Enter a new world of accuracy with HighFinesse/Ångstrom sensitive, compact wavelength meters.

- **The most accurate instruments available**
  Absolute accuracy up to ± 2 MHz with a measurement resolution of 500 kHz
- **Extremely wide wavelength range**
  From hard UV to MID-IR (192 nm – 11 µm)
- **Unrivaled technology without moving parts**
  Allows measuring single pulse, pulse, quasi-cw and cw lasers
- **Unique instrument design**
  Highspeed measurement (up to 500 Hz) and feedback control of up to 8 lasers
- **Fizeau-interferometer technique**
  Insensitive to intensity fluctuations or sidemodes
- **Quick and easy to use due to ultra sensitive detectors**
  < 50 pJ @ 500 nm
- **Ultra wide spectral measurement of cw and pulsed lasers**
  350 – 1100 nm at once with 10 pm resolution

Ångstrom

HighFinesse
Laser and Electronic Systems

Technical Data		Unit	WS5	WS6		WS7	WSU			LSA	HDSA
				6-600	6-200		U-30	U-10	U-2		
Measurement range availability	Standard (350 – 1120 nm)		●	●	●	●	●	●	●	●	●
	UV (248 – 1100 nm)		●	●	●	●	●	○	○	●	○
	UV-II (192 – 800 nm)		●	●	●	●	○	○	○	○	○
	UV-II-VIS (192 – 1190 nm)		○	○	○	○	○	○	○	●	○
	VIS-IR (400 – 1750 nm)		●	●	●	○	○	○	○	○	○
	IR (800 – 1750 nm)		●	●	●	●	●	●	○	●	●
	IR-II (1000 – 2250 nm)		●	●	●	●	○	○	○	○	○
	IR-III (2 – 11 µm)		●	○	●	○	○	○	○	●	○
Absolute accuracy [6]	192 – 370 nm [1]	pm	3	0.6	0.4	0.2	0.1	0.1	0.1	6	–
	370 – 1100 nm	MHz	3000	600	200	60	30	10 [4]	2 [5]	6000 [8]	3000
	1100 – 2250 nm	MHz	2000	400	150	40	20	10 [4]	–	12000	3000
	2 – 11 µm	MHz	2000	–	200	–	–	–	–	1 – 5 nm [13]	–
Quick coupling accuracy (with multi mode fiber)		MHz	3000	600	600 [14]	150	100			12000	3000
Measurement resolution [2]		MHz	1000	100	50	10	5	2	0.5 [5]	3000 [9]	30000
Linewidth option [2]	Accuracy	MHz	2000 [3]	500 [3]	400 [3]	200 [3]	100 [3]			7000 [3]	10000
Measurement speed [7] (depending on PC hardware and settings)	Data acquisition	Hz	600			500				500	20
	Wavelength calculation	Hz	600			400				60	5
	Linewidth calculation	Hz	500			400				50	5
	Pattern display	Hz	300			150				50	15
Required input energy and power	Standard	µJ (or µW) [11]	0.02 – 15			0.01 – 10	0.02 – 15			0.0001 – 0.04	0.05 – 10
	UV	µJ (or µW) [11]	0.02 – 10			0.01 – 6	0.02 – 10	–	–	0.0001 – 0.1	–
	UV-II	µJ (or µW) [11]	0.02 – 200			0.01 – 100	–	–	–	–	–
	IR	µJ (or µW) [11]	2 – 200		1 – 100		2 – 200		–	0.02 – 2	0.05 – 10
	IR-II	µJ (or µW) [11]	2 – 80 [12]				–	–	–	–	–
	IR-III	mW	1	–	1	–	–	–	–	0.2	–
Calibration			Built-in calibration [16]			Built-in calibration [10]	Stabilized HeNe laser or any other well known laser source dv < 3 MHz		SLR-780 or any well known laser source dv < 1 MHz	Built-in calibration [10]	External calibration source (included)
Recommended calibration period			≤ 1 month			≤ 14 days	≤ 10 hours	≤ 1 hour	≤ 2 minutes	≤ 1 month	≤ 2 weeks
Warm-up time			No warm-up time under constant ambient conditions [15]				> 30 minutes			No warm-up time under constant ambient conditions [15]	
Dimensions L × W × H		mm	360×120×120		360 × 200 × 120					325×180×77	360×210×120
Weight		kg	2.8		5.3	5.6	6.3			2.8	4.8
Interface			High-speed USB 2.0 connection								1000BASE-T
Power supply			Power consumption < 2.3 W, power provided directly via USB cable IR-II, IR-III: external power supply included; IR-I and WSU via USB or external power supply possible								external power supply included

1) With multi mode fiber
2) Only for standard range
3) But not better than 5% (LSA: 10%) of the linewidth
4) ± 200 nm around calibration wavelength
5) ± 2 nm around calibration wavelength
6) According 3σ criteria
7) Without switch and autocalibration usage
8) IR-LSA: 800 – 1750 nm: 12 GHz
9) IR-LSA: 15 GHz
10) For IR-II and IR-III ranges: external reference needed, e.g. SLR-1532
11) The cw power interpretation in [µW] compares to an exposure of 1s (generally the energy needs to be divided by the exposure time to obtain the required power)
12) µJ interpretation for pulsed lasers; cw signals need more power in [µW] since the exposure is limited at IR-II devices
13) depending on device type
14) 200 MHz for WS6-200 IR-III
15) except IR-II: > 30 minutes warm-up time required. Otherw. until thermal and air pressure equilibrium is reached.
16) For IR-II and IR-III ranges: external reference needed, e.g. SLR-1532.

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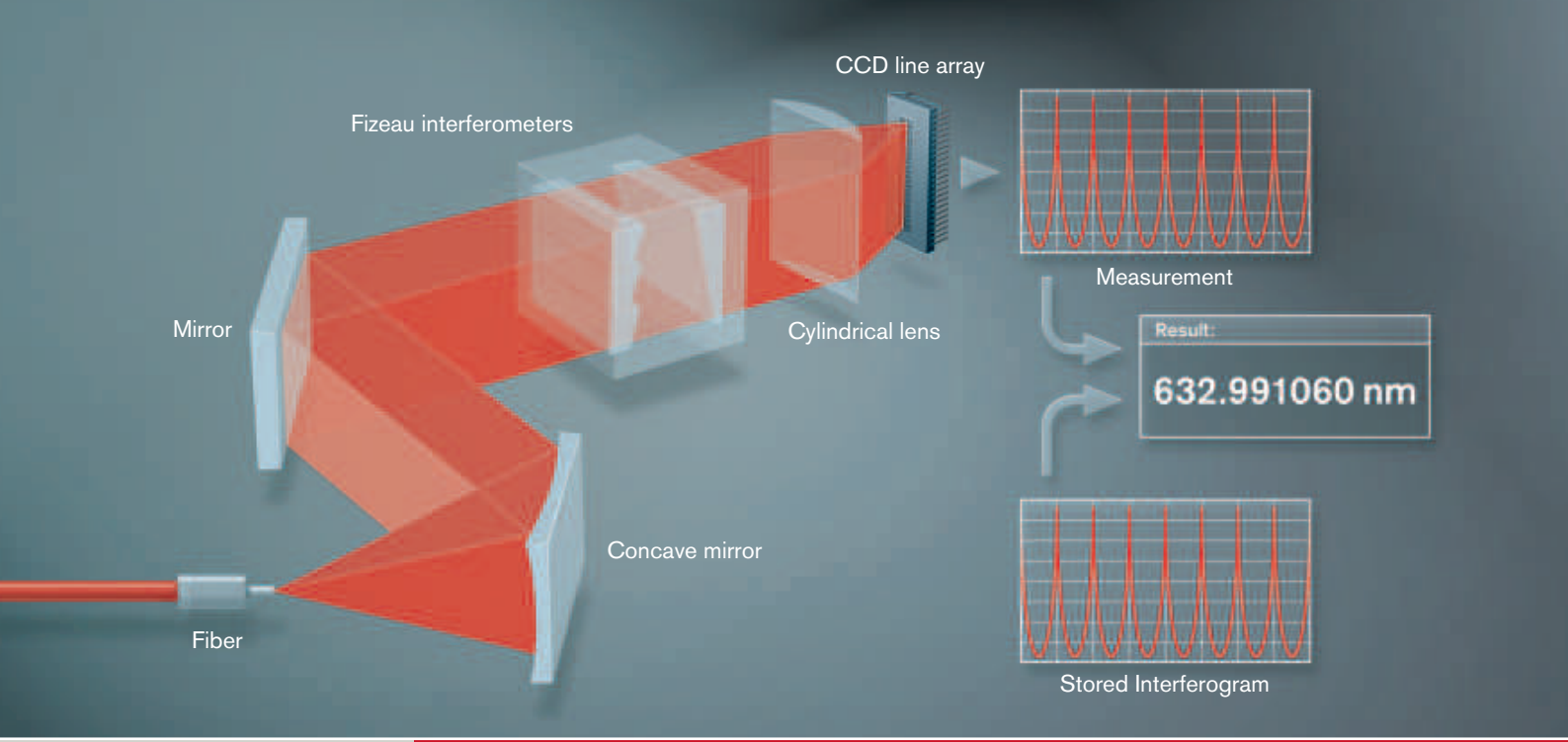


The optical unit consists of Fizeau-based interferometers which are read out by photodiode arrays. We achieve remarkable high accuracy and stability by using exclusive, solid-state, non-moving optics.

The light is coupled into the device via a fiber and then collimated by a mirror, before entering the solid-state Fizeau-interferometers. The interference pattern is projected by a cylindrical lens onto CCD photodiode arrays. This recorded pattern is transferred to your computer via a high-speed USB 2.0 connection which allows data acquisition rates of up to 600 Hz. The software fits and compares the pattern to the previously recorded calibration to calculate the wavelength.

One significant advantage of our Fizeau-based wavelength meters, compared with other available instruments, is the absence of mechanical moving parts. This ensures the high reliability of accuracies up to 2 MHz (absolute) and ensures the outstanding robustness HighFinesse wavelength meters are noted for. The sturdiness of this design has been proven even under extreme conditions such as freefall dropping experiments or in air-borne applications (LIDAR).

Another key benefit is the simplicity our wavelength meters offer. Simply connect the USB cable and run the program supplied. That's all it takes! An additional power supply is not necessary (except WSU and IR-Option), which makes handling especially safe and easy.

The optical unit and the associated electronics are packaged in a compact, thermally insulated housing. The device is connected to the computer via high-speed USB 2.0 port. The user-friendly graphical interface displays all interferometer information and is compatible with Windows. Additionally, all necessary controls and actions can be set, read and performed via external software access. An easy-to-use API can be accessed to completely integrate wavelength meter functionality into your own applications, with development environments such as C/C#/C++, Delphi, VB/VBA, LabVIEW, CVI, HP-Vee and other software.

Basic Features of the Standard Instruments:

■ Pressure consideration for enhanced measurement stability

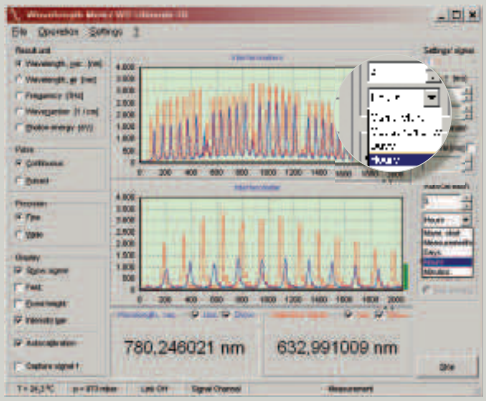
Measurements are temperature and (new) pressure compensated using ultra sensitive temperature and pressure sensors. That way it is possible to use the devices in aviatic measurement environments, high altitudes, LIDAR, ...

■ Thermal insulation for enhanced measurement stability

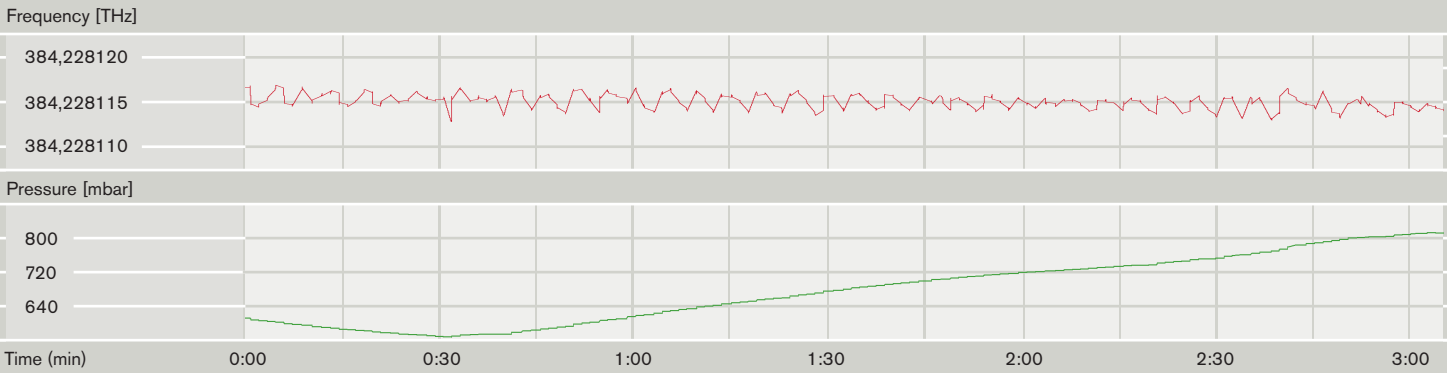
The following graph shows a measurement of a WS6-600 in a climate chamber. The thermally insulated casing contributes to the high stability of wavelength measurements. The internal temperature sensor compensates for thermal drifts.

■ Measurement of Wavelength & Frequency

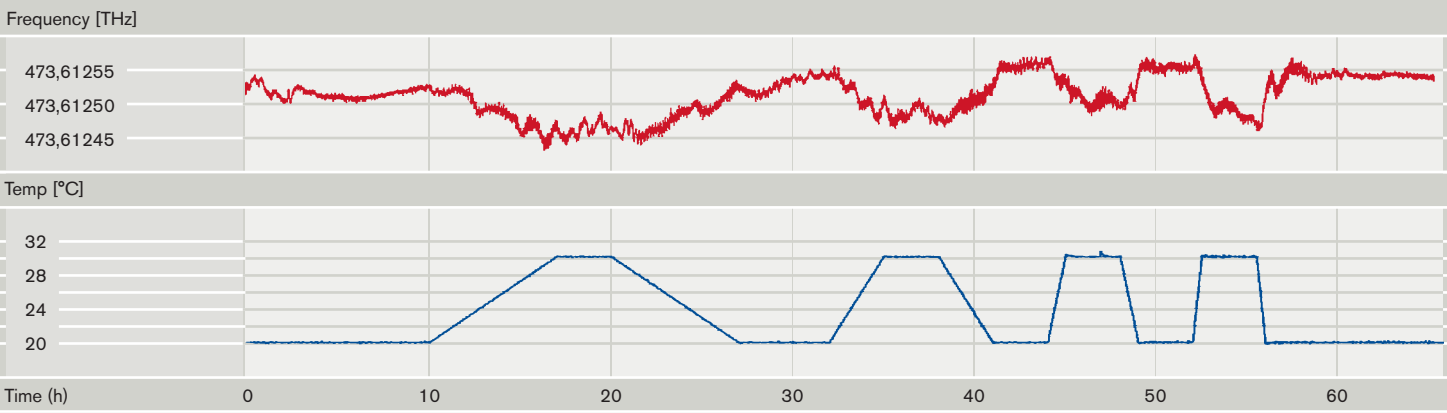
The measurement result is displayed on the computer via the supplied software and graphical user interface. Installation and set-up are fast and easy. The displayed results may be switched between wavelength, frequency, wavenumber or energy to suit your requirements. The interference pattern displayed provides information regarding the spectral profile of pulsed or continuous wave laser sources.



Stability of pressure (Ultimate 2, autocalibration with SLR 780)



Stability of temperature (WS-7, no calibration during whole 3 days measurement)



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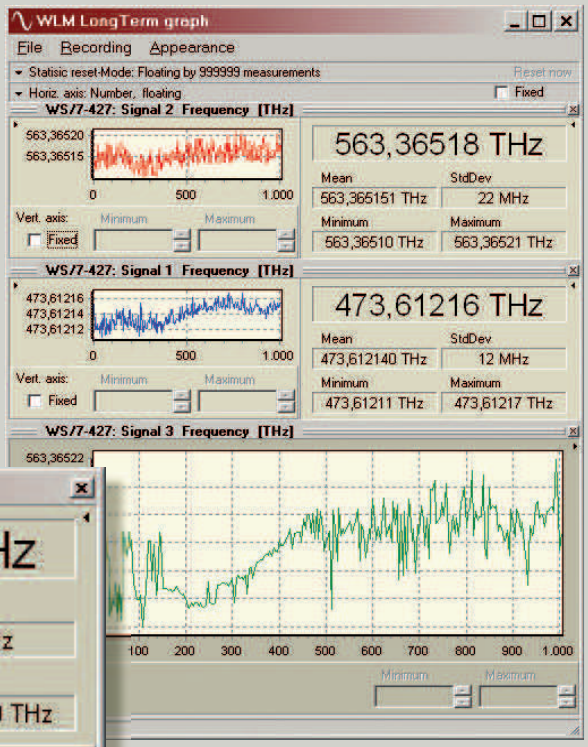
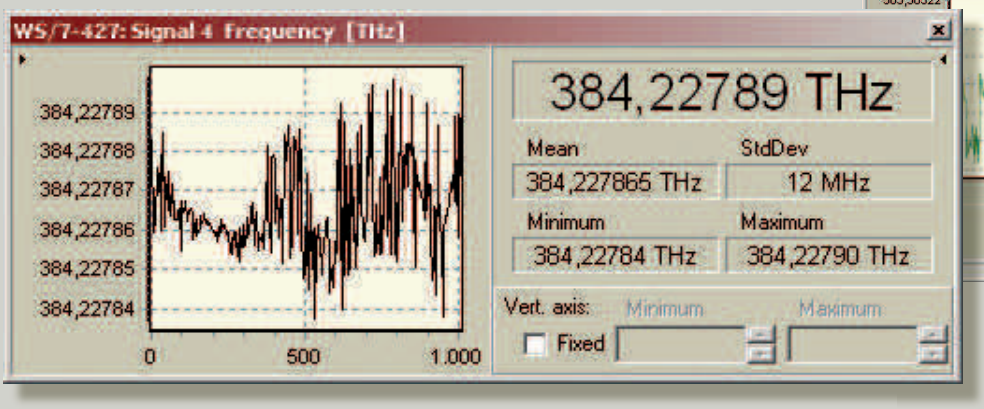
■ Record and Replay Mode

The recording operation mode records all interferometric and measurement-related data to a file and allows subsequent playback.

