Bluetooth® interface for USB2 platform only, range up to 100m, including antenna, Bluesoleil USB-adapter and switch

OEM spectrometers: AvaBench Optical Benches

AvaSpec spectrometer components can also be provided as separate products to be used in OEM applications. Avantes has developed 3 types of UV/VIS optical benches, special for OEM customers. The optical benches AvaBench-45, AvaBench-75-ULS and AvaBench-75 are symmetrical Czerny-Turner designs with fiber optic entrance connector (Standard SMA, others possible), collimating and focussing mirror and diffractional grating. A choice of different gratings with different dispersion and blaze angels enable applications in the 200-1100nm range. The newly designed AvaBench-ULS has full mechanical compatibility for mounting holes with the AvaBench-75, so for OEM customers it is easy to upgrade to the better ULS optical bench.
Wavelength ranges, resolution tables, detector specifications and AvaBench options can be found in the sections on the AvaSpec products.
In the table below the main differences between the optical benches are pointed out.

AvaBench-75-ULS

NEW

The AvaBenches to be connected to the USB2 platform electronics (AS-5216 boards) have a separate video output through a mini-coax cable. The order code for these AvaBenches is -U2.

Technical Data

	AvaBench-45	AvaBench-75	AvaBench-75-ULS
Implemented in	AvaSpec-128 / 256	AvaSpec-1024/2048(L)/ 3648/2048x14	AvaSpec-ULS1024 2048(L)/3648/2048x14
Focal length	45 mm	75 mm	75 mm
Numerical aperture	0.11	0.07	0,07
Wavelength range	200-1100 nm	200-1100 nm	200-1100 nm
Resolution (FWHM)	0.2 – 40 nm	0.025 – 20 nm	0.025 – 20 nm
Stray light	< 0.15%	< 0.1%	< 0.05%
Gratings	different	different	different
Slits	25, 50, 100, 200, 500 µm	10, 25, 50, 100, 250, 500 µm	10, 25, 50, 100, 250, 500 µm
Detector	TAOS 128 / HAM 256	HAM 1024/SONY 2048 TOSHIBA 3648 HAM 2048x14	HAM 1024 / SONY 2048(L) TOSHIBA 3648 /HAM 2048x14
Detector lens	VIS (for TAOS only)	UV/VIS (for 2048/3648 only)	UV/VIS
Order sorting filter	See options	See options	See options
Dimensions, weight	82 x 72 x 20 mm, 130 gr.	120 x 91 x 21 mm, 255 gr.	120 x 91 x 21 mm, 350 gr.

ORDERING INFORMATION	
AvaBench-45-128 (-U2)*	Optical bench, 45 mm focal length, 128 pixel PDA detector, specify grating, wavelength range and options
AvaBench-45-256 (-U2)*	Optical bench, 45 mm focal length, 256 pixel CMOS detector, specify grating, wavelength range and options
AvaBench-75-1024 (-U2)*	Optical bench, 75 mm focal length, 1024 pixel CMOS detector, specify grating, wavelength range and options
AvaBench-75-2048 (-U2)*	Optical bench, 75 mm focal length, 2048 pixel CCD detector, specify grating, wavelength range and options
AvaBench-75-3648-U2	Optical bench, 75 mm focal length, 3648 pixel CCD detector, specify grating, wavelength range and options
AvaBench-75-2048x14-U2	Optical bench, 75 mm focal length, 2048x14 pixel back-thinned CCD detector, specify grating, wavelength range and options
AvaBench-75-ULS-DDDD-U2	OEM ultra low straylight optical bench, 75 mm focal length, specify DDDD = 1024, 2048(L), 3648, 2048x14 pixel detector, specify grating, wavelength range and options

for USB2 platform only

OEM spectrometers: AvaBench NIR Optical Benches

AvaSpec NIR spectrometer components can also be provided as separate products to be used in OEM applications. Avantes has developed different types of NIR optical benches, special for OEM customers. The optical bench AvaBench-50 is available in the 1000-1750nm range for uncooled detectors.
The AvaBench-50TEC is developed for NIR range from 1000-2500nm. The AvaBench-50TEC supports 3 different TE cooled detectors with 256 pixels. They are all symmetrical Czerny-Turner designs with fiber optic entrance connector (Standard SMA, others possible), collimating and a newly designed special toroid focussing mirror and diffractional 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 sections on the AvaSpec products.
In the table below the main differences between the optical benches are pointed out.
The NIR AvaBenches can only be connected to the USB2 platform electronics (AS-5216 boards) and 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-50TEC

