

# H-SMART

## STAND-ALONE AUTOMATED HARMONICS GENERATOR

### FEATURES

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Stand-alone 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> or 5<sup>th</sup> harmonic generator compatible with Q2 and Q2HE series lasers

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Microprocessor controlled **temperature tuned** nonlinear crystals

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Factory-configurable up to **three exit ports**

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**Self-tuning** of crystals for maximum pulse energy

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Build-in **bypass** and/or **attenuator** of fundamental beam (for some models)

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Remote monitoring and control via common with laser or separate **Ethernet** interface

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Optional **enhanced spectral purity** of UV wavelengths

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Optional build-in or attachable motorized attenuator

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Optional build-in or attachable **pulse energy monitor**

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Optional fiber coupled output

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Optional air purging for improved lifetime of UV harmonic crystals and optics

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Optional mounting on common heatsink with Q2 series laser

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### APPLICATIONS

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Laser wavelength conversion

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Laser pulse energy control

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Laser pulse energy monitoring

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H-SMART is stand-alone automated harmonic generator module is designed to be used together with our Q2 and Q2HE series lasers. Module is intended to be mounted side-by-side with laser on common optical table or breadboard.

H-SMART offers automated, hands-free operation thanks to motorized optical mounts, temperature-tuned nonlinear crystals and build-in pulse energy monitors. Status of H-SMART can be remotely monitored and controlled from Q2/Q2HE laser control panel (PC is required). Alternatively, control is possible directly via build-in Ethernet interface.

H-SMART has three exit ports that can be factory-configured to emit up to 5<sup>th</sup> harmonic wavelengths. Most common exit port standard configurations are listed in the “Exit port configuration options” table below. Custom configurations are available by request.

## SPECIFICATIONS <sup>1)</sup>

MODEL	H-SMART
Conversion efficiency <sup>2)</sup>	
Fundamental to second harmonic	> 50 %
Fundamental to third harmonic	> 30 %
Fundamental to fourth harmonic	> 15 %
Fundamental to fifth harmonic	> 6 %
Pulse to pulse energy stability <sup>3)</sup>	
526.5 / 532 nm	< 2.5 % RMS
351 / 355 nm	< 3.5 % RMS
263 / 266 nm	< 4 % RMS
211 / 213 nm	< 5 % RMS
Spectral purity for Port #1 <sup>4)</sup>	> 99%
Typical pulse duration	10 – 20% shorter in each conversion stage
Typical beam diameter	10 – 30 % smaller than pump beam
Beam pointing stability	same as of pump beam
<b>DIMENSIONS</b>	
Harmonic generator (W×L×H)	160 × 270 × 141 mm <sup>3</sup>
Weight	< 5 kg
<b>OPERATING REQUIREMENTS</b>	
Ambient temperature	15 – 30 °C
Relative humidity	10 – 80 % (non-condensing)
Powering	12 VDC <sup>5)</sup>
Average power consumption	< 20 W

<sup>1)</sup> Due to continuous improvements all specifications are subject to change. The parameters marked typical are not specifications. They are indications of typical performance and will vary with each unit we manufacture.

<sup>2)</sup> Conversion efficiency presented here is for Port #1. Conversion efficiency at Port #2 or Port #3 depends on unit configuration and typically are lower than presented here. Please inquire for details.

<sup>3)</sup> When unit is pumped by our Q2 or Q2HE series laser. Measured during 30 seconds operation after warm-up.

<sup>4)</sup> Spectral purity at Port #2 or Port #3 could not be specified for two-wavelength output configuration.

<sup>5)</sup> When supplied with Q2 or Q2HE laser, H-SMART is powered from laser controller.

<sup>6)</sup> See drawing below for port number assignment.

<sup>7)</sup> Wavelength is shown for 1064 nm pump wavelength. For 1053 nm pump wavelength recalculate wavelengths accordingly.

<sup>8)</sup> Shows compatible attenuator model. This option is available only when H-SMART is supplied together with Q2 or Q2HE series laser.

<sup>9)</sup> Shows compatible pulse energy monitor model. This option is available only when H-SMART is supplied together with Q2 or Q2HE series laser.

<sup>10)</sup> Spectral purity is >98 %.

<sup>11)</sup> Both wavelengths exit Port #2, for separation external dichroic mirror is required.

<sup>12)</sup> Spectral purity for this model is >99.9%.