■ Long-term Measurement

This application acquires the measured wavelength and other values (temperature, analog output, etc.), displaying mean, max. and min. wavelengths as well as standard deviations. The software also allows the user to display the idler frequency, by measuring the pump and signal laser, or by showing the frequency distance between two lasers (THz generation). Any number of long-term windows may be opened simultaneously to monitor up to 8 laser sources (multi-channel option) per wavelength meter. No other product offers this flexibility.





■ Internal calibration

LSA, WS5, WS6, WS6-200 and WS7 have as a standard feature automatic internal calibration. The calibration periode is selected either by measurement counts or time between calibrations.

■ Autocalibration

An external calibration source can be connected to a second FC/PC port for WSU-30 and WSU-10 calibration. With WSU-2 autocalibration can be performed via optical switch.

■ Quick coupling possibility

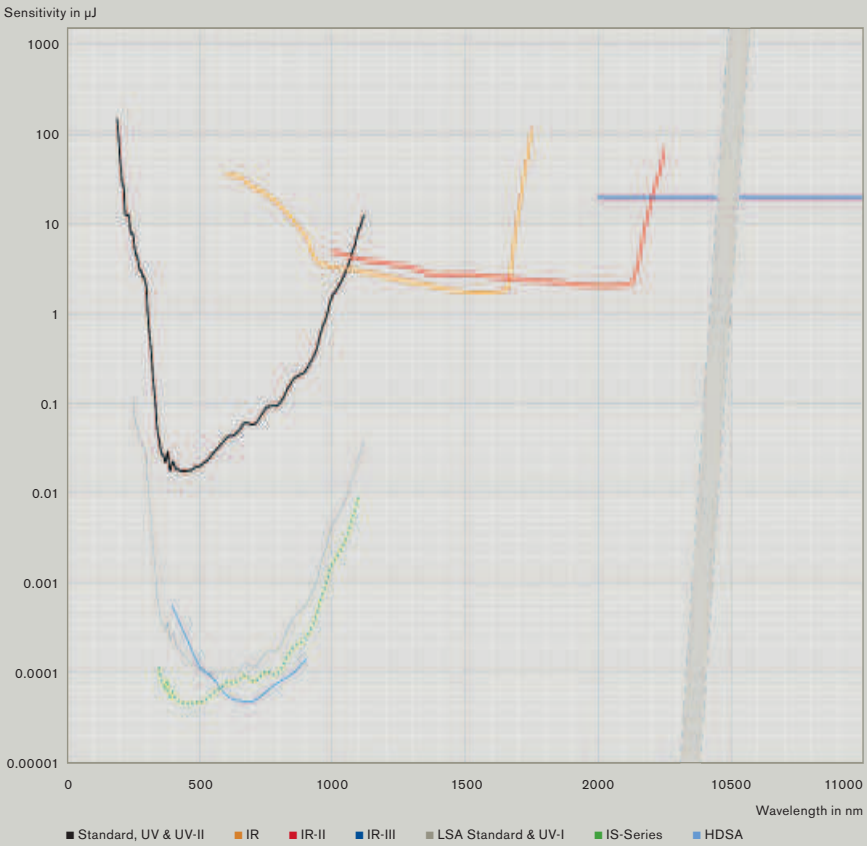
You can easily couple in using a 400 µm fiber by positioning the collimator in the beam by hand. If your laser runs between 370 – 900 nm a power output of approximately 10 µW is sufficient for free-hand coupling.

■ Built-in pulse detection

An integrated mechanism detects the optical peaks from a pulsed laser and allows synchronization with the measurement process.

■ NEW: Highest sensitivity

Most sensitive available detectors and special optical coatings allow highest power sensitivities down to pJ-range for small (IS-Series) and medium (LSA) spectral ranges and very good sensitivity for all ranges.



Sensitivity of WS-series in the available measurement ranges as well LSA and the new IS-series in standard range of 370 – 1100 nm.

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Calibration and Certification

To ensure the high quality and accuracy HighFinesse products are noted for, each wavelength meter is tested and calibrated individually. For this purpose, we use various high-precision laser systems:

Nd:YAG Laser

The diode pumped solid-state laser is frequency doubled and emits at 532 and 1064 nm. The laser frequency is locked to the iodine molecule absorption line R56, 32-0. The frequency of this line is 563.259 651 965 THz[Hol] corresponding to a vacuum wavelength of 532.245 576 181 nm. The uncertainty of this laser system is < 1 MHz.

HeNe Laser

The shown frequency stabilized HeNe-laser emits with a frequency of 473.612 467 THz corresponding to a vacuum wavelength of 632.991 060 nm. The laser has an uncertainty of ± 2×10^{-8}.

Frequency doubled Rubidium Spectroscopy Laser

A grating stabilized semiconductor laser diode is locked to a Rb-transition using saturated absorption spectroscopy it's frequency is doubled with a PPLN crystal. The frequency of the $5S_{1/2}$ F=2 → $5P_{3/2}$ F'=3 transition[Mar] of ^{87}Rb is 384.228 115 147 THz corresponding to a vacuum wavelength of 780.246 021 nm . The respective wavelength after frequency doubling is 390.123 010 nm. The linewidth of this laser system is < 1 MHz.

The measurement uncertainties of the different types of wavelength meters are estimated in accordance with the NIST Guidelines[Tay] as follows:

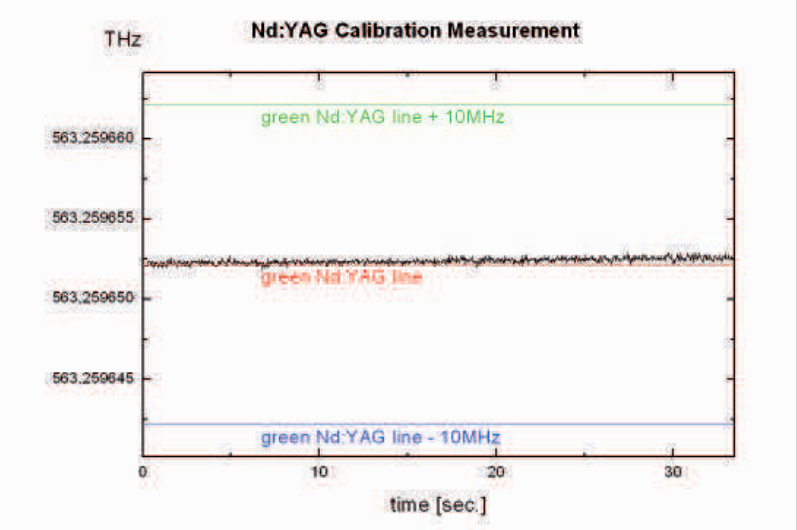
	Abs. accuracy[1]
LSA	6000 MHz
HDSA	3000 MHz
WS5	3000 MHz
WS6-600	600 MHz
WS6-200	200 MHz
WS7	60 MHz
IS/U7 [4]	60 MHz
WSU-30	30 MHz
WSU-10 [2]	10 MHz
WSU-2 [3]	2 MHz

1) in the range 370 – 1100 nm
2) ± 200 nm around calibration point
3) ± 2 nm around calibration point
4) within a wavelength range of several nm's

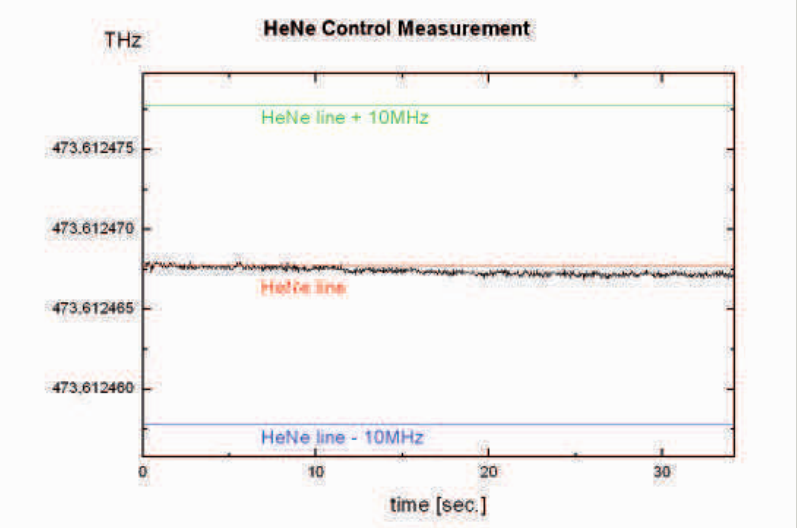
[Hol] R. Holzwarth et al., *Absolute frequency measurement of iodine lines with a femtosecond optical synthesizer*, Appl. Phys. **B 73**, 269-271 (2001).

[Mar] A. Marian et al., *Direct Frequency Comb Measurements of Absolute Optical Frequencies and Population Transfer Dynamics*, **PRL 95**, 023001 (2005).

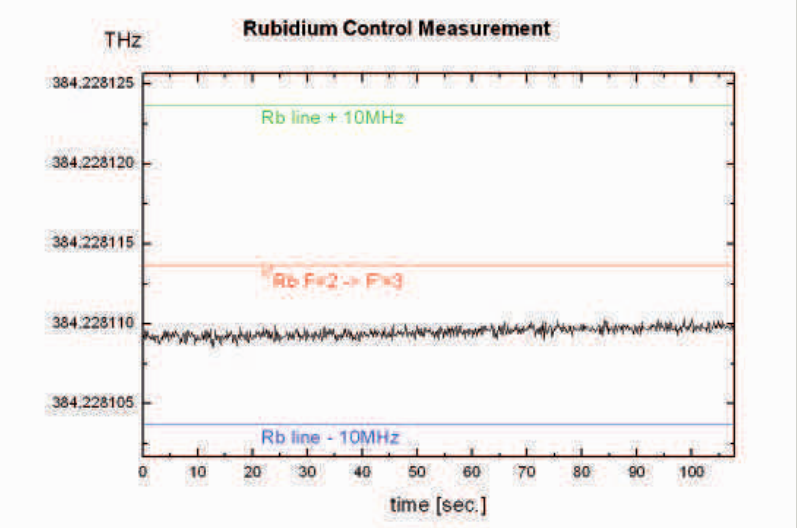
[Tay] B. Taylor and C. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note **1297** (1994).



Typical measurement of an Ultimate-10 after calibration with this Nd:YAG line.



Typical measurement of a stabilized HeNe laser after calibration with the Nd:YAG laser system.



Typical measurement of the Rb-line after calibration with the Nd:YAG laser system.

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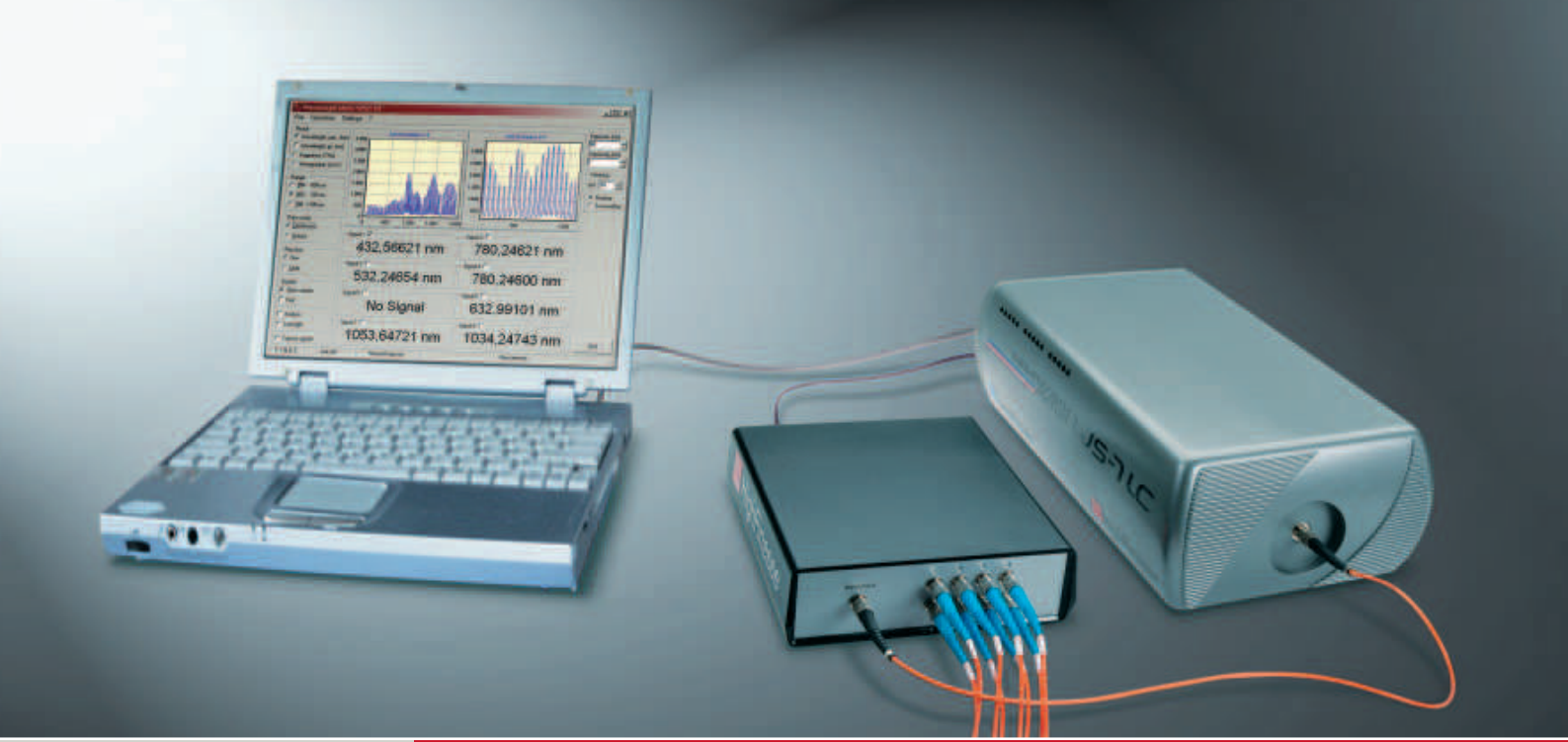


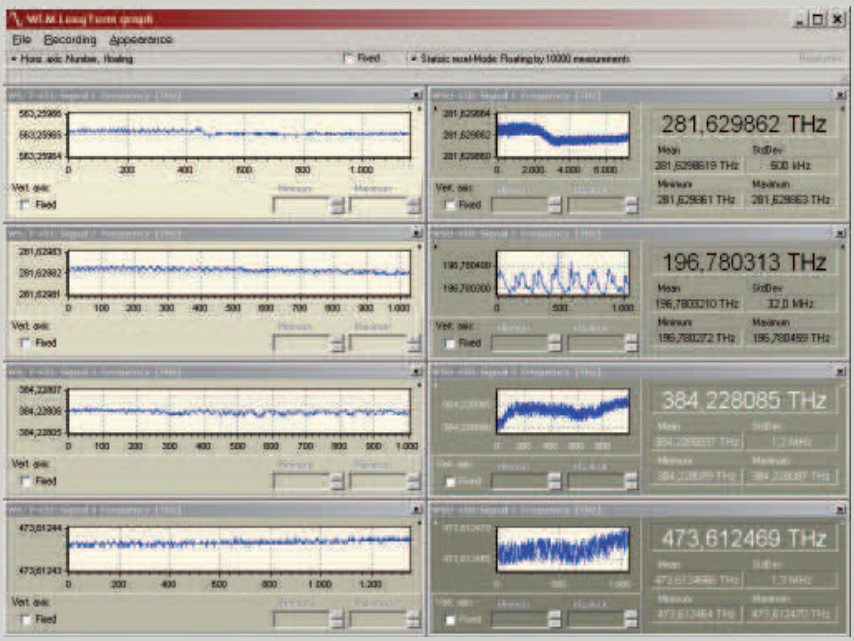
The flexible design of our wavelength meters allows the integration of additional optical components and software modules, enabling customization for your specific application requirements.

The following standard options are available:

Multi Channel Option (MC)

In order to measure the frequencies of more than just one laser at a time, an opto-mechanical switch (MEMS) is used. The combination of our high-speed wavelength meters with one of the quickest fiber switches (MEMS) available allows the measurement of up to 8 channels almost simultaneously. Exposure time and other parameters can be defined independently for each light source.

- Spectral range: 250 nm – 2200 nm
- Fiber: Multimode or Singlemode
- Lifetime: > 10^9 cycles
- Cycle time: 0.2 sec/8 channels
- Peak power: 23 dBm



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The multi-channel switch option provides the possibility for auto-calibration. Any well known laser source connected to the switch can be used for wavelength meter calibration as needed. For WSU we recommend singlemode switches. Multimode switches allow only quickcoupling accuracy.

■ Double-Pulse Trigger Option (DP)

Detecting two different subsequent pulses supplied by one fiber and treating them as individual signals is possible using the double pulse option. In this mode the wavemeter is triggered externally. This allows additional applications as pump and probe measurements for instance.

