# Piezomechanik GmbH

The piezo-based performance optimizer

# OptiSeek

**Will always keep your mechanical setups
in optimum position
with sub-micron accuracy
ensuring maximum process efficiency**


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# Problem and solution statement:

In a lot of high-tech applications, the quality and efficiency of a process is critically dependant on the stability of a distinct mechanical dimension in one or more degrees of freedom:
Even a very small misalignment of these critical dimensions in the setup (in the micrometer or even sub micrometer range) can cause inacceptable results.

Examples are e.g.
- Transmitting maximum light from one optical fiber into a second freely suspended one
- Stabilizing the maximum optical performance of a laser resonator (beam quality and power)
- Stabilizing interferometers, holographic set ups

The OptiSeek regulation systems always keeps your mechanical system at the optimum point, eliminating the impact of potentially misaligning effects like drifts caused by temperature changes, varying mechanical loads or forces on your mechanical setup.
OptiSeek also eliminates the need for bulky or heavy setups to obtain infinitely high stability of your arrangements.
Even lightweight arrangements can be stabilized long-term in the micrometer and sub-micrometer range, giving optimum results by taking advantage of the OptiSeek inherent maximum value seeking strategy.

# How does the OptiSeek work?

The OptiSeek is an autonomous operating device, which only requires an electrical signal from a detector monitoring the intensity of the process effect under study. In the case of optics e.g. a photodiode will do this job.

The OptiSeek provides two output channels to supply up to two piezo actuators in order to control the mechanical alignment of the process effect under study.
The piezo supply voltage is superimposed by a very small amplitude sine-oscillation, produced inside the OptiSeek (Dithering-principle). This results in the equivalent very small mechanical oscillation of the piezoactuators by which the effect under study is modulated.

**This dithering modulation of the effect becomes zero at an extreme value (e.g. the maximum value point of the response): this is the feedback regulation criterion for the OptiSeek.**

The phase sensitive electronics of the OptiSeek compensates for all misaligning effects by permanently readjusting the mechanical arrangement to the maximum efficiency point.
(The system can be set by a simple switch to seek for minimums too.)

**Question: Is the dithering modulation in contradiction to a highly stable process effect?**
**Answer: No!**

*Example*
OptiSeek 150-2 electronics produces a minimum modulation of about 20 mV pp. When a 150 V actuator with 40 µm stroke is used together with the OptiSeek, the mechanical dithering modulation is less than 4 nanometers. The effect modulation is further minimized by the extreme value condition.
**In most applications, the dithering modulation of the system's output is significantly lower than the noise level of the effect under study.**

**Reaction time of the OptiSeek:**
Given a steep mechanical misalignment impact to the mechanical setup, the OptiSeek compensation/settling is typically completed within 0.5 sec.

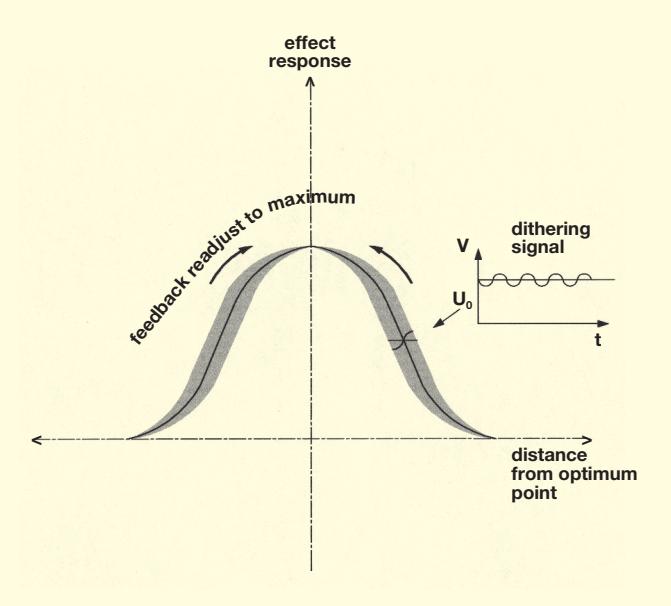


*Fig. 6: Schematic of a response curve of a process effect, showing a maximum point where the OptiSeek locks the mechanical setup in place. The "seeking condition" for the maximum of the response is the diminishing of the dithering modulation amplitude (represented by the grey shade) at the maximum of the response curve*

# Applications in detail

## Fiber-fiber coupling

The efficiency of transferring light from one single mode optical fiber into a free suspended partner fiber depends dramatically on the coaxial alignment of the fiber axis in the submicron range. The slightest deviations from this centering condition will immediately reduce the transfer efficiency of light from one fiber into the other.
The OptiSeek automatically compensates for degrading influences and always holds the system at the maximum transmission point.