NEW

Technical Data

	AvaBench-50	AvaBench-50TEC
Implemented in	AvaSpec-NIR256-1.7	AvaSpec-NIR256-2.0/2.2/2.5
Focal length	50 mm	50 mm
Numerical aperture	0.24	0.24
Wavelength range	1000-1750nm	1000-2500 nm
Resolution (FWHM)	2-50 nm	6-90nm
Stray light	< 0.5%	< 0.5%
Gratings	different	different
Slits	50, 100, 200, 500 µm	50, 100, 250, 500 µm
Detector	HAM-NIR256-1.7	HAM-NIR256-2.0/2.2/2.5
TE Cooling	No	Yes
Order sorting filter	OSF-1000-3	OSF-1000-3 and OSC-NIR for 2.2/2.5
Dimensions, weight	100 x 90 x 40 mm, 500gr.	177 x 125 x 108 mm / 2.5 Kg

ORDERING INFORMATION	
AvaBench-50-NIR256-1.7	OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel InGaAs detector. Specify grating, wavelength range and slit, OSF-1000-3
AvaBench-50-NIR256-2.0	OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE cooled InGaAs detector 2.0µm. Specify grating, wavelength range and slit, OSF-1000-3
AvaBench-50-NIR256-2.2	OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE cooled InGaAs detector 2.2µm. Specify grating, wavelength range and slit, OSF-1000-3, OSC-NIR
AvaBench-50-NIR256-2.5	OEM optical bench with AS-5216 interface, 50 mm focal length, 256 pixel TE cooled InGaAs detector 2.5µm. Specify grating, wavelength range and slit, OSF-1000-3, OSC-NIR

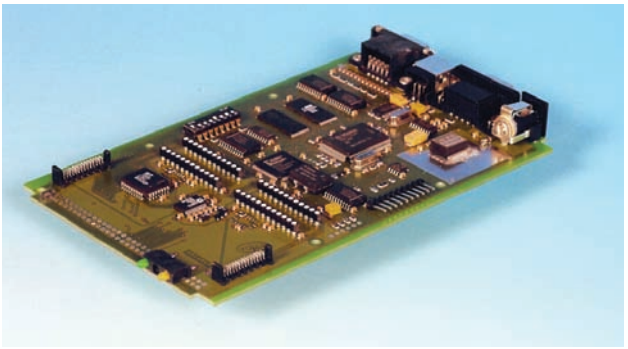
OEM Spectrometers: AS161 Microprocessor board

The AS161 is a modularly designed electronics board with a 16-bit microprocessor, 2 channel 14-bit AD converter and USB/RS-232-interface. The AS-161 electronics board is a part of the AvaSpec spectrometers and can control 2 Avabench spectrometer channels.

Different detector types can be connected to the electronics board interface connectors, such as TAOS Photo Diode Arrays TSL1401, Hamamatsu C-MOS detectors (for example S8378-256Q, S8378-1024Q) and Sony CCD detectors (ILX511, ILX554B).

The board is equipped with an additional sub D15 digital IO connector with 14 programmable I/O ports (2 DI, 12 DO). One digital output is reserved for controlling the flash rate of an external Xenon strobe (single or multiple flashes per scan), one digital output can be 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 reserved for external hardware trigger.

The on-board firmware controls simultaneous data-sampling of the 2 channels. The sampled data is processed through a F(irst) I(n) F(irst) O(ut) interface with possibility of speeding up data transmission time by data reduction, defining a start and stop pixel per



channel. The gain and offset parameters can be adapted per channel as well. The Firmware controls the USB and/or RS-232 interface.

The board can be operated by the extensive AS-161-DLL with many functions to control the electronics board and data sampling parameters (see software section).

Multichannel (3 up to 8 channels) capability can be achieved connecting the master board (AS161M) with backplane connector to 1-3 slave boards (AS161S) with each 2 AD converter channels.