■ Diffraction Grating Hybrid Option (D)

The diffraction grating option allows the analysis of the emission spectrum to an accuracy of 6 GHz, for laser sources with broad emission (but 1/5 of the width in best case). The software automatically searches the spectral section where the laser emission line is located and displays it on the screen. In combination with the additional Fizeau interferometer array this allows wide range applications with a single device.

■ Linewidth Option (L)

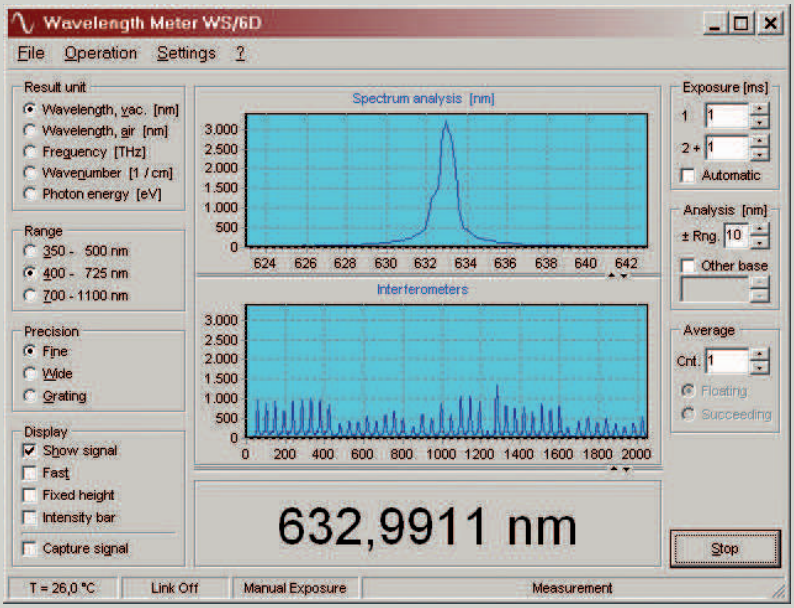
The linewidth estimation of a single-mode laser source is performed by a special algorithm which eliminates the interferometer's instrument response function. The algorithm enables the estimation of the linewidth several times better than the interferometer resolution. The linewidth option can also be used for measuring the linewidth of multimode lasers or lasers with sidebands. In this case, the longitudinal mode splitting needs to be less than 300 MHz and the calculated result is the FWHM of the envelope function of the multi-line spectrum. Any instrument can be upgraded with the L-option, single mode fibers are required.

■ TTL-Trigger Option (TTL)

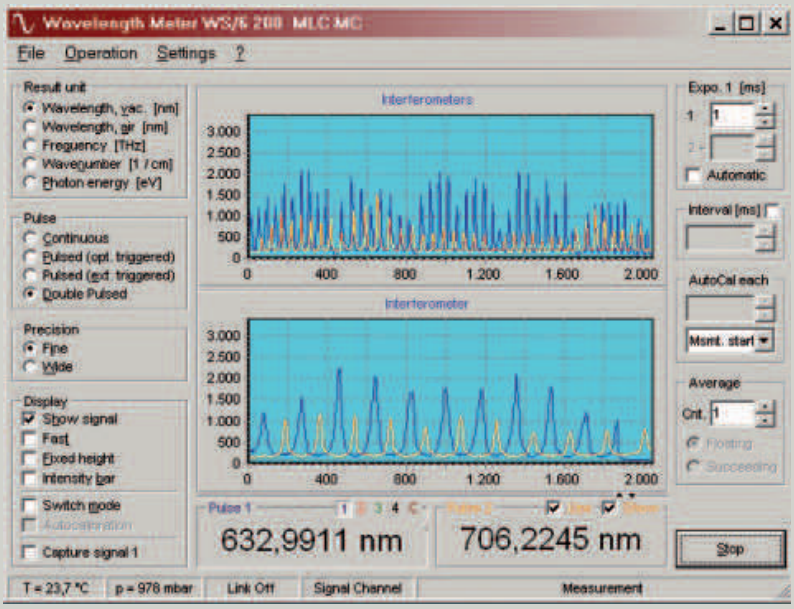
This option allows the user to trigger pulsed measurements externally. There are two different ways to trigger. In mode 1 the TTL-pulse starts the read out of the arrays. Afterwards the CCD-arrays are illuminated until the next TTL-pulse is detected. In mode 2, the TTL-pulse starts the measurement for a user-defined period of time. The TTL option guarantees synchronization between pulsed excitation and measurement. It provides low-noise, pollution-free signals when measuring pulsed signals with low duty cycles.

■ NEW: Intensified Sensitivity (IS-series)

For THz generation or very low signals we can enlarge the sensitivity up to a factor of 1000. Highest sensitivities down to 100 pJ at a narrow range (3 nm) is possible.



Graphical user interface of WS6D. The upper graph shows the grating broadened spectrum, the lower graph the fizeau interferometer pattern of a HeNe.



This figure shows a measurement using the doule-pulse option, where two readings are performed in very quick succession to allow pump and probe measurements for instance.

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Laser Control Option (PID)

Make the laser do what you want it to do! As opposed to bulk error signal generation, the PID option provides full signal processing, accomplished by a software-based Proportional-Integral-Derivative (PID) controller. This option is very useful in experiments where the laser frequency has to fit changing experimental conditions, such as laser cooling, atomic detection, trapping and manipulation as well as Raman spectroscopy and other experiments where the laser frequency has to be actively regulated.

The regulation speed generally is the measurement speed of the Wavelength Meter. Regulations do not slow down the measurements. The regulation quality is the same as the Wavelength Meters' measurement deviation sensitivity and the absolute regulation accuracy is the same as the device' absolute measurement accuracy.

The PID option can do even more: It provides a function generator enabling the user to make the laser's frequency follow any arbitrary mathematical function, e.g. a sine, triangle, rectangle, stairs, trapezoid functions, etc. or any combination thereof.

The add-on program PID-SIM can be used to automatically detect the best regulation parameters and synchronize them with the main program. This method makes it easy to determine optimal regulation parameters. And additionally this program can be used as a regulation database, storing any number of named regulation sets.

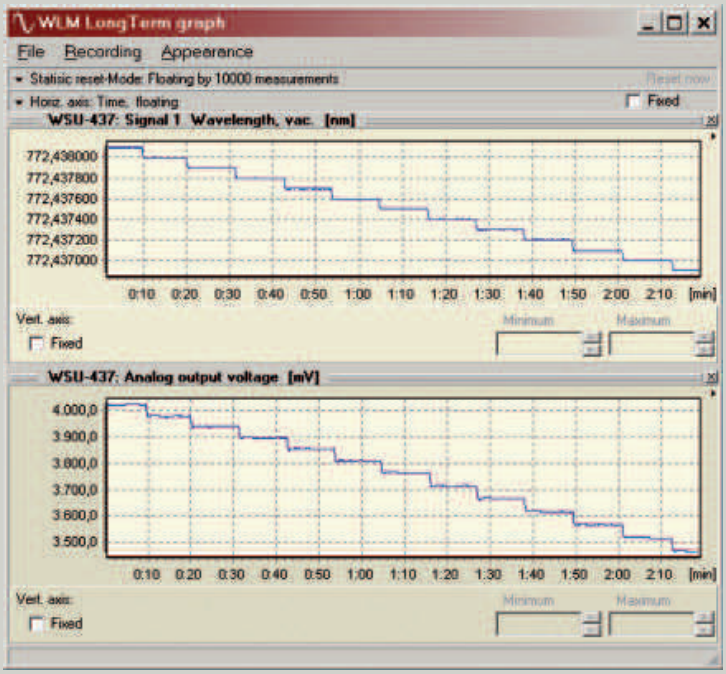
As an example, the figure on the right shows a step-modulation of a DFB laser diode running at 772 nm. The regulation of the emission frequency is done by the signal processing of the PID-controller option. The basic idea is to let the wavelength meter read the actual frequency and pass the result to the signal-processing part of the software, i.e. the PID option. By comparing the measurement result to the desired setpoint, an error signal is generated. The error signal is used by the software PID-controller to calculate the control signal which mainly consists of three contributing parts:

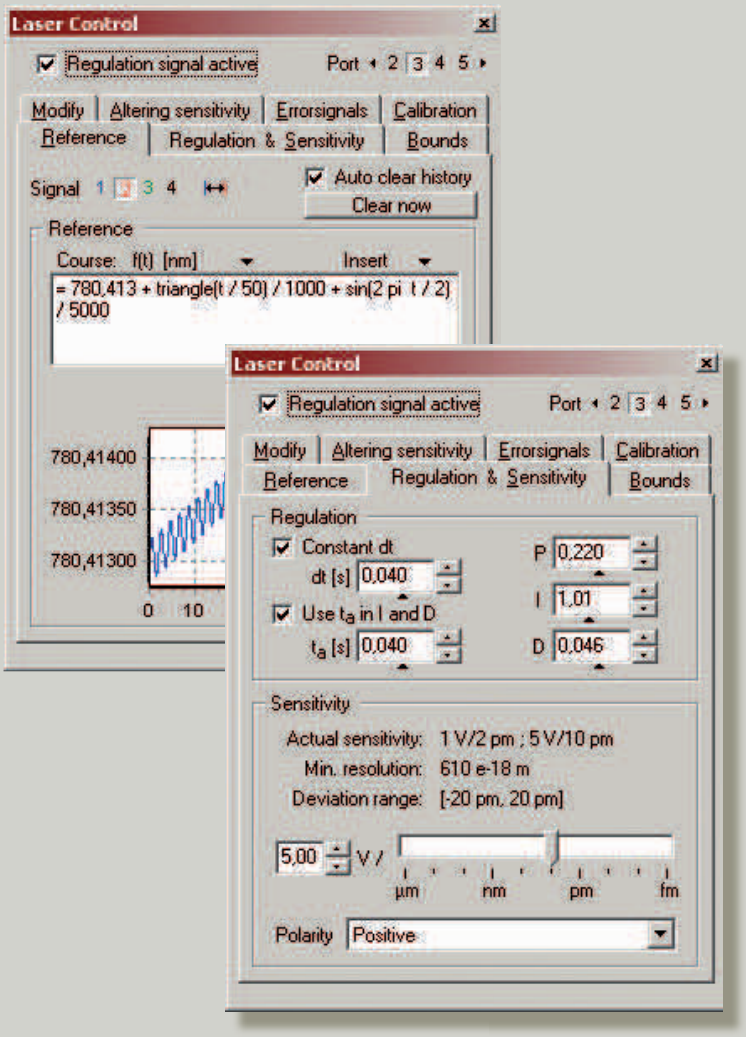
- To "handle the present", the error is multiplied by the proportional parameter P, to drive the output towards the setpoint. The proportional part cares for regulation speed.

- To "handle the past", the error is integrated over a period of time, and the multiplied by the parameter I. The integral part is slow but can take setpoint errors into account.

- To "handle the future", the first derivative of the error is calculated with respect to time and multiplied by the derivative parameter D. This enables the controller to compensate over regulations and resident errors (drift).

The single parameters of the proportional (P), integral (I), and derivative (D) parts and the total output gain (V/nm) can be set independently or generated automatically (PID-Sim).





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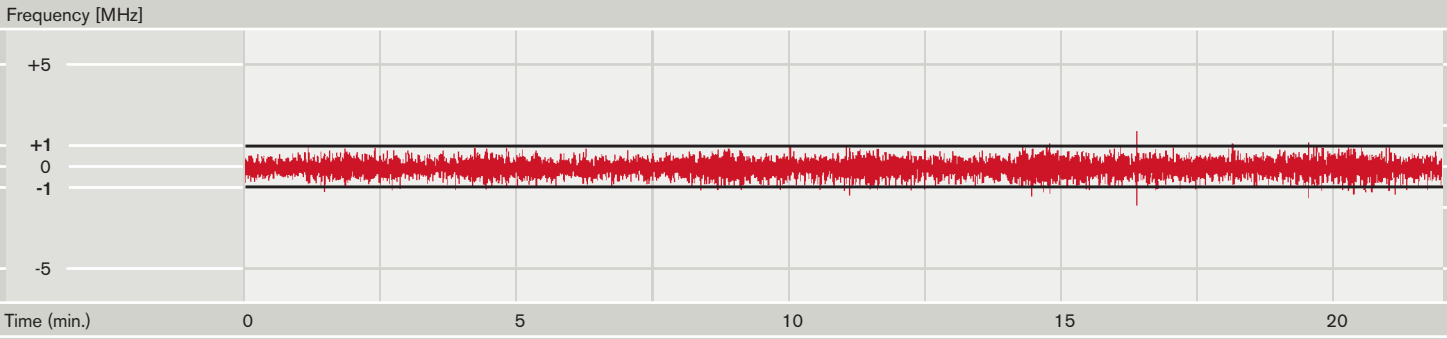
Measurement WS-Ultimate-PID

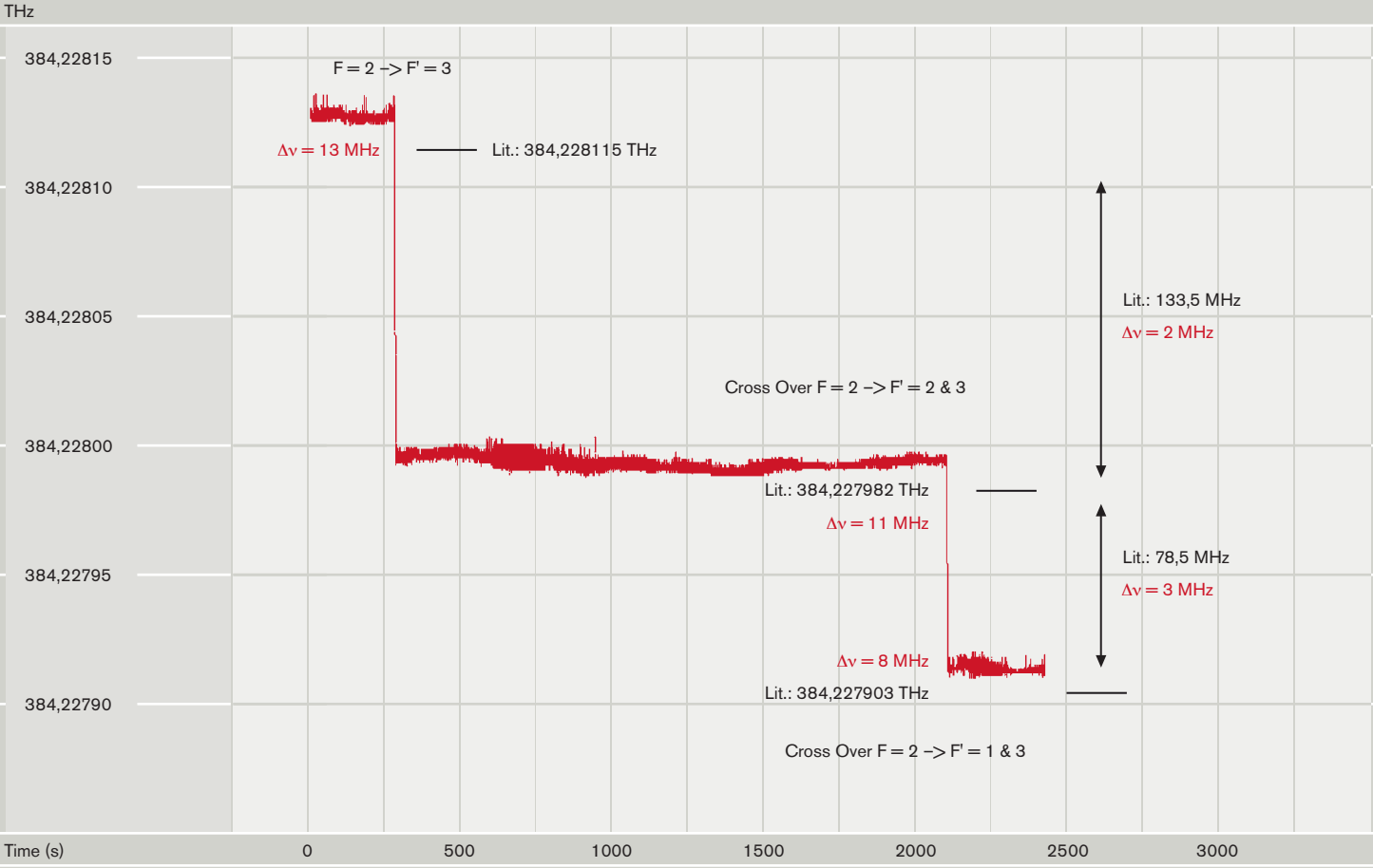


Measurement using the PID-controller

Recent measurements have demonstrated the outstanding accuracy of the WS Ultimate that goes even beyond the specifications. The diagram above shows the frequency stability, ± 2 MHz, of a semiconductor laser diode locked to a WS Ultimate using the PID-controller.

This laser was used for a magneto-optical trap (MOT); the number of atoms remained constant during the 20 minute measurement. The beat signal between the PID controlled laser and the Rb spectroscopy was monitored.

