NOT JUST ANOTHER SPECTROMETER

BTS2048 SERIES
UV-VIS-IR SPECTRORADIOMETER

Gigahertz-Optik
Member of the BERGHOF GROUP

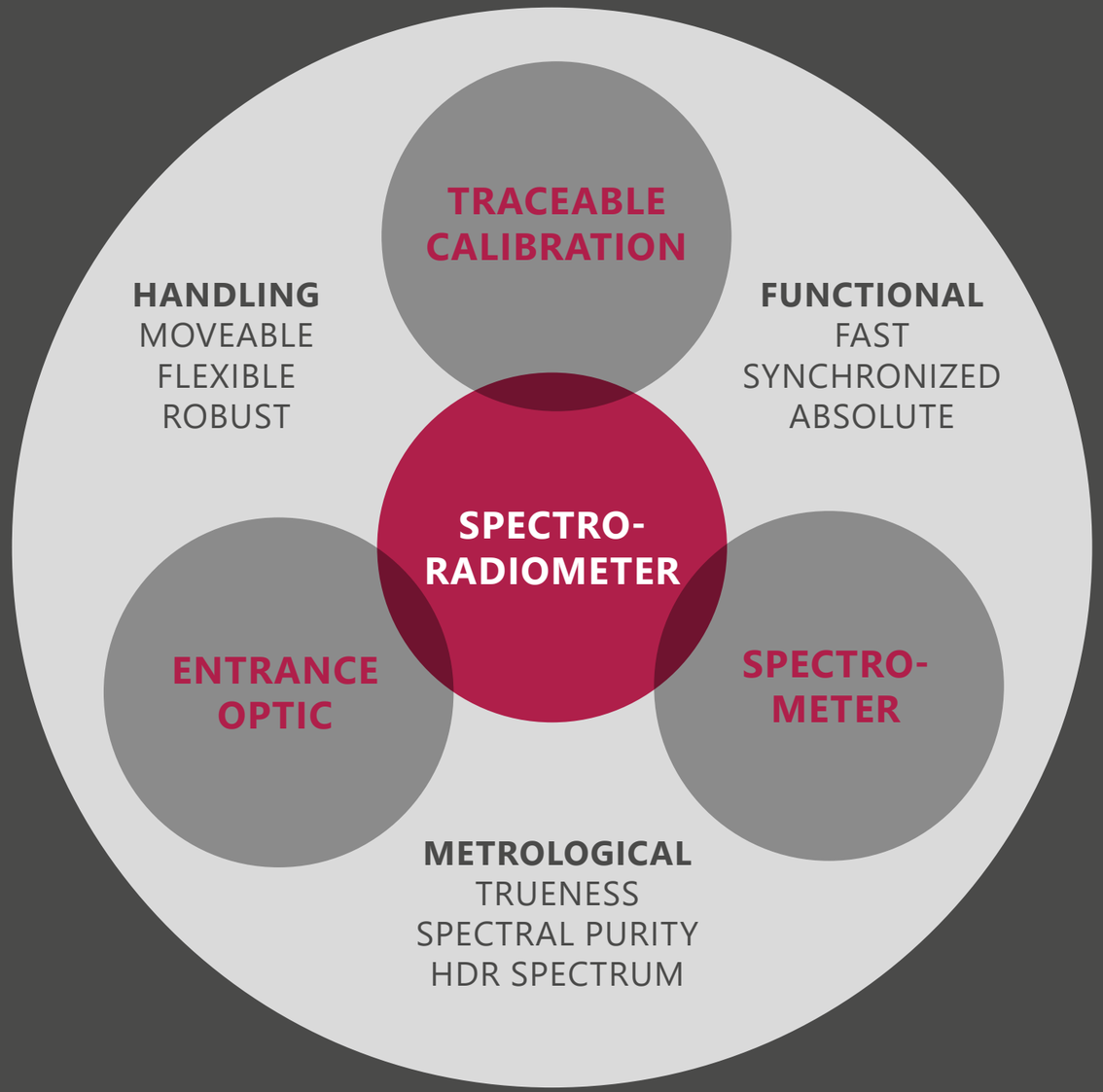
SPEKTRALRADIOMETER
Merkmale wie Genauigkeit, Stabilität, optische Güte und Reproduzierbarkeit sind Kenngrößen welche die Qualität eines Spektralradiometers widerspiegeln, diese sind jedoch nicht ausreichend für die Richtigkeit der Messwerte. Die Richtigkeit der Messwerte in der Anwendung wird zusätzlich durch weitere Einflussgrößen wie Umwelt- und Handhabungsparameter bestimmt. Bei der Auswahl eines Spektralradiometers sollten daher neben seinen technischen Parametern auch Merkmale wie Funktionalität, Handhabung sowie eine vollständige rückführbare Kalibrierung berücksichtigt werden.

Die UV-VIS-IR-Spektralradiometer der BTS2048-Serie stehen für herausragende Spezifikationen. Ihre zusätzlichen Merkmale hinsichtlich Funktionalität und Handhabung sind die bestmöglichen Voraussetzungen für ihre Integration und Verwendung in anspruchsvollen, spektralradiometrischen Messaufgaben. Auf den folgenden Seiten erfahren Sie mehr über diese Merkmale und ihren Nutzen in verschiedenen Applikationen.

SPECTRORADIOMETER
Features such as accuracy, stability, optical quality, and reproducibility are characteristics that reflect the quality of a spectroradiometer, but they are not sufficient to guarantee absolute accuracy of the measurements. The absolute measuring accuracy in the application is additionally determined by further factors such as environmental and handling parameters. When choosing a spectroradiometer, therefore, features such as functionality, handling and a complete traceable calibration should be considered in addition to its technical parameters.

The UV-VIS-IR spectroradiometers of the BTS2048 series offer excellent metrological specifications. Additionally, their many functional and handling features enable the best possible integration and use in demanding spectroradiometric measurement tasks. The following pages illustrate their main features and benefits in some example applications.

