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 further 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 light source, sampling accessories and 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

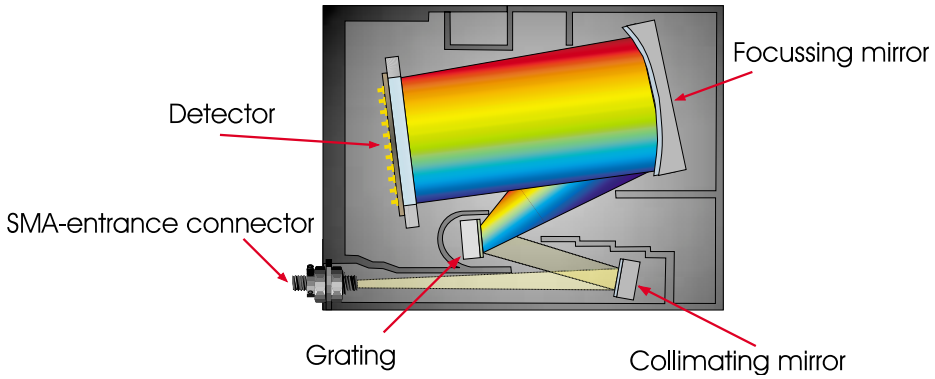


Figure 1 Optical bench design

The heart of the AvaSpec fiber optic spectrometer is an optical bench with 45 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 table 2- section "How to choose the right grating"). The other important component is the detector choice, Avantes offers 4 different detector types with each different sensitivity curves (see figure 5). For UV applications the 256/1024 pixel CMOS detectors or (D)UV-enhanced 2048 pixel CCD detector may be selected.
If you want to combine a wide range with a high resolution, a multiple channel spectrometer (up to 8 channels) may be the best choice.

2. Optical Resolution

If you desire a high optical resolution we recommend to pick 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 pixels, for example 10 µm slit for the best resolution on the AvaSpec-2048 (see table 3 – section "Optical Resolution")

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 higher) 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 28) may be chosen to minimize noise and increase dynamic range at long integration times (60 seconds).

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 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-2048 FT Fast trigger CCD spectrometer (see product section, page 27). Whenever a small amount of pixels needs to be transferred, data transfer time can be enhanced by selecting the pixel range of interest to be transmitted to the PC; in general the AvaSpec-102 may be considered as the fastest spectrometer.

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	-	-	200-1100
Color	102	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	-	350-1100
Fruit-sugar	102	IA	800-1100	-	50	5.4	X	550	-
Gemmology	2048	VA	350-1100	-	25	1.4	X	-	350-1100
High resolution	2048	VD	600-700	-	10	0.07	-	550	-
Irradiance	2048	UA	200-1100	UV	50	2.8	X/-	-	200-1100
Laserdiode	2048	NC	700-800	-	10	0.1	-	550	-
LED	2048	VA	350-1100	-	25	1.4	X/-	-	350-1100
LIBS	2048FT	UE	200-300	DUV	10	0.09	-	-	-
Raman	2048TEC	IB	780-1100	-	50	1.2	X	550	-
Thin Films	2048	UA	200-1100	UV	-	4.1	X	-	200-1100
UV/VIS/NIR	2048	UA	200-1100	UV	25	1.4	X/-	-	200-1100

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.

In Table 2 the complete selection of gratings and wavelength range for the AvaSpec-2048 spectrometer can be found. 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.

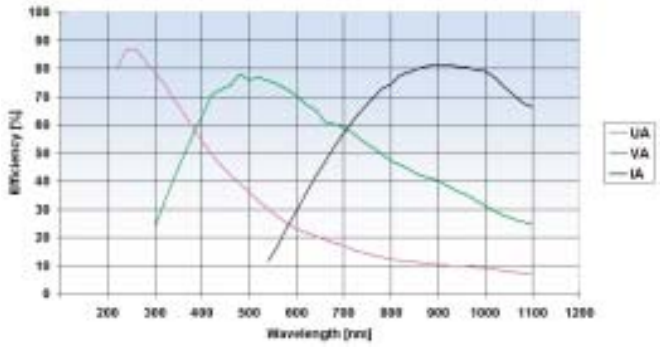
Table 2 Spectral range and gratings for the AvaSpec-2048

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	250	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	250	UD
UV	200-580	115-70*	2400	250	UE
UV	220-400	75-50*	3600	250	UF
UV/VIS	250-850	520	600	370	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
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	630	NC
NIR	600-1100	500	300	1000	IA
NIR	600-1100	500	600	1000	IB

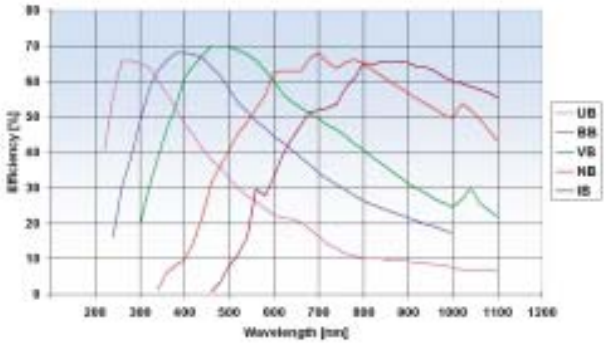
** depends on the starting wavelength of the grating; the higher the wavelength, the bigger the dispersion and the smaller the range to select.*

