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Optical Intensity Stabilization Physics Basel (SP 999)

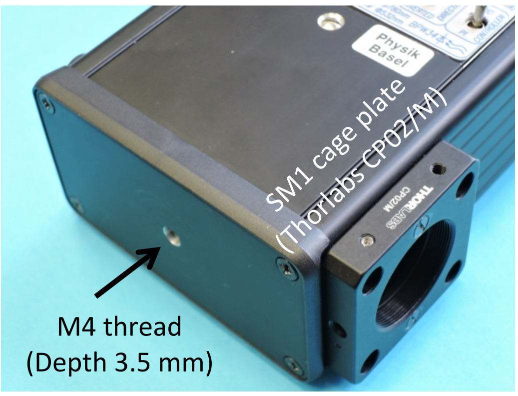
User's Manual | Revision 1.1 | April 2015

Features

- Versatile device for optical intensity stabilization
- Directly mountable an optical table
- "All in one box" prevents from ground loops and interferences
- Large area Si-PIN photodiode: 2.65 mm x 2.65 mm
- 500 kHz small-signal bandwidth of optical receiver
- Wavelength range: 400 nm to 1'100 nm
- Photodiode centered in 30 mm SM1 cage plate (Thorlabs)
- PID controller with large setting ranges
- Internal (stability 10^{-4}) or external SET point source
- "Locked" indicated by green LED
- Controller output "Voltage Limitation" indicated by red LED
- 50 Ohm controller output driver
- Small size: h = 120 mm, w = 50 mm, l = 90 mm
- Low weight: 350 g
- ±15 V Floating Power Supply (SP 874) included

Description

The *Optical Intensity Stabilization* (*OIS*) is versatile and compact box for power stabilization of light sources such as lasers, LEDs or bulbs. It includes all components (optical receiver, PID controller and SET point generator) to perform stand-alone, high precision and low noise optical intensity control. This "all in one box" approach prevents from cabling several single devices which often leads to problems with ground loops or interferences.

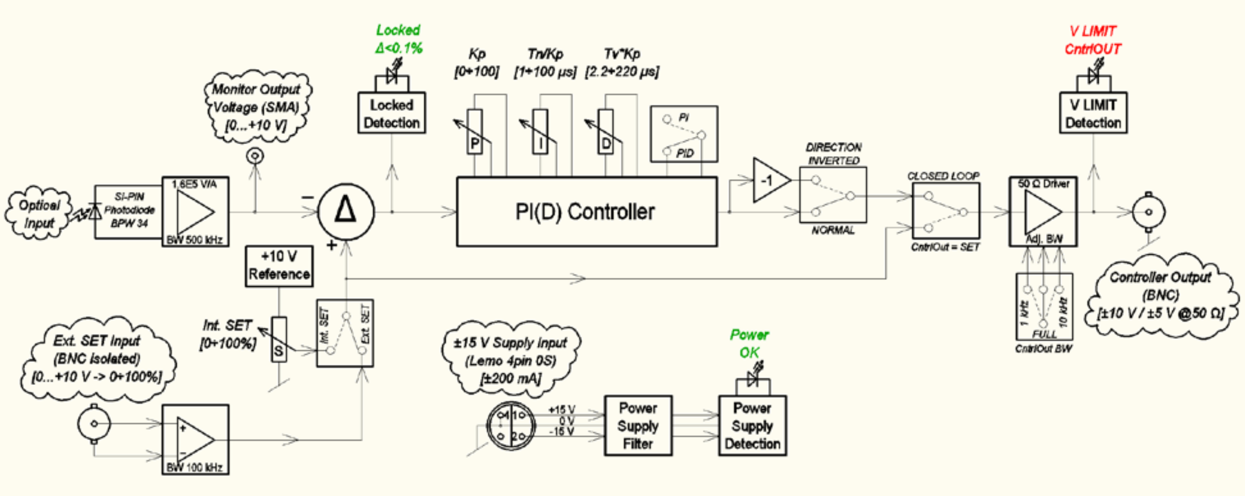


The *OIS* has a M4 thread (depth 3.5 mm) at the bottom. This allows attaching a metrical post for directly mounting the device on an optical table (see photos on the left).

By using a beam splitter, a fraction of the optical power must be focused to the large area (7 mm^2) photodiode which is mounted in the center of a 30 mm cage plate; it is a SM1 cage plate (type CP02/M) from the company Thorlabs.

