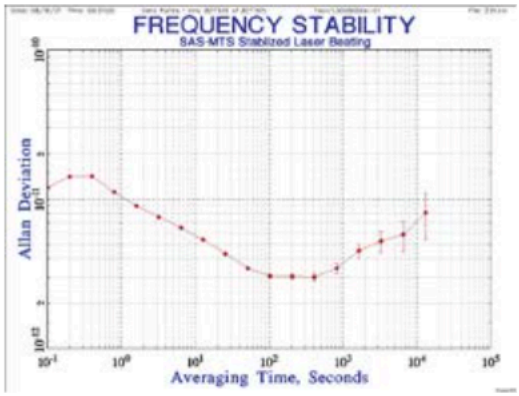
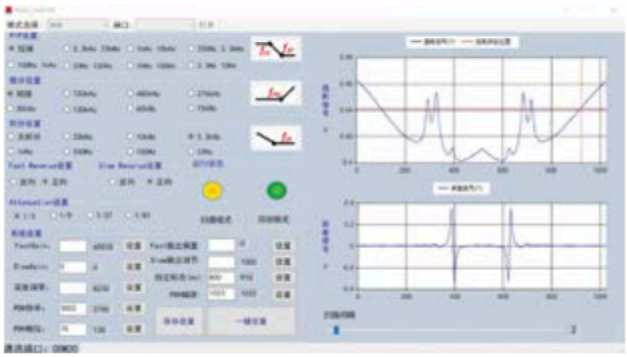


- Locking precision: <±100kHz (23h)
- Frequency stability: <1×10^{-11} (1000s)

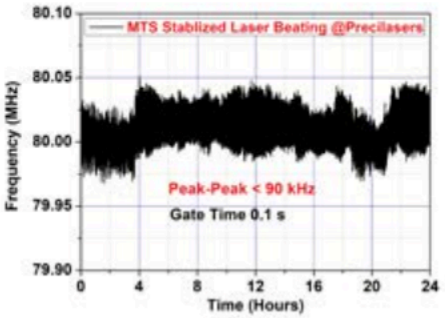
◆MTS-locking

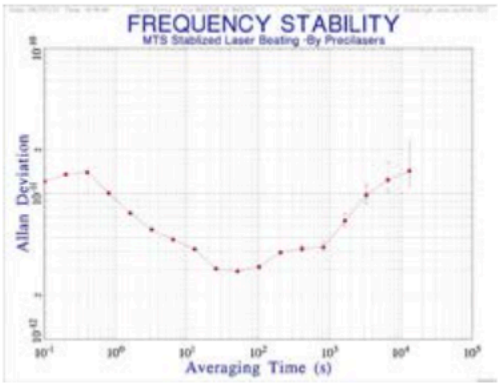
Unlike SAS-locking, MTS-Locking is under extern-modulation mode and the spectrum signal getting from demodulation can directly serve as error signal. Also take the MTS of ^{85}Rb atom as example, integrated optical module provide both SAS signal and modulated MTS signal to Preci-Lock. After demodulation, the MTS signal will be error signal for frequency locking while the SAS signal here will be a reference signal. Due to their different principles, locking point of MTS and SAS are not the same.



SAS (reference) signal and MTS (error) signal in Preci-Lock sofeware

Take also the beating test with two independent MTS-locking module.

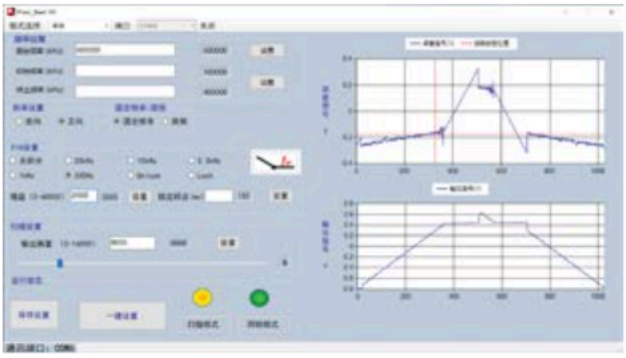




- Locking precision: <±100kHz (24h)
- Frequency stability: <1×10^{-11}(1000s)

◆Beat phase/frequency locking module

Beat phase/frequency locking module is used for frequency locking of multi-lasers. PreciLasers has launched a frequency control system for dual-channel 780nm laser device which serves as the laser source of ^{87}Rb gravimeter and gradiometer. Frequency of channel1 is locked to the resonance peak with MTS-locking while channel2 is locked 6.834GHz offset from channel1 with beat phase locking. This dual-channel laser can offer almost all the laser that is needed for a ^{87}Rb gravimeter.