Technical Data

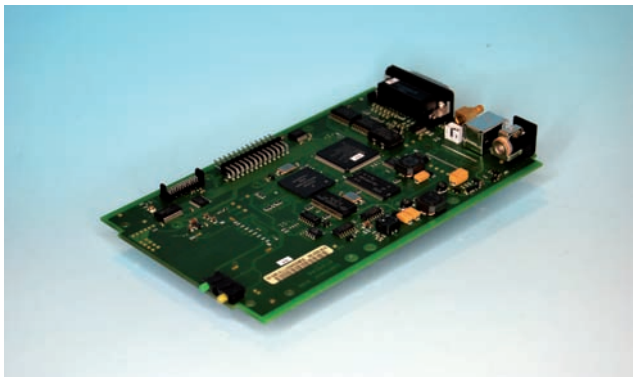
Microprocessor	Infineon, C161RI, 16 bit, 24 MHz
Memory	128 K EEPROM, 128K RAM, 8 bit
A/D converter	14 bit, 2 channels
Integration time	2ms – 60 seconds
Data Transfer speed	Sony ILX511/554 2048 pixels, 2 MHz, 14-31 ms /scan (10-2048 pixels) for 1 channel
	Hamamatsu 8378-256Q, 200kHz, 7-9 ms /scan for 1 channel
	TAOS 1301/1401, 2MHz, 6-7 ms / scan for 1 channel
USB interface	Version 1.1, 12 Mbit
RS-232 interface	Baudrate 115200 bps, DB-9 female connector
Power supply	12 VDC, reverse polarity protection, 160 mA (+ 20 mA per detector)
Temperature range	0 - 55 °C
Dimensions, weight	162.5 x 100 mm, 97 gr.

ORDERING INFORMATION	
AS161	Microprocessor board with 2 channel 14-bit AD and RS-232/USB interface, specify detector type, see below
AS161M	AS161 master board with RS-232/USB interface and backplane connector, specify detector type, see below
AS161S	Slave board with 2 channel 14-bit AD and backplane connector, specify detector type, see below
For all boards, specify detector type	
-ILX	for Sony ILX511 / 554B detectors (AvaSpec-2048)
-H8378-256	for Hamamatsu S8378-256 detectors (AvaSpec-256)
-H8378-1024	for Hamamatsu S8378-1024 detectors (AvaSpec-1024)
-TAOS	for TAOS 1401 detectors (AvaSpec-102/128)

OEM Spectrometers: AS5216 Microprocessor board

The AS-5216 is a revolutionary new design electronics board to support a wide range of new detectors and both high speed (USB2.0) and wireless (Bluetooth®) communication. The AS-5216 board is based on a powerful 5216 Coldfire® processor, running at 64 Mhz, 16-bit AD converter and USB2.0/RS-232-interface. The AS-5216 electronics board is part of the AvaSpec-USB2 platform spectrometers. Different detector types can be connected to the electronics board, such as TAOS Photo Diode Arrays (TSL1401), Hamamatsu C-MOS detectors (S8378-256Q, S8378-1024Q), Sony CCD detectors (ILX554B), Toshiba CCD detectors (TCD-1304), Hamamatsu back-thinned CCD detector (S9840) and Hamamatsu InGaAs NIR detectors (G92xx series).

For the Hamamatsu back-thinned detector a separate power converter board is needed and for the NIR detector 2.0/2.2/2.5µm a separate TE controller board is needed. The board is equipped with an additional HD26 digital IO connector with 13 programmable IO ports (3 DI, 10 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 trigger. The AS-5216 board can be synchronized with other AS-5216 boards to control the simultaneous data-sampling of 2-127 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. Optional a Bluetooth® interface for wireless communication and on-board SD card for stand-alone applications (no PC connected) is available.

The board can be operated by the extensive AS-5216-DLL with many functions to control the electronics board and data sampling parameters (see software section).

Technical Data

Microprocessor	Coldfire®, 5216, 32 bit, 64 MHz	
Memory	512 KB Flash Memory, 64KB RAM	
External Memory (optional)	SD card with FAT12/16/32 file system 64MB-16GB	
A/D converter	16 bit, 2 channels for video signal	
Integration time	10 µs – 10 minutes (detector dependent)	
Data Transfer speed	1.5 ms/scan for Hamamatsu 8378-256Q, 500 kHz	1.8 ms/scan for Sony ILX554 2048 pixels, 2 MHz
	1.1 ms/scan for TAOS 1401 2MHz	3.7 ms/scan for Toshiba TCD1304, 1 MHz
	2.24 ms/scan for Hamamatsu S9840, 1.5 MHz	1.6 ms/scan for Hamamatsu 92XX, 500 kHz
USB interface	2.0 high speed, 480 Mbps	
RS-232 interface	Baudrate 115200 bps, HD-26 female connector	
Bluetooth® Interface (optional)	721 kbit/s, external antenna	
DIO interface	HD-26 connector, 2 Analog in, 2 Analog out, 3 Digital in, 12 Digital out, trigger, synch.	
Power supply	Default USB power, 350 mA 12 VDC, reverse polarity protection, 350 mA	
Temperature range	0 - 55 °C	
Dimensions, weight	162,5 x 100 mm, 97 grams	