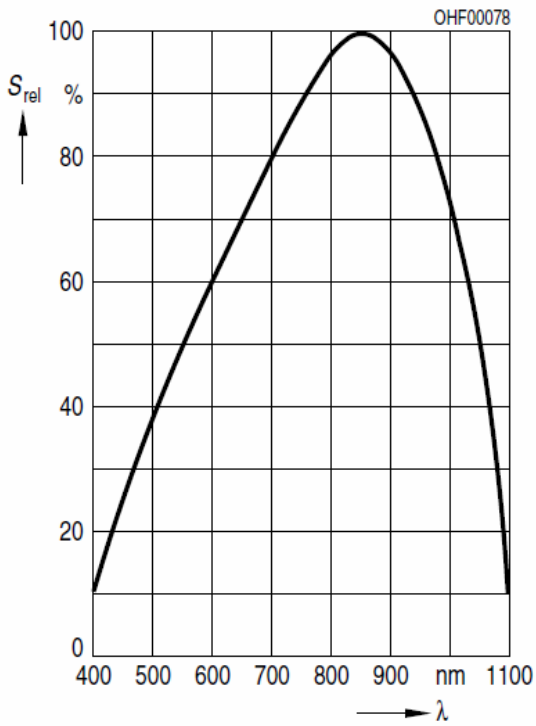
Block Diagram

The block diagram of the *OIS* is shows below; it might be helpful for understanding the function of the four switches on the front-panel of the device.



Optical Receiver / Monitor Output

The optical receiver consists of a silicon PIN photodiode BPW 34 (OSRAM) followed by a transimpedance amplifier with a gain of $1.6 * 10^5$ V/A. The photodiode has a square sensitive area with a dimension of 2.65 mm x 2.65 mm, corresponding to an active area of 7 mm^2.



The relative spectral sensitivity of this photodiode is shown in the graph on the left; it covers a wavelength range from 400 nm to 1'100 nm. The maximal photosensitivity of 0.62 A/W (corresponds to 100%) is reached at a wavelength of 850 nm.

The output voltage (0…+10 V) of the transimpedance amplifier is wired to the *Monitor OUT* (SMA connector) on the top-panel. This output is designed to drive high-impedance loads such as oscilloscopes or voltmeters. The monitor output impedance is 510 Ohm and therefore when terminated with 50 Ohm the measured voltage is divided by a factor of around ten. A *Monitor OUT* voltage of 0…+10 V corresponds to 0…100% optical power.

The *Monitor OUT* voltage sensitivity at 850 nm is about 10 µW/V and drops to roughly 20 µW/V when using a 532 nm laser. The maximum monitor output voltage of +10 V corresponds to an optical power of 100 µW @ 850nm and 200 µW @ 532 nm. To estimate the sensitivity of other laser-wavelengths use the graph above.

The small-signal bandwidth of the optical receiver is 500 kHz and the large signal response is limited by its slew-rate of 2.3 V/µs.

PID Controller / SET point / Controller Output

The analog PID controller is adjusted by three potentiometers (P-part, I-part and D-part) on the top-panel. On the front-panel the D-part can be completely switched off (*PID, PI*) and then the controller works with the P-part and I-part only. This might be helpful when ringing or oscillations occur in the PID controller mode due to the fast D-part.

The P-part (*Kp*) can be adjusted from *0÷100*, the I-part (*Tn/Kp*) from *1÷100 µs* and the D-part (*Tv*Kp*) from *2.2÷220 µs*. To cover the 1:100 ranges of the PID-parameters, while maintaining a fine-tuning for small values, logarithmic potentiometers are used. The printed scales for the PID settings on the top-panel are round figures only.

A switch on the front-panel selects the internal or external SET point source. The internal SET point is adjusted by a linear potentiometer on the top-panel from 0…+10 V corresponding to 0÷100% of optical power. The value is derived from a stable 10 V reference source and it has a typical stability of 10^{-4} after warmup of one hour.
The external SET point voltage is entering via a differential receiver with an input impedance of 25 kOhm. The 0…+10 V input voltage correspond to 0÷100% of the optical intensity. The small-signal bandwidth of the external SET input is 100 kHz.

For testing and tuning the light source, the SET point voltage (internal or external) can be wired directly to the controller output. For using this mode the switch (*CLOSED LOOP / CntrlOUT=SET*) on the front-panel must be in the position *CntrlOUT=SET*. For characterizing the control process it is often helpful to measure its step response with an oscilloscope. To do that, use the position *CntrlOUT=SET*. Then apply a small step around the typical operating point of the light source at the external SET input while measuring the signal response at the *Monitor OUT*. When the timing characteristic of the control process is known, the PID-parameters can be heuristically estimated.

The control loop direction can be altered between *NORMAL* and *INVERTED* by a switch on the front-panel. *NORMAL* means that the optical intensity of the light source increases for a positive controller output voltage. When the optical intensity decreases for a positive voltage, the *INVERTED* direction must be selected.

The output impedance of the controller output is 50 Ohm. For high impedance loads the output voltage swing is maximum ±10 V; while driving a 50 Ohm load it is reduce to ±5 V. When reaching the maximum controller output voltage (+10 V or -10 V) the red LED *V LIMIT CntrlOUT* on the top-panel gets activated. Please note, when fast changing the SET point while the PID control loop is closed, the red LED can be turned on shortly due to the fast D-part of the PID controller.

