Laser Lock Box: What is it, and how is it different from the Phasemeter?

Learn the basics of the Laser Lock Box on Moku:Pro

What is the Laser Lock Box?

The stability of a laser's frequency is important in many applications including precision metrology, spectroscopy, quantum information processing, and even fiber optic communications. Laser frequency stabilization is typically performed by locking a noisy laser to a more stable reference, such as an optical cavity or an atomic resonance. This allows the stability of the reference to be transferred to the stability of the laser's frequency.

Laser frequency stabilization feedback systems typically contain many components such as waveform generators, phase shifters, mixers, filters, and PID servo controllers. The Moku Laser Lock Box incorporates all these elements and makes them digitally controllable to provide a simple, high-performance laser locking solution.

Moku:Pro vs. Moku:Lab Laser Lock Box

Output range

Moku:Pro has a higher output voltage of ±5 V into 50 Ω vs. the Moku:Lab output range of ±1 V into 50 Ω. This allows users to drive controllers or other devices.

Channel count

Moku:Pro has four channels, while Moku:Lab has two.

Input/Output bandwidth

Moku:Pro has higher modulation frequencies, allowing users more flexibility in what lasers they can lock.

PID Controllers

Moku:Pro has a second integrator in the fast feedback PID Controller. This provides I^2 or $1/F^2$ slope of the feedback signal.

Embedded Oscilloscope

Moku:Pro provides additional probe points throughout the signal path to utilize the embedded Oscilloscope. This makes troubleshooting and signal monitoring more flexible.

Laser Lock Box vs. Phasemeter

Some customers may not know the difference between the Laser Lock Box and the Phasemeter when it comes to laser locking.

Laser Lock Box

The Laser Lock Box enables users to lock to a resonance frequency (often in an optical reference cavity or atomic transition). It provides highly accurate and precise measurements of frequency differences between the laser and cavity resonance. The digital signal processing helps to avoid low-frequency noise generated in analog electronics.

Phasemeter

The Phasemeter allows users to perform phase locking of one laser to another laser or locking to a sine wave. The Phasemeter tracks and records the phase, frequency, and amplitude with high dynamic range. This instrument is more useful than a Lock-in Amplifier if the phase is expected to drift over time or if the frequency is unknown or changing.

The Phasemeter can phase-lock outputs — this generates sine waves that are phase-locked to inputs to amplify weak signals. It provides built-in spectral analysis tools for power and amplitude spectral density and Allan deviation.

PID Controllers

There are two PID Controllers built into the Laser Lock Box. When users lock a laser, they need both fast and slow feedback to maintain the lock. One PID Controller controls a very high-speed actuator with a low range. It can react very quickly but can't track very far. If a laser drifts outside of that actuator's range, then that actuator cannot provide a large enough correction signal and the lock may be lost.

A slow actuator with a much larger range can help in this case. While it is slower to react, it can hold the lock over a much wider range of parameters for a far longer time by ensuring that the fast actuator doesn't saturate. The combination gives users the best of both worlds — a tight lock that can last a long time.

On Moku:Pro, this uses two out of four outputs. When using Moku:Lab, this means that users are utilizing both outputs. This means users cannot use the modulation signal. Users can still output the modulation signal on the same channel as the slow controllers by using an external, analog device (biased-T) to separate the low-frequency controller signal and high-frequency modulation signal. To avoid this, Moku:Pro may be a better solution or some customers.

Applications

The Laser Lock Box is ideal for researchers in atomic, molecular, and optical physics (AMO physics), spectroscopy, interferometric measurements, quantum research, optical sensing, and more. Applications include but are not limited to the following:

- Gravitational wave detection
- Quantum computing (photon, ion, cold atom)
- Quantum optics
- Absorption spectroscopy (gas detection)
- Servo controls
- Phase locked-loops
- Atomic clocks
- Atom optics
- Precision optical measurements
- Optical metrology
- Coherent LiDAR
- Beam steering
- Precision interferometry
- Cold atom interferometry
- Space-based quantum communication
- Fiber-towed arrays (submarine systems for detection/mapping for minerals exploration and defense)

Questions or comments?

Please contact us at support@liquidinstruments.com