THE BENEFITS



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TRUENESS

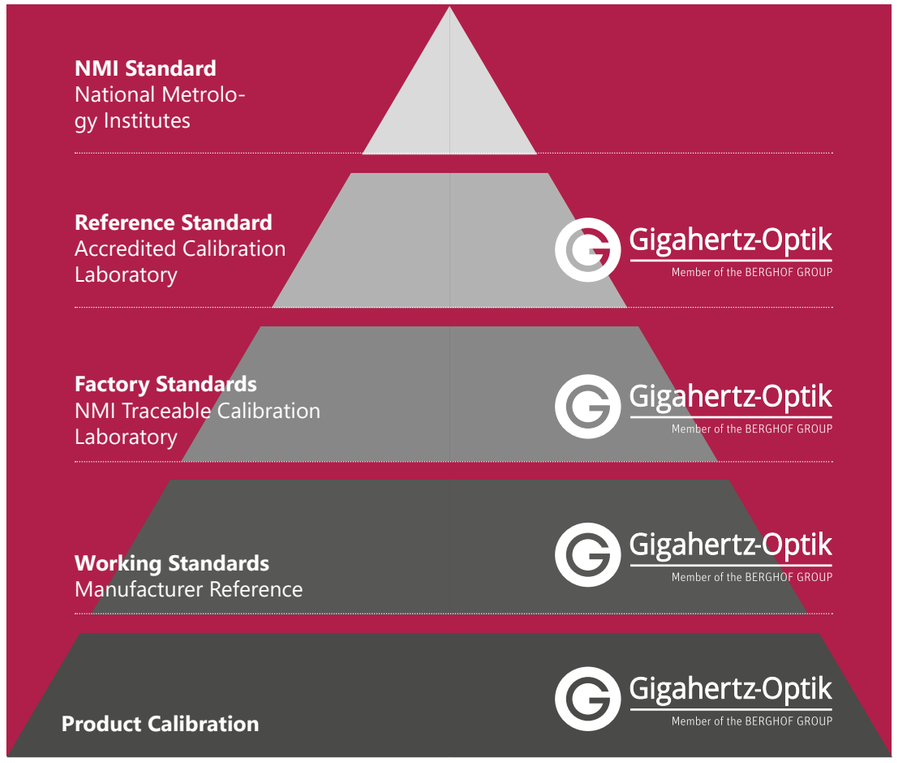
The correctness of a measured value is always associated with a measurement uncertainty; the amount of this uncertainty depends on several parameters, e.g.:

- Calibration uncertainty of the spectroradiometer
- Metrological quality of the spectroradiometer (wavelength precision and stability, linearity, stray light, etc.)
- Environmental influences
- Operating and handling conditions

In order to offer a high quality calibration and characterization of the BTS2048 series spectroradiometers, the calibration procedure includes several steps:

- Factory calibration of the linearity of all the pixels in the spectrometer array sensor on an optical bench of the Gigahertz-Optik measuring laboratory to correct for manufacturing-related tolerances of the sensors and technology based nonlinearities (according to CIE 233)
- Wavelength dependent optical bandpass characterization and correction by tunable laser (according to CIE 214)
- Optional stray light correction matrix by tunable laser (according to CIE 233)
- Wavelength calibration at multiple wavelengths within the specified spectral sensitivity range of the spectrometer array using spectral line lamps (according to CIE 233)
- Factory calibration of the absolute spectral responsivity in ISO units traceable to a National Metrological Institute (NMI). The measured quantity is determined by the measuring optics of the spectroradiometer. Optional DAkkS test certificates are available.

The traceability of its calibrations in absolute quantities to National Metrological Institutes (NMI) is of particular importance to the optical radiation measuring laboratory of Gigahertz-Optik. The reference standards used for calibration are therefore confirmed in each calibration certificate. For users who require proof of DIN EN ISO / IEC 17025, the DAkkS accredited Gigahertz-Optik DAkkS test laboratory offers DAkkS test certificates as an option to the factory calibrations.



Traceability Pyramid shows the unbroken chain of feedback from product calibration to NMI standard.

application example

The traceable calibration provided with the BTS2048-UV-S qualifies it as a reference spectroradiometer for the absolute calibration of UV-C irradiance for all types of UV-C emission spectra.

Feedback from Cornell University

LightAndPlantHealth.org is a multi-institutional, international, and multidisciplinary collaboration lead by Cornell AgriTech-Geneva, in partnership with the National Life Sciences University of Norway (NMBU), the RPI Lighting Research Center, University of Florida, and USDA.

We use the BTS2048-UV-S as a calibration standard for a diversity of towable and robotic UVC arrays that we deploy across multiple crops for non-pesticidal suppression of plant diseases and insect pests.

The unit allows growers to fabricate units with minimal guidance from us. The BTS2048-UV-S documents precise irradiance in the UVC range post-fabrication, leading to accurate dosing of crops with UV.

SPECTRAL PURITY

Spectroradiometers are required to measure absolute radiometric quantities...

Spectroradiometers are required to measure absolute radiometric quantities within narrow wavelength intervals over a given spectral region. However, complete spectral purity within each of the desired narrow wavelength intervals is not possible. In part, this can result from the spectrometer's imperfect slit function (optical bandpass effects), but often the dominant source of spectral impurity arises from stray light within the spectrometer. Some of the broadband incident optical radiation will inevitably be scattered inside the spectrometer. Each pixel of the array sensor provides a signal that comprises the desired monochromatic radiation as well as some unwanted scattered light component. Failure to suppress this stray light can result in significant measurement errors.

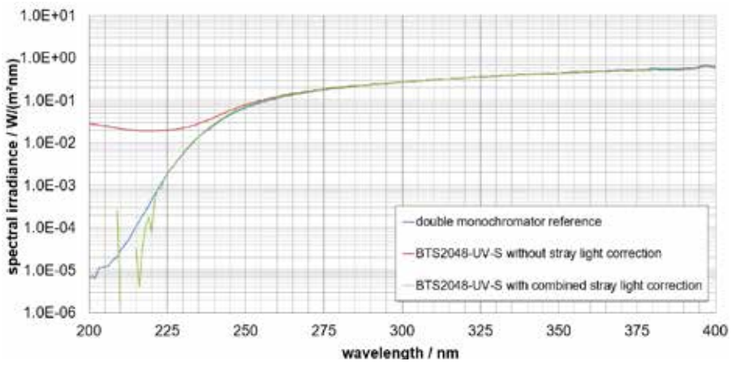


Image: Stray light can have a significant influence on the measurement results of a spectroradiometer. This is especially true in the UV spectral region when there are very significant intensity differences within an emission spectrum.

Zuber, R. and M. Ribnitzky (2019). „Combined Out of Range and In Band stray light correction for array spectroradiometers." CIE Session 2019 - OP76.

application example

Feedback from NASA/Jet Propulsion Laboratory, Pasadena, California

Remote sensing systems are used to provide data for a diverse number of applications, including green-house gas monitoring, pollution and its correlation with adverse health effects, and weather forecasting. The systems may be deployed on aircraft or on satellites that circulate the Earth to provide global coverage.

To be effective, these sensors must be accurately calibrated. That is, the relationship between the incident light and output signal must be determined. This relationship is established in a laboratory using large uniform light source. It is required that this output light be known to a high level of accuracy. This is particularly difficult to do in the ultraviolet (UV), because the incandescent bulbs that produce the light have a large visible and infrared component.

