

## LightMachinery Spectrometers Detailed Technical Specifications



## Hyperfine HF Series for Weak Sources

### Adjustable range HF models

	HF-8989-1	HF-8989-2{e}	HF-8989-3	HF-8995-1	HF-8991-3	HF-8995-2	HF-8995-3 (Plasma)
<b>Spectral region</b>	Vis			NIR			
<b>Spectral resolution***</b>	1.3 pm (0.05/cm)	1.6 {1.4} pm (0.05/cm)	1.6 pm (0.04/cm)	2.0 pm (0.03/cm)	2.0 pm (0.02/cm)	2.5 pm (0.02/cm)	0.9 pm (0.01/cm)
<b>Resolving power</b>	$3.6 \times 10^5$	$3.4 \{4.2\} \times 10^5$	$4.1 \times 10^5$	$3.8 \times 10^5$	$4.4 \times 10^5$	$4.0 \times 10^5$	~1 million
<b>Total spectral range</b>	425-500 nm	500-600 nm {520-640 nm}	600-700 nm	700-800 nm	800-950 nm	950-1100 nm	775-900 nm
<b>Simultaneous range</b>	13 nm	16 nm {14 nm}	16 nm	20 nm	20 nm	25 nm	9 nm
<b>Sim. range/resolution</b>	10 000						
<b>Motorized grating?</b>	Yes						
<b>Absolute accuracy</b>	$\pm 20$ pm						
<b>Acquisition speed</b>	>10 Hz						
<b>Fiber input</b>	SMF or MMF (105 $\mu$ m, 0.22 NA), FC/PC (specified pre-purchase)						
<b>Slit width</b>	5 or 10 $\mu$ m						5 $\mu$ m
<b>F# / NA</b>	~f/4.5						~f/6
<b>Typical throughput</b>	>25 %						~10 %
<b>Calib. source needed?</b>	Yes, HyperCal or user-provided						
<b>Typical FSR crosstalk</b>	<1 %						<1.5 %
<b>VIPA FSR</b>	75 GHz	75 GHz {60 GHz}	60 GHz	60 GHz	50 GHz	50 GHz	30 GHz
<b>Default sensor</b>	sCMOS						
<b>Sensor dynamic range</b>	$\sim 9 \times 10^3$						
<b>Sensor QE</b>	~65%	~70%	~70%	~55%	~30%	<10%	~40%
<b>Approx. min. input power (105 <math>\mu</math>m, 0.22 NA)</b>	~5 pW pse	~5 pW pse	~5 pW pse	~6 pW pse	~10 pW pse	~0.1 nW pse	~8 pW pse
<b>Approx. min. input power (SMF)</b>	~0.05 pW pse	~0.05 pW pse	~0.05 pW pse	~0.06 pW pse	~0.1 pW pse	~1 pW pse	~0.08 pW pse
<b>Trigger</b>	Yes						
<b>Dimensions</b>	A						D

### Notes and upgrades:

- **The following is included with all standard models:**
  - Spectrometer with integrated sensor and accessories
  - SpectraLoK software for real-time acquisition and more
  - Computer and accessories
- **Upgrades for the Hyperfine HF Series** (available for certain models)
  - \*\*\*UHR upgrade: 1.8X increase in resolving power
  - ULC upgrade: 5 X decrease in crosstalk, available for certain models
  - Camera upgrade: cooled CCD, lower noise sCMOS, ICCD, or other user-selected camera
  - High-speed upgrade: up to 1000 Hz
  - HyperCal calibration source
  - Other beta-stage upgrades are available upon request (see extended datasheet for more details)
- **All models are customizable;** don't hesitate to ask us!