Figure 2 Grating Efficiency Curves

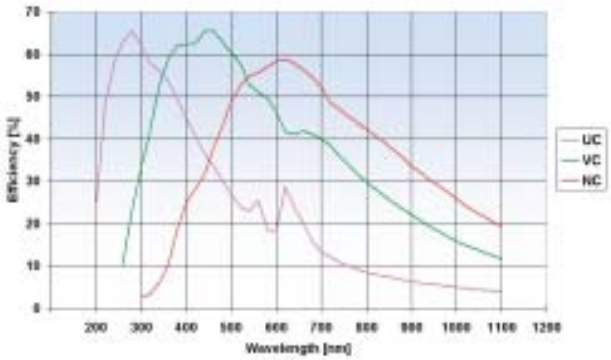
300 Lines/mm Gratings



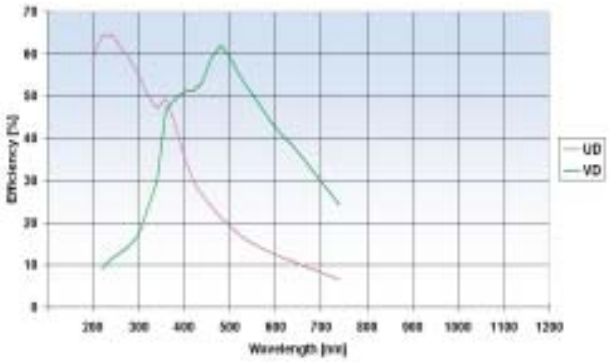
600 Lines/mm Gratings



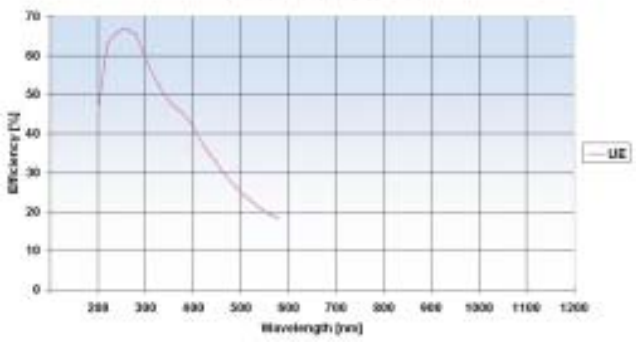
1200 Lines/mm Gratings



1800 Lines/mm Gratings



2400 Lines/mm Grating



3600 Lines/mm Grating

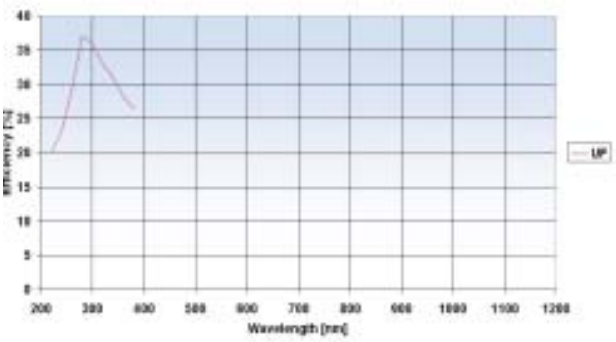
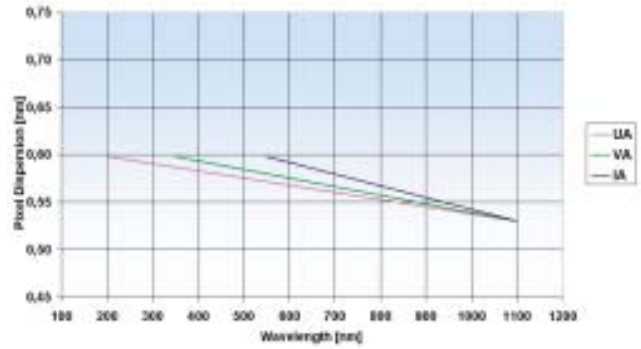
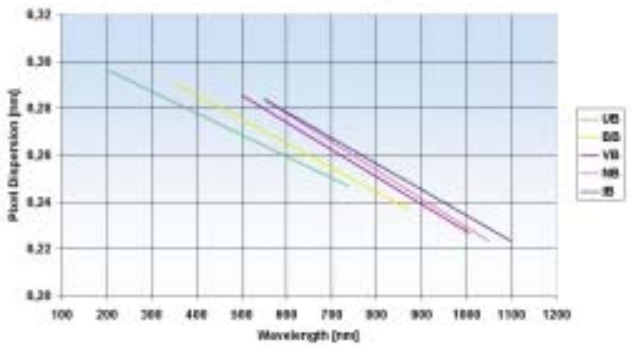


Figure 3 Grating Dispersion Curves

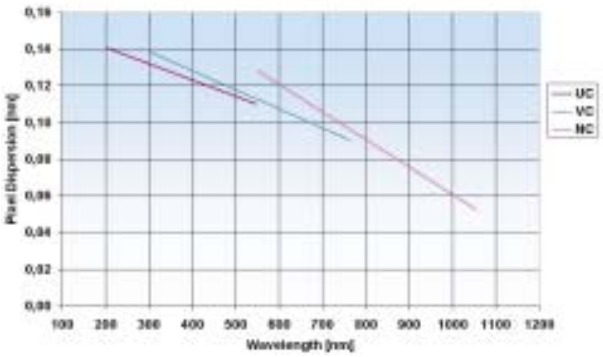
300 Lines/mm Gratings



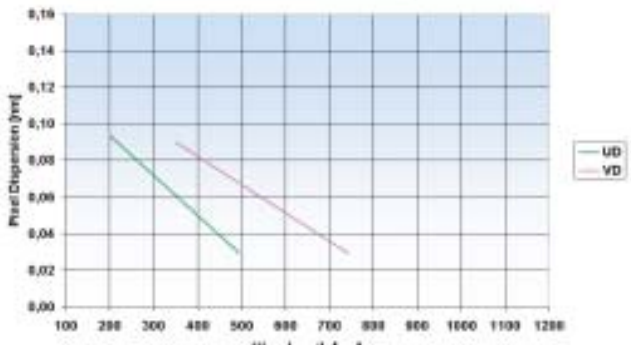
600 Lines/mm Gratings



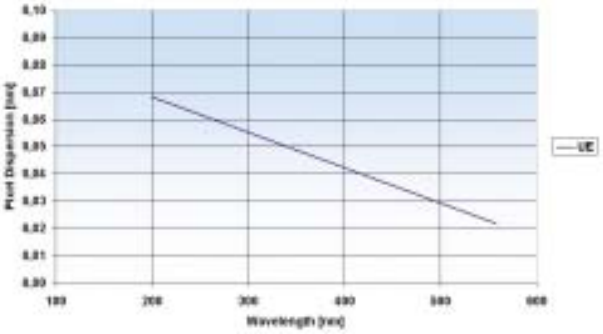
1200 Lines/mm Gratings



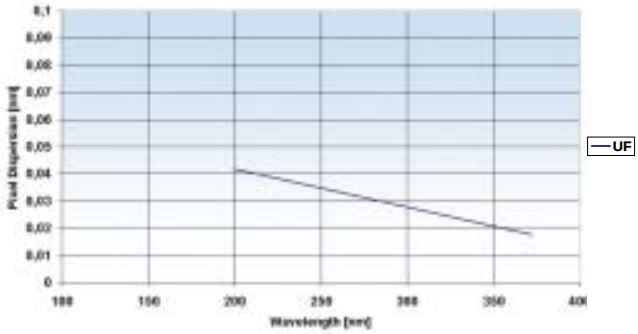
1800 Lines/mm Gratings



2400 Lines/mm Grating



3600 Lines/mm Grating



How to select optimal Optical Resolution?