ORDERING INFORMATION	
AS5216	Microprocessor board 16-bit AD and USB2.0/RS-232 interface, specify detector type, see below
AS5216-BT	Microprocessor board 16-bit AD and USB2.0/RS-232 and Bluetooth Interface, SD card, specify detector type, see below
For all boards, specify detector type	
- ILX	for Sony ILX554B detectors (AvaSpec-2048-USB2)
- H8378-256	for Hamamatsu S8378-256 detectors (AvaSpec-256-USB2)
- H8378-1024	for Hamamatsu S8378-1024 detectors (AvaSpec-1024-USB2)
- TAOS128	for TAOS 1401 detectors (AvaSpec-128-USB2)
- TOS3648	for Toshiba 1304 detectors (AvaSpec-3648-USB2)
- HAM2048x14	for Hamamatsu S9840 detectors (Avaspec-2048x14-USB2), extra pcb incl.
- NIR256	Hamamatsu G92xx series InGaAs NIR detectors (AvaSpec-NIR256-1.7)
- NIR256TEC	Hamamatsu G92xx series with TEC InGaAs NIR detectors (AvaSpec-NIR256-2.0/2.2/2.5), extra pcb incl.

Avaspec Spectrometer Interface Cables

For both AvaSpec-USB1 and -USB2 platform spectrometers a wide range of interface cables is available to connect to our light sources and comprehensive line of accessories.

In the tables below information can be found what interface cable should be ordered for which configuration for both USB1 and USB2 platforms. Generally the interface cables are 2m long, different lengths are available on request.

Avaspec interface cables

USB1 platform spectrometers (DB15/DB9 connector)

Connect to	Product code	Description
RS-232	**IC-DB9-2**	Interface cable AvaSpec to RS-232, 9 pole
USB	**IC-USB-2**	Interface cable AvaSpec to USB port on PC, 2m
AvaLight-S / AvaLight-XE	**IC-DB15-2**	Interface cable AvaSpec to AvaLight-S with shutter for auto save dark/ lamp off, AvaLight-XE control
External Hardware Trigger	**IC-Extrig-2**	Interface cable AvaSpec-USB1 to External trigger pushbutton, 2m
Avalight-S / Avalight-XE External Hardware Trigger	**IC-DB15-Extrig-2**	Interface Y-cable AvaSpec to External trigger pushbutton and AvaLight-S with shutter, 2m
Avalight-S FOS-2	**IC-DB15-FOS2-2**	Interface Y-cable AvaSpec-USB1 platform to FOS-2 and AvaLight-S with shutter, 2m

USB2 platform spectrometers (DB26 / SMB connector)

Connect to	Product code	Description
RS-232	**IC-DB26/DB9-2**	Interface cable AvaSpec-USB2 platform DB26 male to RS-232 DB9 female cable, 2m
USB2	**IC-USB2-2**	Interface cable AvaSpec to USB port on PC, 2m
AvaLight-S / AvaLight-XE	**IC-DB26-2**	Interface cable AvaSpec-USB2 platform to DB15 for AvaLight-S with shutter for auto save dark/ lamp off, AvaLight-XE control
BNC-Ext. Hardware Trigger	**IC-DB26-EXTRIG-BNC-2**	Interface cable AvaSpec-USB2 platform to BNC plug External trigger, 2m
External Hardware Trigger	**IC-Extrig-USB2**	Interface cable AvaSpec-USB2 to External trigger pushbutton, 2m
RS-232 AvaLight-S / AvaLight-XE	**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
Avalight-S / Avalight-XE External Hardware Trigger	**IC-DB26-Extrig-USB2**	Interface Y-cable AvaSpec-USB2 to External trigger pushbutton and AvaLight-S with shutter, 2m
Avalight-S FOS-2	**IC-DB26-FOS2-2**	Interface Y-cable AvaSpec-USB1 platform to FOS-2 and AvaLight-S with shutter, 2m
Other USB2 spectrometer	**IC-COAX-SMB-0,25**	Synchronization coax cable with 2 SMB connectors 0.25m for Avaspec USB2 platform

AvaSpec services and calibrations

Wavelength calibration
All AvaSpec spectrometers standard come with a wavelength calibration and coefficients to calculate wavelength from pixelnr which are installed on-board, inside of 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 vs. the original wavelength calibration, then the spectrometer can be recalibrated by the end-user, using the Avalight-CAL with the auto-calibration software routine in AvaSoft-FULL.