## EXIT PORT CONFIGURATION OPTIONS <sup>6)</sup>

H-SMART-	Port #1			Port #2	Port #3
	WL <sup>7)</sup>	AT <sup>8)</sup>	EM <sup>9)</sup>	WL <sup>7)</sup>	WL <sup>7)</sup>
SH	532 nm	-AT2	-EM2	1064 nm <sup>10)</sup>	—
SH-AT1	1064 nm	build-in	-EM1	532 nm <sup>10)</sup>	—
SH-AT2	532 nm	build-in	-EM1	1064 nm <sup>10)</sup>	—
SH/SP	532/1064 nm selectable	-AT	-EM/BB	—	—
TH	355 nm	-AT3	-EM3	532&1064 nm <sup>11)</sup>	—
TH-2P	355 nm	-AT3	-EM3	532&1064 nm <sup>11)</sup>	—
TH-AT1	355 nm	-AT3	-EM3	532 nm <sup>10)</sup>	—
TH-3P	1064 nm	build-in	build-in	532 nm <sup>10)</sup>	355 nm <sup>10)</sup>
TH/SP	355/532/1064 nm selectable	build-in	-EM/BB	—	—
FH	266 nm	-AT4	-EM4	532&1064 nm <sup>11)</sup>	—
FH-1P	266 nm	-AT4	-EM4	—	—
FH-2P	266 nm	-AT4	-EM4	532&1064 nm <sup>11)</sup>	—
FH-AT1	266 nm	-AT4	-EM4	532 nm <sup>10)</sup>	—
FH-3P	1064 nm	build-in	build-in	532 nm <sup>10)</sup>	266 nm <sup>10)</sup>
FH/SP	266/532/1064 nm selectable	build-in	-EM/BB	—	—
SH/TH/FH-3P	355 nm	-AT3	-EM3	532&1064 nm <sup>11)</sup>	266 nm
FiH	213 nm <sup>12)</sup>	-AT5	-EM5	—	—
FiH/FH	213/266 nm selectable <sup>12)</sup>	—	-EM/BB	—	—



## AUXILIARY EQUIPMENT

Attachable motorized attenuator for up to 5<sup>th</sup> harmonic beam

Attachable pulse energy monitor with analog and/or digital output

Fiber coupled output

Air purging unit for improved lifetime of UV harmonic crystals and optics

Module functionality can be even more extended by auxiliary equipment:

- Pulse energy of harmonic wavelength can be adjusted with our attachable or stand-alone motorized attenuators. Models for up to 5<sup>th</sup> harmonic are available.
- Pulse energy can be monitored by our attachable pulse energy monitor that can be attached directly to the harmonic generator or attenuator exit port.
- Fiber coupled output is available by request. Please inquire for detailed specifications.
- Air purging unit (APU) is recommended for improved lifetime of UV harmonic crystals and optics. APU can be integrated together with AC/DC mains adapter and controller into compact 19" rack module. Please inquire for detailed specifications.

H-SMART flexible design and microprocessor controlled operation enabled to implement number of advanced features:

- › **Single output port** – motorized selection of required wavelength, emitted through the same exit aperture.
- › **Self-tuning** – automatic, microprocessor controlled tuning of non-linear crystal temperatures for maximum pulse energy.
- › **Monitoring** – monitoring of pulse energy at fundamental or harmonic wavelength.
- › **Bypass** – laser fundamental beam can bypass H-SMART with minimal losses on internal optical components.
- › **Attenuation** – ability to attenuate output pulse energies without change of laser pump energy, helping to minimize changes to beam profile and pulse duration.
- › **Enhanced spectral purity** – improved to 99.9% spectral purity of exit wavelengths.

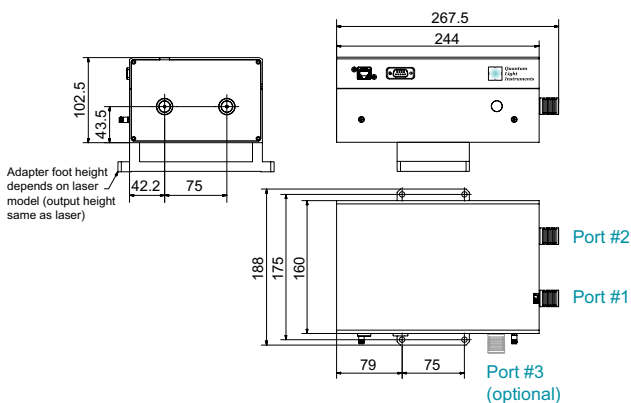
## ADVANCED FEATURES

H-SMART-	No. of exits	Self-tuning	Monitoring	Bypass	Attenuation	Enhance spectral purity
SH	2	optional	optional	—	optional	—
SH-AT1	2	optional	optional	✓	✓	—
SH-AT2	2	optional	optional	—	✓	—
SH/SP	1	✓	✓	✓	optional	—
TH	2	optional	optional	—	optional	—
TH-2P	2	✓	✓	—	optional	—
TH-AT1	2	✓	optional	—	✓	—
TH-3P	3	✓	optional	✓	✓	—
TH/SP	1	✓	optional	—	✓	—
FH	2	optional	optional	—	optional	—
FH-1P	1	✓	optional	—	optional	✓
FH-2P	2	✓	✓	—	optional	—
FH-AT1	2	✓	✓	—	✓	—
FH-3P	3	✓	✓	✓	✓	—
FH/SP	1	✓	optional	—	✓	✓
SH/TH/FH-3P	3	✓	✓	—	optional	—
FiH	1	✓	optional	—	optional	✓
FiH/FH	1	✓	optional	—	—	✓