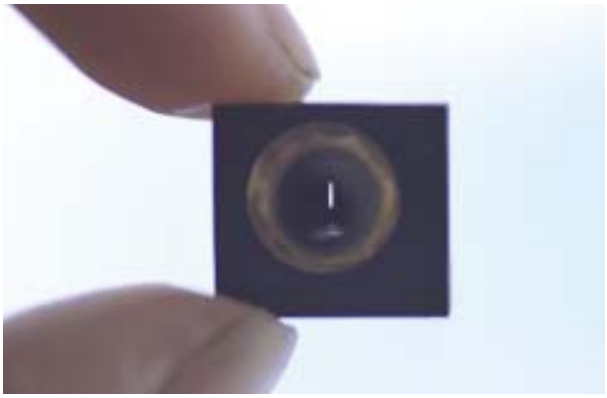
The optical resolution is defined as the minimum difference in wavelength that can be separated by the spectrometer. For separation of two spectral lines it is necessary to image them at least 2 array-pixels apart. Because the grating determines how far different wavelengths are separated (dispersed) 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 or 50 x 1000 µm high or 100, 200 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.

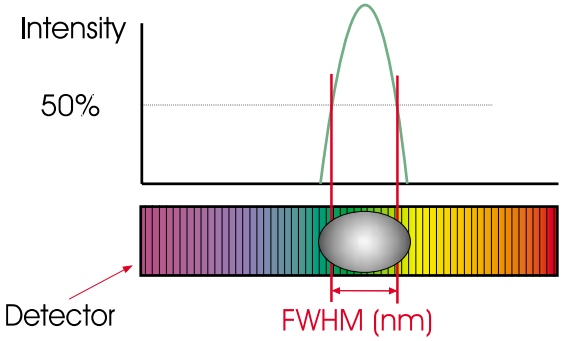


Figure 4 Full Width Half Maximum

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, 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 (900-2200nm) InGaAs arrays are implemented.

CCD Detectors (AvaSpec-2048)

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.

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

UV enhancement

For applications below 350 nm with the AvaSpec-2048 a special detector coating (UV or DUV) 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 and the UV phosphor coating enhances the detector response in the region 200-350nm. The overall efficiency of the UV coating in the visible range is better than the DUV coating (see Figure 5 Detector Spectral Sensitivity curves). The DUV coating has a very fast decay time, typ. in ns range and is therefore useful for fast trigger LIBS applications. The decay time for the UV coating is much longer (several hundred µsec).

Photo Diode Arrays (AvaSpec-102)

A silicon photodiode array consists of a linear array of multiple photo diode elements, for the AvaSpec-102 this is 102 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.

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

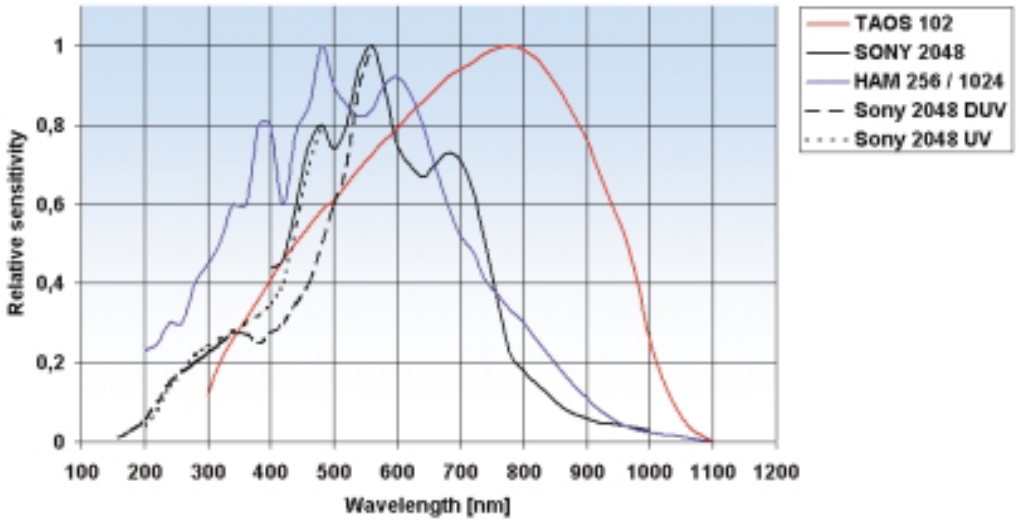
CMOS linear image sensors (AvaSpec-256/1024)

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).

Figure 5 Detector Spectral sensitivity curves



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 for AvaSpec-2048) will increase the system sensitivity by a factor of 3-5, depending on the fiber diameter used.

In Table 4 the overall sensitivity is given for the detector types currently used in the AvaSpec spectrometers as output in counts per ms integration time. 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.

Table 4 Detector specifications

Detector	TAOS 102	HAM256	HAM1024	SONY2048
Type	Photo diode array	CMOS linear array	CMOS linear array	CCD linear array
# Pixels, pitch	102, 85 µm	256, 25 µm	1024, 25 µm	2048, 14 µm
pixel width/height	77 x 85 µm	25 x 500 µm	25 x 500 µm	14 x 56 µm
Sensitivity (AvaLight-HAL, 8 µm fiber) in counts per ms integration time	1000 counts (AvaSpec-102)	30 counts (AvaSpec-256)	30 counts (AvaSpec-1024)	5000 counts (AvaSpec-2048)
Peak wavelength	750 nm	500 nm	500 nm	500 nm
Signal/Noise	1000:1	2000 :1	2000 :1	250 :1
Dark noise	Ca. 15 counts	Ca. 7 counts	Ca. 11 counts	Ca. 10 counts
Wavelength range	360-1100 nm	200-1000 nm	200-1000 nm	200*-1100 nm
Frequency	2 MHz	330 kHz	330 kHz	2 MHz

** UV coated*

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

Encasing the spectrometer in a light tight housing eliminates ambient stray light.