As an option the spectrometer can also be returned to Avantes for recalibration, called 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 intensity output, 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 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 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 the spectrometer to measure the light energy of unknown sources require an irradiance calibrated spectro-meter.

For all AvaSpec spectrometers both irradiance and radiance calibrations can be offered. Irradiance calibrations (µW/cm²) are normally performed on a system with a fiber optic cable and a cosine corrector or integrating sphere. Radiance calibrations (µW/cm²/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 for 3 different wavelength ranges, UV (200-400nm), VIS (360-1100nm) and NIR (1100-2500nm). All systems are calibrated versus an NIST traceable irradiance calibration standard and come with a complete report and calibration files, which can be loaded directly into AvaSoft-IRRAD.

More information on irradiance can be found in the software section (AvaSoft-IRRAD) and the section applications – irradiance measurements.

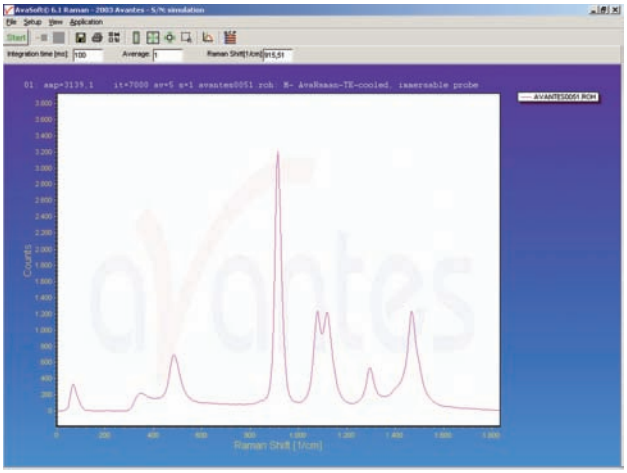
Alternatively irradiance calibrated light sources, such as AvaLight-DHS-Cal and AvaLight-HAL-CAL are available to perform your own irradiance calibration.

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

AvaRaman Raman System

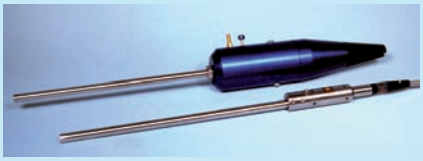
The AvaRaman Raman System is a fully integrated, low-cost system for applications requiring Raman techniques. The AvaRaman system consists of a laser diode, an AvaSpec 2048 CCD-array spectrometer and an expanded range of fiber optic probes. The AvaRaman System is available for multiple Raman wavelengths and is equipped with a USB2 interface. The USB2 Raman system with TEC has the advantage of a thermo-regulated cooled CCD detector.
All AvaRaman systems come with special AvaSoft-Raman software (see software section). Complementary Panorama-PRO software is available (see software section) for Raman interpretation and functional group assignment. The AvaRaman System is optimized for maximum sensitivity. The maximum integration time is 60 seconds.
The AvaRaman is especially useful for analysis, such as reaction monitoring, product identification, remote sensing, and the characterization of highly scattering particulate matter in aqueous solutions, gels and other media.
The AvaRaman System is also available with different Laser types other than the standard 785nm, such as Ar-Ion 514 nm, solid-state 50 or 100 mW green (532 nm) lasers or HeNe lasers 633nm.
The AvaRaman probes can be selected from the table.

Raman signal for ethanol



Technical Specifications

	AvaRaman-532	AvaRaman-532 TEC	AvaRaman-785	AvaRaman-785TEC
Signal to noise Ratio	200:1 for Benzene	200:1 for Benzene	200:1 for Benzene	300:1 for Benzene
Resolution	10 cm^{-1}	10 cm^{-1}	16 cm^{-1}	8 cm^{-1}
Spectrometer	AvaSpec-2048 with grating NC (535-752nm), slit-25, DCL-UV/VIS	AvaSpec-2048TEC with grating NC (535-752nm), slit-25, DCL-UV/VIS TE Cooled	AvaSpec-2048 with grating IB (780-1100nm), slit-50, DCL-UV/VIS	AvaSpec-2048TEC with grating NC(780-930nm), slit-25, DCL-UV/VIS TE Cooled
Raman Shift	100-5400 cm^{-1}	100-5400 cm^{-1}	100-3600 cm^{-1}	100-2100 cm^{-1}
Laser output	532 nm, 50mW	532 nm, 50mW	785nm, 500 mW, Class 3b	785nm, 500 mW, Class 3b
Laser Wavelength	532nm	532nm	785 nm	785 nm
Laser Bandwidth	< 0.1 nm	< 0.1 nm	< 0.2 nm	< 0.2 nm
Dimensions housing	310 mm x 235 mm x 135 mm	320 mm x 450 mm x 135 mm	310 mm x 235 mm x 135 mm	320 mm x 450 mm x 135 mm