The BTS2048-UV-S spectrometer is calibrated in absolute radiometric units, and incorporates a set of optical band-pass and long-pass filters to reject the stray light caused by longer wavelengths that would otherwise impact the measurement accuracy of UV light detection.

Stray light suppression in BTS2048 UV-VIS-IR spectroradiometers is achieved through both technological design considerations and correction methods:

- Optimum optical design and use of high-quality optical components
- Clean room environment for manufacturing processes
- Light trap concepts and broadband absorption coatings of internal surfaces
- Bandpass and edge filter concepts in UV spectroradiometers. E.g. a filter wheel for up to 6 optical band-pass and long-pass filters is used in order to combine several stray light corrected sub-measurements into one full measurement (a kind of different double monochromator principle, optical filters in combination with array spectroradiometer)
- Stray light matrix correction methods based on line spread functions (LSF) measured with tunable laser (CIE 233).

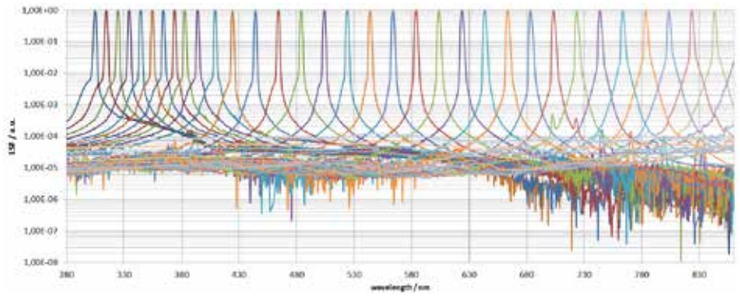
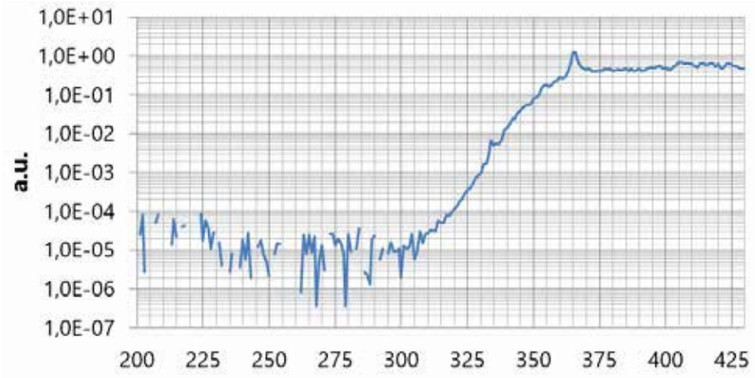
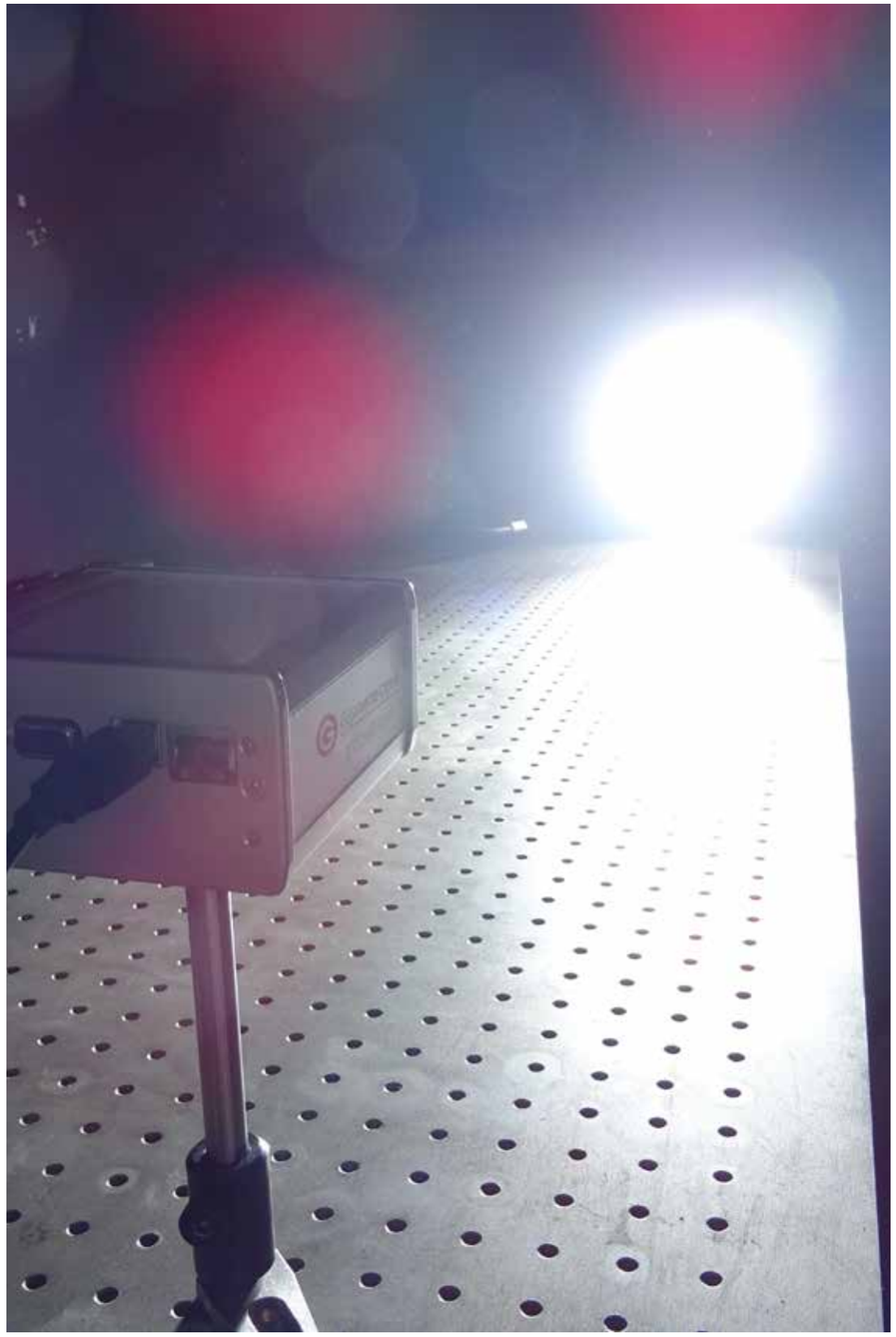


Image: LSF of a spectroradiometer measured using an OPO (tunable laser)

One of the key requirements for capturing HDR spectra is that the detector array has no cross-talk between the pixels. This is the only way to avoid a false signal being generated in neighboring pixels when the pixels are overexposed. Furthermore, very good linearity of the measurement system is important, in order to stitch together the single measurements without measurement errors.