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 laser light, shining into the optical bench and measuring light intensity at pixels far away from the laser projected beam. Other methods use a halogen light source and long pass- or band pass filters.

Typical stray light performance is <0.05 % at 600 nm; <0.10 % at 435 nm; <0.10 % at 250 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 in the SMA entrance connector or an order sorting coating on the HAM1024 or SONY2048 detector. In Table 5 a wide range of optical filters for installation in the optical bench can be found. The use of following long-pass filters is recommended: OSF-475 for grating NB and NC, OSF-515/550 for grating NB and OSF-590 for grating IB.

In addition to the order sorting coatings we implement partial UV coatings on Sony 2048 detectors to avoid second order effects from UV response and to enhance sensitivity and decrease noise in the Visible range.
This partial UV coating is done automatically for the following grating types:

- UA for 200-1100 nm, UV400/DUV400, only first 400 pixels coated
- UB for 200-700 nm, UV800/DUV800, only first 800 pixels coated

Table 5 Filters installed in the AvaSpec spectrometer series

OSF-385	Permanently installed 1 mm order sorting filter @ 371 nm
OSF-475	Permanently installed 1 mm order sorting filter @ 466 nm
OSF-515	Permanently installed 1 mm order sorting filter @ 506 nm
OSF-550	Permanently installed 1 mm order sorting filter @ 541 nm
OSF-590	Permanently installed 1 mm order sorting filter @ 581 nm
OSC-200-1100	Order sorting coating 200-1100nm for grating UA in AvaSpec-1024/2048
OSC-350-1100	Order sorting coating 350-1100nm for grating VA in AvaSpec-1024/2048

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, technical specifications and applications.
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 RS232 to allow easy interfacing with or without computer environment.

Table 6 Fast selection guide

Product name	Electronics	Optical bench	Detector	Housing
AvaMouse	Electronics board with RS-232/USB and Xenon lightsource	AvaBench-28 (380-780 nm)	TAOS 102	
AvaSpec-102	AS-161 with USB	AvaBench-45, all gratings 360-1100 nm	TAOS 102	
AvaSpec-256	AS-161 with USB	AvaBench-45, all gratings 200-1100 nm	HAM 256	
AvaSpec-1024	AS-161 with USB	AvaBench-75, all gratings 200-1100 nm	HAM 1024	
AvaSpec-2048	AS-161 with USB	AvaBench-75, all gratings 200-1100 nm	Sony 2048	
AvaSpec-xxx-2 xxx = 102/256/1024/ 2048	AS-161 with USB, 2 channels	AvaBench-45/75, all gratings 200-1100 nm	TAOS 102 HAM 256/1024 or Sony 2048	
AvaSpec-xxx-y xxx = 102/256/1024 2048 Y = 3-8	AS-161M with 1-3 AS-161S, 3-8 channels	AvaBench-45/75, all gratings 200-1100 nm	TAOS 102 HAM 256/1024 or Sony 2048	 

AvaMouse Handheld Reflection Spectrophotometer

AvaMouse

The AvaMouse is a handheld reflection spectrophotometer that can be easily connected to a computer´s RS-232 or USB interface. It has a built-in Xenon flash lamp, with 35 flashes per second, and a miniaturized optical bench with a photodiode array. The AvaMouse can be used for reflection measurements in the visible range to determine color of flat surfaces.

It further comes with comprehensive AvaSoft-Color software, enabling you to do colorimetric measurements to determine L*, a*, b*, hue and Chromaticity values.

A customer-specific database can be built up in AvaSoft with multiple reference colors, so ΔE values can be followed in time-dependent series. The AvaMouse comes with a calibrated reference tile and a PS-12VDC/1.25A power supply.

Technical Data

Wavelength range	380-780 nm
Resolution	5 nm
Measurement aperture	1.5 x 2 mm / 0° geometry
AD converter	12 bits
Illumination	Xenon flash, 35 Hz, 45° geometry
Colorimeter accuracy	dE < 0.3 (averaging = 12)
Measurement speed	0.9 sec (averaging =12)
Interface	RS-232 or USB
Software	AvaSoft Color, L, a, b, hue, C, X, Y, Z, dE, dL, da, db
Dimensions	130 x 70 x 50 mm / 180 grams

	ORDERING INFORMATION
AvaMouse-EUR	Handheld spectrometer for color measurements, incl. AvaSoft-Color, calibrated reference tile and PS-12VDC/1.25A EUR power supply
AvaMouse-UK	Handheld spectrometer for color measurements, incl. AvaSoft -Color, calibrated reference tile and PS-12VDC/1.25A UK power supply
AvaMouse-US	Handheld spectrometer for color measurements, incl. AvaSoft -Color, calibrated reference tile and PS-12VDC/1.25A USA power supply
AvaMouse-AUS	Handheld spectrometer for color measurements, incl. AvaSoft -Color, calibrated reference tile and PS-12VDC/1.25A Australian power supply
-USB	AvaMouse with USB interface instead of RS-232

AvaSpec-102 Fiber Optic Spectrometer

The AvaSpec-102 Fiber Optic Spectrometer is based on the AvaBench-45 symmetrical Czerny-Turner design with 102 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 PDA is connected to an electronics board with 14 bit AD converter and USB/RS-232 interface. Applications for this instrument are e.g. low cost color measurements. A 15-pin digital I/O connector enables external triggering and control of shutter and pulsed light sources from the Avantes product line.

Start and stop pixel can be defined to speed up data transfer.

The AvaSpec-102 is also available as dual channel or multiple channel instrument (up to 8 channels), where all spectra are taken simultaneously.

The AvaSpec-102 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12V/1.25A power supply. AvaSoft-full and application software can be ordered separately. Alternatively the AvaSpec-102-SPU is available as an option to run on USB power and does not need an additional power supply.