Error signal and output signal in Preci-Beat software

Beat phase/frequency locking is realized with Preci-Beat controller. A fast PD measures the beat signal between two lasers and the PFD module in Preci-Beat generates error signal with the beat signal and a reference signal, the laser frequency will then be locked by PID module.

The 3.4 GHz beat signal from two 1560nm lasers

For ^{87}Rb atom gravimeter, frequency chirping or jumping of laser is needed. A typical example is the Raman lasers whose frequency need to change within 3 pulses to compensate the doppler effect. Preci-Beat provides frequency jumping function with a switching time below 10 μs.

ULTRA-LOW NOISE FIBER LASER

High Power、Low RIN、Narrow Linewidth

Single Frequency Fiber laser with low Relative Intensity Noise (RIN) have wide application in quantum optics, pumping lasers, lidar, coherent optical communications, high-precision optical sensing, optical measurement, and precision spectroscopy. For example, the laser for trapping atoms in optical lattice demands not only high output power, but also low RIN to reduce the resonance between the lattice and atoms and low frequency noise (FN) to reduce the spatial vibration, which is quite important for the atoms lifetime in the lattice. In the atomic interferometer and atomic clock application, high power laser could lead to more atoms, uniform interaction area and high measurement SNR.

Fig. 1, Schematic of the low noise fiber laser.
*The doubler module is equipped with SHG model

PreciLasers offers high power low noise 1064 nm and 1550 nm fiber laser with low FN and low RIN seed + low noise fiber amplifier shown in Fig. 1. In Fig. 2, the amplifier will not introduce the extra frequency noise and the linewidth broadening is measured to be less than 1 Hz. The RIN of the amplifier is ultra-low(RIN<-140 dBc/Hz (>5 kHz), RIN integration from 10 Hz-10 MHz <0.03%). Also, the wavelength could extend to be 1020-1120 nm for Ytterbium-doped fiber amplifier and 1530-1596 nm for Er-doped fiber amplifier. With stable single pass frequency doubling module, the low noise fiber laser wavelength could extend to be 510-556 nm and 765-798 nm . In the process of frequency doubling, the linewidth of the laser is doubled, and the intensity noise (RIN) is only increased by 6 dB, thus inheriting the low noise characteristics of the fundamental frequency light.

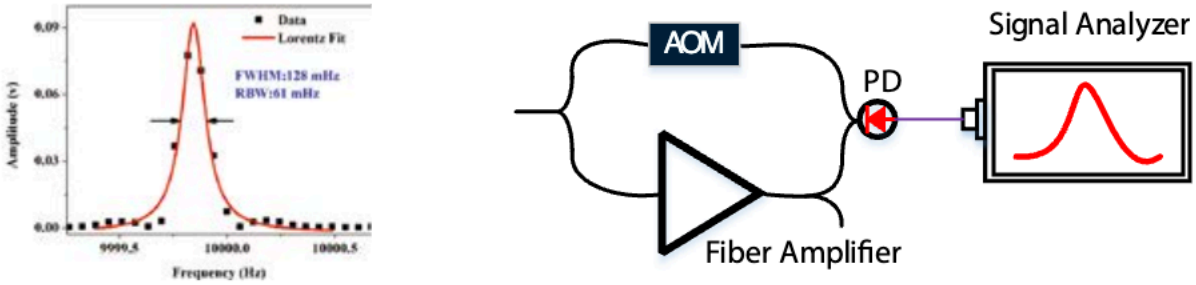
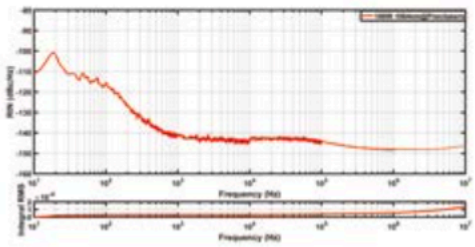


Fig. 2, Linewidth broadening test and result

PreciLasers offers a high-power (up to 130 W), low intensity noise, narrow linewidth highly-reliable 1064 nm fiber laser solution for the optical lattice application.