Saturation spectroscopy



Saturation spectroscopy measured by a WS7

The diagram shows a measurement with the WS Ultimate on a rubidium saturation spectrum ($^{87}Rb\ D_2$, $5S_{1/2} => 5P_{3/2}$)

Three lines are shown. **Black:** literature value
Red: measurement and mean deviation

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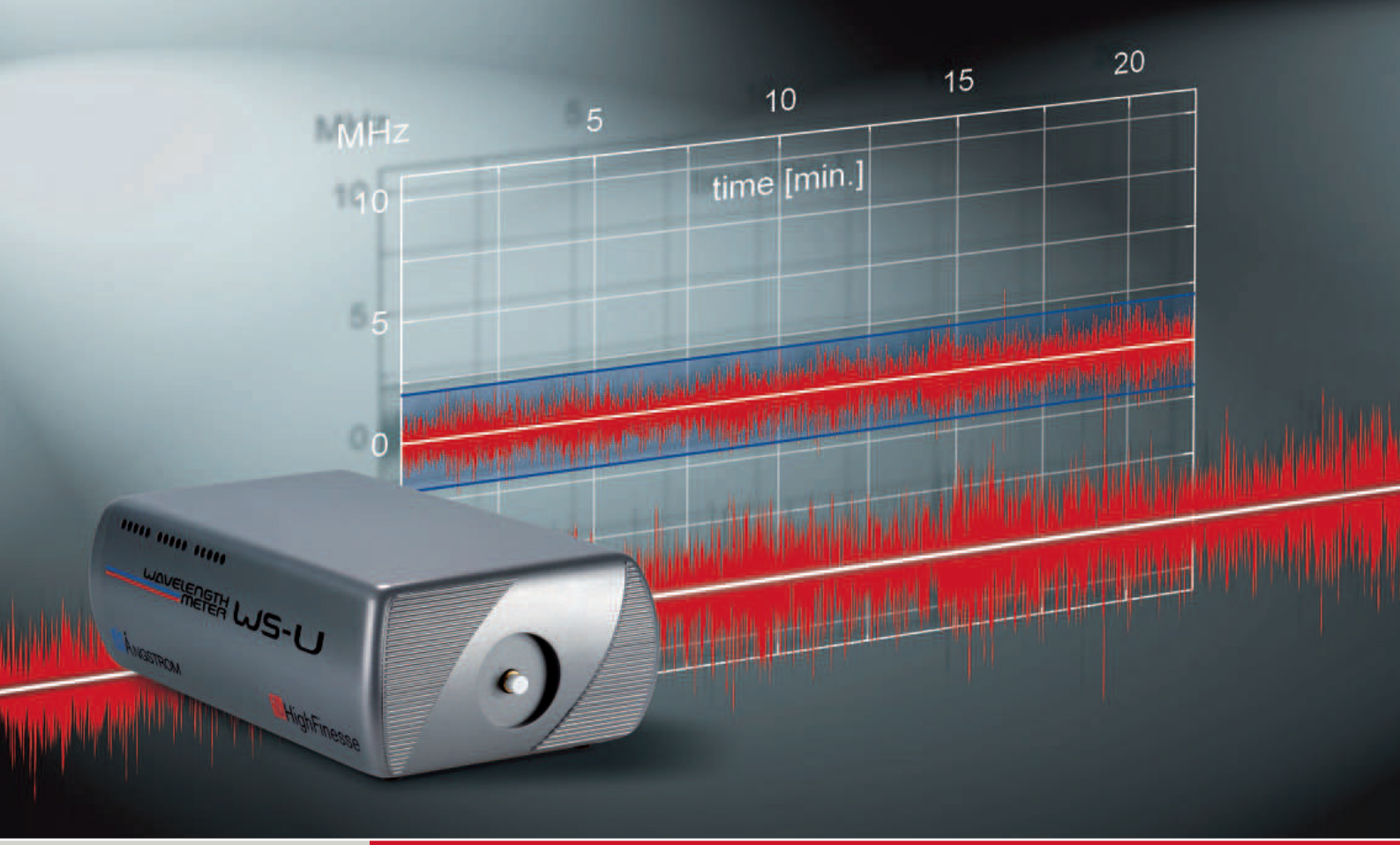

Laser Feedback Control: deviation down to ± 2 MHz

- **Continuous control of your lasers with our PID-Software**
- **Frequency deviation within ± 2 MHz (rms < ± 500 kHz) with our WS Ultimate-2**
- **Simultaneous control of up to 8 lasers**
- **Wavelength range: 192 – 11000 nm**
- **Repetition Rate: up to 100 Hz**

High resolution spectroscopy can be replaced by a HighFinesse/Ångstrom Wavelength Meter. Absolute measurement and regulation accuracy in MHz-range is reached in the spectral range of 350 – 1750 nm. In UV (192 – 350 nm) and MIR (2 – 11 µm) 100 MHz regulation accuracy is possible.

High measurement and feedback speed for in-situ frequency control of cw-laser-sources like singlemode diode lasers, DFB lasers, Dye lasers, TiSa laser or any pulsed laser application (LIDAR) is reached.

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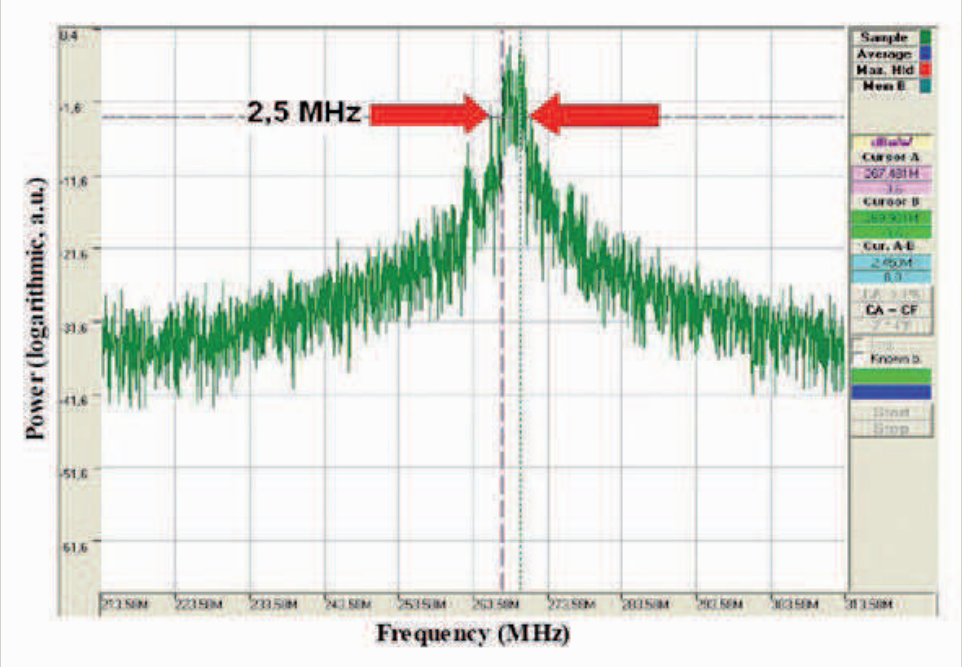
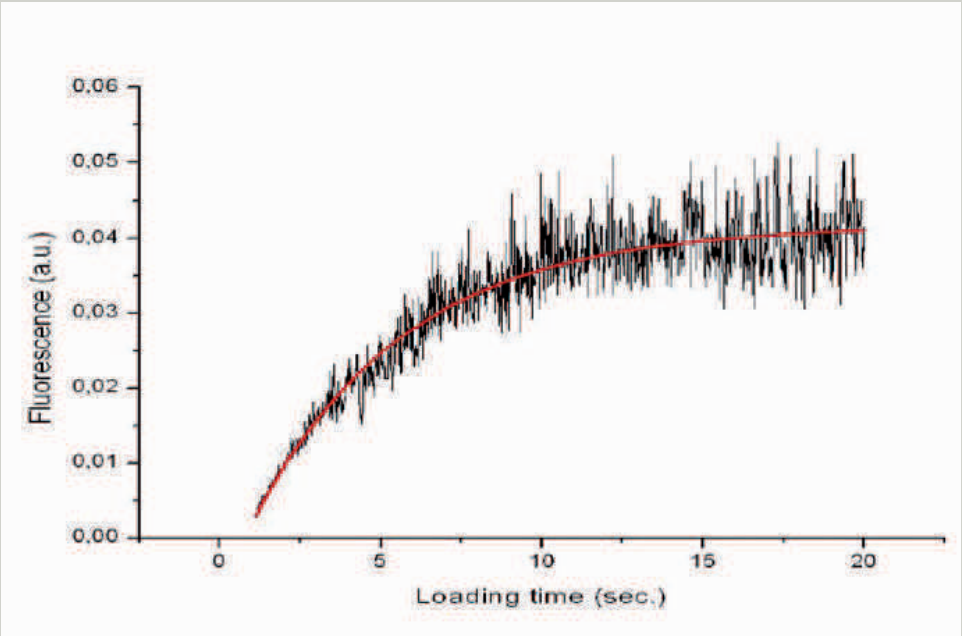
■ **Application Example:**
HighFinesse DFB laser diode controlled by WS Ultimate-10. Typical linewidth of the HighFinesse DFB laser < 2,5 MHz. High quality laser current and temperature controllers are available at HighFinesse.



■ **Spectroscopic Application:**
Loading a Magneto-Optical-Trap (MOT) with cold atoms. Laser frequencies of two DFB lasers are controlled by WS Ultimate-10. Fluorescence signal of cold Rb-atoms measured by a photodiode.

Further information:
www.highfinesse.com



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Email info@highfinesse.com

Additional information and distributors:
www.highfinesse.com

WS5 Precision Wavelength Meter

Absolute accuracy: 3000 MHz, resolution: 1000 MHz

NEW: VIS-IR measurement range (400 – 1750 nm)

Compact, reliable and versatile

The robust, compact HighFinesse/Ångstrom WS5 precision wavelength meter is designed for everyday control of pulsed and cw laser sources. It can be operated with very low light intensity coupled through an easy-to-use optical multi-mode fiber. Optical elements and electronics are housed in a compact, thermally insulated casing.

Power supply and data readout are accomplished with any PC via a USB interface. The wavelength meter is ready for use as soon as the software delivered with the device is installed. There is no warm-up time required under constant ambient conditions.

To enable customized applications, the WS5 design allows the integration of additional options – even years after purchase.

Enter a new world of accuracy!

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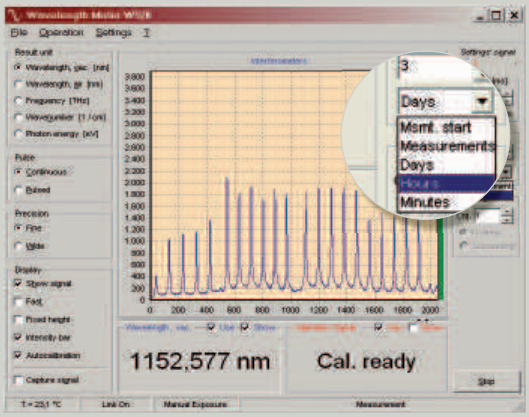
Technical Data		Unit	WS5
Measurement range availability	Standard (350 – 1120 nm)		●
	UV (248 – 1100 nm)		●
	UV-II (192 – 800 nm)		●
	VIS-IR (400 – 1750 nm)		●
	IR (800 – 1750 nm)		●
	IR-II (1000 – 2250 nm)		●
	IR-III (2 – 11 µm) [8]		●
Absolute accuracy [4]	192 – 370 nm [1]	pm	3
	370 – 1100 nm	MHz	3000
	1100 – 2250 nm		2000
	2250 – 11000 nm		2000
Quick coupling accuracy (with multi mode fiber)		MHz	3000
Measurement resolution		MHz	1000
Linewidth option [2]	Accuracy	MHz	2000 [3]
	Max. bandwidth	GHz	50
Measurement speed [5] (depending on PC hardware and settings)	Data acquisition	Hz	600
	Wavelength calculation		600
	Linewidth calculation		500
	Pattern display		300
Required input energy and power	Standard	µJ (or µW) [6]	0.02 – 15
	UV		0.02 – 10
	UV-II		0.02 – 200
	IR		2 – 200
	IR-II		2– 80 [7]
	IR-III	mW	1 [9]
Fizeau interferometers	FSR	GHz	~100
Grating Option [2]	Spectral resolution	λ/Δλ	different designs possible: up to 20000 [10]
Coupling fiber diameter		µm	400
Calibration			Built-in calibration [11]
Calibration period			≤ 1 month (will be detected and done automatically [11])
Warm-up time			No warm-up time under constant ambient conditions (except IR-II: > 30 minutes warm-up time required) Otherw. until thermal and air pressure equilibrium is reached.
Dimensions L × W × H		mm	360 × 120 × 120
Weight		kg	2.8
Interface			High-speed USB 2.0 connection
Power supply			Power consumption < 2.3 W, supply directly via USB cable; IR-II, IR-III: external power supply included; IR-I and WSU via USB or external power supply possible

1) With multi mode fiber 2) Only for standard range 3) But not better than 5 % of the linewidth 4) According 3σ criteria 5) Without autocalibration usage 6) The cw power interpretation in [µW] compares to an exposure of 1s (generally the energy needs to be divided by the exposure time to obtain the required power) 7) [µJ] interpretation for pulsed lasers; cw signals need more power in [µW] since the exposure is limited at IR-II devices 8) For further information on IR-III devices see separate sheet 9) Signal/noise in this case will be 5:1, thus averaging is required 10) Not IR-III. For IR-III λ/Δλ = 450 11) not IR-III, external calibration source needed, e.g. SLR1532



Internal calibration

Automatic calibration with built-in wavelength standard, settable measurement counts or time period between calibrations.

Typical WS5 applications

The WS5 is a standard instrument for wavelength monitoring of tunable pulsed or cw laser sources such as Diode laser, Titanium Saphire Laser, Dye Laser, etc. It is well suited for spectroscopic applications with normal resolution.

Available WS5 options

■ Diffraction grating (D) ■ PID-controller (PID) ■ Multi-channel Switch (MC)
■ Double pulse (DP) ■ TTL-trigger (TTL)

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Additional information and distributors:
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WS6 High-Precision Wavelength Meter

WS6-600, absolute accuracy: 600 MHz, resolution: 100 MHz
WS6-200, absolute accuracy: 200 MHz, resolution: 50 MHz

NEW: VIS-IR measurement range (400 – 1750 nm)

High performance and compact design

The HighFinesse/Ångstrom WS6 high-precision wavelength meter is a highly sensitive wavelength meter with integrated calibration for pulsed and continuous laser sources.

The WS6-600 combines both compact design and high resolution, achieved by a single set of multiple interferometers arranged in a unique geometric configuration. The WS6-200 uses 2 sets of multiple interferometers which triples the accuracy.

The WS6 design allows the integration of additional options, even years after purchase.

The WS6 is connected to the PC via a USB interface. The wavelength meter is ready for use as soon as the software delivered with the device is installed. There is no warm-up time required under constant ambient conditions.

Enter a new world of accuracy!

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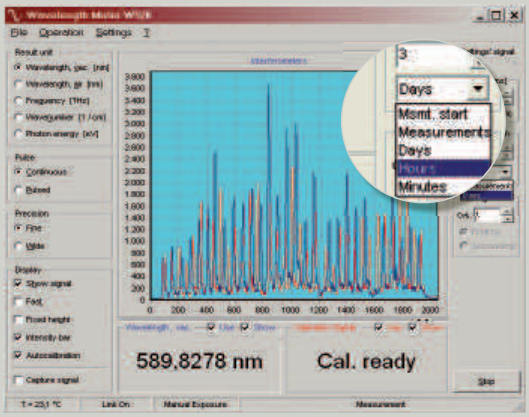
Technical Data		Unit	WS6-600	WS6-200
Measurement range availability	Standard (350 – 1120 nm)		●	●
	UV (248 – 1100 nm)		●	●
	UV-II (192 – 800 nm)		●	●
	VIS-IR (400 – 1750 nm)		●	●
	IR (800 – 1750 nm)		●	●
	IR-II (1000 – 2250 nm)		●	●
	IR-III (2 – 11 µm)		○	● [12]
Absolute accuracy [5]	192 – 370 nm [1]	pm	0.6	0.4
	370 – 1100 nm	MHz	600	200
	1100 – 2250 nm	MHz	400	150
	2 – 11 µm	MHz	–	200
Quick coupling accuracy (with multi mode fiber)		MHz	600	600
Measurement resolution		MHz	100	50
Linewidth option [3]	Accuracy	MHz	500 [4]	400 [4]
	Max. bandwidth	GHz	50 (UV, IR: 10)	
Measurement speed [6] (depending on PC hardware and settings)	Data acquisition	Hz	600	500
	Wavelength calculation	Hz	600	400
	Linewidth calculation	Hz	500	400
	Pattern display	Hz	300	150
Required input energy and power	Standard	µJ (or µW) [7]	0.02 – 15	
	UV	µJ (or µW) [7]	0.02 – 10	
	UV-II	µJ (or µW) [7]	0.02 – 200	
	IR	µJ (or µW) [7]	2 – 200	1 – 100
	IR-II	µJ (or µW) [7]	2 – 80 [9]	
	IR-III	mW		1 [10]
Fizeau interferometers [2]	FSR	GHz	std.: ~15 (100); UV, IR: ~20 - 30	
Grating Option [3]	Spectral resolution	λ/Δλ	different designs: up to 20000	– [11]
Coupling fiber diameter		µm	400 µm	400 µm or single mode fiberset
Calibration			Built-in calibration [8]	
Calibration period			≤ 1 month (will be detected and done automatically [8])	
Warm-up time			No warm-up time under constant ambient conditions (except IR-II: > 30 minutes warm-up time required) Otherw. until thermal and air pressure equilibrium is reached.	
Dimensions L × W × H		mm	360 × 120 × 120	360 × 200 × 120
Weight		kg	2.8	5.3
Interface			High-speed USB 2.0 connection	
Power supply			Power consumption < 2.3 W, supply directly via USB cable; IR-II, IR-III: external power supply included; IR-I and WSU via USB or external power supply possible	

1) With multi mode fiber 2) Values for wide-/fine-mode 3) Only for standard range 4) But not better than 5% of the linewidth 5) According 3s criteria 6) Without autocalibration usage 7) The cw power interpretation in [µW] compares to an exposure of1s (generally the energy needs to be divided by the exposure time to obtain the required power) 8) not IR-III, external calibration source needed, e.g. SLR1532 9) [µJ] interpretation for pulsed lasers; cw signals need more power in [µW] since the exposure is limited at IR-II devices 10) Signal/noise in this case will be 5:1, thus averaging is required 11) Not IR-III. For IR-III λ/Δλ = 450 12) For further information on IR-III devices see separate sheet



Internal calibration

Automatic calibration with built-in wavelength standard, settable measurement counts or time period between calibrations.