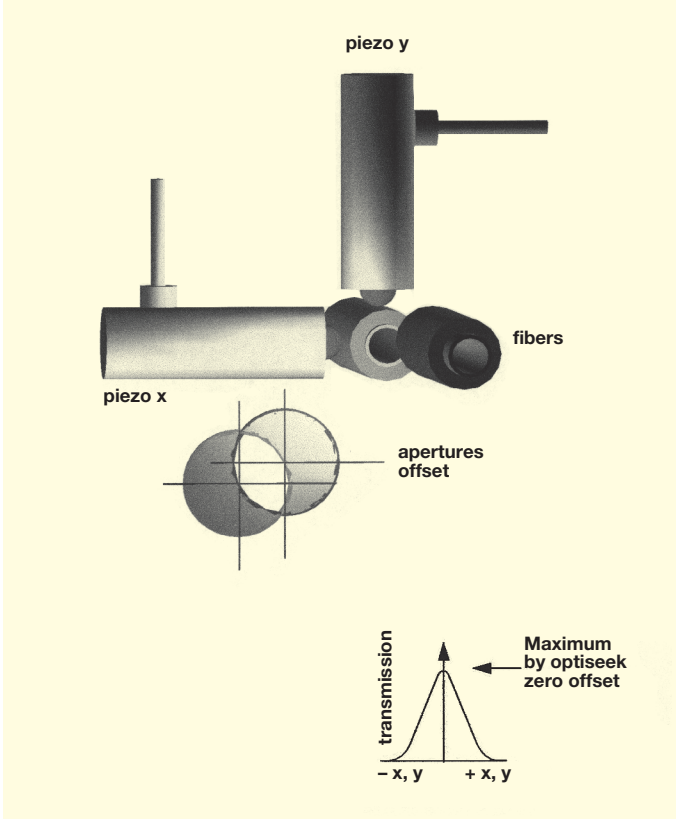


*Fig. 2: Schematic of a coupling of free monomode fibers by translational xy control via piezostacks*

## Maximizing optical power of lasers, minimizing noise

The laser output power and beam quality of a laser arrangement depend significantly on the mechanical quality of the resonator as defined by the parallelism of the end mirrors.

The OptiSeek compensates for all types of slow tilting/misalignments of these end mirrors due to thermal drifts.