AvaSpec-102

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 45 mm focal length
Wavelength range	360-1100 nm
Resolution	1.4 –64 nm, depending on configuration (see table)
Stray light	< 0.3%
Sensitivity (AvaLight-HAL, 8 µm fiber)	1000 counts per ms integration time
Detector	Photo diode array, 102 pixels
Signal/Noise	1000:1
AD converter	14 bit, 2 MHz
Integration time	1 msec – 60 sec
Interface	USB version 1.1, 12 Mbps RS-232, baudrate 115.200 bps
Data transfer speed	6-7 ms / scan (depending on # pixels transferred)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out
Status LED	Green = power, yellow = scan
Power supply	12 VDC, reverse polarity protection ,160 mA (PS-12V/1.25A) or 5VDC USB power
Dimensions	175 x 110 x 44 mm(1 channel) 175 x 165 x 85 mm (2 channels)

Grating selection table for AvaSpec-102

Use	Useable range	Spectral range (nm)	Lines/mm	Blaze (nm)	Order code
VIS/NIR	360-1100	400	300	300	UA
VIS	360-750	100	1200	250	UC
VIS	360-850	200	600	370	BB
VIS/NIR	360-1100	800	150	500	VZ
VIS/NIR	360-1100	400	300	500	VA
VIS	360-850	200	600	500	VB
VIS	400-980	100	1200	500	VC
NIR	500-935	200	600	750	NB
NIR	500-1000	100	1200	630	NC
NIR	600-1100	400	300	1000	IA
NIR	600-1100	200	600	1000	IB

Resolution table (FWHM) for AvaSpec-102

	Slit size (µm)			
Grating (lines/mm)	**50**	**100**	**200**	**500**
150	12.8	12.8	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-102	Fiber Optic Spectrometer, 45 mm Avabench, 102 pixel PDA detector, USB/RS-232 interface, incl AvaSoft-Basic, USB interface cable and a PS-12V/1.25A power supply, specify grating, wavelength range and options
AvaSpec-102-2	Dual Channel Fiber Optic Spectrometer, 2* 45 mm Avabench, 102 pixel PDA detector, USB/RS-232 interface, incl AvaSoft-Basic, USB interface cable and a PS-12V/1.25A power supply, for both channels specify grating, wavelength range and options
Options	
-SPU	self powered USB, no additional power supply added
DCL-VIS	Detector collection lens to enhance sensitivity, PMMA, 360-1100nm
SLIT-XX	Slit size, please specify XX = 50, 100, 200, 500 µm
OSF-YYY	Order sorting filter for reduction of 2nd order effects, please specify YY= 385, 475, 515, 550, 590 nm

AvaSpec-256 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 CMOS detector is connected to an electronics board with 14 bit AD converter and USB/RS-232 interface.

The AvaSpec-256 is specially suitable for low noise applications. A 15-pin digital I/O connector enables external triggering and control of shutter and pulsed light sources from the Avantes product line.

Start and stop pixel can be defined to speed up data transfer.

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-12VDC/1.25A power supply. AvaSoft-full and application software can be ordered separately.

AvaSpec-256

Alternatively the AvaSpec-256-SPU is available as an option to run on USB power and does not need an additional power supply.

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 45 mm focal length
Wavelength range	200-1100 nm
Resolution	0.4 –64 nm, depending on configuration (see table)
Stray light	< 0.2%
Sensitivity (AvaLight-HAL, 8 µm fiber)	30 counts per ms integration time
Detector	CMOS linear array, 256 pixels
Signal/Noise	2000:1
AD converter	14 bit, 330 kHz
Integration time	2 msec – 60 seconds
Interface	USB version 1.1, 12 Mbps RS-232, baudrate 115.200 bps
Data transfer speed	7-9 ms / scan (depending on # pixels transferred)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out
Status LED	Green = power, yellow = scan
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.25A) or 5VDC USB power
Dimensions	175 x 110 x 44 mm (1 channel) 175 x 165 x 85 mm (2 channels)

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	250	UZ
UV/VIS/NIR	200-1100	400	300	300	UA
UV/VIS	200-850	200	600	250	UB
UV	200-750	100	1200	250	UC
UV/VIS	250-850	200	600	370	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

Resolution table (FWHM) for AvaSpec-256

	Slit size (µm)				
Grating (lines/mm)	**25**	**50**	**100**	**200**	**500**
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, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, specify grating, wave length range and options
AvaSpec-256-2	Dual channel Fiber Optic Spectrometer, 2 * 45 mm Avabench, 256 pixel CMOS detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, for both channels specify grating, wavelength range and options
Options	
-SPU	self powered USB, no additional power supply added
SLIT-XX	Slit size, please specify XX = 25, 50, 100, 200, 500 µm
OSF-YYY	Order sorting filter for reduction of 2nd order effects; please specify YY= 385, 475, 515, 550, 590 nm

AvaSpec-1024 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 15 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The CMOS detector is connected to an electronics board with 14 bit AD converter and USB/RS-232 interface.
The AvaSpec-1024 is specially suitable for low noise applications with good resolution. A 15-pin digital I/O connector enables external triggering and control of shutter and pulsed light sources from the Avantes product line.
Start and stop pixel can be defined to speed up data transfer.
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-12VDC/1.25A power supply.

AvaSpec-1024

AvaSoft-full and application software can be ordered separately.
Alternatively the AvaSpec-1024-SPU is available as an option to run on USB power and does not need an additional power supply.

Technical Data

Optical Bench	Symmetrical Czerny-Turner, 75 mm focal length
Wavelength range	200-1100 nm
Resolution	0.10 –20 nm, depending on configuration (see table)
Stray light	< 0.1%
Sensitivity (AvaLight-HAL, 8 µm fiber)	30 counts per ms integration time
Detector	CMOS linear array, 1024 pixels
Signal/Noise	2.000:1
AD converter	14 bit, 330 kHz
Integration time	4 msec – 60 seconds
Interface	USB version 1.1, 12 Mbps RS-232, baudrate 115.200 bps
Data transfer speed	12-20 ms / scan (depending on # pixels transferred)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out
Status LED	Green = power, yellow = scan
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.25A) or 5VDC USB power
Dimensions	175 x 110 x 44 mm (1 channel) 175 x 165 x 85 mm (2 channels)

