



## 780nm laser frequency locking module

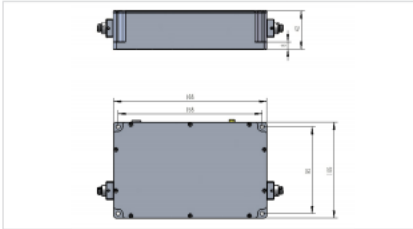


### The product description

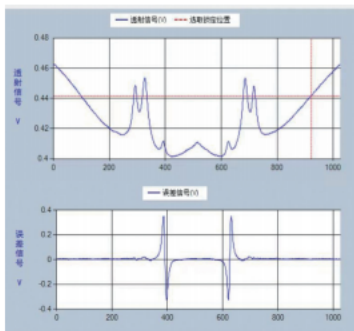
Cold atom experiments with Rb need lasers with specific frequency and Erbium group launches different frequency locking schedules for 780nm laser. We built up an all-fiber-connected frequency locking module with an integrated optical system and other optical fiber devices. This module can offer stable SAS or MTS signal and together with our laser controller Preci-Lock, frequency locking with good long-term stability is realized. The frequency difference between two lasers should keep to a constant value in some cold atom experiments. For 87Rb atom gravimeter, the frequency difference of cooling laser and repumping laser should be about 6.6GHz and for the two Raman lasers the value is 6.834GHz. PreciLasers has launched a specialized laser controller Preci-Beat for offset frequency locking in the range from 50MHz to 8GHz with beat frequency/phase locking technique.

#### ◆ Integrated optical module

With integrated spatial frequency-locking module, PreciLasers builds an all-fiber-connected frequency locking module. This module gives a stable SAS or MTS signal at Rb D2 line and the spectrum can offer error signal for frequency locking of 780nm laser.



Dimensions of integrated frequency-locking optical module



SAS and MTS signal from the integrated optical module

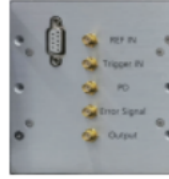
#### ◆ Multi-function laser controller





Erbium group offers a multi-function laser controller for frequency locking under different condition. The controller, which is named Preci-Lock, is integrated with modem, PID module and High-Voltage amplifier and it can work as error signal generator, PID servo and PZT driver at the same time. All function of PreciLock is controlled by software with no physical button or knob. The controller can work in different mode under customized. Under internal-modulation mode laser is locked with SAS or AS while under external-modulation mode laser is locked with MTS or PDH technique.

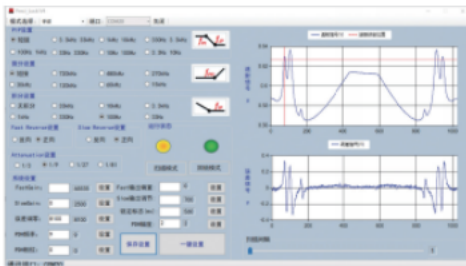
For multi-channel lasers, Erbium group offers another laser controller Preci-Beat for offset frequency locking. Preci-Beat is integrated with PFD and PID module and is also controlled with software.



Front panel of Preci-Beat

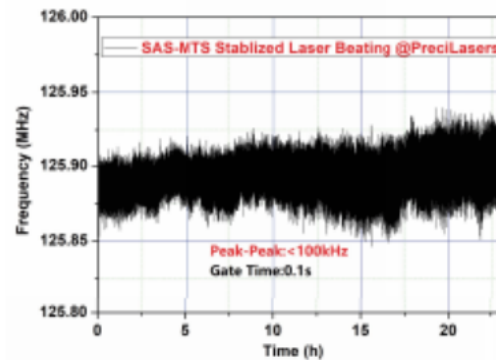
### ◆ SAS-locking

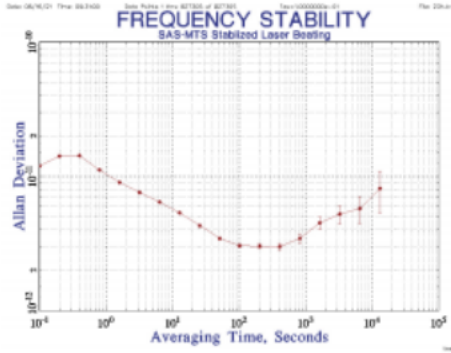
Frequency locking with SAS is based on Lock-in amplifier. Take the SAS of 85Rb atom as example, Preci-Lock get SAS signal from integrated optical module and generate error signal with lockin amplifier, the PID module in Preci-Lock will then lock the frequency of 780nm laser.



SAS and error signal in Preci-Lock software

We build two independent SAS-locking system for 780nm laser and take a laser beating test with their 1560nm seed laser. This can show the stability of frequency locking.

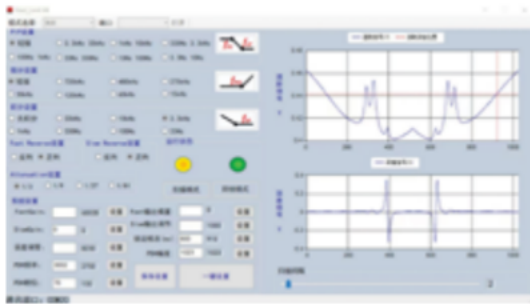




- Locking precision:  $<\pm 100\text{kHz}$  (23h)
- Frequency stability:  $<1 \times 10^{-11}$  (1000s)

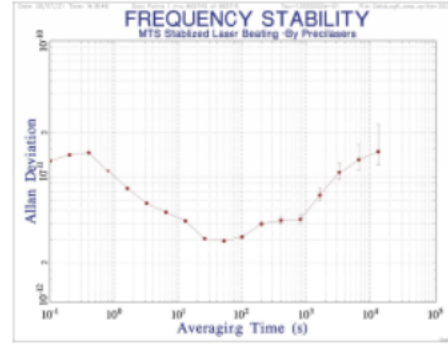
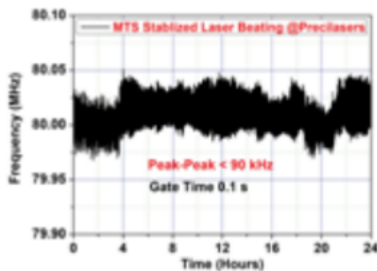
◆ MTS-locking

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  $^{85}\text{Rb}$  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 software

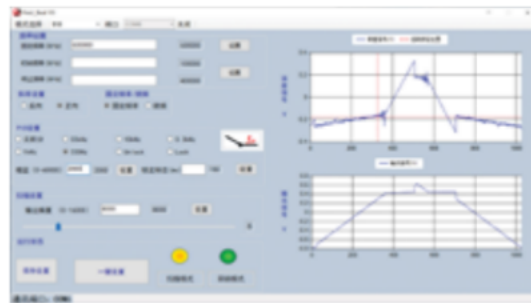
Take also the beating test with two independent MTS-locking module.



- Locking precision:  $<\pm 100\text{kHz}$  (24h)
- Frequency stability:  $<1 \times 10^{-11}$  (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  $^{87}\text{Rb}$  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  $^{87}\text{Rb}$  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  $^{87}\text{Rb}$  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  $\mu\text{s}$ .