Typical relative intensity noise power density spectrum (RIN) * of 90 W FL-SF-1064

Model	FL-SF-1064-130	FL-SF-1064-100	FL-SF-1064-50
Central Wavelength[1] , nm	1064	1064	1064
Linewidth, kHz	< 10	< 10	< 10
Tuning Range, GHz	10	10	10
Power after ISO, W	>130	>100	>50
RIN	RIN: -140 dBc/Hz (100 kHz) RMS Integration: <0.05% (10Hz-10 MHz)	RIN: -140 dBc/Hz (100 kHz) RMS Integration: <0.05% (10Hz-10 MHz)	RIN : -140 dBc/Hz (100 kHz) RMS Integration: <0.05% (10Hz-10 MHz)
Beam Quality	TEM_{00} , M^2<1.15	TEM_{00} , M^2<1.15	TEM_{00} , M^2<1.15
Polarization	Linearly Polarized , > 300: 1	Linearly Polarized , > 300: 1	Linearly Polarized , > 300: 1
P-P, RMS Power Stability	<0.5 %@3hrs	<0.5 %@3hrs	<0.5 %@3hrs
Cooling	Water Cooling	Water Cooling	Air Cooling/Water Cooling
Output Connector	Space (300*240 mm^2)	Space (300*240 mm^2)	Fiber

1: Wavelength could be selected from 1020-1112nm

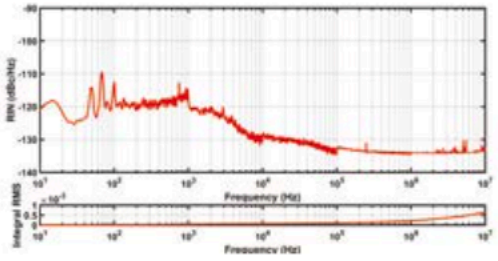
Key Features:

- Low Intensity Noise (-140 dBc/Hz @100 kHz)
- Narrow Linewidth(<10 kHz)
- Good Beam quality (M^2 <1.2)
- High Output Power (up to 100 W)
- Operation in harsh conditions
- Full Protection System

Applications:

- Optica Lattice
- Optical Tweezers
- Optical Traps
- Pump laser for OPO

With single pass and resonant cavity SHG module, low noise 532 nm laser could be generated with output power up to 30 W, which has been applied in optical lattice application.



Typical 10 W 532 nm laser RIN spectrum

Model	FL-SF-532-10(Single Pass SHG)	FL-SF-532-30(Resonant Cavity SHG)
Central Wavelength[1] , nm	532	532
Linewidth, kHz	< 20	< 20
Tuning Range, GHz	20	20
Output Power, W	10	30
RIN	RIN: -130 dBc/Hz (100 kHz) RMS Integration: <0.05%(10Hz-10 MHz)	RIN: -130 dBc/Hz (100 kHz) RMS Integration: <0.05% (10Hz-10 MHz)
Beam Quality	TEM_{00} , M^2<1.2	TEM_{00} , M^2<1.1
Polarization	Linearly Polarized , > 100: 1	Linearly Polarized , > 100: 1
Power Stability	<0.5 %@3hrs	<0.5 %@3hrs
Cooling	Air Cooling/Water Cooling	Air Cooling/Water Cooling

1 Central Wavelength could be selected from 510-540 nm

Key Features:

- Narrow Linewidth<20 kHz
- Low Intensity Noise (-130 dBc/Hz @ 100 kHz)
- High Power (up to 30W @ LN-YFA-SHG)
- Good Beam Quality (M^2 <1.2)
- Linearly Polarize
- Active Power Stability