Typical WS6 applications

The WS6 is well suited for scientific applications and spectroscopic applications with high resolution. Low-light intensity and fast readout make it ideal for monitoring diode lasers, frequency-doubled laser sources or optical parametric oscillators.

Available WS6 options

■ Diffraction grating (D) ■ Linewidth (L) ■ Multi-channel Switch (MC)
■ PID-controller (PID) ■ TTL-trigger (TTL) ■ Double pulse (DP)

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WS7 Super-Precision Wavelength Meter

Absolute accuracy: 60 MHz, resolution: 10 MHz

NEW: with internal calibration source

Superb precision for a wide range of applications

The HighFinesse/Ångstrom WS7 super-precision wavelength meter is a highly sensitive wavelength meter for pulsed and continuous laser sources.

The superb precision of the WS7 is achieved by using two sets of multiple interferometers in a special geometric configuration.

To enable customized applications even years after purchase, the WS7 design allows the integration of additional options.

The WS7 is connected to the PC via a USB interface. The wavelength meter is ready for use as soon as the software delivered with the device is installed. There is no warm-up time required under constant ambient conditions.

Enter a new world of accuracy!

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Technical Data		Unit	WS7
Measurement range availability	Standard (350 – 1120 nm)		●
	UV (248 – 1100 nm)		●
	UV-II (192 – 800 nm)		●
	IR (800 – 1750 nm)		●
	IR-II (1000 – 2250 nm)		●
Absolute accuracy [5]	192 – 370 nm [1]	pm	0.2
	370 – 1100 nm	MHz	60
	1100 – 2250 nm		40
Quick coupling accuracy (with multi mode fiber)		MHz	150
Measurement resolution		MHz	10
Linewidth option [3]	Accuracy	MHz	200 [4]
	Max. bandwidth	GHz	10
Measurement speed [6] (depending on PC hardware and settings)	Data acquisition	Hz	500
	Wavelength calculation		400
	Linewidth calculation		400
	Pattern display		150
Required input energy and power	Standard	µJ (or µW) [7]	0.01 – 10
	UV		0.01 – 6
	UV-II		0.01 – 100
	IR		2 – 200
	IR-II [8]		2 – 80
Fizeau interferometers [2]	FSR	GHz	4 (20 – 30)
Coupling fiber diameter		µm	400 µm or single mode fiberset
Calibration			Built-in calibration [9]
Calibration period			≤ 14 days [9]
Warm-up time			No warm-up time under constant ambient conditions (except IR-II: > 30 minutes warm-up time required) Otherw. until thermal and air pressure equilibrium is reached.
Dimensions L × W × H		mm	360 × 200 × 120
Weight		kg	5.6
Interface			High-speed USB 2.0 connection
Power supply			Power consumption < 2.3 W, supply directly via USB cable, IR-II: external power supply included; IR-I and WSU via USB or external power supply possible

1) With multi mode fiber 2) Values for wide-/fine-mode 3) Only for standard range 4) But not better than 5 % of the linewidth 5) According gσ criteria 6) Without autocalibration usage 7) The cw power interpretation in [µW] compares to an exposure of 1 s (generally the energy needs to be divided by the exposure time to obtain the required power) 8) [µJ] interpretation for pulsed lasers; cw signals need more power in [µW] since the exposure is limited at IR-II devices 9) not IR devices, external calibration source needed, e.g. SLR1532

Quick coupling with included multi mode fiber

Free-hand measurement with an accuracy of 150 MHz due to the high sensitivity and by default included multi mode fiber.

Typical WS7 applications

The WS7 is a high-resolution device for precision measurement in a wide variety of applications: molecular and atomic spectroscopy, gas detection with Raman scattering or laser-induced fluorescence, LIDAR systems, high-resolution spectroscopy, laser frequency stabilization and for calibration in combination with frequency combs.

Available WS7 options

- Linewidth (L)
- Multi-channel Switch (MC)
- PID-controller (PID)
- TTL-trigger (TTL)
- Double pulse (DP)

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WS Ultimate Wavelength Meter

Absolute accuracy: up to 2 MHz
Measurement Resolution: up to 500 kHz

For unrivaled precision!

The HighFinesse/Ångstrom WS Ultimate is the unsurpassed high-end instrument for wavelength measurement of pulsed or continuous laser sources. It delivers superb absolute and relative accuracy to address the highest application requirements.

The unmatched precision of the WS Ultimate is achieved by using two special multiple interferometer arrays in a unique geometric configuration.

The WSU is connected to the PC via a USB interface. The wavelength meter is ready for use as soon as the software delivered with the device is installed. Both optical elements and assigned electronics are packaged in a compact, thermally insulated housing.

The WSU design enables the integration of additional options, allowing customized solutions to specific applications even years after purchase.

Enter a new world of accuracy!

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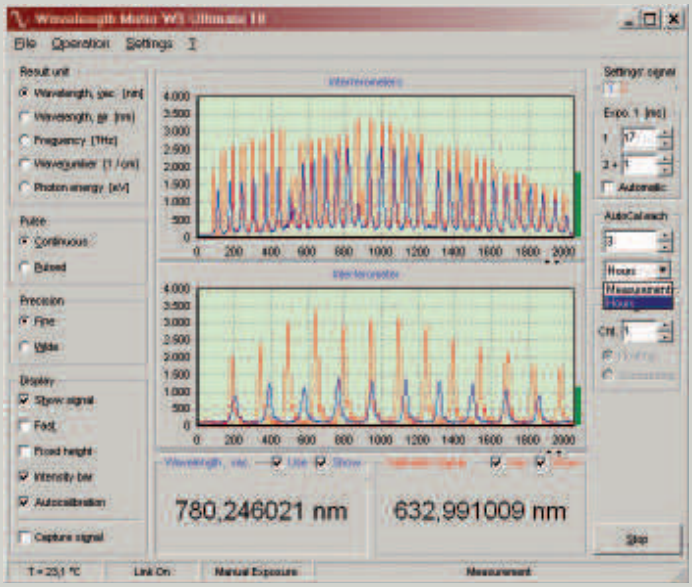
Technical Data		Unit	WSU-30	WSU-10	WSU-2
Measurement range availability	Standard (350 – 1120 nm)		●	●	●
	UV (248 – 1100 nm)		●	○	○
	IR (800 – 1750 nm)		●	●	○
Absolute accuracy [7]	192 – 370 nm [1]	pm	0.1	0.1	0.1
	370 – 1100 nm	MHz	30	10 [5]	2 [6]
	1100 – 2250 nm	MHz	20	10 [5]	–
Quick coupling accuracy (with multi mode fiber)		MHz	100		
Measurement resolution		MHz	5	1 [5]	0.5 [6]
Linewidth option [3]	Accuracy	MHz	100 [4]		
	Max. bandwidth	GHz	0,8 (for high accuracy mode) – 8 (for low accuracy mode)		
Measurement speed [8] (depending on PC hardware and settings)	Data acquisition	Hz	500		
	Wavelength calculation	Hz	400		
	Linewidth calculation	Hz	400		
	Pattern display	Hz	150		
Required input energy and power	Standard	µJ (or µW) [9]	0.02 - 15		
	UV	µJ (or µW) [9]	0.02 – 10	–	–
	IR	µJ (or µW) [9]	2 – 200		–
Fizeau interferometers [2]	FSR	GHz	2 (15-20)		
Coupling fiber diameter		µm	400 µm or single mode fiberset		
Calibration			Stabilized HeNe laser or any other well known laser source dν < 3 MHz		Any well known laser source dν < 1 MHz
Calibration period			≤ 10 hours	≤ 1 hours	≤ 2 minutes
Warm-up time			> 30 minutes		
Dimensions L × W × H		mm	360 × 200 × 120		
Weight		kg	6.3		
Interface			High-speed USB 2.0 connection		
Power supply			Power consumption < 2.3 W, supply directly via USB cable, IR-II: external power supply included; IR-I and WSU via USB or external power supply possible		

1) With multi mode fiber 2) Values for wide-/fine-mode 3) Only for standard range 4) But not better than 5% of the linewidth 5) ± 200 nm around calibration wavelength 6) ± 2 nm around calibration wavelength 7) According to oσ criteria 8) Without autocalibration usage
9) The cw power interpretation in [µW] compares to an exposure of 1s (generally the energy needs to be divided by the exposure time to obtain the required power)



Autocalibration Option

Automatic, continuous calibration with calibration wavelength standard, settable measurement counts or time period between calibrations.

Quick coupling with included multi mode fiber

Fast measurement with an accuracy of 100 MHz due to the high sensitivity multi mode fiber provided.

Typical WSU applications

The WSU high-end wavelength meter is mostly used in specialized applications, such as scientific measurement and frequency standards, laser frequency stabilization for laser cooling, high-precision spectroscopy and atomic optics. The device's unparalleled accuracy of up to 2 MHz allows for high-precision wavelength control for example in high-end LIDAR applications.

Available WSU options

■ Linewidth (L) ■ Multi-channel Switch (MC)
■ PID-controller (PID) ■ TTL-trigger (TTL) ■ Double pulse (DP)

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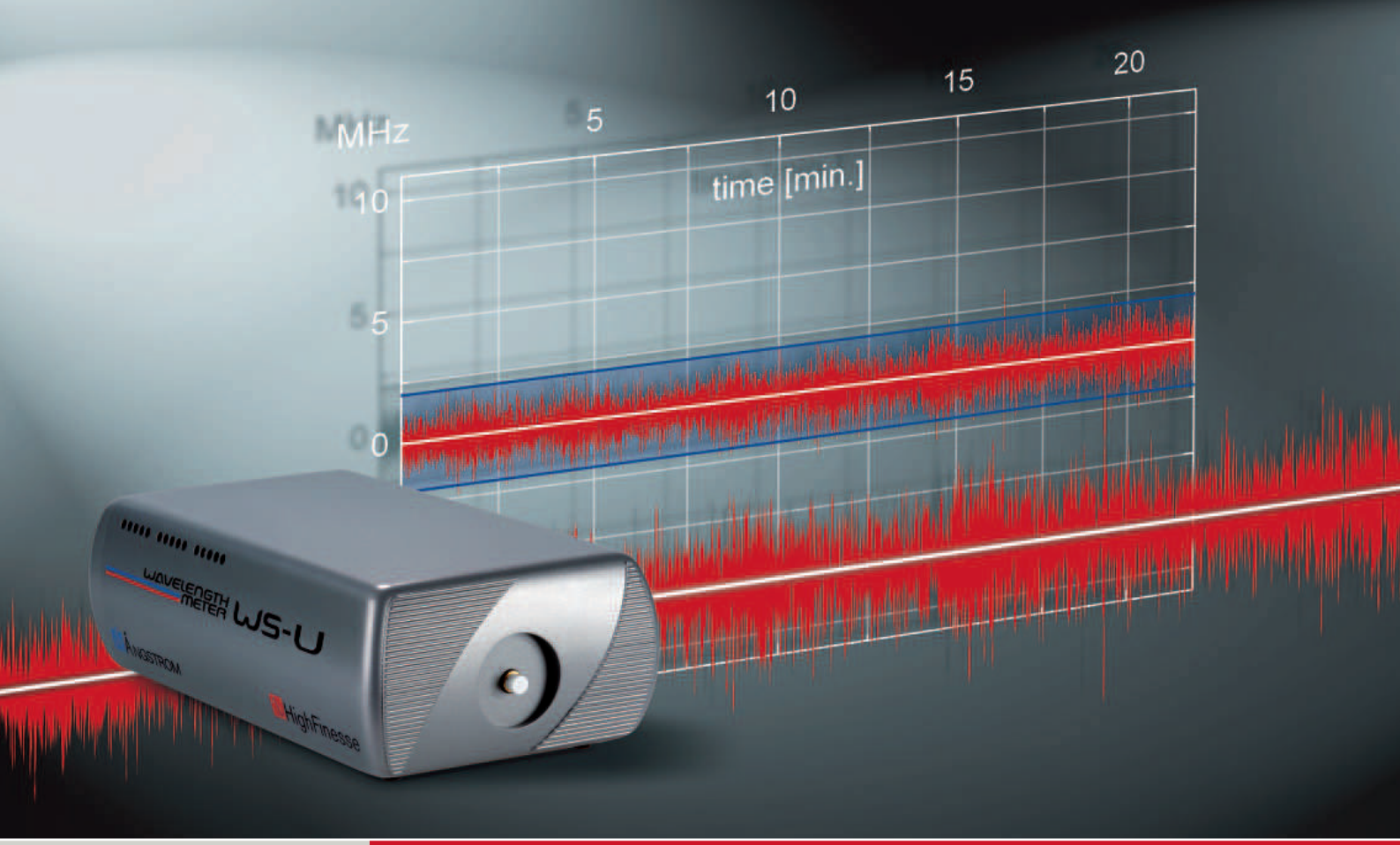

Autocalibration via external fiber input

for the Wavelength Meter WS-Ultimate

For ultimate accuracy and stability of measurements with our WS-Ultimates, it is possible to perform automatic recalibration of the wavelength meter at user defined intervals, from weeks to between every measurements. This automatic procedure takes less than one second before automatically returning to your laser. No user intervention is required. When used in conjunction with the PID option, no loss of control of the laser is experienced.

In order to use this option a calibration laser (normally a HeNe but other lasers can be used, too) is fiber coupled to an additional input on the wavelength meter. An internal switching module will then automatically switch between the laser being monitored and the calibration source. The software then updates the calibration data file.

You never need to stop your work or return your wavelength meter to assure its accuracy!

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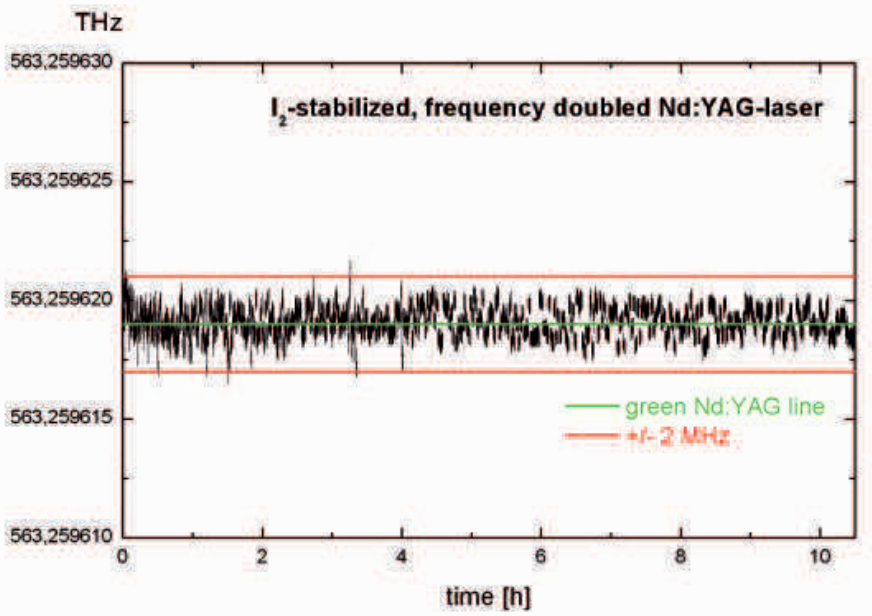
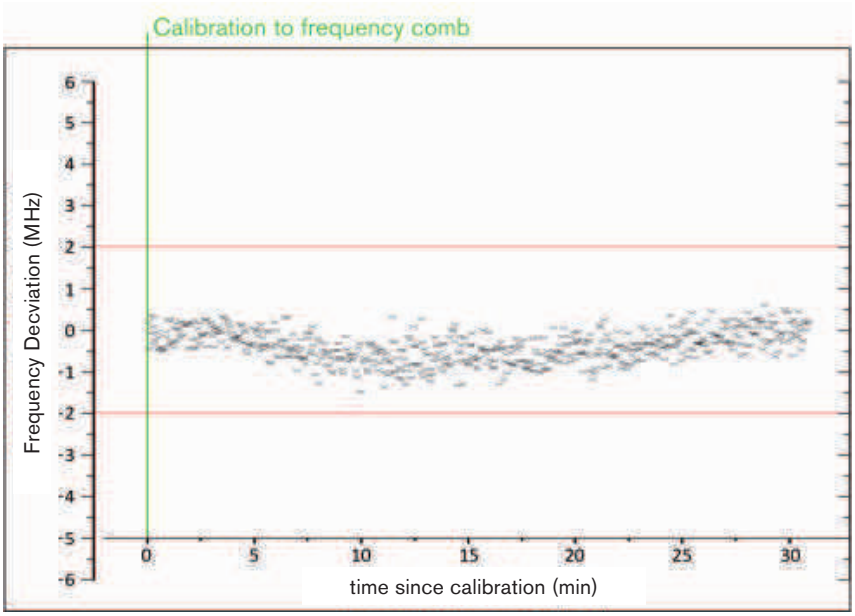


Note: The hardware supports a standard calibration range between 600 nm and 800 nm. Other calibration ranges are available on request.

■ Application Example:

Frequency measurement on a stabilized Nd:YAG-laser (532.245 576 nm) by WS Ultimate autocalibrated to a stabilized HeNe-laser (632.991 060 nm, 1 calibration per minute). The absolute accuracy of the measurement is within ± 2 MHz.



Constant lab conditions

Absolute accuracy within 3 min ± 500 kHz

■ Application Note:

The WS Ultimate-2 is calibrated to a frequency comb at t = 0. A diode laser at 960 nm is frequency controlled by the PID option of the WS Ultimate.

The diagram shows the frequency deviation between the diode laser and the reference comb mode.

If autocalibration is activated in a time sequence of a few minutes, the WS-U2 can be used as a reference that is comparable with high resolution atomic spectroscopy. The PID option enables direct laser frequency control just as locking to atomic spectra.

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Additional information and distributors:
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Laser Spectrum Analyser – LSA

Absolute accuracy: 6000 MHz
Wavelength deviation sensitivity: 1000 MHz

The LSA is designed to analyse the multi-line or broadband spectrum of light sources like cw and pulsed lasers, gas discharge lamps, super luminescence diodes, semiconductor laser diodes and LEDs.

