
The extended cavity diode laser ECDL-7910R is a tunable source of high-coherent radiation in near infrared. The central wavelength of the working range is 795 nm. However, the detuning of 2 nm to short and long wavelengths is possible. The laser can be used in metrology, spectroscopy and interferometry.

ECDL-7910R consists of an optical head and an electronic unit connected by a cable via connectors DHS-15. The standard length of the cable is 1.8 m. The plug of the electronic unit must be inserted into the earthed socket. The optical head is grounded. However, it is necessary to remember that there is a high voltage supplying piezo-element under the lid of the optical unit. The piezo-element is accessible when the lid is taken off.

The optical head

The optical head (Fig.1) consists of a laser diode heat-sink (pos.1), an antireflection coated laser diode (LD) with an objective (N_A=0.45; f=4.2mm; output aperture - 5mm), thermoelectric microcoolers (Peltier elements), thermosensors mounted into the laser diode heat-sink and into the case of the optical head (two 15 kOhm thermistors). The laser diode is rigidly integrated with the collimating objective in a common module. The common module (pos.2) is inserted into the heat-sink. Two loops of thermostabilization keep the temperatures of both the heat-sink and the case (pos.8) constant regardless of each other, such that the case of the optical head serves as a radiator of an internal loop of thermostabilization and the base of the optical head serves as a radiator of an external one. The base of the optical head has longitudinal side slots to mount the head onto an optical table.

The optical cavity of the tunable laser is formed by the rear high-reflective facet of the laser diode and the Littrow diffraction grating (1800 grooves/mm). The grating is attached to an angled seat (pos.3), which defines the proper direction of the laser beam diffraction. A piezo-element (pos.6) varies simultaneously the incidence angle of the laser beam and the cavity length. This allows extending the range of continuous tuning. The adjustment screw (pos.5) rotating the grating realizes the coarse tuning of the laser wavelength.

The precise matching of the wave reflected from a grating and the incident one is crucial for an extended cavity diode laser to obtain high coherence and significant output
power at the same time. The ECDL-7910R does not have control knobs to adjust the position of the collimating objective in respect to the laser diode and to align the laser beam in vertical direction. All these important settings require serious skills, and they are made on an assembling stand in advance. In the case of laser diode degradation the common module of a laser diode and a collimating objective must be replaced as a unit.

Contrary to the collimating objective the vertical alignment of the laser beam still remains possible even after demounting of the ECDL from the assembling stand. The horizontal axle of the diffraction grating is gripped by a collet. The collet closes or opens when the vertical lock-screw (pos.4) is turned clockwise or counter-clockwise respectively. The slightly asymmetrical grip of the horizontal axle in the collet rotates the axle when the screw locks the collet. Typically clockwise rotation of the lock-screw moves the laser beam up; counter-clockwise rotation moves the beam down. Do not rotate the lock-screw more than a quarter of a turn! Otherwise it might be broken or the horizontal axle might be completely released. If more beam shift is necessary, then the Γ-shaped lever from the maintenance kit must be used. It can be inserted into the slot of the axle butt-end and fixed.
by M2 screw. The horizontal axle rotates freely when the lock-screw is loosened. One can
tight the lock-screw after alignment taking into account the above mentioned axle rotation
during tightening.

Typically the output beam of a laser diode is astigmatic. Therefore, sometimes the
most effective optical feedback is achieved at the slightly convergent output beam, that is to
say the inessential convergence (∼2×10⁻³) of a laser beam does not demonstrate the wrong
alignment of the ECDL.

The electronic unit.

The electronic unit (ULDC200DP – the universal laser diode controller) controls the
laser diode current and temperature, the temperature of the laser case, and the length of an
external part of the laser cavity with accuracy sufficient to get the required output
characteristics of the ECDL-7910R. An analog power supply provides all voltages essential
for control circuits: stabilized ±15V, +200V, ±5V and unstabilized ±8V. There are three fuse
sockets under the unit lid close to the line connector. One socket corresponds to the line
voltage of 240V AC, another one – to the voltage of 220V AC and third one – to 117V AC.
Only one fuse of 2A must be inserted into the relevant socket! One more fuse of 160 mA
(F4 from Fig. 9) protects the output of the high-voltage power supply from the abridgement.
To open the unit lid unscrew four screws from the unit bottom.

There are few functional zones on the front panel of the electronic unit reflecting
operation of a current source (CURRENT), a temperature controller (THERMO), a high-
voltage amplifier (PZT), a laser diode shunt, and a lock-in amplifier (LD-LOCK) (Fig.2). A
lock-in amplifier is optional, and its description is further omitted.

The CURRENT zone includes a digital monitor, control knobs of LD current level
(LEVEL), scan amplitude (SWEEP), and current cut-off (LIMIT). A double-color light
emitting diode (LED) is on in the case of current limitation. The maximum current value of
the electronic unit (ULDC200DP) is 200 mA. The full scan amplitude of the current is about
50 mA.

The current source of the ULDC200DP (DP – dual polarity) can be used for laser
diodes with the grounded cathode as well as for diodes with the grounded anode. To switch
polarity of the current source it is necessary to open lid of the electronic unit and to change
the position of the switches SW2 and SW3 (Fig.8, Fig.14). The operating current is indicated
as a positive value when the current source is in the “grounded cathode” mode, and the
current value is negative if the LD anode is grounded.
Fig. 2. The front and rear panels of the electronic unit.