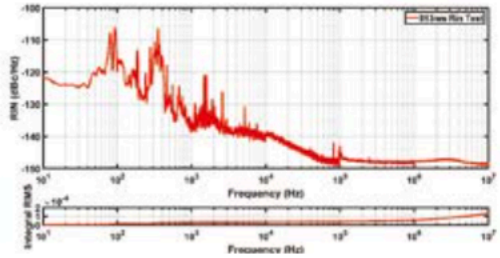
Applications:

- Optica Lattice
- Optical Tweezers
- Pump laser for Ti: Sapphir laser

759/813NM ULTRA-NOISE SINGLE FREQUENCY LASER

FL-SF-759-XX-CW FL-SF-813-XX-CW

PreciLasers offers a high-power, low intensity noise, narrow linewidth highly reliable 759/813nm fiber laser solution (FL-SF-759-2-CW, FL-SF-813-4-CW) for the magic-wavelength optical for Yb/Sr atomic clock.

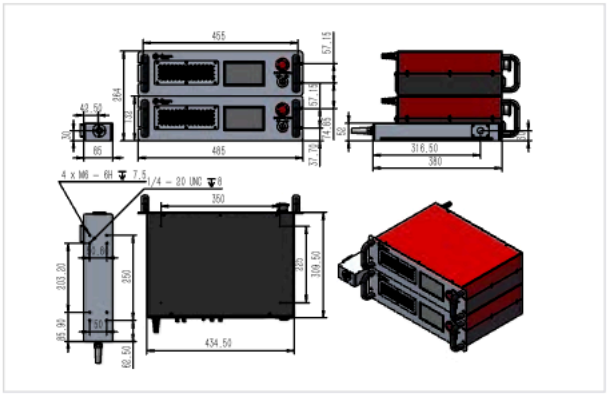


Typical 4 W 813nm laser RIN spectrum

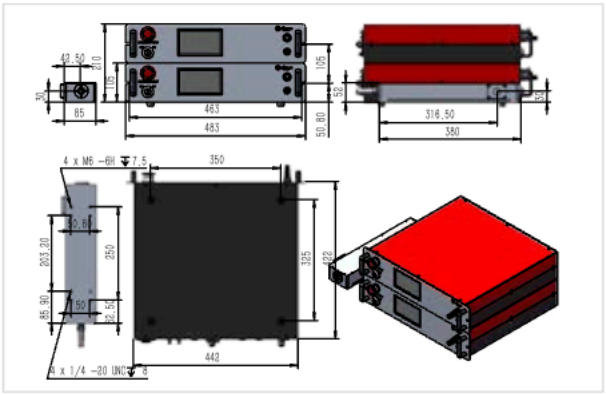
- Narrow Linewidth<20 kHz
- Low intensity Noise (RIN -140 dBc/Hz @ 100 kHz)
- High output power (2W@759nm 10W@ 813nm)
- Excellent beam quality (M^2 <1.1)
- Wavelength Tunable and high feedback bandwidth

Model	FL-SF-759-XX-CW FL-SF-813-XX-CW	
Central Wavelength[1], nm	759	813
Linewidth(100us integration), kHz	< 50	< 20
Output Power, W	>2	>10
Feedback Bandwidth, MHz	>1MHz	
Tuning Range, GHz	>80GHz	
RIN	RMS Integration：<0.05% (10Hz-10 MHz)	
Beam Quality	TEM_{00}, M^2<1.1	
Polarization	Linearly Polarized , > 300: 1	
RMS Power Stability	<0.2%@8h	
Cooling	Air Cooling/Water Cooling	

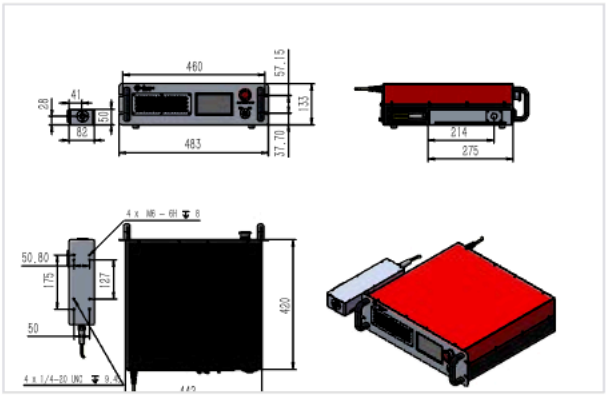
1:Wavelength could be selected from 614-1000nm