- **Sensitivity: 5 nJ @ 633 nm**
- **Low stage spectral resolution ($\lambda/\Delta\lambda_{FWHM}$): 500**
- **High stage spectral resolution ($\lambda/\Delta\lambda_{FWHM}$): 20000 (SM fiber), 10000 (50 µm fiber)**
- **Max. signal bandwidth: 2 THz**
- **Linewidth measurement included accuracy: 10 %**
  Min. linewidth $\delta\lambda/\lambda = 2*10^{-5}$ (e.g. 10 GHz @ 633 nm)
  Max. linewidth: 1.5 THz
- **Built-in light source for autocalibration**

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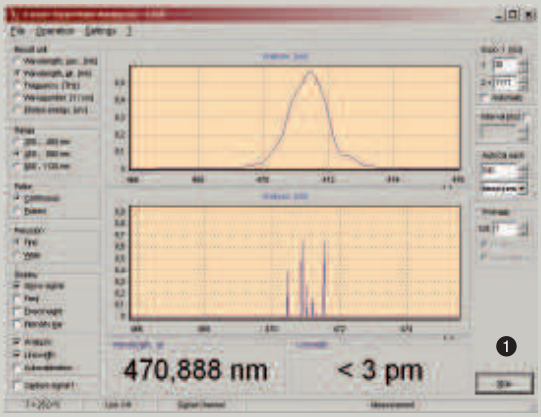
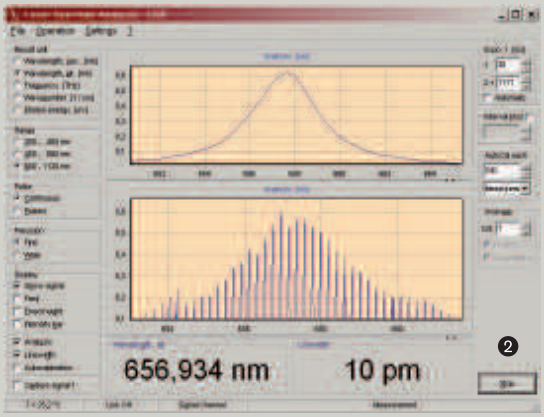
Technical Data		Unit	LSA
Measurement range availability	Standard (350 – 1120 nm)		●
	UV-I (248 – 1100 nm)		●
	UV-II (192 – 800nm)		○
	UV-II-VIS (192 – 1190nm)		●
	IR-I (800 – 1750 nm)		●
	IR-II (1000 – 2250 nm)		○
	IR-III (2 – 11 µm)		● 7)
Absolute accuracy 4)	192 – 370 nm 1)	pm	6
	370 – 1100 nm	MHz	6000
	IR-I		20000
Quick coupling accuracy (with multi mode fiber)		MHz	20000
Wavelength deviation sensitivity	248 – 370 nm	pm	5
	370 – 1100 nm	MHz	3000
	IR-I		5000
Spectral resolution	Standard, UV		20000 (single mode), 10000 (multi mode)
	IR-I		4000 (single mode), 2000 (multi mode)
Linewidth High stage 2)	Accuracy		10%
	Min. linewidth	MHz	Standard, UV: 3000 3), IR-I: 40 GHz 9)
	Max. linewidth	THz	1.5
Measurement speed 5) (depending on PC hardware and settings)	Data acquisition	Hz	500
	Wavelength calculation		60
	Linewidth calculation		50
	Pattern display		50
Required input energy and power	Standard	µJ (or µW) 6)	0.0001 – 0.04
	UV		0.0001 – 0.1
	IR		0.02 – 2
Diffraction grating	FSR	GHz	~5400
Coupling fiber diameter		µm	50 µm or single mode fiber set
Calibration			Built-in calibration 8)
Calibration period			≤ 1 month
Warm-up time			No warm-up time under constant ambient conditions Otherwise until thermal and air pressure equilibrium is reached.
Dimensions L × W × H		mm	325 × 180 × 77
Weight		kg	2.8
Interface			High-speed USB 2.0 connection
Power supply			Power consumption < 2.3 W, supply directly via USB cable; IR-III: external power supply included; IR-I and WSU via USB or external power supply possible

1) With multi mode fiber 2) Only for standard range of 370 – 1100 nm 3) But not better than 5% of the linewidth 4) According 3σ criteria 5) Without autocalibration usage 6) The cw power interpretation in [µW] compares to an exposure of 1s (generally the energy needs to be divided by the exposure time to obtain the required power) 7) For further information on IR-III devices see separate sheet 8) not IR-III, external calibration source needed, e.g. SLR1532 9) But not better than 10% of the linewidth

Sample measurements of the Laser Spectrum Analyser





1 Neon discharge lamp: The group of Ne-lines (spontaneous emission) filtered by interference filter. The upper graph represents the spectrum in the first diffraction order, the lower graph represents the 90th order after mathematic analysis.

2 Spectrum of a laser diode right below threshold. Mode spacing 200 pm.

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Additional information and distributors:
www.highfinesse.com

High Definition Spectrum Analyser – HDSA

NEW: HDSA-Telecom C-band (1500 – 1600 nm)

The HDSA is designed to analyse emission spectra of any complexity, while processing the entire spectral range at once. The fundamental principle of HighFinesse products "no moving optics" applies to the HDSA as well, so cw as well as pulsed light sources can be measured.

- **Entire spectral range at once:**
  Standard 450 – 900 nm
  Extendend 350 – 1050 nm
  IR 940 – 1740 nm
  Telecom 1500 – 1600 nm
  other ranges on request
- **Extreme sensitivity: 5 pJ @ 633 nm**
- **Exposure time: 1 ms – 2 s**
- **Measurement and tracking of any selected line/area**
- **Record and replay mode**

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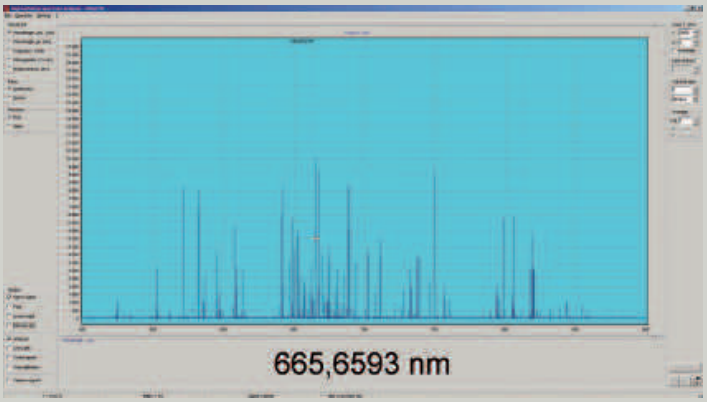
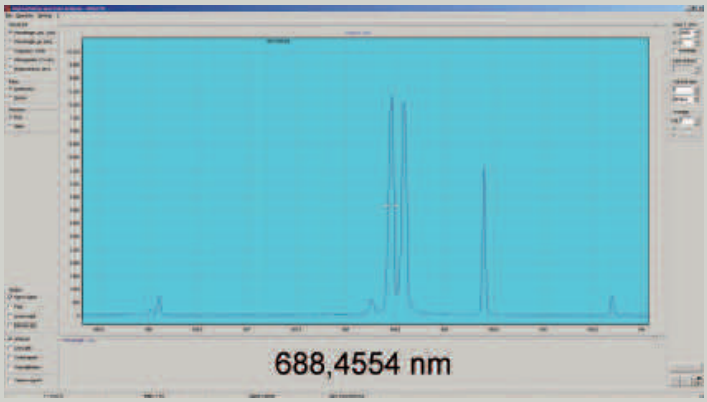
Technical Data		Unit	HDSA
Measurement range availability	Standard (450 – 900 nm)		●
	Extendend (350 – 1050 nm)		●
	IR (940 – 1740 nm)		● [1]
	Telecom (1500 - 1600 nm)		●
Absolute accuracy	Standard, Extendend	GHz	5
	IR	GHz	20
	Telecom	GHz	3
Wavelength deviation sensivity	Standard, Extendend	GHz	0.6
	IR	GHz	1.2
	Telecom	GHz	0.6
Spectral resolution (λ/Δλ) over the entire spectral range	Standard		10000 (criteria: FWHM @ 633 nm)
	Extendend		15000 (criteria: FWHM @ 633 nm)
	IR		5000 (criteria: FWHM @ 1550 nm)
	Telecom		20000 (criteria: FWHM @ 1550 nm)
Measurement speed [2] (depending on PC hardware and settings)	Data acquisition Standard, Extended	Hz	30
	Data acquisition IR	Hz	up to 90
	Full spectrum calculation Standard, Extended	Hz	16 spectra/sec
	Full spectrum calculation IR	Hz	up to 70 spectra/sec
Required input energy and power [3]	Standard	pJ	50 (@ 633 nm)
	Extendend	pJ	25 (@ 633 nm)
	IR	nJ	5 High-Gain / 100 Low-Gain (@ 1523 nm)
	Telecom	nJ	100
Diffraction grating		GHz	~5500
Calibration		µm	External calibration source (included in delivery)
Calibration period			≤ 7 days
Warm-up time			No warm-up time under constant ambient conditions
Dimensions L × W × H		mm	360 × 210 × 120
Weight		kg	~4.5
Interface	Standard, Extendend		1000BASE-T Gigabit Ethernet connection to PC
	IR		USB 2.0 connection to PC
	Telecom		USB 2.0 connection to PC
Power supply	Standard, Extendend		External power supply included; Power consumption: 5 W
	IR		Power supply via USB 2.0
	Telecom		Power supply via USB 2.0

1) in development 2) without autocalibration usage 3) The cw power interpretation in [µW] compares to an exposure of 1s (generally the energy needs to be divided by the exposure time to obtain the required power)

Sample measurements:



Typical measurement of the spectrum of a gas discharge lamp.
The HDSA resolves lines over the entire spectral range.



The picture shows a high resolution zoom into two specific spectral lines of the measurement on the left.

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Mid-IR Wavelength Meter:

WS5 IR-III, absolute accuracy: 3000 MHz, resolution: 1000 MHz
WS6-200 IR-III, absolute accuracy: 200 MHz, resolution: 100 MHz

Measuring cw and pulsed lasers between 2 – 11 µm

The HighFinesse/Ångstrom IR-III high-precision wavelength meter is especially designed for Mid-IR applications and is able to measure continuous as well as pulsed laser sources. It uses two sets of multiple interferometers arranged in a unique geometric configuration.

The device is connected to the PC via a USB interface. The wavelength meter is ready for use as soon as the software delivered with the device is installed. There is no warm-up time required under constant ambient conditions.

Enter a new world of accuracy!

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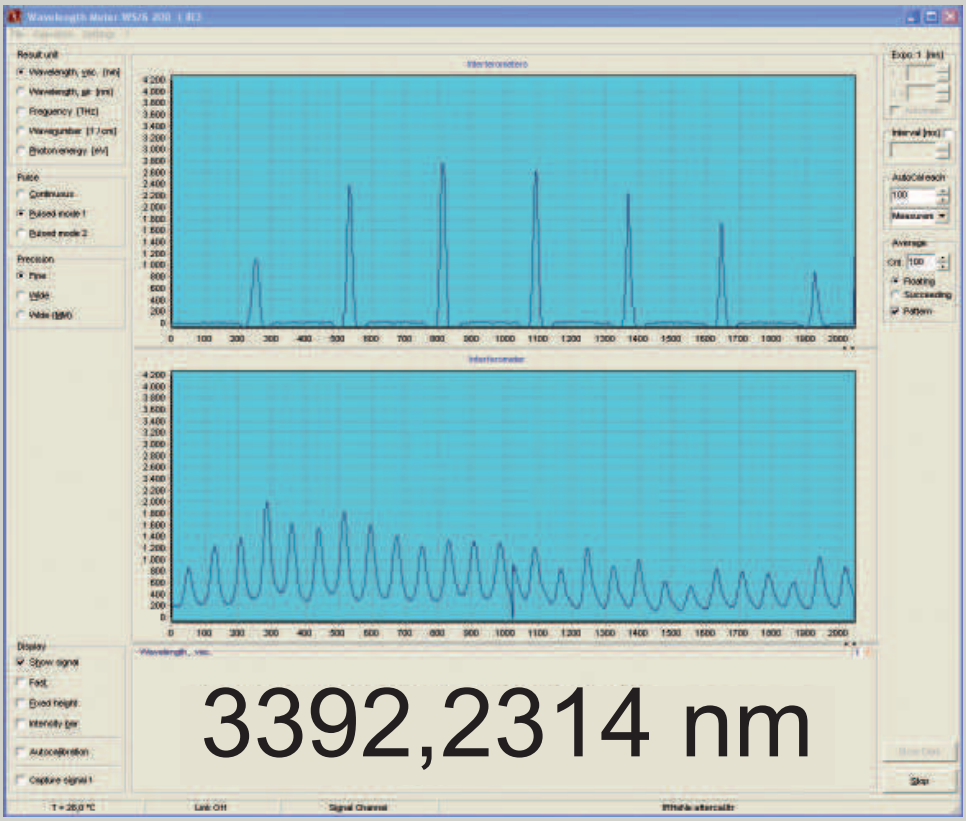
Technical Data		Unit	WS5 IR-III	WS6-200 IR-III
Measurement range		µm	2 – 11	
Absolute accuracy [1]		MHz	3000	200
Quick coupling accuracy		MHz	3000	200
Measurement resolution		MHz	1000	100
Measurement speed (depending on PC hardware and settings)		Hz	50 – 100	
Required input energy and power [2]	Pulsed	µJ	20	
	cw	mW	1	
Fizeau interferometers [3]		FSR (GHz)	80	8(80)
Coupling fiber			PIR-450/500 or CIR-450/500	
Calibration			dν < 100 MHz [4]	dν < 10 MHz [4]
Calibration period			30 minutes	
Warm-up time			No warm-up time required	
Dimensions L × W × H		mm	360 × 120 × 120	
Weight		kg	5.8	
Interface			High-speed USB 2.0 connection	
Power supply			External power supply included	

1) according to 3σ criteria 2) Signal/noise will be 5:1, thus averaging is required 3) Values for fine/wide-mode 4) E.g. Highlight SLR-1532 (not included)



Available IR-III options

■ Single PID-controller (PID) ■ Trigger option (TTL)

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NEW: Mid-IR Laser Spectrum Analyser – LSA IR-III

Customized Mid-IR Spectrometer: choose any intervall in the range of 2 – 11 µm with maximal achievable accuracy!

Analyse single-line, multi-line or broadband spectra of any pulsed or cw Mid-IR light sources.

- **Typical combinations of range / accuracy / spectral resolution:**

LSA IR-III$_{2-3}$:	2 – 3 µm	/	1 nm	/	15 nm
LSA IR-III$_{2-6}$:	2 – 6 µm	/	2 nm	/	20 nm
LSA IR-III$_{2-11}$:	2 – 11 µm	/	5 nm	/	30 nm

- **Pulsed / cw laser measurements**
- **Sensitivity: 10 µJ / 0.2 mW**
- **Linewidth measurement accuracy: 15% (≥ 10 GHz)**

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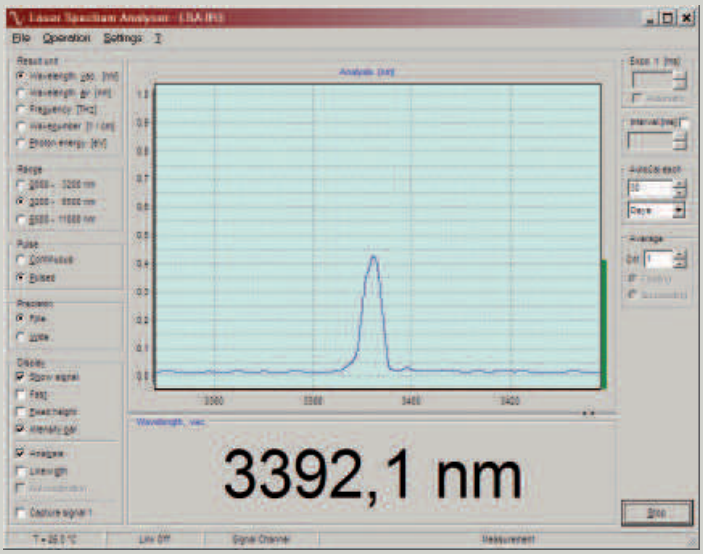
Laser and Electronic Systems

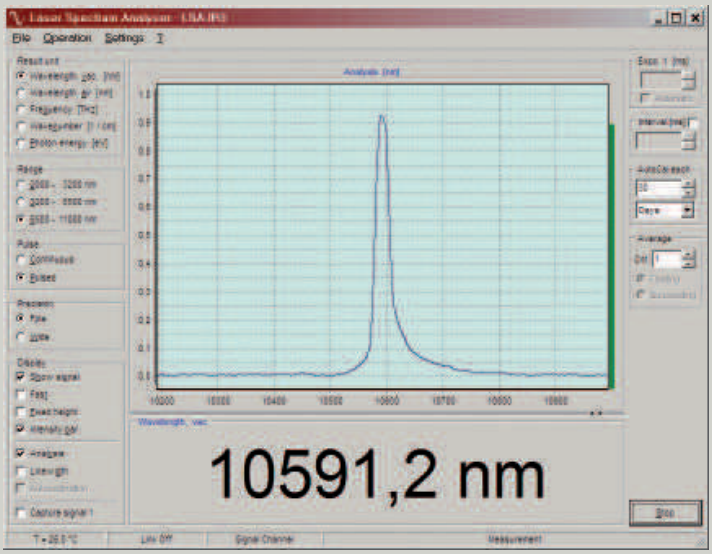
Technical Data LSA IR-III		Unit	Type 2 – 3	Type 2 – 6	Type 2 – 11
Measurement range		µm	2 – 3	2 – 6	2 – 11
Absolute accuracy [1]		nm	1	2	5
Relative accuracy			1.25×10^{-4}	3×10^{-4}	5×10^{-4}
Wavelength deviation sensitivity			0.7×10^{-4}	1.5×10^{-4}	2.5×10^{-4}
Spectral Resolution		nm	15	20	30
Linewidth measurement accuracy			15%		
Maximal linewidth		THz	1 (up to 15 [2])		
Measurement speed (depending on PC hardware and settings)	Wavelength & linewidth calculation	Hz	200		
	Analysis		15		
Required input power	Pulsed	µJ	10		
	cw	mW	0.2		
Diffraction Grating	FSR	THz	~ 2.7		
Coupling fiber			PIR-450/500 or CIR-450/500		
Calibration			SLR-1532, SLR-1550, or 3.39 µm HeNe calibration laser (not included)		
Calibration period			15 days		
Warm-up time			No warm-up time needed		
Dimensions L x W x H		mm	325 × 180 × 77		
Weight		kg	3.0		
Interface			High-speed USB 2.0 connection		
Power supply			External power supply included		