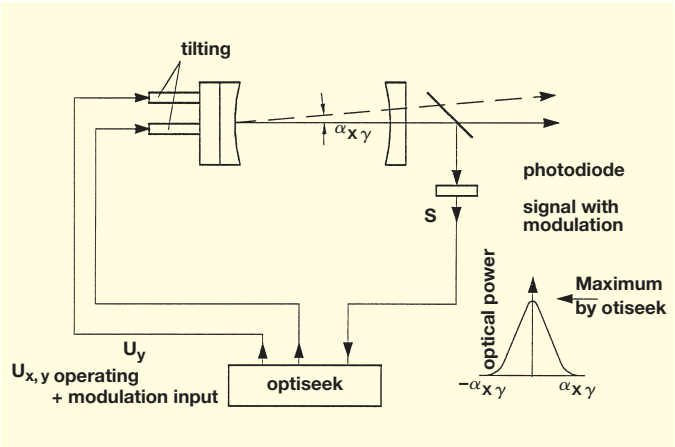


*Fig. 3: Schematic of an OptiSeek laser resonator stabilization*

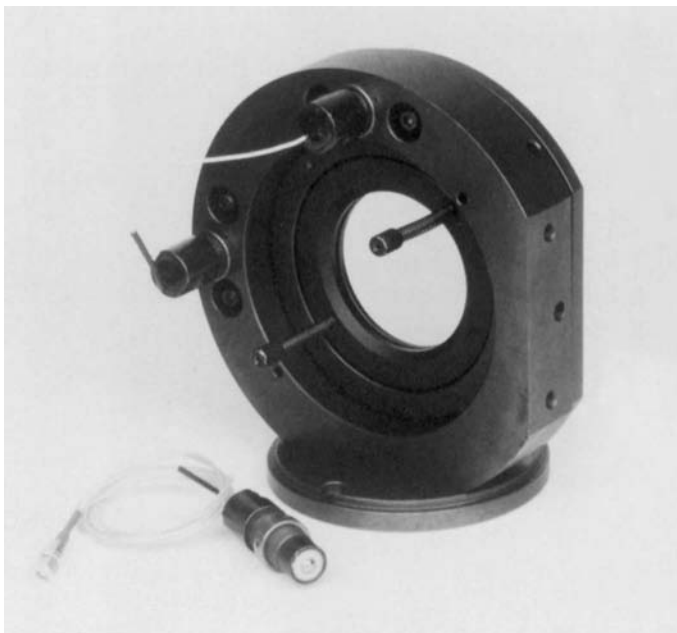

*Fig. 4: 2-dim tilting mirrormount with FPSt srcewed in piezocartridges for OptiSeek Control of a laser resonator*

## Potentiometric measurements in cell biology

A microelectrode must be kept at the point of minimum or maximum electro potential of a biological cell.
The electrode position will follow microscopic movements or deformations of the cell structure according to these criteria and the electrode tip will always stay at the potential maximum point within the cell.

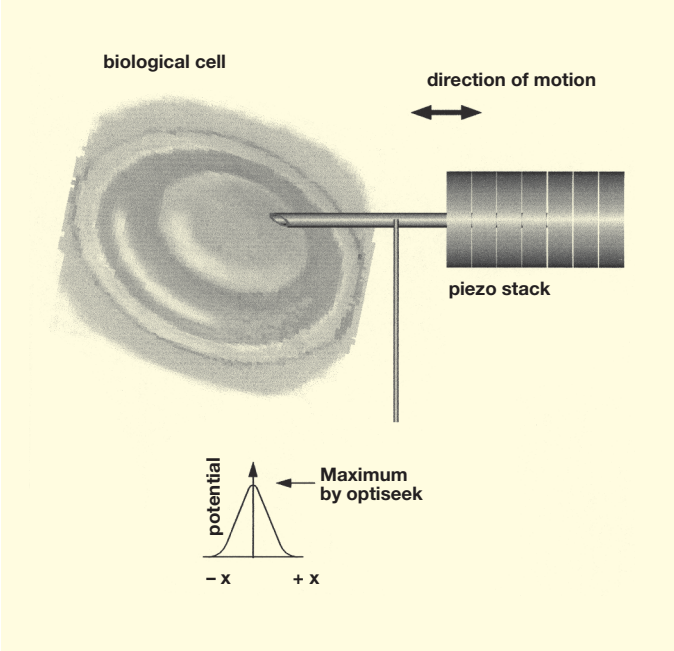


*Fig. 5: Schematic showing stabilization of a potentiometric electrode arrangement to keep the electrode at the maximum of the cell potential*

## What are the advantages of the OptiSeek?

The advantage of being able to adjust the mechanical arrangement to an extreme value (maximum/minimum) of the effect under study is twofold:

a. The process effect is always optimized towards an extreme value (maximum or minimum defined by the user)
b. Due to the extreme value condition obtainable by the OptiSeek strategy, the sensitivity to mechanical noise/ vibration is also minimized.
c. The OptiSeek electronics provides a maximum bipolar piezo supply voltage as opposed to the usual unipolar electronics provided by other suppliers. This results in a gain of 30% more stroke for any type of piezo.

E.g. an OptiSeek stabilized laser can continuously be held at maximum stable optical output power for unlimited time. The optical output also shows strongly reduced optical noise.
No delay in using the arrangement when a potential warm-up of the mechanics occurs or when any readjustment is necessary due to other circumstances.
The OptiSeek further stabilizes your arrangement against varying load conditions of the mechanical structure, which would otherwise cause a degradation of the efficiency of the system.