## Hyperfine HF Series for Weak Sources

### Fixed range HF models

	HF-7888-LLL (beta)	HF-8999-PK-LLL * (Brillouin)	HF-8888-UV (LIBS, beta)	HF-9332	HF-9353 (beta)
Spectral region	UV-Vis-NIR	UV-Vis-NIR	UV	Vis	NIR
Spectral resolution***	0.2 - 0.8 pm	0.3 – 1 pm	30 pm (0.8/cm)	25 pm (0.9/cm)	40 pm (0.5/cm)
Resolving power	~1 million	~1 million	~1*10 <sup>4</sup>	~2*10 <sup>4</sup>	~2*10 <sup>4</sup>
Total spectral range	Fixed 2 – 8 nm selected within 350-1080 nm	1-2 nm centered on 355, 457, 532, 660, or 780 nm	Fixed 60 nm selected within 200 - 400 nm	450 – 700 nm	750-1050 nm
Simultaneous range	2 – 8 nm	1-2 nm	60 nm	250 nm	300 nm
Sim. range/resolution	~10 000	~1000 - 6000	~2000	~10000	~7500
Motorized grating?	No				
Absolute accuracy	<±10 pm	<±10 pm	<± 50 pm		
Acquisition speed	>10 Hz				
Fiber input	SMF or MMF (105 um, 0.22 NA), FC/PC (specified pre-purchase)	SMF	MMF (105 um, 0.22 NA), SMA		
Slit width	5 or 10 um	No slit	5 um		
Approx. aperture	~f/4.5		~f/5	~f/4	~f/4
Typical throughput	>25 %				
Calib. source needed?	No				
Typical FSR crosstalk	~0.5 %	<0.2 %	<1%		
VIPA FSR	15 or 30 GHz	15, 30, or 50 GHz	2000 GHz	1000 GHz	660 GHz
Default sensor	sCMOS		CMOS		
Sensor dynamic range	~9 *10 <sup>3</sup>	~2 *10 <sup>4</sup>	~3 *10 <sup>4</sup>	~4 *10 <sup>3</sup>	~4 *10 <sup>3</sup>
Sensor QE	<1% - 70%	~45 – 80%	~15-60 %	~65 %	~13%
Approx. min. input* power (105um, 0.22 NA)	5 pW - 1 nW pse	NA	~10 pW pse	~1 pW pse	~5 pW pse
Approx. min. input* power (SMF)	0.05 - 10 pW pse	~5 pW pse	NA		
Trigger	Yes	NA	Yes		
Form factors	E	D	A	C	C

### Notes and upgrades:

- **The following is included with all standard models:**
  - o Spectrometer with integrated sensor and accessories
  - o SpectraLoK software for real-time acquisition and more
  - o Computer and accessories
- **Upgrades for the Hyperfine HF Series** (available for certain models)
  - o \*\*\*UHR upgrade: 1.8X increase in resolving power
  - o ULC upgrade): 5 X decrease in crosstalk, available for certain models
  - o Camera upgrade: cooled CCD, lower noise sCMOS, ICCD, or other user-selected camera
  - o High-speed upgrade: up to 1000 Hz
  - o HyperCal calibration source
  - o Other beta-stage upgrades are available upon request (see extended datasheet for more details)
- **All models are customizable;** don't hesitate to ask us!

## Hyperfine HN Series for Bright Sources

### Adjustable range HN models

	HN-8989-1	HN-8989-2{e}	HN-8989-3	HN-8995-1	HN-8991-3	HN-8995-2	HN-8995-2-0.9
<b>Spectral region</b>	Vis			NIR			
<b>Spectral resolution***</b>	1.3 pm (0.05/cm)	1.6 {1.4} pm (0.05/cm)	1.6 pm (0.04/cm)	2.0 pm (0.03/cm)	2.0 pm (0.02/cm)	2.5 pm (0.02/cm)	0.9 pm (0.01/cm)
<b>Resolving power</b>	$3.6 \times 10^5$	$3.4 \{4.2\} \times 10^5$	$4.1 \times 10^5$	$3.8 \times 10^5$	$4.4 \times 10^5$	$4.0 \times 10^5$	~1 million
<b>Total spectral range</b>	425-500 nm	500-600 nm {520-640 nm}	600-700 nm	700-800 nm	800-950 nm	950-1100 nm	1030-1090 nm
<b>Simultaneous range</b>	13 nm	16 nm {14 nm}	16 nm	20 nm	20 nm	25 nm	9 nm
<b>Sim. range/resolution</b>	10 000						
<b>Motorized grating?</b>	Yes						
<b>Absolute accuracy</b>	<± 20 pm						
<b>Acquisition speed</b>	>10 Hz						
<b>Fiber input</b>	SMF or MMF (400 um, 0.39 NA), FC/PC (specified pre-purchase)						
<b>Slit width</b>	5 or 10 um						5 um
<b>Approx. aperture</b>	~f/4.5						~f/6
<b>Typical throughput</b>	~0.2 %						
<b>Calib. source needed?</b>	Yes, HyperCal or user-provided						
<b>Typical FSR crosstalk**</b>	<0.7 %						<1 %
<b>Etalon FSR</b>	75 GHz	75 GHz {60 GHz}	60 GHz	60 GHz	50 GHz	50 GHz	30 GHz
<b>Default sensor</b>	CMOS			sCMOS			
<b>Sensor dynamic range</b>	~4 *10 <sup>3</sup>			~9 *10 <sup>3</sup>			
<b>Sensor QE</b>	~60	~65	~55	~55%	~30%	<10%	~40%
<b>Approx. min. input power (200 um, 0.22 NA)</b>	0.5 nW pse	0.5 nW pse	0.6 nW pse	0.6 nW pse	~1 nW pse	~5 nW pse	~0.8 nW pse
<b>Approx. min. input power (SMF)</b>	5 pW pse	5 pW pse	6 pW pse	6 pW pse	~10 pW pse	~50 pW pse	~8 pW pse
<b>Trigger</b>	Yes						
<b>Dimensions</b>	A						