1) According 3σ criteria 2) Broad line versions. For further information please contact us

Sample measurements of the Laser Spectrum Analyser

Spectra of a non stabilized 3.4 µm HeNe and a CO_2 laser measured with the Laser Spectrum Analyser





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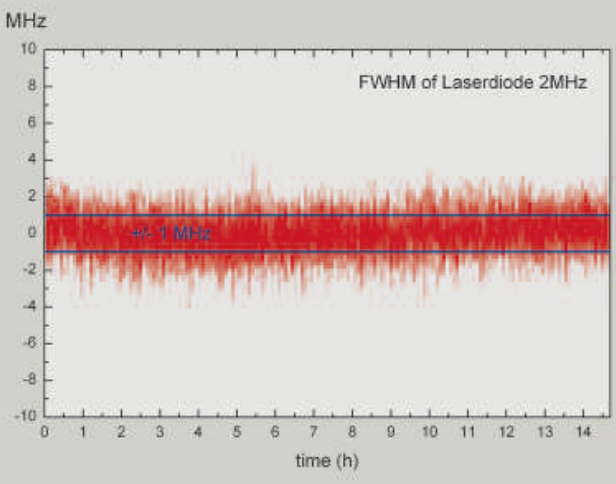
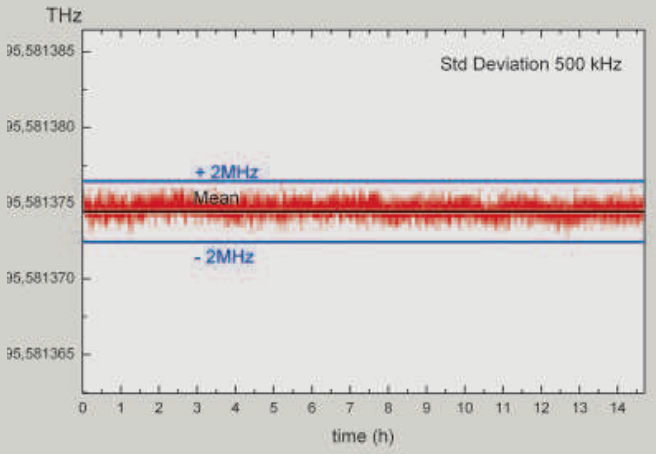
Highlight series: Stabilized Laser References

Calibration sources for all HighFinesse wavelength meters

- **Fiber coupled laser output**
- **Wavelengths: 780 nm, 850 nm, 895 nm, 1532 nm, 1555 nm other wavelengths on request**
- **Output power (adjustable): 0 – 3 / 0 – 10 mW @ 1532 & 1555 nm 0 – 5 mW @ 780, 850 & 895 nm**
- **Frequency stability and absolute Accuracy: better than ± 2 MHz at constant temperature conditions**
- **Self (re-)calibration**
- **Compact design**
- **Easy to use - „Plug & Play“**



Measurement of the beat signal with a frequency comb over 14 hours



Longterm measurement by WSU IR-I wavelength meter

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HighFinesse calibration sources

- **Stabilized HeNe Laser @ 632 nm**
  SL-02
  Suitable for U30 (standard and UV-ranges)

- **Stabilized HeNe Laser @ 632 nm**
  SL03 + Isolator
  Suitable for U10 (standard and UV-ranges)

- **Stabilized Laser Reference @ 780, 850 & 895 nm**
  SLR-780, SLR-850 & SLR-895
  Suitable for U10 and U2 (standard and UV-ranges)

- **Stabilized Laser Reference @ 1532 & 1555 nm**
  SLR-1532 & SLR-1555
  Suitable for WSU IR, WS7 IR, WS7 IR-II, WS6-200 IR-III & LSA IR-III

- **Infrared HeNe Laser @ 3.39 µm**
  MIR-HeNe
  Suitable for LSA IR-III

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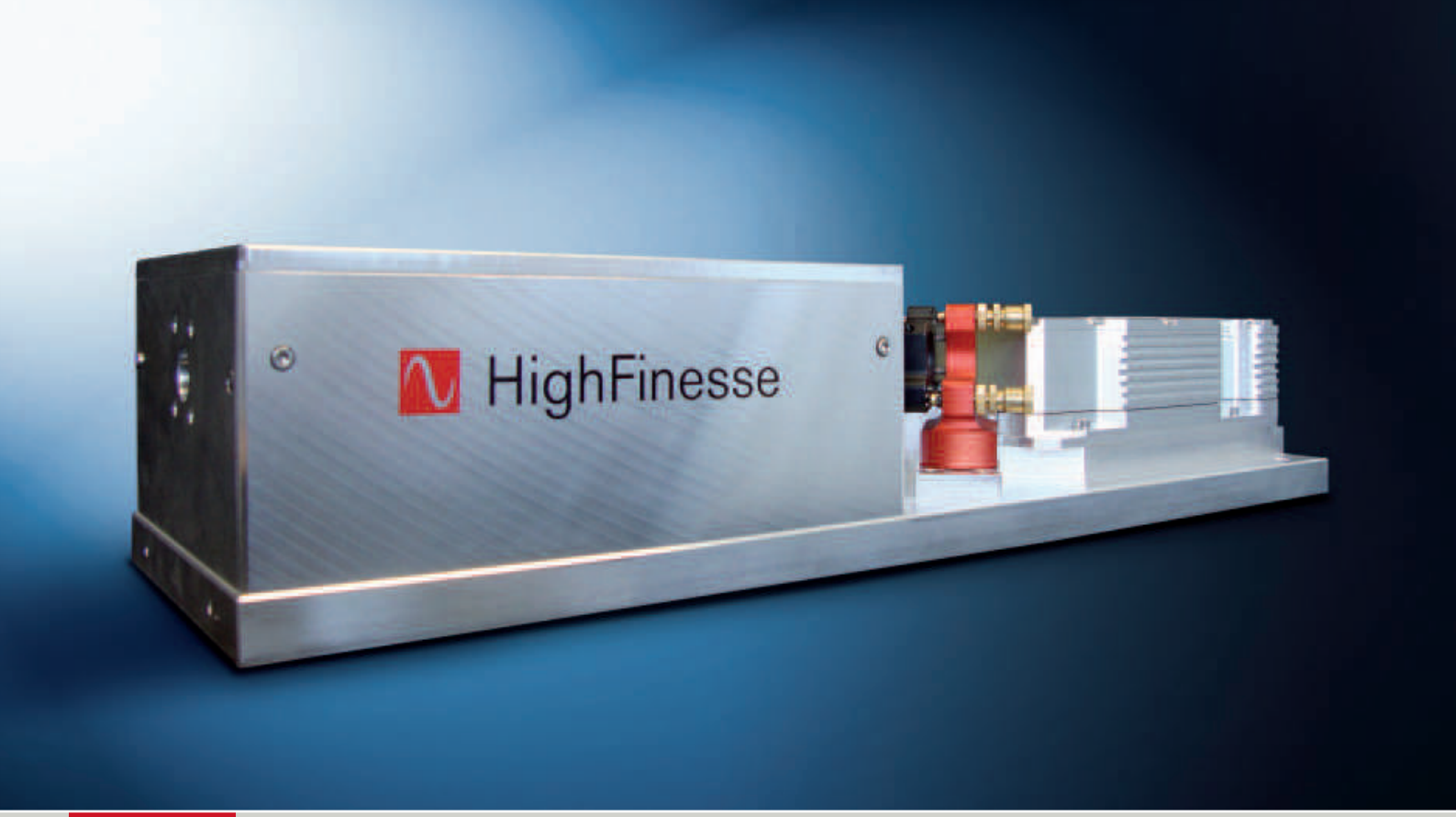

NEW: TS:fast – cw Ti:sapphire laser*

- Ultrabroad tuning range
- High-speed tunable
- Stand alone device
- Easy to use: no user adjustments needed
- Fiber coupled
- Compact design

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Laser and Electronic Systems

* Picture may differ from original product.

CW Titanium:Sapphire Laser

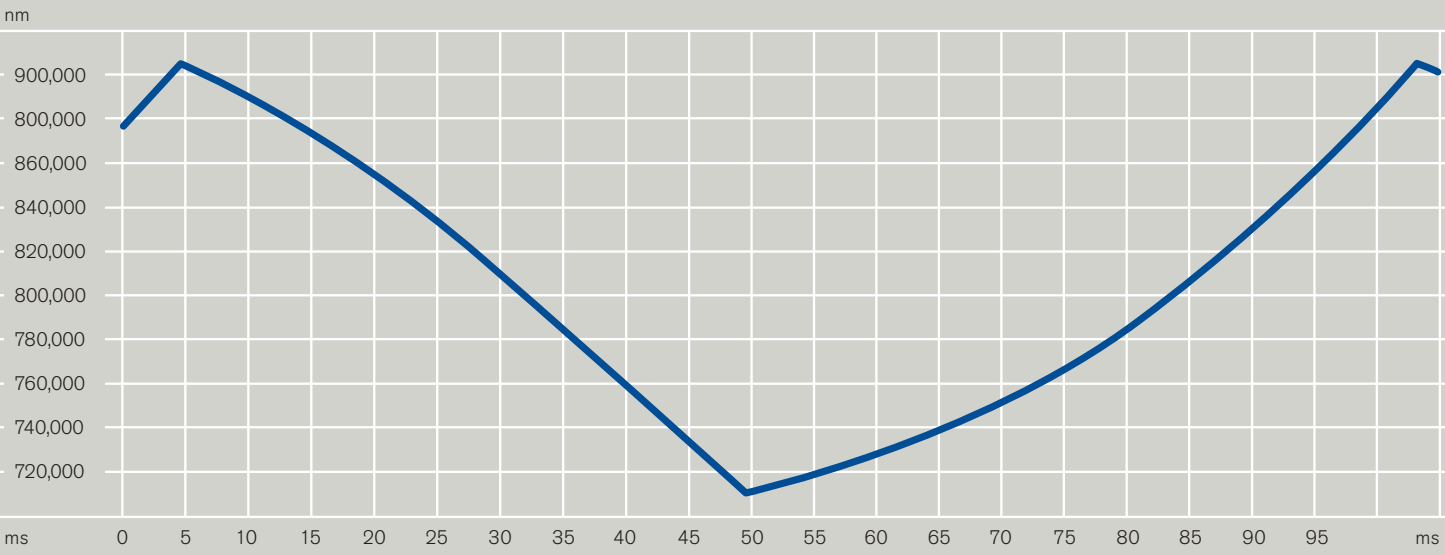
The TS:fast was developed as a stand alone high-speed tunable laser for quick scans in biological, chemical and medical applications like OCT (Optical Coherence Tomography) and spectroscopy.

The casing contains the Ti:sapphire laser as well as the pump laser. This combination makes the overall structure compact and exceedingly robust.

Laser specifications	Unit	TS:fast
Wavelength	nm	680 – 1000 [1]
Linewidth	GHz	< 20
Coherence length	mm	> 15
Tuning speed	Hz	up to 500
Output power	mW	< 5 after SM fiber [2]

1) Broader ranges on request 2) High power version on request, max. 2 W

Ultra-fast modehop free scan



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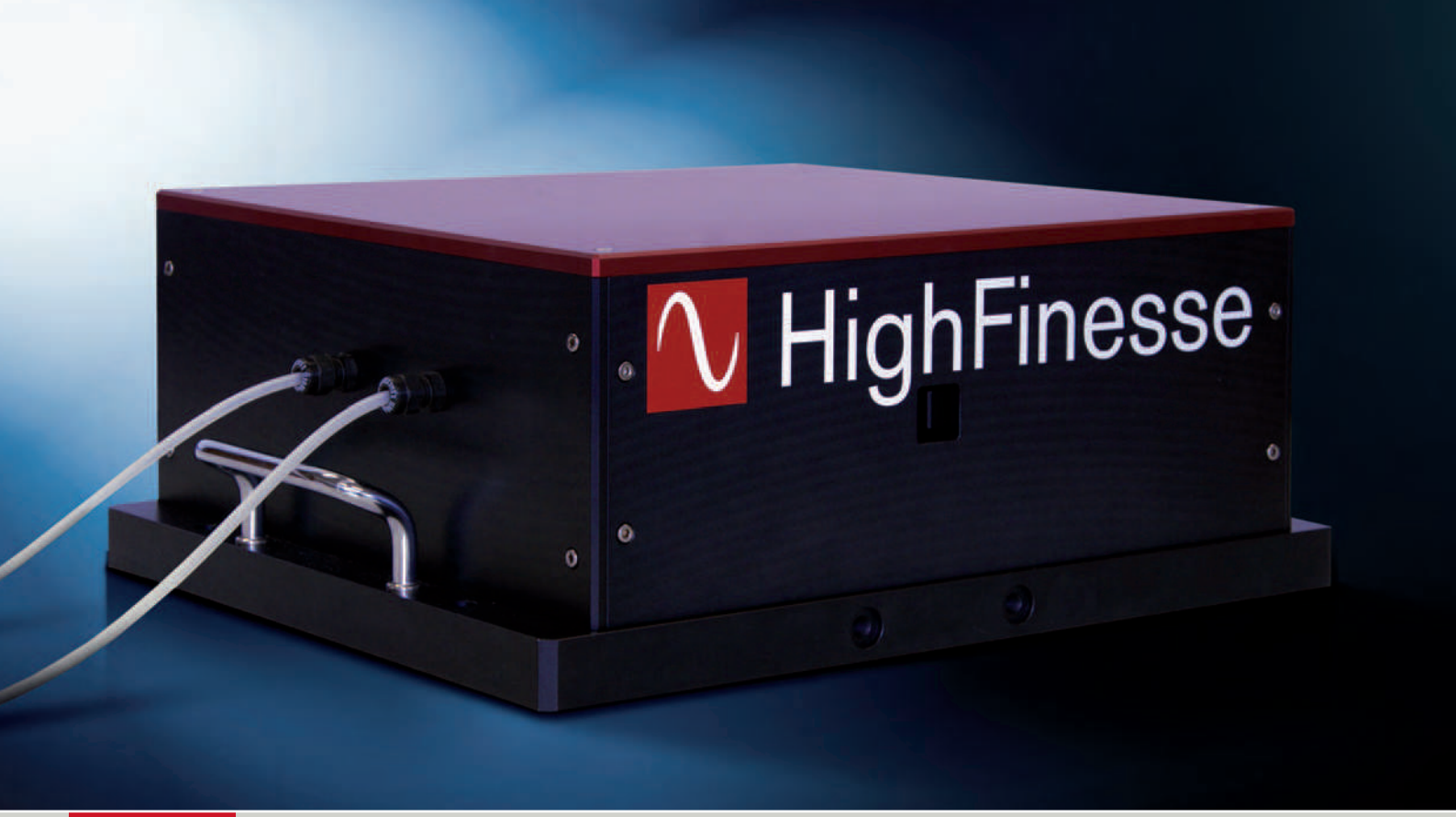

NEW: TS:precise – cw Ti:sapphire laser*

- Perfect beam parameters
- Modular design
- Easy to use: almost no user adjustments needed
- Stand alone device with integrated pump source and SHG
- Robust and compact design
- Unique patent pending slides technology and dedusting unit

HighFinesse
Laser and Electronic Systems

* Picture may differ from original product.

CW Titanium:Sapphire Laser

Innovative SINGLE+ Ti:Sapphire Laser Technology* for scientific and industrial applications.

Laser specifications	TS:precise
Modes of operation	Single mode (with filter cavity)
	Single mode plus two sidebands with adjustable power ratio (carrier/sideband separation 2 GHz)
	Two mode operation – advantageous for second harmonic generation
Enhanced efficiency	Significantly enhanced output power as compared with conventional technologies
In combination with HighFinesse Second Harmonic Generation	Up to a factor of six enhanced harmonic power as compared with conventional technologies
Tunability	Full Ti:Sapphire range
Compact, robust design	Drastically simplified alignment due to SINGLE+ Technology*
In combination with HighFinesse wavelength meters	Absolute optical frequency control with an accuracy to below 1 MHz
Applications	Single and multiple frequency high resolution laser spectroscopy
	Laser cooling (the most universal and powerful source for this application)
	Optical lattices, optical tweezers and dipole traps (Two mode operation allows for doubling the trap depth)
	Spectroscopy on biological and chemical samples
	Environmental analysis

* The unique SINGLE+ Ti:Saphire Laser Technology developed by HighFinesse introduces a new quality and performance regime for Ti:Saphire laser products. The fundamentally new laser design avoids intracavity optical isolators and etalons and thereby reaches improved output power, compact design and high reliability.