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	250	UB
UV	200-750	220	1200	250	UC
UV	200-650	160	1800	250	UD
UV	200-580	100	2400	250	UE
UV	220-400	50	3600	250	UF
UV/VIS	250-850	450	600	370	BB
VIS/NIR	300-1100	900	300	500	VA
VIS	360-1000	450	600	500	VB
VIS	300-800	220	1200	500	VC
VIS	350-750	160	1800	500	VD
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

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, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply ,specify grating, wavelength range and options
AvaSpec-1024-2	Dual channel Fiber Optic Spectrometer, 2 * 75 mm Avabench, 1024 pixel CMOS detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply ,for both channels specify grating, wavelength range and options
Options	
-SPU	self powered USB, no additional power supply added
SLIT-XX	Slit size, please specify XX = 25, 50, 100, 200, 500 µm
OSF-YYY	Order sorting filter for reduction of 2nd order effects, please specify YY= 385, 475, 515, 550, 590 nm
OSC-200-1100	Order sorting coating 200-1100nm for grating UA
OSC-350-1100	Order sorting coating 350-1100nm for grating VA

AvaSpec-2048 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 15 different gratings with different dispersion and blaze angles enable applications in the 200-1100nm range. The CCD detector is connected to an electronics board with 14 bit AD converter and USB/RS-232 interface. The AvaSpec-2048 is specially suitable for low light level and high resolution applications. Special detector coatings can enhance the CCD performance for UV range and a detector collection lens offers high sensitivity. A 15-pin digital I/O connector enables external triggering and control of shutter and pulsed light sources from the Avantes product line.
Start and stop pixel can be defined to speed up data transfer.

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

AvaSpec-2048

The AvaSpec-2048 comes with AvaSoft-basic, a complete manual, USB interface cable and a PS-12VDC/1.25A power supply. AvaSoft-full and application software can be ordered separately. Alternatively the AvaSpec-2048-SPU is available as an option to run on USB power and does not need an additional power supply.

Technical Data

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)	5.000 counts per ms int. time
Detector	CCD linear array, 2048 pixels
Signal/Noise	250:1
AD converter	14 bit, 2 MHz
Integration time	2 msec – 60 seconds
Interface	USB version 1.1, 12 Mbps RS-232, baudrate 115.200 bps
Data transfer speed	14-31 ms / scan (depending on # pixels transferred)
Digital IO	DB-15 connector, 2 Digital in, 12 Digital out
Status LED	Green = power, yellow = scan
Power supply	12 VDC, reverse polarity protection, 160 mA (PS-12V/1.25A) or 5VDC USB power
Dimensions	175 x 110 x 44 mm (1 channel) 175 x 165 x 85 mm (2 channels)

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	250	UB
UV	200-750	250-220*	1200	250	UC
UV	200-650	165-145*	1800	250	UD
UV	200-580	115-70*	2400	250	UE
UV	220-400	75-50*	3600	250	UF
UV/VIS	250-850	520	600	370	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
NIR	500-1050	500	600	750	NB
NIR	500-1050	220-150*	1200	630	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*

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, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, specify grating, wavelength range and options
AvaSpec-2048-2	Dual channel Fiber Optic Spectrometer, 2 * 75 mm Avabench, 2048 pixel CCD detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, for both channels specify grating, wavelength range and options
Options	
-SPU	self powered USB, no additional power supply added
DUV	Deep UV detector coating >150 nm
UV	UV detector coating >200 nm, required for applications <360 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	Order sorting filter for reduction of 2nd order effects, please specify YY= 385, 475, 515, 550, 590 nm
OSC-200-1100	Order sorting coating 200-1100nm for grating UA
OSC-350-1100	Order sorting coating 350-1100nm for grating VA

AvaSpec Multichannel Fiber Optic Spectrometers

AvaSpec-4 channel in desktop

The AvaSpec 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 (102, 256 or 1024 or 2048 pixels), the spectrometer channels can of course 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 under AvaSoft software.
Multichannel housing can be in 9.5" desktop (for 1-4 channels) or 19" rack mount housing (1-8 channels)

AvaSpec-8 channel in rack mount

ORDERING INFORMATION	
AvaSpec-102-x-DT	Multichannel AvaSpec-102 Fiber Optic Spectrometer with x channels in desktop housing, for all channels specify grating, wavelength range and options
AvaSpec-102-x-RM	Multichannel AvaSpec-102 Fiber Optic Spectrometer with x channels in rack mount housing, for all channels specify grating, wavelength range and options
AvaSpec-256-x-DT	Multichannel AvaSpec-256 Fiber Optic Spectrometer with x channels in desktop housing, for all channels specify grating, wavelength range and options
AvaSpec-256-x-RM	Multichannel AvaSpec-256 Fiber Optic Spectrometer with x channels in rack mount housing, for all channels specify grating, wavelength range and options
AvaSpec-1024-x-DT	Multichannel AvaSpec-1024 Fiber Optic Spectrometer with x channels in desktop housing, for all channels specify grating, wavelength range and options
AvaSpec-1024-x-RM	Multichannel AvaSpec-1024 Fiber Optic Spectrometer with x channels in rack mount housing, for all channels specify grating, wavelength range and options
AvaSpec-2048-x-DT	Multichannel AvaSpec-2048 Fiber Optic Spectrometer with x channels in desktop housing, for all channels specify grating, wavelength range and options
AvaSpec-2048-x-RM	Multichannel AvaSpec-2048 Fiber Optic Spectrometer with x channels in rack mount housing, for all channels specify grating, wavelength range and options

AvaSpec-2048FT Fast Trigger Fiber Optic Spectrometer

The AvaSpec-2048FT is a special version of the AvaSpec-2048, that can start integration time with only one microsecond delay after an external trigger. The external trigger can be applied by TTL signal to a Digital-in port in the AvaSpec´s DB-15 interface connector. A TTL output port is available to trigger a pulsed laser and the nanoseconds delay before starting the integration time can be set in software, the option for -42 ns negative delay makes it extremely useful for measuring pulsed lasers.

These features allow the AvaSpec-2048FT to be implemented in applications where a fast response or accurate timing to an external trigger is needed with only ±21 ns jitter, such as measuring products on conveying belts. The TTL output port can be used for Laser Induces Breakdown Spectroscopy (LIBS) and fluorescence applications, where measurement needs to start after the laser has been fired.