Measurement of a high power stage projector.



HDR SPECTRUM

The exposure time of spectrometer arrays will be adjusted according to the maximum intensity measured.

The exposure time (integration time) of spectrometer arrays will be adjusted according to the maximum intensity measured. In the case of emission spectra with very high intensity differences (large dynamic range), this static exposure time can reduce resolution to a few counts for spectral regions which show very low signals. This may lead to not inconsiderable measurement uncertainties or to significant effects simply not being resolved.

An exposure series with different exposure times, which are in the end combined to one measurement, can reduce the effects of a fixed exposure time on the measurement uncertainty.

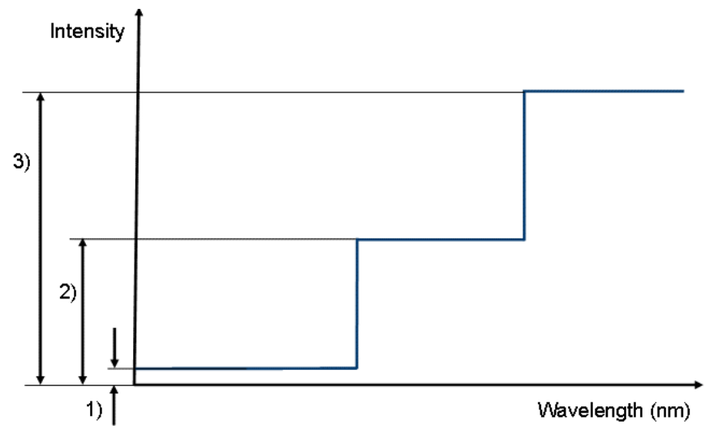


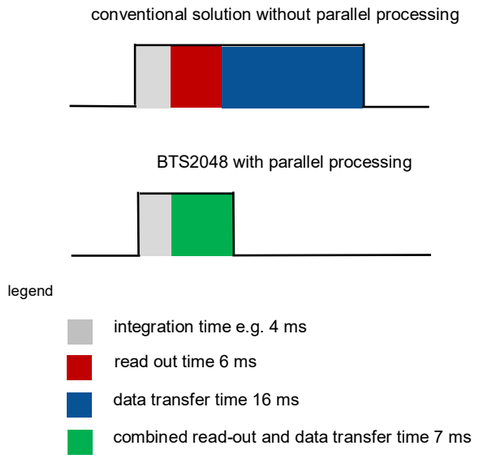
Image: Example exposure series with three different exposure times
1) Long exposure time for an optimal signal-to-noise ratio in the spectral range 1) with possible saturation in the spectral range 2) and 3). 2) Exposure time for optimum signal-to-noise ratio in the spectral range 2) with low resolution in the spectral range 1) and saturation in the spectral range 3). 3) Short exposure time for an optimal signal-to-noise ratio in the spectral range 3) with reduced signal-to-noise ratio in the spectral range 1) and 2). 4) These three single measurements, are combined (stitched) into one High Dynamic Range (HDR) measurement. Thereby from each single measurement only the well resolved signals are used.

FAST

The data-logging of spectral measurements of light sources whose emission spectrum changes rapidly with time requires the handling of immense amounts of data.

Several criteria determine the maximum possible recording rate:

- For CCD arrays, sensitivity is set by the integration time and any additional optical attenuation filters. The wide range of integration times of the BTS2048 UV-VIS spectroradiometer from 2 µs up to 4 s or 60 s (depends on version) enables measurement over a very wide dynamic range without changing the attenuation filter thereby avoiding any measurement interruption or additional sources of measurement uncertainty. The short integration times are achieved by an incorporated electronic shutter. Typically, alternative devices start with integration times of only 5 ms, which is more than a factor of 1000 (OD3) worse.
- The control electronics of the BTS2048 UV-VIS-IR spectroradiometer incorporates three microprocessors for sensor control, measurement data evaluation and data transmission and thus supports parallel measurement and data acquisition
- The BTS2048 UV-VIS-IR spectroradiometers with their Ethernet interface offer a maximum in terms of data transmission speed of typically 7 ms for 2048 pixels.



application example

Spectral measurement of the time-burning behavior of pyrotechnic rescue devices with the BTS2048-VL.

Pyrotechnic signaling devices are distress signals that indicate the need for assistance in the event of danger. In Germany, only products approved by the Federal Institute for Materials Testing (BAM) may be used.

The BTS2048-VL spectroradiometer records the time course of the light intensity. For this purpose, the luminous intensity is calculated from the illuminance measurement and the distance between the distress signal and the measurement device. Light color and emission spectrum are also measured.

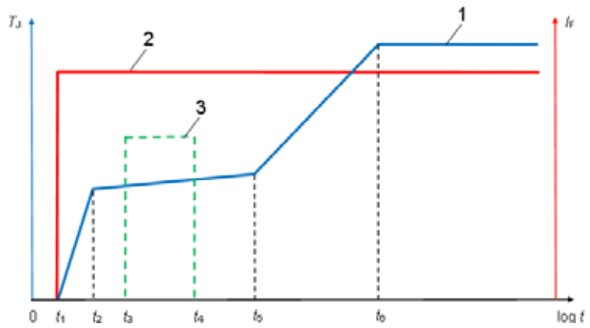
In addition to its technical features, the BTS2048-VL is particularly suitable for this measuring task due to its mobility and compatibility with standard photographic tripods.

SYNCHRONIZED

In CCD arrays, the charges resulting from the exposure of each pixel within the sensor are successively transported through a shift register to a central A / D converter.

The pixel charges are measured one after the other. For very short measurements (µs range) mechanical shutters are too slow, hence some pixels might still be exposed to light during the mechanical shuttering process. In order to overcome this, it is necessary to set the responsivity of all pixels to zero before and after the measurement simultaneously. This is done with the electronic shutter of the BTS2048 spectroradiometers.