TS:precise with SINGLE+ Ti:Sapphire Laser Technology

System specifications		TS:precise
Output power	6 W pump	> 2000 mW
	5 W pump	> 1600 mW
	4 W pump	> 1000 mW
	3 W pump	> 680 mW
	2 W pump	> 340 mW
Harmonic output power	6 W pump	> 1000 mW
	5 W pump	> 640 mW
	4 W pump	> 360 mW
	3 W pump	> 160 mW
	2 W pump	> 40 mW
Optical output power noise		< 1 %
Tunability		700 – 1040 nm and 350 – 520 nm *
Single mode scanning range	slow / fast rate	1 Hz: > 20 GHz / 1 kHz: > 1.5 GHz
Linewidth		< 50 kHz
Spatial mode		TEM_{00}
		Rayleigh length: 50 mm
		Beam divergence: 2.2 mrad (half angle)
		Beam waist radius: 0.11 mm
Polarization		Horizontal
Laser head dimensions	(LxWxH)	400 × 450 × 150 mm / 157 × 177 × 59 ''
Control unit dimensions	(LxWxH)	310 × 465 × 100 mm / 121 × 183 × 39 ''
Operating voltage	Volt	110 ± 5 % / 230 ± 5 %
Cooling requirements		Closed loop chiller included
External frequency control		Analog/digital/computer/absolute wavelength control
Pump laser		Laser Quantum Finesse
Ambient temperature range		15 to 30 °C

* In combination with HighFinesse Second Harmonic Generation

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Precision Current Sources for Cold Atoms Physics

- Extremely low-noise bipolar transistor technology
- Ultra-fast response time
- Precise control
- From milliamps up to 200 A
- High impedance or galvanically isolated inputs (option)
- Battery supply (option)
- SMD based compact current sources from mains/battery supply

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Precision Current Sources

The current sources of the series BCS (bipolar current source), UCS (uniploar current source) and CCS (constant current source) from HighFinesse have been developed for precision experiments in the fields of quantum optics and ultracold atoms. They are especially suitable for generating extremely low noise source currents and for controlling magnetic fields with highest precision.

Power Features		
Types	BCS-series	Analog controlled, bipolar current generator with continuous sweep through zero (bipolar transistor technology)
	UCS-series	Analog controlled, unipolar current generator with continuous sweep to zero (bipolar transistor technology)
	CCS-series	Constant current generator (bipolar transistor technology)
Current Range	Up to 200 A	Supply: one/three phase mains voltage. Cooling: air/water cooling
	Up to 20 mA	Supply: battery incl. recharge unit
Specification		Current- /voltage range individually as required
Current Outputs		Floating or grounded (adjustable)
Control	Analog	With ±10 V control voltage
	Manual (option)	10-turn-potentiometer
Trigger Characteristics		Trigger sets the current to zero. Configuration to interlock is possible. Trigger changes between two current values (alternative option)
Response Time		Adjustable between 100 µs und 100 ms
Waviness of the Current		$< 10^{-5}$ (characteristic multiplication factor)
Current Noise		$\frac{I_{noise}(RMS) * R_{max}}{I_{max} * R_{max}} <$ -90 dB (typically between -95 and -110 dB) Due to careful electronic design for noise protection
Adjustment Accuracy		0.1 % (of total amplitude) 1 % (of total amplitude) with galvanic isolation
Temperature Coefficient		25 ppm/K
Monitor		LCD current display
Case		Standard 19" rack system
Quasi-Galvanic Isolation (option)		High ohmic input (5,1 MΩ) for analog control port and optocoupler for trigger
Galvanic Isolation (option)		Optical isolation amplifier (150 ppm/K) for analog control port and optocoupler for trigger
Battery connection Set (option)		For operation from batteries (up to 20 A)
Guarantee		12 months guarantee by manufacturer, extended service options

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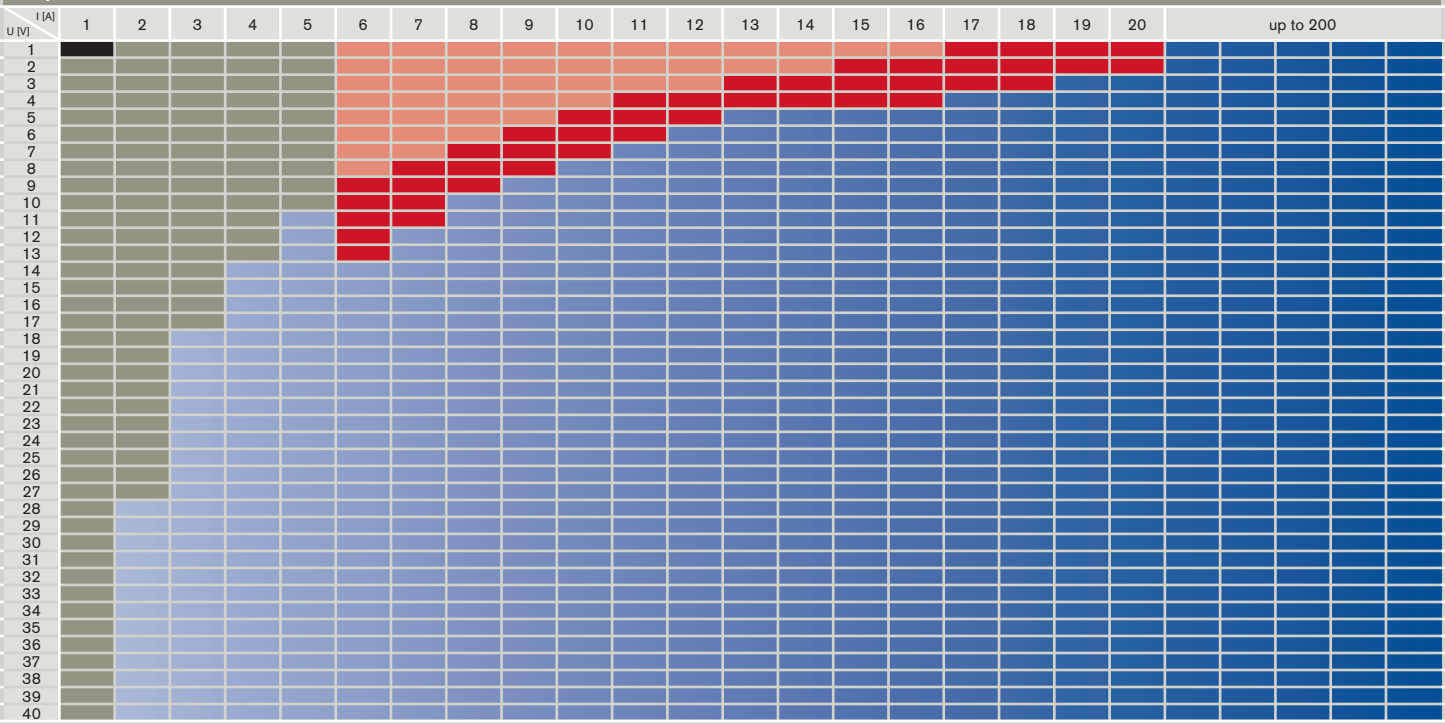
Power Categories
Current- and Voltage-Characteristics

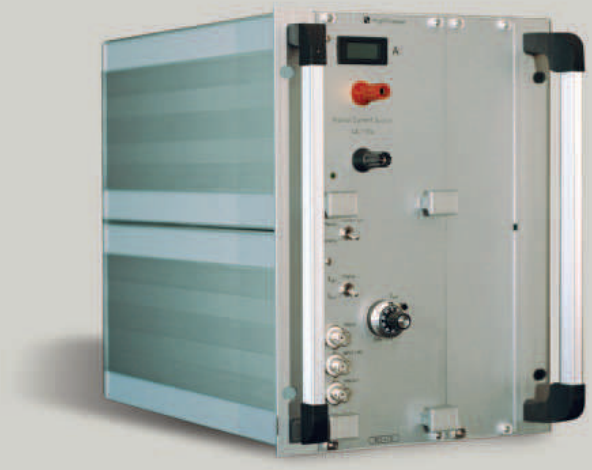
High Finesse offers precision current sources of the BCS-, UCS- and CCS-series in several power categories, within which the requested current- and voltage characteristics may be tuned individually (survey). The modular construction permits the individual control of the current and voltage ranges as well as response times and inductive load capacity, and thus enables an accurate adjustment to the requirements. On request, we offer current sources with maximum current and voltage values beyond the standard power range listed below and with customer specified control options.

Bipolar Current Sources (BCS I/U)



Higher voltages on request.

Power Category	Design
	1 One phase mains voltage supply, air cooling
	2 Three phase mains voltage supply, air cooling
	3 Three phase mains voltage supply, ventilator cooling
	S Water cooled models
	B For battery models up to 10 mA, please see our separate data sheet.

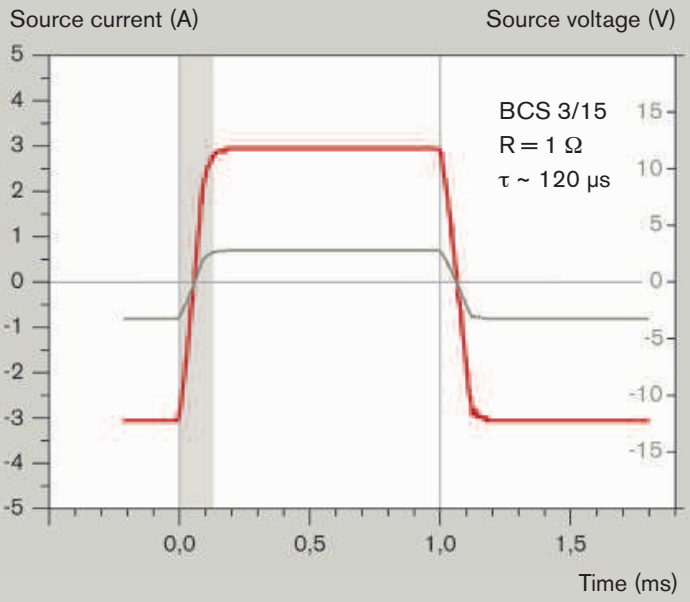


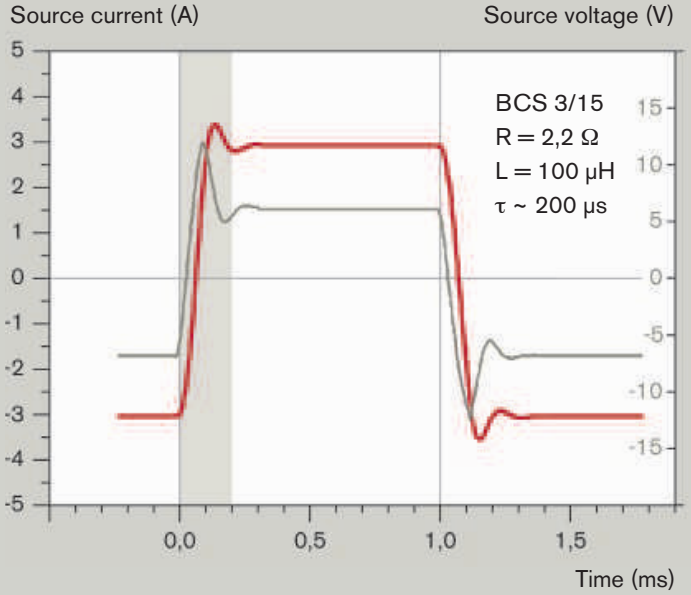
Standard BCS current source.
(Exact size depends on the power category.)

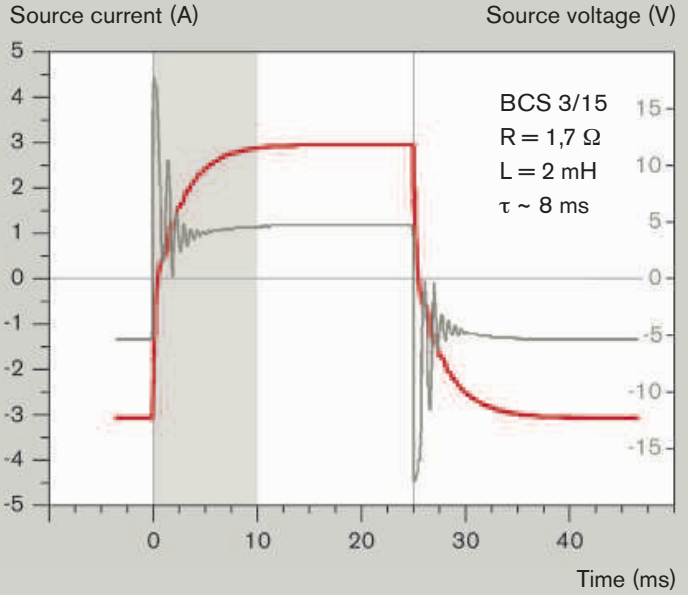
Battery supplied bipolar precision current with integrated recharge unit (up to 10mA). Please request for separate data sheet.

Response Time

A fundamental requirement for current sources in scientific research is the short and controllable response time. The precision current sources of HighFinesse feature extremely short response times which are conveniently adjusted to the experimental conditions. The diagrams show the typical behaviour measured at different loads and settings.





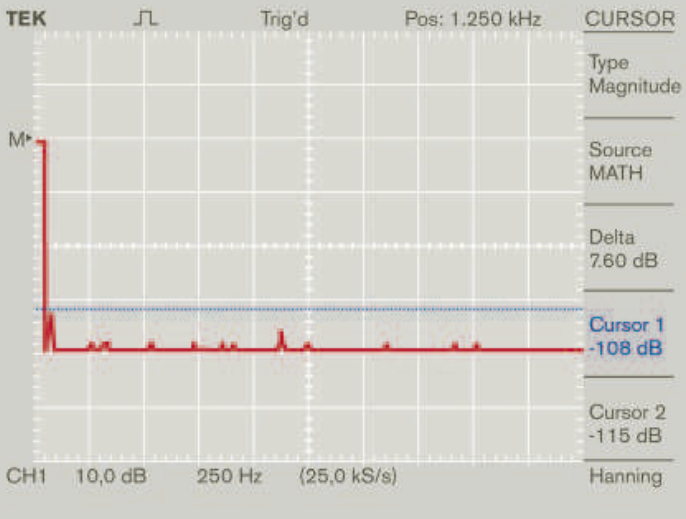


Noise Spectrum

The use of current sources in precision applications requires high accuracy, stability and low-noise currents. Current sources by HighFinesse were designed to meet these requirements. The diagram shows the FFT-spectrum of the BCS 3/15 current source between 0 and 2500 Hz. The spectrum shows a noise level below -108 dB V_{RMS}.

The measurement was taken at 3A and an ohmic load of 1 Ω Trigger: AC line; Average: 128.
Voltage noise < 4 μV_{RMS}.

Each current source is tested carefully before delivery, so the switching time and noise characteristics are included in the manual.



We are pleased to accommodate your individual requirements concerning special features, response time, and accuracy. Furthermore, we offer current sources beyond our standard power ranges on request. We look forward to receiving your inquiry.

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Lynceus-320 InGaAs Camera

The Lynceus-320 is a fast and lightweight InGaAs camera with high sensitivity and a wide dynamic range. The InGaAs focal plane array has a resolution of 320 × 256 pixels and offers a full framerate of 50 fps. A USB 2.0 interface serves as power supply and guarantees convenient compatibility with PC driven operations.

Possible applications involve water and moisture detection, profiling infrared laser beams and analyzing NIR spectra or lasers, testing silicon wafers, seeing through glas, viewing objects with temperature >400°C and sorting objects according to their NIR reflection behaviour.

- Digital framerate: 50 fps
- Spectral range: 0,9 - 1,7 µm
- Size: 89 x 63 x 79 mm
- Weight: 380 g
- Dynamic range: 60 dB
- Passive cooling
- Interface & power supply via USB 2.0
- Windows 2000 and later

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IR filter testing –
looking through glass

Water absorption –
fluid level monitoring

Radiation insulation analysis

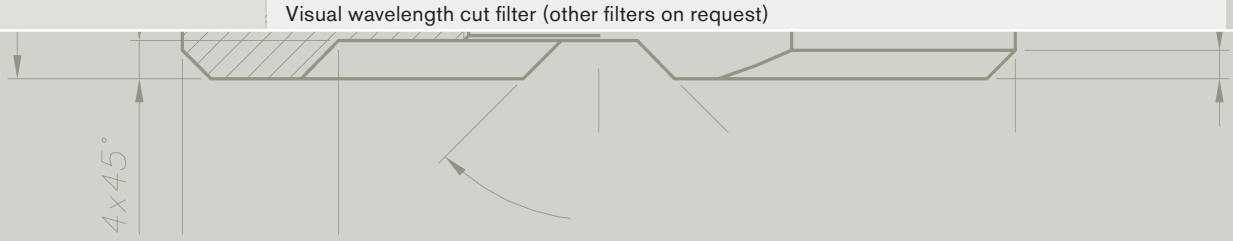
Thermal imaging

Camera specifications	
Dimensions	89 × 63 × 78 mm (L × W × H)
Weight	380 g – without lens
Lens mount	C-mount
Power consumption	Power supply via USB 2.0
Camera cooling	Passive cooling
Ambient operating temperature	ca. 0 – 50 °C
Humidity	non condensing
Dynamic range	60 dB, 1600:1 in low gain

Array specifications	
Type of sensor	InGaAs (Focal Plane Array)
Wavelength range (spectral band)	0.9 – 1.7 µm
Resolution	320 × 256 pixels
Pixel size	30 × 30 µm
Framerate	50 fps
Read out mode	global
Array cooling	uncooled
Exposure time range	40 µs – 40 ms
Nonlinearity capacity (max. deviation)	< 2 %
Gain low/high	0.77 / 14.38 µV / e-, 25 °C

Interface	
Operation mode	PC driven
Camera control	USB 2.0
Image acquisition	USB 2.0
Triggering	TTL
Software	Demonstration software and SDK for camera
Software features	image stabilization, storing images and videos, image histogram, line profiles, image correction algorithms (brightness, contrast, gamma correction), dynamic image transposition (top-to-bottom + left-to-right), time control, image live view, array control
Compatibility	Windows 2000 and later

Accessories	
Interface cable	USB 2.0 cable included
Lens	16.2 mm f/1.4 included (other lenses on request)
Filter	Visual wavelength cut filter (other filters on request)



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