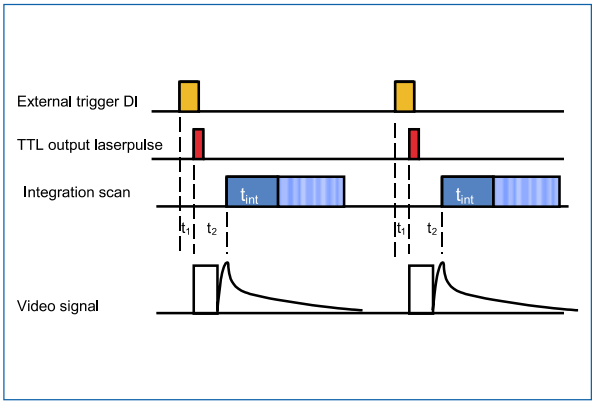
The AvaSpec-2048FT can be delivered in all configurations and has all features of the AvaSpec-2048.

AvaSpec-2048FT

NEW

The Multichannel AvaSpec-2048FT-8 allows you to do LIBS measurements in the 200-1000nm range with <0.1 nm resolution .

Timing Diagram



t_1 = delay laserpulse after ext. trigger, fixed 1320ns (jitter ± 21 ns)

t_2 = programmable delay start integration time -42ns – 2.7 ms in 42ns steps (jitter = 0 ns)

t_{int} = integration time 2ms-60 sec

ORDERING INFORMATION	
AvaSpec-2048FT	Fast Trigger Fiber Optic Spectrometer, 75 mm Avabench, 2048 pixel CCD detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, specify grating, wavelength range and options
AvaSpec-2048FT-X	Multichannel Fast trigger Fiber Optic Spectrometer, X * 75 mm Avabench, 2048 pixel CCD detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable and PS-12V/1.25A power supply, for X channels specify grating, wavelength range and options
Options	See under AvaSpec-2048

AvaSpec-2048TEC Thermo-electric Cooled Fiber Optic Spectrometer

AvaSpec-2048TEC

NEW

The AvaSpec-2048TEC is a special version of the AvaSpec-2048, where the Sony 2048 CCD detector is mounted on a one-stage Peltier cooling device. This Peltier cooling element can reduce the temperature of the CCD chip by ca. 30°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-2048TEC 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-2048TEC can be delivered as one or 2-channel instruments. All the standard options and gratings of the normal AvaSpec-2048 are available.

The AvaSpec-2048TEC is built into a desktop housing, that has a cooling fan to actively ventilate the heatsink of the Peltier cooling element and an internal power supply.
The AvaSpec-2048TEC-2 is mounted into a 19" rackmount housing.

Technical Data

Temperature cooled CCD	ΔT = ca. -30 °C versus ambient
Time to stabilize	1-2 Minutes
Dynamic Range improvement for it > 5 seconds	> Factor 10
Dark Noise improvement for it > 5 seconds	Factor 2-3
Peltier cooling internal Power supply	Ca. 3.0 V, 4A
External Power supply	85-264 VAC, 30W
Dimensions	310 x 235 x 135 mm (1 channel) Desktop 310 x 450 x 135 mm (2 channel) 19" Rackmount

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 in desktop housing, specify grating, wavelength range and options
AvaSpec-2048TEC-2	Multichannel Thermo-Electric Cooled Fiber Optic Spectrometer, 2 * 75 mm Avabench, 2048 pixel TE cooled CCD detector, USB/RS-232 interface, incl AvaSoft-Basic, USB cable, for 2 channels in 19" Rackmount housing specify grating, wavelength range and options
Options	See under AvaSpec-2048

AvaBench Optical Benches

AvaBench-45

The AvaSpec spectrometer components can also be used for OEM customers. Avantes has developed 3 types of optical benches, specially for OEM customers. The AvaBench-28 is a Littrow design with injection molded optics and includes a patented design of a grating lens. The AvaBench-28 is primarily designed for color measurements and optimised for 380-750 nm. This optical bench is implemented in the AvaMouse.

The other benches AvaBench-45 and AvaBench-75 are symmetrical Czerny-Turner designs with fiber optic entrance connector (Standard SMA, others possible), collimating and focusing mirror and diffractional grating. A choice of different gratings with different dispersion and blaze angels enable applications in the 200-1100nm range.
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 difference between the optical benches is pointed out.

AvaBench-75

Technical Data

	AvaBench-28	AvaBench-45	AvaBench-75
Implemented in	AvaMouse	AvaSpec-102 / 256	AvaSpec-1024 / 2048
Focal length	28 mm	45 mm	75 mm
n.a.	0,09	0,11	0,07
Wavelength range	380-780 nm	200-1100 nm	200-1100 nm
Resolution (FWHM)	16 nm	0,2 – 40 nm, see table	0,04 – 20 nm, see table
Stray light	< 0.4 %	< 0.15%	< 0.1%
Gratings	Lens grating	different	different
slits	200 µm, 2 mm height	25, 50, 100, 200, 500 µm	10, 25, 50, 100, 250, 500 µm
Detector	TAOS 102	TAOS 102 / HAM 256	HAM 1024 / SONY 2048
Detector lens	Standard, VIS	VIS (for TAOS only)	UV/VIS/NIR (for Sony only)
Order sorting filter	n.a.	See options	See options
Dimensions	49 x 34 x 31 mm	82 x 72 x 20 mm	120 x 91 x 21 mm

ORDERING INFORMATION	
AvaBench-28-102	OEM optical bench, 28 mm focal length, 102 pixel PDA detector, specify grating, wavelength range and options
AvaBench-45-102	OEM optical bench, 45 mm focal length, 102 pixel PDA detector, specify grating, wavelength range and options
AvaBench-45-256	OEM optical bench, 45 mm focal length, 256 pixel CMOS detector, specify grating, wavelength range and options
AvaBench-75-1024	OEM optical bench, 75 mm focal length, 1024 pixel CMOS detector, specify grating, wavelength range and options
AvaBench-75-2048	OEM optical bench, 75 mm focal length, 2048 pixel CCD detector, specify grating, wavelength range and options