AvaRaman-PRB-XXX 3/8" SS low-cost focusing probe with a 90µm excitation fiber and 200µm read fiber. Multiple focal lengths available (5 mm, 7.5mm(standard), 10mm). Manual shutter included, 1.5 m fibers. Specify XXX=excitation wavelength	
AvaRaman-PRB-FP-XXX 1/2" SS focusing probe with a 90µm excitation fiber and 200µm read fiber. Multiple focal lengths available (5 mm(standard), 7.5mm, 10mm) Specify XXX=excitation wavelength	
AvaRaman-PRB-FIP-XXX 5/8" immersible SS focusing probe for in-situ measurements with a 100µm excitation fiber and 200µm read fiber. It can withstand 200°C. Specify XXX=excitation wavelength	
AvaRaman-PRB-FC-XXX 3/8" immersible SS process probe for in-situ measurements with a 100µm excitation fiber and 200µm 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 500mW laser 532 nm, FWHM 0.2nm AvaSpec-2048-USB2 Spectrometer with 1200 lines/mm grating set 535-752nm, 25µm slit, DCL-UV/VIS AvaSoft-Raman Raman application stand-alone software for the AvaRaman system, AvaRaman-GL-532 laser safety goggles
AvaRaman-532-TEC-USB2	Consisting of following elements: Solid state 500mW laser 532 nm, FWHM 0.2nm TE cooled AvaSpec-2048TEC-USB2 Spectrometer with 1200 lines/mm grating set 535-752nm, 25µm slit, DCL-UV/VIS AvaSoft-Raman Raman application stand-alone software for the AvaRaman system, AvaRaman-GL-532 laser safety goggles
AvaRaman-785-USB2	Consisting of following elements: Solid state 500mW laser 785 nm, FWHM 2.5nm AvaSpec-2048-USB2 Spectrometer with 600 lines/mm grating set 780-1100nm, 50µm slit, DCL-UV/VIS AvaSoft-Raman Raman application stand-alone software for the AvaRaman system, AvaRaman-GL-785 laser safety goggles
AvaRaman-785TEC-USB2	Consisting of following elements: Solid state 500mW laser 785 nm, FWHM 0.2nm TE Cooled AvaSpec-2048TEC-USB2 Spectrometer with 1200 lines/mm grating set 780-930nm, 25µm slit, DCL-UV/VIS AvaSoft-Raman Raman application 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 ½" Raman probes
AvaRaman-Calibrationtile	PTFE White tile in holder for 3/8" raman probe

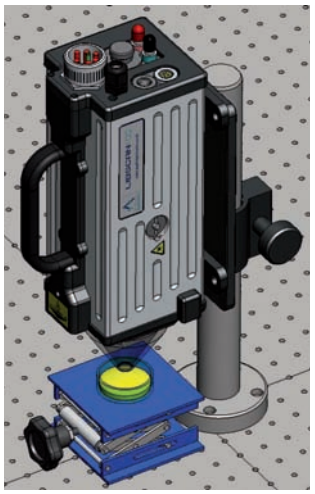
AvaLIBS-50 and AvaLIBS-100 Laser Induced Breakdown Spectroscopy Systems

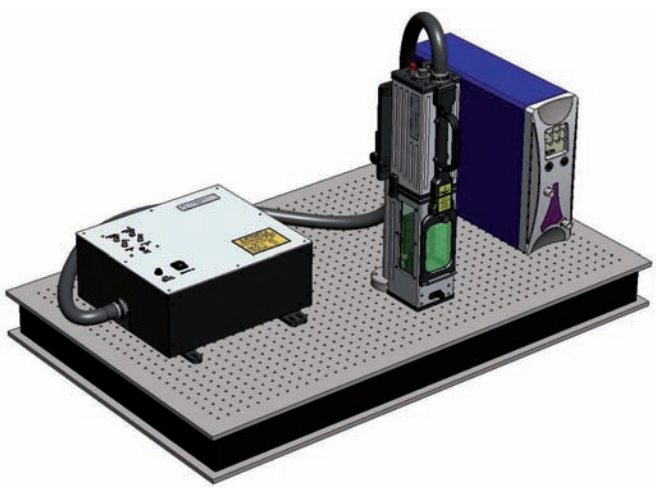
AvaLIBS is a novel-design modular system which utilises Laser-Induced Breakdown Spectroscopy (LIBS) for the elemental characterisation of materials. The highly modular and versatile design adopted in AvaLIBS will appeal to scientists and engineers interested in developing LIBS technology for their particular application area. AvaLIBS is also well-suited for use in an academic teaching laboratory where ease of use and safety are of paramount importance.