## What must be provided to operate the OptiSeek:

The user must provide a signal from a detector, monitoring the intensity of the process effect under study without delay in time and put it into the OptiSeek.
(Notice: phase sensitive operating principle of OptiSeek.)
In case of an optical experiment, examples for detectors are photo sensors/diodes/multipliers.
Inside the OptiSeek, the detector signal is capacitively coupled so that mainly the electrical charge content of the signal is relevant and not the signal voltage levels. Further on, only the modulated parts of the electronic signal are evaluated, the capacitive coupling filters out the DC part.

Using the OptiSeek electronics, one or two piezoactuators controlling one or two independent degrees of freedom, can be operated. Independence of these 2 degrees of freedom is necessary to avoid crosstalk between the two channels and malfunction of the feedback.

The total stroke of these actuators is defined by the expected mechanical maximum offset of the mechanics for which compensation for is required.

*Example:*
When the mechanical drift of a critical parameter in a setup is about 100 µm, the compensating piezo must show at least a 100 µm stroke. Usually the piezo range is chosen a little bit higher to ensure that the control range of the system is not limited, even under most adverse conditions. The drift behavior of the setup must be roughly known in order to set the piezoactuators to a proper starting position.

## Which piezo actuators can be operated by the OptiSeek?

The OptiSeek controls are available for all standard output voltage ranges adapted to Piezomechanik's piezo stack program.

| | |
|---|---|
| OptiSeek 150/2: | output: - 30 V thru + 150 V / 30 mA,<br>Supplying all actuators PSt 150.....<br>or higher rated elements |
| OptiSeek 500/2: | output - 100 V thru + 500 V / 15 mA,<br>Supplying all actuators PSt 500.....<br>or higher rated elements |
| OptiSeek 1000/2: | output -200 V thru + 1000 V / 8 mA<br>Supplying all actuators PSt 1000..... |

Generally, the Optiseek can be combined with all kinds of piezoelectric or electrostrictive actuating principles, like piezoelectric tubes, strips, bending bimorphs, shear plates.

# Operating parameters provided by the OptiSeek Feedback Control:

A. Selector switch for “Minimum/Maximum”. The user can define whether the OptiSeek seeks for a minimum or a maximum of the process effect.

B. Dithering Amplitude:
The amplitude of the internally generated sine-signal to vibrate the piezo slightly can be selected over a wide range. The final setting depends on your requirement i.e. the larger the signals; the shorter is the reaction time of the OptiSeek.The maximum dithering amplitude is defined by the onset of an inacceptable modulation of the process effect.

C. Dithering frequency:
Can be varied between 20 Hz and 300 Hz. The higher the frequency, the shorter the reaction time. Attention must be paid to all kinds of mechanical resonances within your system impacting your effect under study. The OptiSeek dithering frequency must be held well outside these resonances. Otherwise phase shifting between dithering signal and signal response occurs, leading to malfunction.

D. Integration time:
The shorter the integration times, the shorter is the reaction time of the OptiSeek controlled system.
The longer the integration times, the lower are the residual fluctuations of the system.

E. Reset: The OptiSeek regulation part can be de-activated causing the device to behave like a simple power supply by selection of the output voltage via “offset” potentiometers located on the front panel.
The dithering excitation remains active to enable the user to check the system’s detector response.
“Reset” can be applied manually by a front switch or by short-circuiting the “reset” connector.

F. Offset:
On reset, the piezo output voltage of each channel can be manually varied by a potentiometer.
This is useful to pre-adjust the system (works only when feedback is “off”).

## Connectors

| | |
|---|---|
| **Detector Signal Input:** | BNC |
| **Piezovoltage Output:** | BNC for OptiSeek 150 V / 500 V<br>LEMOSA 0S 250 for OptiSeek 1000 |
| **Monitor:** | BNC<br>Each piezo voltage output can be monitored real time e.g. an oscilloscope with a reduction factor of 1:1000<br>This is helpful to study the detector response in correlation with the dithering modulation |
| **Size:** | WxDxH 255x305x160 mm |
| **Weight:** | 4.7 kg |

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