### Notes and upgrades:

- **The following is included with all standard models:**
  - o Spectrometer with integrated sensor and accessories
  - o SpectraLoK software for real-time acquisition and more
  - o Computer and accessories
- **Upgrades for the Hyperfine HN Series** (available for certain models)
  - o \*\*\*UHR upgrade: 1.8X increase in resolving power
  - o ULC upgrade (beta): 5 X decrease in crosstalk, available for certain models
  - o Camera upgrade: user-selected camera
  - o High-speed upgrade: up to 1000 Hz
  - o HyperCal calibration source
  - o Other beta-stage upgrades are available upon request (see extended datasheet for more details)
- **All models are customizable;** don't hesitate to ask us!

## Hyperfine HN Series for Bright Sources

### Fixed range HN models

	HN-7888-LLL (beta)	HN-8888-UV (beta)	HN-9332	HN-9353	HN-9352 (beta)	HN-9354
Spectral region	UV-Vis-NIR	UV	Vis	NIR	VIS-NIR	NIR
Spectral resolution***	0.2 - 0.8 pm	30 pm (0.8/cm)	25 pm (0.45/cm)	40 pm (0.3/cm)	15 pm	10 pm
Resolving power	~1 million	~1*10 <sup>4</sup>	~4*10 <sup>4</sup>	~4*10 <sup>4</sup>	~5*10 <sup>2</sup>	~1*10 <sup>5</sup>
Total spectral range	Fixed 2 – 8 nm selected within 350-1080 nm	Fixed 60 nm selected within 200 - 400 nm	450 – 700 nm	750-1050 nm	530-534 nm 1060-1068 nm	1010-1080 nm
Simultaneous range	2 – 8 nm	60 nm	250 nm	300 nm	4 & 8 nm	70 nm
Sim. range/resolution	~10 000	~2000	~10000	~12000	~800	~7000
Motorized grating?	No					
Absolute accuracy	<±10 pm	<± 50 pm				
Acquisition speed	>10 Hz					
Fiber input	SMF or MMF (50um, 0.22 NA), FC/PC (specified pre-purchase)	SMF, FC/PC				
Slit width	5 or 10 um	No slit				
Approx. aperture	~f/4.5	~f/4				
Typical throughput	~0.2 %					
Calib. source needed?	No					
Typical FSR crosstalk	~0.3 %	<1 %	<0.5 %			
Etalon FSR	15 or 30 GHz	2000 GHz	1000 GHz	660 GHz	150 GHz	150 GHz
Default sensor	sCMOS	CMOS				
Sensor dynamic range	~9 *10 <sup>3</sup>	~3 *10 <sup>4</sup>	~4 *10 <sup>3</sup>	~4 *10 <sup>3</sup>	~4 *10 <sup>3</sup>	~6 *10 <sup>3</sup>
Sensor QE	<1% - 70%	~15-60 %	~65 %	~13%	<5% - 65%	<5%
Approx. min. input* power (200um, 0.22NA)	0.5 - 100 nW pse	NA				
Approx. min. input* power (SMF)	5 pW - 1 nW pse	~10 pW pse	~1 pW pse	~5 pW pse	~1 - 20 pW pse	~20 pW pse
Trigger	Yes					
Form factors	E	A	C	B		

### Notes and upgrades:

- **The following is included with all standard models:**
  - o Spectrometer with integrated sensor and accessories
  - o SpectraLoK software for real-time acquisition and more
  - o Computer and accessories
- **Upgrades for the Hyperfine HN Series** (available for certain models)
  - o \*\*\*UHR upgrade: 1.8X increase in resolving power
  - o ULC upgrade): 5 X decrease in crosstalk, available for certain models
  - o Camera upgrade: user-selected camera
  - o High-speed upgrade: up to 1000 Hz
  - o HyperCal calibration source
  - o Other beta-stage upgrades are available upon request (see extended datasheet for more details)
- **All models are customizable;** don't hesitate to ask us!