AvaLIBS may be operated in "open-beam" mode as a Class IV laser system or fitted with one of a range of fully-interlocked modular sample chambers as a Class I laser system. In either configuration the system can be operated with the AvaLIBS Head held or mounted in any orientation offering further flexibility in the types of sample that can be analysed.

Features

- Modular and versatile design, suitable for laboratory and field applications
- High-efficiency plasma light collection optics (3 UV-Vis channels and 3 Vis-NIR channels)
- Laser options: 50 mJ 1064 nm laser (AvaLIBS-50) and 100 mJ 1064 nm laser (AvaLIBS-100)
- Gas purge feature (for connection to external inert gas supply – Argon, Nitrogen, Helium)
- Optional imaging camera for viewing the sample before, during and after LIBS analysis
- May be operated with one of a number of removable, modular sample chambers (to Class I laser safety standards) or without (Class IV "open beam" configuration)
- Optional vertical support stand with height adjustment (facilitates operation of AvaLIBS Head in vertical orientation – with or without sample chamber)
- Up to six spectrometer modules may be installed (approx. 185 – 900 nm)
- External laser power supply easily disconnected to facilitate transportation
- May be operated with laptop PC or other suitable device running Microsoft Windows





System Specifications AvaLIBS base unit

AvaLIBS Head	Integrated laser beam expander and six-channel plasma light collection optics. Horizontal or vertical operation, connected to Spectrometer console by 1.7 m flexible umbilical containing 6 optical fibers. Approx. dimensions 300x130x120 mm, weight 4 kg
Software	Specline and AvaSoft
AvaLIBS Spectrometer console (up to 6 spectrometer channels)	Contains spectrometers (up to 6), sync cables, USB hub, gas purge inlet (feeds purge gas to AvaLIBS head), laser safety interlock circuit, trigger input to spectrometers. Approx. dimensions 335 x 375 x 160 mm, weight 8 kg
Computer Interface	USB 2.0
Power connections	5VDC, 3A via plug-in adapter 100-240VAC(included)

Laser Specifications

	YAG-LASER-50	**YAG-LASER-100**
Laser Type	Quantel Big Sky Ultra Q-switched Nd: YAG (Class 4)	Quantel Big Sky Ultra Q-switched Nd: YAG (Class 4)
Wavelength	1064 nm	1064 nm
Energy/Pulse	50 mJ/pulse	100 mJ/pulse
Pulse duration	7 ns (±2ns)	7 ns (±2ns)
Beam diameter	3 mm	4 mm
Repetition Rate	Up to 20 Hz	Up to 20 Hz
Power Supply	110-220 VAC, 800W	110-220 VAC, 800W
Power supply approx. dimensions, weight	360 mm x 435 mm x 140 mm, 14 kg	360 mm x 435 mm x 140 mm, 14 kg

Spectrometer Specifications

Spectrometer AvaSpec-2048-LIBS1 AvaSpec-2048-LIBS2 AvaSpec-2048-LIBS3	**Wavelength range** (185-256nm), FWHM 0.1nm (255-315nm), FWHM 0.1nm (314-316nm), FWHM 0.2nm	**Spectrometer** AvaSpec-2048-LIBS4 AvaSpec-2048-LIBS5 AvaSpec-2048-LIBS6	**Wavelength range** (414-498nm), FWHM 0.2nm (496-718nm), FWHM 0.5nm (716-904nm), FWHM 0.4nm
Resolution possible		< 0.1 nm	
Detector type		CCD, 2048 pixels per channel	
Programmable Integration time delay		min 1.28 µs, steps 21 ns	
Integration time		Min. 1.1 ms	