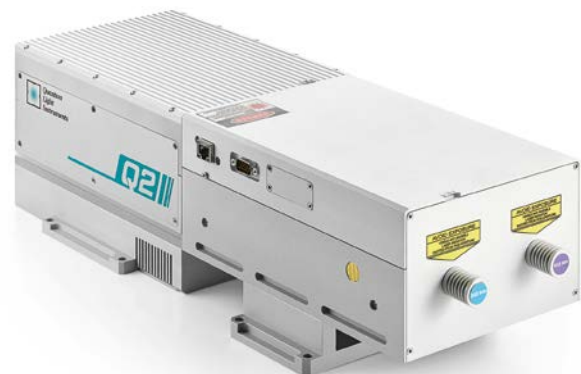
Most of high performance birefringent crystals are hygroscopic, which might limit their lifetime in humid environment. However, if they are continuously kept at higher than ambient temperatures, the lifetime of crystals can be significantly extended and can be even longer

than laser system itself. To keep crystals dry, H-SMART module needs to be always connected to the power source. If power is not available, the module should be stored in dry environment.

## DRAWINGS



H-SMART dimensions (in mm) & port numbering



Q2 laser head with H-SMART harmonics generator attached

# MOTORIZED ATTENUATORS & PULSE ENERGY MONITORS

## ATTENUATOR FEATURES

Drop-in attachable to the laser body attenuators for **1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> or 5<sup>th</sup>** harmonics of Nd:YAG or Nd:YLF lasers

Up to **98%** maximum transmission

Precise transmission control by stepper motor in microstepping mode (12800 steps/rotation)

Transmission adjustment resolution **<0.15 %**

Remote control via common with laser **Ethernet** interface

Optional stand-alone version for mounting on optical table

Optional side port transforms attenuator to variable beam splitter

## PULSE ENERGY MONITOR FEATURES

Drop-in laser pulse energy or power monitoring (up to **100 samples/second**)

Less than **2 %** insertion losses

**12-bit** resolution

Average pulse energy and pulse-to-pulse stability calculation

Sample&Hold analog output from BNC socket on the rear panel of laser controller

Digital readout through laser **Ethernet** interface

Optional broadband version for 210 – 2300 nm range

## ATTENUATOR SPECIFICATIONS <sup>1)</sup>

MODEL	ATTENUATORS				
	AT1	AT2	AT3	AT4	AT5
Design wavelength	1064 nm	532 nm	355 nm	266 nm	213 nm
Typical max transmission <sup>2)</sup>	98 %	95 %	90 %	75 %	65 %
Typical min transmission <sup>2)</sup>	1 %			0.5 %	
Output polarization <sup>3)</sup>	linear, horizontal			linear, rotating	
Resolution	< 0.15 %				
Accuracy	± 0.5 %				
Clear aperture	6 mm				
Stepper motor	12800 steps / 360 deg, 4-phase, 1A				
Dimensions (W×L×H)	42 × 54 × 77 mm <sup>3</sup>				
Weight	< 0.4 kg				

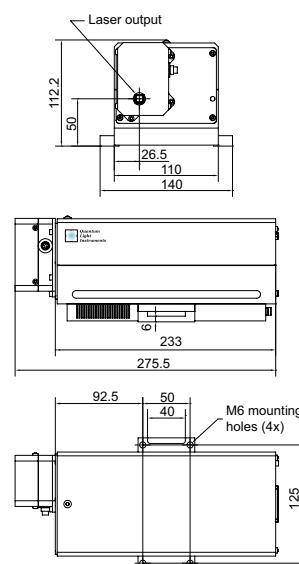
## PULSE ENERGY MONITOR SPECIFICATIONS <sup>1)</sup>

MODEL	PULSE ENERGY MONITOR					
	EM1	EM2	EM3	EM4	EM5	EM/BB
Design wavelength	1064 nm	532 nm	355 nm	266 nm	213 nm	210 – 2600 nm
Insertion loss	< 2 %					
Detector type	photodiode				pyroelectric	
Resolution	12 bit					
Accuracy	± 3 %					
Clear aperture	6 mm					
Dimensions (W×L×H)	24 × 28 × 48 mm <sup>3</sup>					
Weight	< 0.1 kg					

<sup>1)</sup> Due to continuous improvements all specifications are subject to change. The parameters marked typical are not specifications. They are indications of typical performance and will vary with each unit we manufacture.

<sup>2)</sup> Depends on polarization state of laser. Depolarization of laser beam might affect values provided here.

<sup>3)</sup> For some models polarization plane depends on angular position of polarizer.



Dimensions (in mm) of Q1 laser with attenuator attached



Attenuator and pulse energy monitor attached to the laser head