## Descriptions and definitions:

<b>Spectral region</b>	Rough indicator of the spectral range: divided as UV (<400 nm), Vis (400-700 nm), and NIR (>700 nm)
<b>Spectral resolution</b>	Resolution refers to how close two narrow features can be while remaining distinguishable. It is specified here in terms of the FWHM of an instrument-limited feature. <b>Specified in the middle of the total spectral range.</b> The minimum value is specified, typically ~10-20% better resolution is achieved.
<b>Resolving power</b>	Defined as the ratio wavelength / FWHM resolution.
<b>Total spectral range</b>	Spectral range over which the instrument can be tuned in the case of rotatable grating spectrometers. Spectral range covered by fixed grating spectrometers.
<b>Simultaneous range</b>	Spectral range covered in a single measurement (single shot). Corresponds essential to the total spectral range in the case of fixed grating spectrometers.
<b>Sim. range/resolution</b>	Refers to the number of distinct spectral elements measured in a single shot. Literally the ratio of the simultaneous range and the spectral resolution.
<b>Motorized grating?</b>	Indicates whether the grating angle is fixed or adjustable.
<b>Absolute accuracy</b>	Characterizes how close the measured position of a given feature is in comparison to its “true” wavelength. Specified as the maximum wavelength error that can be observed at any time in the case of fixed grating spectrometers and immediately following calibration in the case of rotatable grating spectrometers.
<b>Acquisition speed</b>	Number of spectra per second that can be acquired (when it is not limited by the exposure).
<b>Fiber input</b>	Describes the required fiber input: the core type can be single mode fiber (SMF) and/or multimode fiber (MMF, typically on the order of 0.22 NA 105um); the connector type can be FC/PC or SMA. Free beam coupling can be accommodated in certain spectrometers, please contact us for details.
<b>Slit width</b>	The HF spectrometers combine a VIPA and a diffraction grating in a cross-dispersion configuration. The grating dispersion direction requires a slit; this is the slit width specified. Note that physically, the slit height is several mm; however the “used slit height” is simply equal to the core diameter of the fiber in the case of etalon-based spectrometers (HNs) and a fraction of the core diameter of the fiber in the case of VIPA-based spectrometers (HFs).
<b>Approx. aperture</b>	Approximate F-number of the spectrometer, namely the ratio of the collimator’s focal length / collimator’s (and subsequent optics’) clear aperture.
<b>Typical throughput</b>	Rough estimate of the fraction of input photons reaching the sensor (specified for a SMF input; for a MMF input, the throughput is lower and varies with the NA and the core size).
<b>Calib. source needed?</b>	Specifies whether an external calibration source is needed or not. Essentially, fixed grating spectrometers do not require a calibration source while rotatable grating spectrometers do. The external calibration source must be provided by the user or a HyperCal can be purchased.
<b>Typical FSR crosstalk</b>	Amplitude level of the small artefacts associated with the cross-dispersion configuration ( <b>for reference only, approximate level in the middle of the range</b> ). The crosstalk of strong features manifests as small “echoes” located precisely at +/- 1 VIPA or etalon FSR (free spectral range).
<b>VIPA or etalon FSR</b>	Free spectral range of the etalon or VIPA.
<b>Default sensor</b>	Type of camera included with the base model. Note that a megapixel 2D sensor array is required due to the 2D dispersion configuration.
<b>Sensor dynamic range</b>	Dynamic range of the default sensor, defined as the ratio of the well depth / read out noise.
<b>Sensor QE</b>	Quantum efficiency of the default sensor ( <b>specified approximately in the middle of the range of interest</b> ).
<b>Approx. min. input power (MMF)</b>	Rough estimate of the min power required per spectral element ( <b>specified approximately in the middle of the range of interest</b> ) for the signal to be well above background (i.e. for the signal-to-background ratio to reach on the order of >10) with an exposure of 1 second. Note that in the tables, “pW pse” stands for “pW per spectral element”
<b>Approx. min. input power (SMF)</b>	Same as above, but considering a SMF.
<b>Trigger</b>	Specifies whether the default sensor supports external triggering.
<b>Form factors</b>	Standard sizes and weights: A dimensions: 250 x 600 x 150mm, weight; 20Kg B dimensions: 200 x 200 x 90mm, weight; 2Kg C dimensions: 160 x 200 x 100mm, weight; 1.5Kg D dimensions: 700 x 150 x 400mm, weight; 28Kg E dimensions: 700 x 150 x 250mm, weight; 28Kg