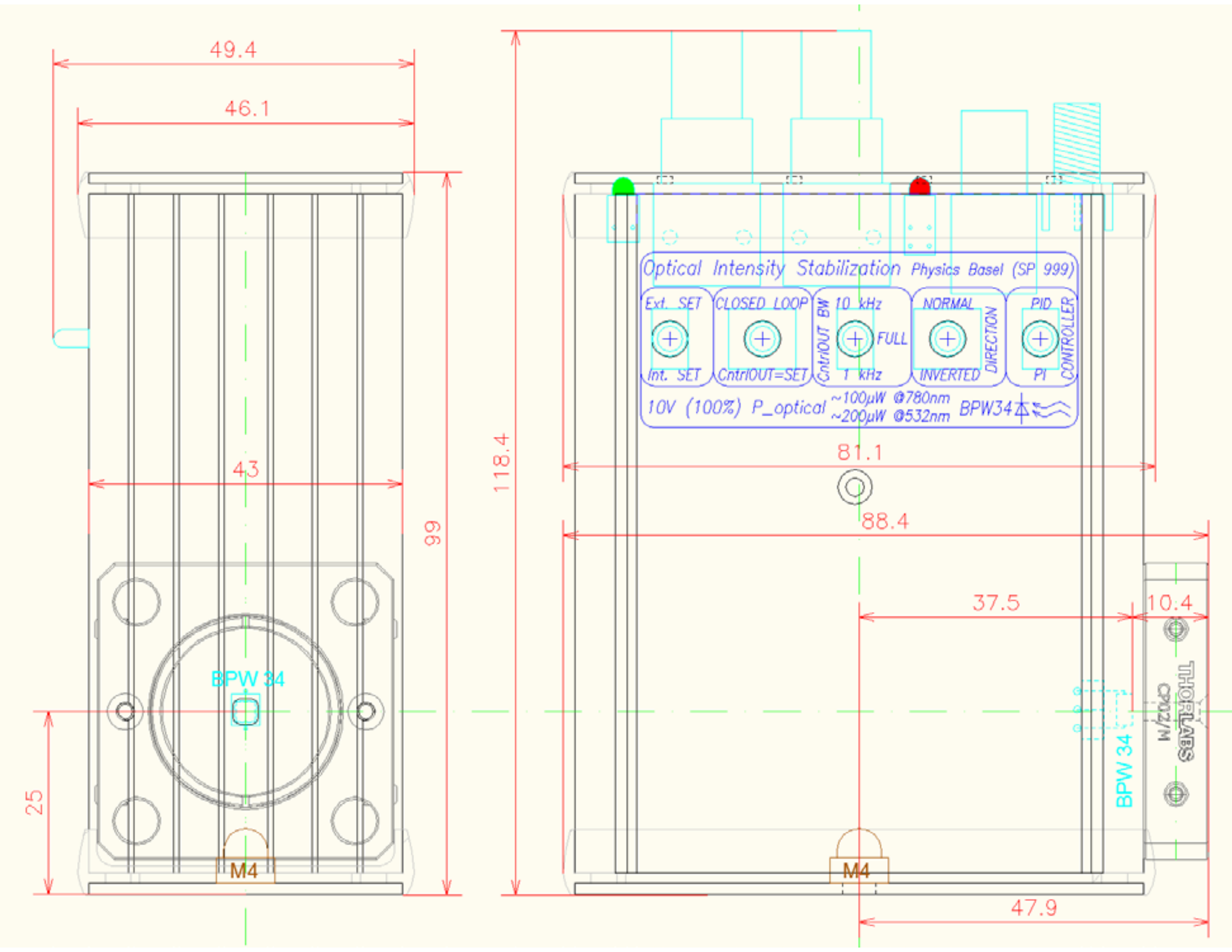
The bandwidth of the output driver can be reduced to 10 kHz or 1 kHz; this is done with the three position switch *FULL, 10 kHz, 1 kHz* on the front-panel.

When the control-loop is locked and works stable, the error signal entering the PID controller gets very small. If the error signal is smaller than 0.1% (10 mV) the green LED *Locked* on the top-panel is turned on. When the closed control loop works stable, the green LED *Locked* must be turned on and the red LED *V LIMIT CntrlOUT* must be off (while the SET point voltage is constant).

Information to PID controllers and its dimensioning can be found here:
http://en.wikipedia.org/wiki/PID_controller
http://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method

Mechanics

The overall dimensions of the *OIS* are approximately: Height 120 mm; Width 50 mm; Length = 90 mm
Below the exact dimensions [mm] of the *OIS* can be found; the photodiode has its center position 25 mm above the bottom plate with the M4 thread.



Power Supply

The *OIS* must be supplied by a low noise and low ripple ±15 V power supply. If possible, use the included *±15 V Floating Power Supply* (SP 874); this is a low noise linear regulated wall plug power supply. The maximal supply current drawn from the *OIS* is ±200 mA. The green LED *Power OK* on the top-panel lights up when the applied supply voltages are valid. The housing of the *OIS* is connected to 0 V (GND) of the power supply.

A 4pin LEMO connector of the series 0S is used to connect the supply voltages; a LEMO connector of the type *FFA.0S.304.CLAC44* fits into the plug of the *OIS*. The pin connection is the following:

PIN 1: +15 V, 200 mA
PIN 2: -15 V, 200 mA
PIN 3: not connected
PIN 4: GND / 0 V / Housing