Schematic depiction: Change of TJ when energized

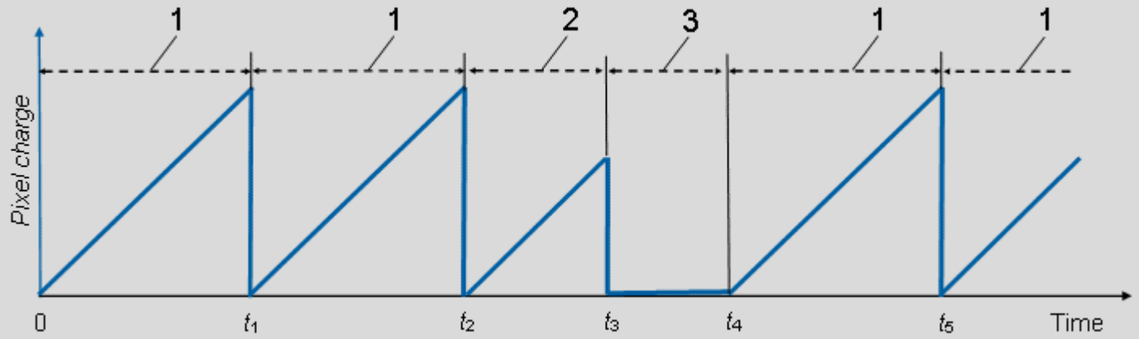


Legend: t time in s (logarithmic representation); 1 Time course of the temperature change TJ of the PN junction of the LED; 2 Time course of the forward current IF; 3 Time course of the measurement; TJ Junction temperature in ° C; IF Forward current in A

Image: TPI21-TH Semiautomatic LED Measurement System for luminous flux, color and spectra with junction temperature controller. The integrating sphere moves into position to measure the LED in its test holder.

Legend
1 Integration time
2 Interrupted integration time
(by electronic shutter)
3 No charge (Electronic shutter active)
f4 Synchronized measurement start of all pixels

Schematic depiction: Pixel charge process



The BTS2048 UV-VIS-IR spectroradiometers offer a number of special features for fast measurements:

- Electronic shutter to zero all pixels of the CCD array detector before and after a snapshot
- Synchronization of the measurement by an internal trigger (provided by incorporated photodiode) or by an external trigger signal
- Delay-free triggering of the measurement (jitter in the ns range), since the trigger signal is passed directly via the processor to the CCD sensor
- Multiple trigger protocols
- Flicker measurements with the BTS2048 series

application example

Despite the most sophisticated manufacturing technologies used by the semiconductor industry, the light output and color temperature of LEDs varies from chip to chip. Therefore, binning is employed to maximize yields and to categorize products.

A fast measurement of the LEDs excludes their temperature response, which affects light intensity and emission spectrum. In order to avoid the need for a time-consuming burn-in process before their measurement, LEDs are measured shortly after switch on. This type of measurement requires precise synchronization of the LED power supply and the measurement device. The electronic shutter of the BTS2048 spectroradiometer allows synchronized measurements. The measurement itself is described in DIN 5032 Part 9.

BTS2048-VL

Measurand	Unit	Optic
Spectral irradiance	W/m^2 nm (W/cm^2 nm)	Diffuser with precise cosine field of view function. Directly attached to the instrument (standard version).
Photometric unit: Illuminance	lx (fc)	

BTS2048-UV-S-F with CP-CD-IL-10

Measurand	Unit	Optic
Spectral irradiance	W/m^2 nm (W/cm^2 nm)	Diffuser with precise cosine field of view function. Attached by fiber optic to the instrument.
Photometric unit: Illuminance	lx (fc)	

BTS-SOLAR

Measurand	Unit	Optic
Spectral irradiance	W/m^2 nm	Limited field of view optic on sun tracker for direct solar irradiance

BTS2048-VL with ISD-15-V01

Measurand	Unit	Optic
Spectral radiant flux	W / nm	Integrating sphere for 2Pi emitters. Sphere configured with dust protective entrance window and auxiliary lamp. Option: Re-calibration lamp
Photometric unit: Luminous flux	lm	

BTS2048-VL with ISD-100HF-V06

Measurand	Unit	Optic
Spectral radiant flux	W / nm	Hinge frame integrating sphere for 4Pi emitters. One hemisphere for opening. Height-adjustable sample holder. Auxiliary lamp. Option: Re-calibration lamp
Photometric unit: Luminous flux	lm	

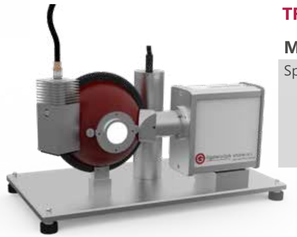
LDM-C50 WITH BTS2048

Measurand	Unit	Optic
Spectral radiance	W/sr nm	Radiance optic for measuring distances betwen 0.45 m to infinity.

BTS2048-VL with GB-GD-RB40-2

Measurand	Unit	Optic
Spectral radiant intensity distribution	W/sr nm	Goniometer. Option: BTS2048 mounting adapter for existing goniometer. Software developing kit.

TFUV10 including BTS2048-UV-2



Measurand	Unit	Optic
Spectral radiant flux	W / nm	Integrating sphere for 2Pi UV LEDs. Sphere configured with UV-C conditioning lamp to reduce UV-C fluorescence. Auxiliary lamp. Option: Re-calibration lamp

ABSOLUTE RADIOMETRIC MEASUREMENTS

To measure optical radiation in different absolute radiometric quantities, spectroradiometers require different entrance optics with corresponding calibrations.

Gigahertz-Optik manufactures a wide range of accessory optics in standard and custom designs for the BTS2048 UV-VIS-IR spectroradiometers with associated calibrations traceable to National Metrological Institutes (NMI).

BTS2048-IR

Measurand	Unit	Optic
Spectral irradiance	W/m^2 nm	Diffuser with precise cosine field of view function. Directly attached to the instrument (standard version).

BTS2048-VL-TEC with LDM-1901

Measurand	Unit	Optic
Optical hazard effective radiance of LEDs	W/sr nm	Radiance optic with 200 mm and 1000 mm focal length to measure optical hazards to the retina. IEC / EN 62471 compliant within the wavelength range from 300 nm to 1050 nm.

TFCT25 including BTS2048-VL-TEC

Measurand	Unit	Optic
Spectral irradiance for monitoring	$W/(m^2$ nm) $W/(cm^2$ nm)	Integrating sphere configured with light source(s) for use as uniform light source. Spectroradiometer for monitoring system spectral irradiance with calibration correction to display spectral radiance at the exit port of the uniform light source.

ROBUST

One of the biggest challenges for a spectroradiometer is its use outdoors.

It's not just about weatherproofing the device. The real challenge is to maintain high standards of accuracy, robustness, and repeatability under acute environmental conditions.

From the standpoint of robustness, several parameters have to be considered for outdoor use:

- Mechanical stability in static and moving applications
- Temperature resistance to hot and cold ambient conditions as well as direct sunlight
- Water and dust tightness
- Self-cleaning of the entrance optics of ice and moisture

This requires a robust design of the measuring device with as few mechanical control elements as possible and a staggered temperature strategy for the spectrometer and its protective cover.
The BTS2048 spectroradiometers, with their compact design and temperature stabilized CCD array sensor along with an additional temperature controlled weatherproof housing, offer the required robustness for hard outdoor use in continuous monitoring applications.