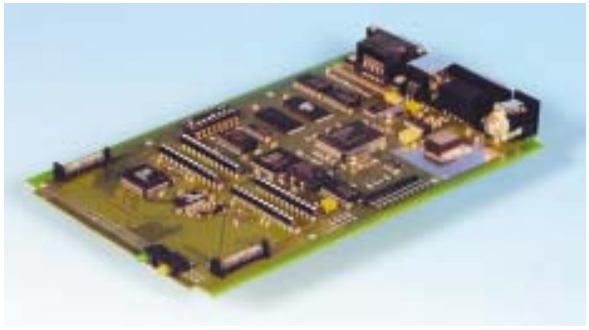
AS161 Microprocessor board

Avantes has developed a modularly designed electronics board with a 16-bit microprocessor, 2 channel 14-bit AD converter and USB/RS232-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 TSL 1301, 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 out port is reserved for controlling the flash rate of an external Xenon strobe (single or multiple flashes per scan), one digital out port can be used to control external TTL-shutter devices, for the AS-161-FT-ILX 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 the 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 msec /scan (10-2048 pixels) for 1 channel
	Hamamatsu 8378-256Q, 200kHz, 7-9 msec /scan for 1 channel
	TAOS 1301, 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	162.5 x 100 mm

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)
-FT-ILX	Fast trigger FPGA for LIBS and fluorescence for Sony ILX554B detector (AvaSpec-2048FT)
-H8378-256	for Hamamatsu S8378-256 detectors (AvaSpec-256)
-H8378-1024	for Hamamatsu S8378-1024 detectors (AvaSpec-1024)
-TAOS	for TAOS 1301 detectors (AvaSpec-102)

TE Cooled Analytical NIR Spectrometers using Fiber Optics

NIR Fiber Optic Spectrometers

The NIR spectrometers are each available with one of four different detectors covering the NIR wavelength range (900-2200nm).The spectrometers are "handshake" connected to your computer with Windows platform using a USB interface integrated into the spectrometer. Comprehensive SPEC™ instrument software to control the instrument, readout and display data is included. This uses Microsoft Windows™ as the base operating system. All components are sealed and mounted inside the spectrometer housing, requiring no adjustments or maintenance. The NIR spectrometer performs repeatable, high-speed measurements (as short as 10 micro-seconds integration times and 2 milliseconds sample rate). The permanent wavelength calibration (within 1 nm) makes the NIR spectrometer the ideal instrument for process control or laboratory use. Thermo-electrically cooled InGaAs diode array systems provide good stability. Additional features include internal or external trigger mode, single or continuous scan, with various trigger modes all software selectable. Light is collected from a variety of accessory sample holders and optomechanical geometries using a 400 micron active diameter fiber optic. This allows transmission, absorbance, and reflectance measurements to be made. A frequently used light source with these spectrometers is the AvaLight-HAL in high power setting.

Technical Data

Product	NIR-128-1.7	NIR-256-1.7	NIR-512-1.7	NIR-256-2.2
Wavelength Range	900nm -1700nm			1100nm -2200nm
Input fiber	SMA905 interconnect to FC-IR400 400 µm /NIR			
Input slit	50 µm	50 µm	25 µm	50 µm
Detector	InGaAs	InGaAs	InGaAs	Extended InGaAs
Pixels, size	128, 50 x 500 µm	256, 50 x 500 µm	512, 25 x 500 µm	256, 50 x 500 µm
Resolution (FWHM)	12 nm	6.0 nm	3.0 nm	8.0 nm
TE Cooling (ΔT vs. ambient)	Stabilized	Single stage ΔT = 25 °C		Dual stage ΔT = 32 °C
Max Integration time	500 ms	8 sec	8 sec	20 ms
Photometric Repeatability	± 0.15%	<50 µAU Variation between 100 data points, each 1000 samples		<1mAU
Outputs	Modular Connector: Trigger, Two Strobes, Light Source Shutter Control and two Fiber Optic Switch Controls.			
PC Interface	USB			
Power Requirements	85-265 VAC / 47-63 Hz			
Dimensions, weight	300 x 90 x 190 mm , 3.35 kg			

ORDERING INFORMATION	
NIR128-1.7-USB	NIR Fiber optic Spectrometer, 0.9-1.7 um, 128 pixels, USB interface
NIR256-1.7-USB	NIR Fiber optic Spectrometer, 0.9-1.7 um, 256 pixels, TE cooled ΔT = 25 °C, USB
NIR512-1.7-USB	NIR Fiber optic Spectrometer, 0.9-1.7 um, 512 pixels, TE cooled ΔT = 25 °C, USB
NIR256-2.2-USB	NIR Fiber optic Spectrometer, 1.1-2.2 um, 256 pixels, TE cooled ΔT = 32 °C, USB

NIR-128 spectrometers

The compact NIR spectrometer features RS-232 interfacing and has a 128 pixel uncooled InGaAs - array detector. The NIR-128 spectrometer is delivered with 1100-1700nm range. The spectrum is generated by coupling the light through a silica fiber with SMA905 termination into the center layer, which contains a molded diffraction grating. The light is guided by metal reflection between the wave-guide bottom and top.

The spectrometer comes with our comprehensive AvaSoft-basic software (AvaSoft-FULL and -XLS available) and is equipped with a 16-bit controller module. The obtained data, read out by the programmable electronics, are pre-processed onboard and sent by RS-232 to the PC.
A separate filter GL-RG1000-3 should be ordered with the instrument to suppress second order effects.

Technical Data

Wavelength range	1100-1700 nm
Spectral Resolution	16 nm
Pixel Dispersion	11 nm/pixel
Straylight attenuation	> 15dB (>30 dB with Software correction algorithm)
Optical Entrance	SMA 905 with 300µm fiber
Slit	50 µm
Detector	InGaAs, uncooled
Pixels	128, 50 µm x 500 µm
Dynamic Range	10.000:1
AD converter	16 bit, 150 kHz
Integration time	1 ms – 50 ms
Data transmission time	50 ms
Interface	RS-232
Software	AvaSoft (AvaSoft-FULL and -XLS available)
Dimensions	115 x 82 x 32 mm

ORDERING INFORMATION	
NIR128-1.7-RS232	NIR Fiber Optic Spectrometer, 1.1-1.7 µm, 128 pixels, RS-232 output
GL-RG1000-3	separate 50x50x3 mm long pass filter >1000 nm