AvaSoft operating software

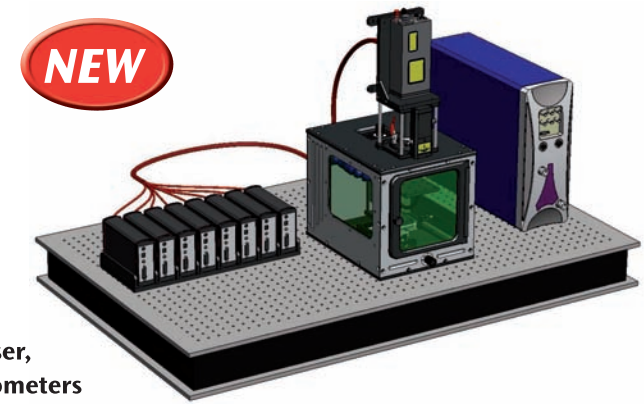
The AvaSoft software controls the exact timing between the laser pulse and the start of the integration time. The timing is controlled by the laser or external pulse generator and synchronized with the AvaSpec spectrometer by running the spectrometer in external trigger mode. In this mode, the spectrometer receives a TTL-input signal from the laser, or simultaneously with the laser. The integration time delay is synchronized with this input signal. The AvaSoft software allows averaging, setting of integration time delay and integration time. The saved data can be imported directly into the Specline analytical software package (see section software).

Sample chamber Specifications

	AvaLIBS-SC-1	AvaLIBS-SC-2	AvaLIBS-SC-3
Axis, travel path	1 axis, 20mm	2 axis, 20 mm each	3 axis, 50 mm each
Approx. dimensions	100 x 100 x 200 mm	100 x 100 x 250 mm	260 x 280 x 320 mm
Safety protection	Electrical interlock to laser power supply, laser protective window, OD 6+		

AvaLIBS Modules – an alternative method of configuring a LIBS system

AvaLIBS modules offer a convenient and flexible method of configuring a LIBS system. Six channel (AvaLIBS-module-6) and eight channel (AvaLIBS-module-8) versions are available. Each optical channel is connected to an individual spectrometer using a single-core optical fiber. This allows the user to select one or more spectrometers according to their needs. In addition to the 50 mJ and 100 mJ laser described below, the AvaLIBS modules may be used with a variety of other lasers using an appropriate adaptor plate (contact us for further details).



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

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	AvaLIBS-module-6		AvaLIBS-module-8	
Laser	YAG-LASER-50	YAG-LASER-100	YAG-LASER-50	YAG-LASER-100
Sample chambers	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	
Fiberoptics	N* x FC-UV200-2			
Spectrometers	Up to 6 spectrometers - as specified by user		Up to 8 spectrometers - as specified by user	
Cable set	IC-LIBS-SET-N*			

** N = number of channels*

ORDERING INFORMATION	
AvaLIBS-50 and AvaLIBS-100	
AvaLIBS-BASE	AvaLIBS-50/AvaLIBS-100 head and spectrometer console, including 6 spectrometers, incl. AvaSoft-FULL, excl. laser
YAG-LASER-50	50mJ Nd:YAG laser, including power supply
YAG-LASER-100	100mJ Nd:YAG laser, including power supply
Imaging kit (optional)	Miniature CCD colour camera, camera mount, IR blocking filter, plug-in power adaptor, 5.6" LCD colour monitor, USB 2.0 video grabber
AvaLIBS-SC-1	1-axis sample chamber, couples to AvaLIBS head
AvaLIBS-SC-2	2-axis sample chamber, couples to AvaLIBS head
AvaLIBS-SC-3	3-axis sample chamber, couples to AvaLIBS head
Vertical support stand (optional)	Adjustable height vertical support stand for AvaLIBS head
AvaLIBS-Specline-A (optional)	Spectroscopy analytical software for LIBS, finding and identifying spectral lines, incl. database for atoms and ions
AvaLIBS Modules	
AvaLIBS-module-6	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)
Adaptor plate for Ultra laser	For attaching AvaLIBS modules to Ultra laser head (50mJ or 100mJ)
Imaging kit (optional)	Miniature CCD colour camera, camera mount, IR blocking filter, plug-in power adaptor, 5.6" LCD colour monitor, USB 2.0 video grabber
Vertical support stand (optional)	Adjustable height vertical support stand for AvaLIBS-module-6 and AvaLIBS-module-8
FC-UV200-2	Fiber Cable, UV/VIS, 2m, SMA terminated (6 or 8 pcs needed)
AvaLIBS-module-8	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)
AvaSpec-2048-LIBS	AvaLIBS Spectrometer channel, Avaspec-2048-USB2, 2048 CCD detector, specify grating, wavelength range and options, AVASOFT-FULL and LIBS