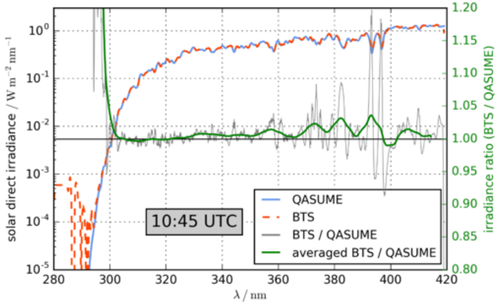


Image 2

With the weatherproof BTS2048-UV-S-WP spectroradiometers, an array spectroradiometer which is able to compete with double monochromators is now available for the first time. This quality has been shown in several inter-comparison campaigns. With this technology the mentioned limiting features of double monochromator spectroradiometers can be significantly improved upon.

As part of the German Solar UV Monitoring Network, the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz) has carried out a validation of the BTS array spectroradiometer for measuring solar UV radiation in alpine climate regions. BTS2048-UV-S-WP measurements were compared with those of a double monochromator spectroradiometer.

After one-year's use at the Schneefernerhaus research station on the Zugspitze Mountain, the array spectroradiometer has proved to be a good alternative to double monochromators. The generally shorter measurement time of the array measurement technology enables, for instance, more accurate measurements under fast changing cloud conditions.

Image 1: CCD array spectroradiometer with sun tracker for recording the total ozone column (TOC) by direct measurements of solar radiation in the UV spectral range

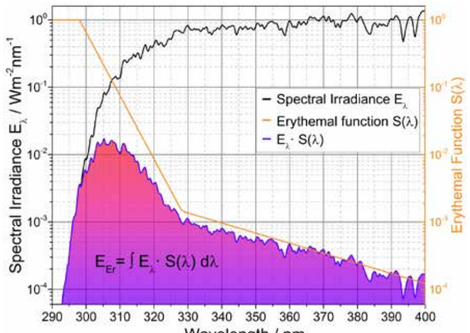
Image 2: BTS2048-UV-S-WP at mount Zugspitze

application example

For monitoring solar UV radiation and the resulting UV index, double monochromators were the standard measuring instrument for spectral irradiance due to their high stray light suppression (according to WMO recommendations). Only these devices provided a sufficiently high dynamic range and stray light suppression to accurately determine e.g. solar UV Index. For total ozone column Dobson, Brewer or the double monochromator based QASUME are accepted worldwide. In order to achieve this sufficient stray light suppression, the limiting features of the double monochromator spectroradiometer were accepted:

- Large footprint with resulting low mobility
- Mechanical drive assemblies with high maintenance requirements
- Scanning grating measuring method with long measuring times
- Significantly higher price

With the weatherproof BTS2048-UV-S-WP spectroradiometers, an array spectroradiometer which is able to compete with double monochromators is now available for the first time. This quality has been shown in several inter-comparison campaigns. With this technology the mentioned limiting features of double monochromator spectroradiometers can be significantly improved upon.



Erythemally weighted spectral irradiance E_{Er}

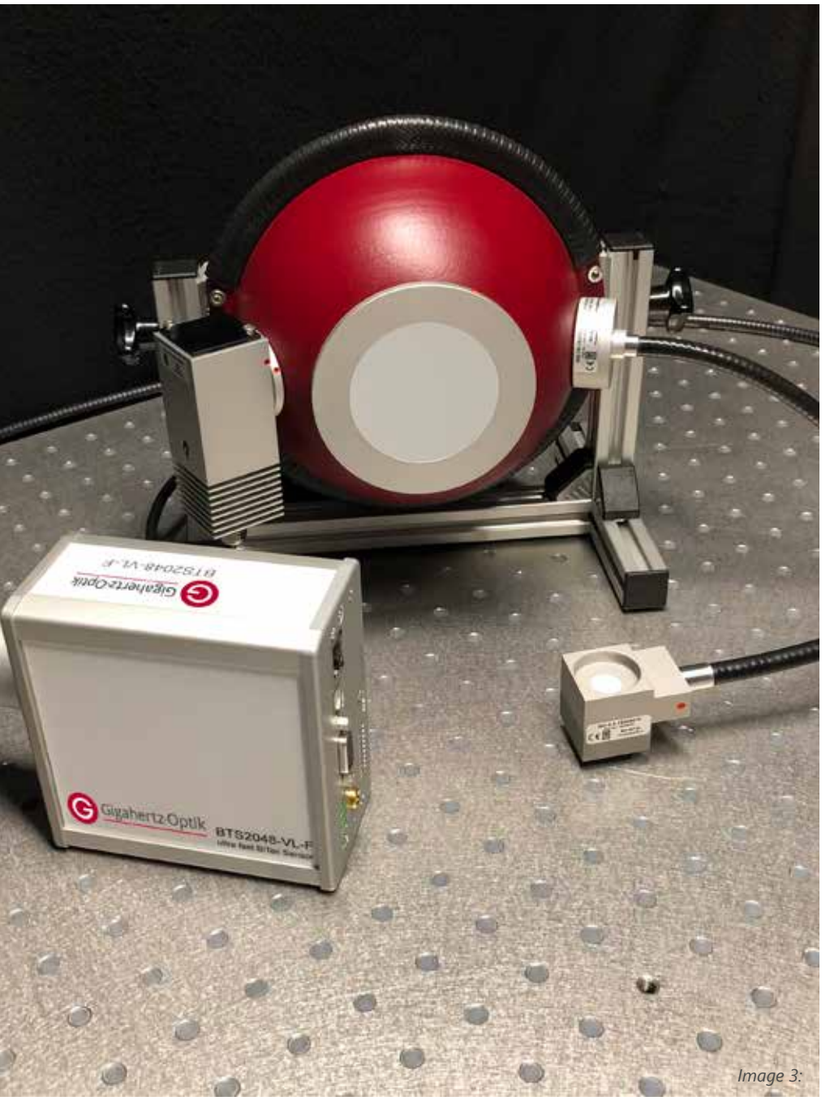


Image 3:

Another feature of the fiber optic bundles is bifurcation. Dividing the fiber into e.g. two branches offers the possibility to illuminate two meters in parallel or to connect two complementary products at the same time to a spectroradiometer. Three or more meters are also possible in order to cover all needs.

Image 1:

Image 2:

FLEXIBLE

A special feature of the BTS2048 spectroradiometer is its integrated diffuser.