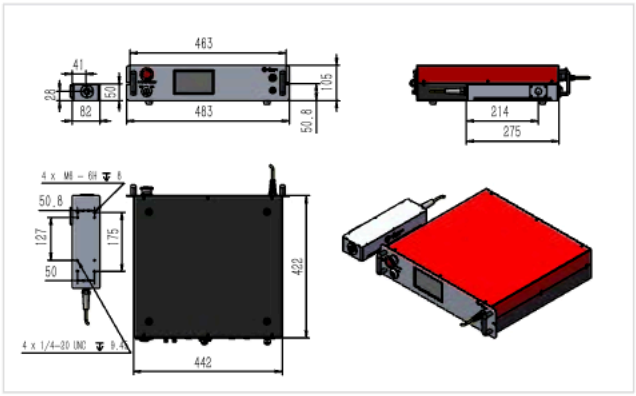
Size for Air-cooling Version



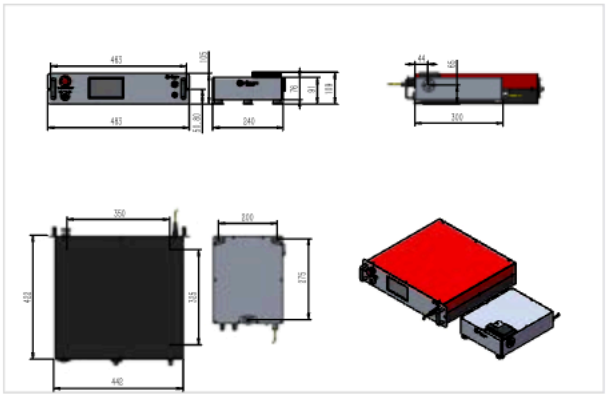
Size for Water-Cooling Version



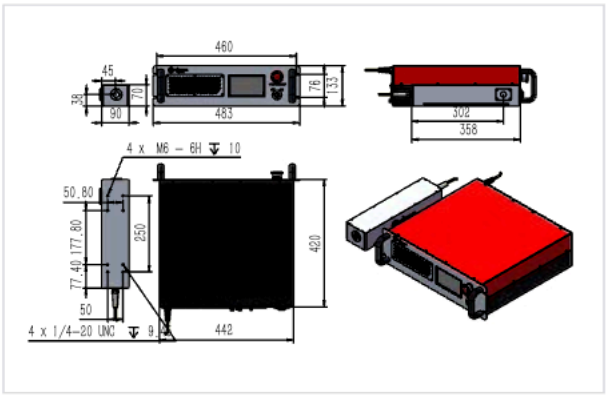
1064 nm 50 w LN fiber laser-Air Cooling



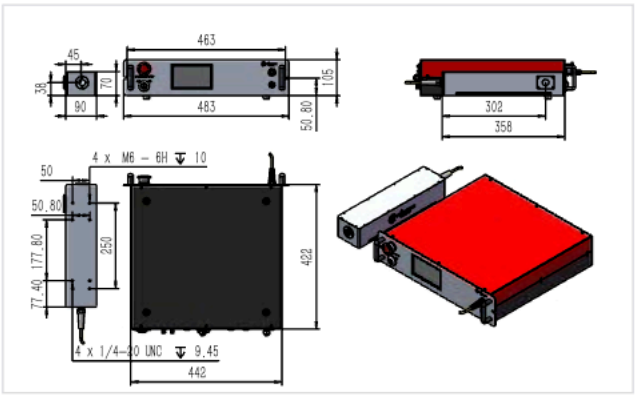
1064 nm 50 w LN Fiber Laser-Water Cooling



1064 nm LN Fiber Laser



532 nm 10 W LN fiber laser-Air Cooling



532 nm 10 W LN Fiber Laser-Water Cooling