In combination with its compact dimensions, the BTS2048 instrument is suitable for measuring spectral irradiance, illuminance and light color while mobile. In addition, they can be attached directly to goniometers, integrating spheres, radiance optics, etc. The additional complexity and cost of a light guide with the required precision connector is avoided.

Despite all these features, even the BTS2048 series compact spectroradiometers may be too big for some applications or the direct use of electronics in the light source area may not be possible. In such cases, BTS2048 devices are available with a fiber optic connection as an alternative solution.

Image 1: UV spectroradiometer BTS 2048-UV-S-F with flexible light guide and diffuser with axial alignment

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Image 2: BTS 2048-VL-TEC with BTS 2048-UV with Y-light guide for spectrometric radiometric measurement tasks in the extended spectral range from 200 nm to 1050 nm

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Image 3: Large and small integrating spheres connected to a BTS2048-UV-S by means of a Y-light guide

application example

We, Promega (USA), are developing optical devices for biophysical and genomic analysis. The spectrometer is used to test and evaluate various materials and light sources. The fiber optic option with cosine diffuser was not a special requirement. We use it as an auxiliary feature to extend the spectroradiometer's functionality and make it more universal across the full range of our tests and experiments.

PORTABLE

The BTS2048 is an extremely compact self-contained spectroradiometer.

Formerly, high accuracy spectroradiometers only came in bulky housings many with heavy base plates limiting their portability and mobility. This type of spectroradiometer generally required connection into the application via flexible fiber optic light guides.

The BTS2048 is an extremely compact self-contained spectroradiometer. It easily mounts into existing apparatus ready to operate without the de-stabilizing effects of light guides. Nevertheless, it offers all the necessary features and functionalities for high-quality radiometric measurement tasks in the UV-VIS-IR spectral range:

- Compact metal housing (103 mm x 107 mm x 52 mm)
- Low weight (500 grams)
- Front adapter for connection to complementary product range
- 1/4-inch, 20-tpi UNC and M6 threads for mounting
- No limitation of the operating orientation
- Diffuser with precise cosine field of view for direct measurement of irradiance and illuminance
- USB-2 and Ethernet interface
- I / O interface

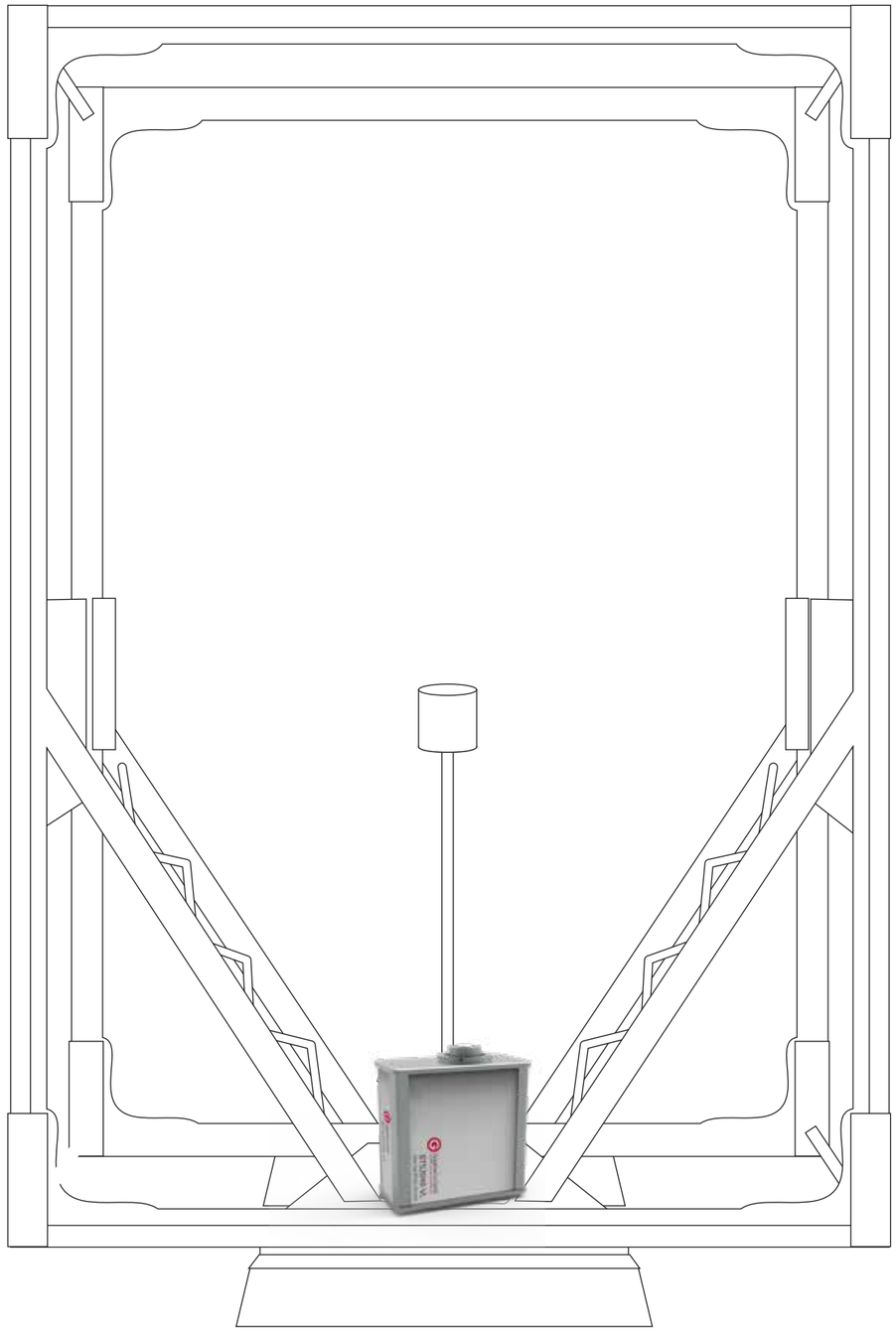


Image: BTS2048-VL-TEC retrofit into a goniometer system

application example

Goniometers measure the spatial light intensity distribution of lamps and luminaires. Historically, photometric broadband detectors have been used for such goniometric measurements. For traditional light sources, e.g. halogen lamps and fluorescent tubes, the quality of those instruments was quite sufficient.

LEDs can exhibit significant variation in their spectral emission distribution. For example, this can be caused by the distribution of phosphor within a device package or by lens effects (e.g. chromatic aberration). Therefore, spectral light meters are recommended and increasingly required for the measurement of LEDs. Of course, the spectral differences of the LEDs also affect the color temperature (CCT). Retrofitting the goniometer to measure the spatial color temperature distribution also expands the benefits of the goniometer in use.

On goniometers with a swivel arm, the detector is guided around the light source to measure the light intensity distribution. If the original photometric filtered detector is to be replaced by a spectroradiometer, then it must have a number of features:

- Compact size and easy mounting
- Accuracy and reliability in all operating positions for mounting on the swivel arm
- Short measurement times and high sensitivity for a high throughput rate of measurements
- Powerful processor for measurement data evaluation
- Fast data transfer to the computer
- Software development tool for the integration of the instrument in the user software
- Traceable calibration

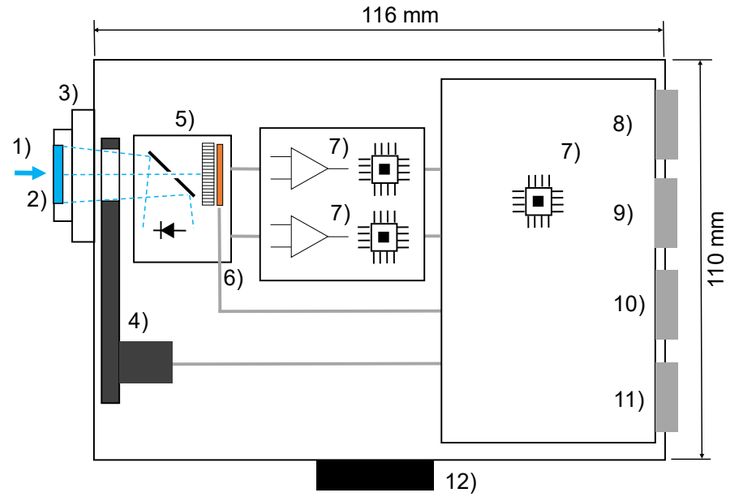
The BTS2048-VL-TEC spectroradiometer fulfills the requirements listed above in all respects.

SPECIFICATIONS

Model	Optical bandwidth	Measurement optic
200 nm - 430 nm		
BTS2048-UV	0.8 nm	Diffusor window
BTS2048-UV-F	0.8 nm	Fiber connector
BTS2048-UV-S	0.8 nm	Diffusor window
BTS2048-UV-S-F	0.8 nm	Fiber connector
BTS-Solar	0.8 nm	Diffuser window with narrow F.O.V. tube Sun tracker and sun finder
200 nm - 550 nm		
BTS2048-UV-2	1.0 nm	Diffusor window
BTS2048-UV-2-F	1.0 nm	Fiber connector
200 nm - 900 nm		
BTS2048-UVVISNIR		
280 (350) nm - 1050 nm		
BTS2048-VL	2.0 nm	Diffusor window
BTS2048-VL-F	2.0 nm	Fiber connector
BTS2048-VL-TEC	2.0 nm	Diffusor window
BTS2048-VL-TEC-F	2.0 nm	Fiber connector
BTS2048-VL-TEC-WP	2.0 nm	Diffusor window
350 nm - 1100 nm		
BTS2048-VISNIR-TEC	2.0 nm	Diffusor window
BTS2048-VISNIR-TEC-F	2.0 nm	Fiber connector
400 nm - 530 nm		
BTS2048-BS	0.3 nm	Diffusor window
950 nm - 2150 nm		
BTS2048-IR	9 nm	Diffusor window
200 nm - 3000 nm		
SST-18xx	0.8 nm (200 to 430 nm) 2.0 nm (280 to 1050 nm) 9 nm (950 to 2150 nm) 850 nm (2150 to 3000 nm)	Diffusor window

TECHNICAL FEATURES

The BTS2048 UV-VIS-IR spectroradiometers offer technical functions for high-quality spectroradiometric measurement tasks in a wide variety of applications.



1)	Radiation input	Optical radiation directly enters the BTS2048 through its diffuser window
2)	Measurement optics	Different input optics are available: • Diffuser made of high quality quartz material provides a precise cosine field of view adjustment and allows the measurement of the spectral irradiance or illuminance without additional optics • Fiber adapters allow connection of flexible fiber optic light guides
3)	Front mount	The front mount of the BTS2048 spectroradiometers enables stable attachment to integrating spheres and other accessories
4)	Filter wheel	The compact filter wheel between input optics and BiTec sensor for best stability. In addition to a light-tight aperture for dark offset measurements, the filter wheel is equipped with attenuation filters and optical correction filters, depending on the BTS model. The optical attenuation filters are implement with hole-patterned technology and thus offer spectrally neutral transmission. UV versions are fitted with special bandpass and long-pass filters for optimum stray light rejection.
5)	BiTec-Sensor	The BiTec sensor is constructed with two detectors. The BiTec Sensor is constructed with two detectors. Depending on the spectral range, there is either a CCD (UV and VIS devices) or a CMOS (IR devices) array as the first detector and a photodiode as the second detector. Each of the two high-quality detectors on their own offers design-related benefits and limitations. Through bilateral correction, these detectors ensure precise radiometric and spectroradiometric measurement values over a huge dynamic range.
6.	Peltier cooler	The cooling of the array detector allows longer exposure times due to reduced noise. The UV or IR spectroradiometers are generally offered with a Peltier cooling element. For the visible spectral range instruments, the Peltier cooler is available as an option.
7)	Electronic	BTS2048 ‘s sophisticated electronic design incorporates three microprocessors. Two are used to evaluate the array detector and the photodiode. The 32 bit main processor is responsible for the calculation of absolute values from the measured data and interface communication.
8)	Ethernet interface	Very fast data transfer rate. LAN UDP protocol.
9)	USB interface	USB V2.0 (500 mA power in laptop mode)
10)	RS232/RS485 interface	Industry standard
11)	Voltage, Synchronization and I / O	Power supply (required for Peltier cooler and maximum CPU utilization) Trigger input (different options, falling / rising edge, delayed, etc.)
12)	Housing	Stable, EMC protected metal construction. 1/4-inch, 20-speed UNC and M6 threaded socket for mounting

Gigahertz-Optik

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With its innovative and high-quality products as well as application solutions, Gigahertz-Optik enjoys a high regard from its international customers within the field of optical radiation measurement technology. As a manufacturer, Gigahertz-Optik offers standard and custom-made solutions. Regular investments in new technologies ensure that Gigahertz-Optik is able to offer modern measuring solutions to its customers in industry and science.

Broadband light measurement devices

- UV radiometers
- Photometers
- Light hazard meters

Spectral light meters

- Handheld devices
- High-end devices
- UV-VIS-IR Spectroradiometer
- Weather-proof devices
- Light transmission

Complementary products

- Integrating spheres
- Integrating sphere light sources
- Calibration standards
- Electronics, optomechanics
- Optically diffuse materials

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