The internal triangular-wave generator can modulate the LD current at line frequency and its sub-harmonics $f$, $f/2$, $f/4$, $f/8$. To set frequency of modulation, only one corresponding jumper of the DIP-8 switch on the printing board (SW5) must be set in position ON. Taking into account the low-frequency mechanical resonance of the laser cavity, the frequency $f/2$ (that is 30 Hz for USA and 25 Hz for Europe) is preset in ECDL-7910R. The higher frequencies might be used, if the high sweep rate is important and the excess amplitude ripple in the vicinity of extremum can be neglected. The trimmer of current cut-off (LIMIT) is located above the SWEEP knob. Such a current limitation might be necessary to prevent degradation of a laser diode due to accidental current overload. The current overload indicator (a red LED for positive polarity and a green one for negative polarity) is to the right from the corresponding trimmer.

The THERMO zone includes two trimmers of temperature adjustment for internal (LD) and external (CASE) loops of thermostabilization. Clockwise rotation of the trimmers results in increase of the object temperature. Two double-color LEDs are above the corresponding trimmers. They reflect the state of the thermoloops. The absence of any light in THERMO zone indicates the regular temperature regime of a laser diode and a laser case. The green color of a LED informs on active cooling of the corresponding object, that is the outer temperature is higher than the pre-set object temperature. The red color of a LED displays heating (the outer temperature is below the pre-set temperature). The LEDs in the
The pushbutton in the THERMO zone is required to indicate the value of the reference resistor, which sets the temperature of a laser diode. The display of the ULDC200DP reads its resistance in kiloohms at the pressed pushbutton.

The PZT zone includes the knobs of alternative (GAIN) and constant (OFFSET) voltages applied to piezo-elements. The control signal of a high-voltage amplifier is similar to the one of a current source, and the relative phase of two signals allows realizing the synchronous change of the LD current and the laser cavity length. This expands the continuous tuning range of the output laser frequency. To scan piezo the full resource of the high-voltage amplifier can be used providing ±200V. The maximum PZT tuning is obtained at neutral position of the OFFSET knob. The constant phase difference between the signal of an internal oscillator and a line frequency allows minimizing the influence of line pickup under optical data recording.

The LD-LOCK zone includes a switch of a laser diode shunt (LD) and an indicator of the shunt state. It is recommended to keep a laser diode shorten (the LED does not light) at the moment of electronics switching on and then till the changeover of the LD and case temperature to a steady state. When the LD switch is on (the LED lights green) the shunt changes its value gradually from about 0.1 Ohm to tens MOhm during a few seconds removing a short circuit and protecting the LD from the transients. Also the shunt protects a laser diode from a current overload when one of the ±15V voltages breaks down.

The line connector, the input connector for high-frequency (up to 50 kHz) current modulation (MOD), the input connector of an external control signal, the switch of a control signal (EXT-INT), and the output connector of the built-in generator (RAMP) are placed in the upper row of the rear panel. There are the power switch and the optical head connector (DHR-15M) in the lower row. The triangular signal of about 3V \(_{\text{p-p}}\) from the RAMP output can be used to control or to synchronize external devices. In order to control the output frequency of the ECDL-7910R by an external signal the EXT-INT switch must be set into the EXT position. In this case the output of the built-in sweep generator is disconnected from the inputs of the current source and the high-voltage amplifier. The signal from the MOD connector is directly coupled to the current source regardless of position of the EXT-INT switch.

**Activation of the ECDL-7910R.**

1. Connect the cable between the optical and electronic units.
2. Check up the settings of the SWEEP and LEVEL knobs. They have to be in the extreme left position.

3. Turn on the power supply switch on the rear panel of the electronic unit and wait until the LEDs in the THERMO zone stop flashing.

4. Turn on the laser by the LD switch and set the recommended current.

Disabling the ECDL-7910R.

1. Set both the AC and the DC to zero (the SWEEP and LEVEL knobs are in the extreme left position).
2. Turn off the laser current by the LD switch.
3. Switch off the power supply.

Frequency tuning and alignment of the ECDL-7910R.

The mechanical stability of the ECDL-7910R is high enough to keep the laser output in close vicinity of the particular wavelength (say atomic transition) for weeks, so that the LD current and the PZT voltage remain the only means to tune the laser precisely to this desirable wavelength. However, the degraded characteristics of the ECDL (increasing of the threshold current, output power reducing, tuning range reducing, poor side-mode suppression ratio, amplitude noise increasing) might indicate that realignment of the extended cavity is necessary.

The following experimental data specify the operation of the ECDL-7910R and might serve as references for its alignment. Fig.3 shows the output power of the ECDL-7910R when the internal triangular-wave generator modulates the laser current. The clearly observed steps of the power-on-current dependence are resulted from the extended cavity mode-hops. The Rb absorption is revealed at some certain steps in Fig.3 (the regions surrounded by the red ellipses). The Rb cell is warmed up to make the absorption more evident.

The transmission of the Rb cell at the constant current and the gradually changing PZT voltage is shown on Fig.4. Three consecutive extended-cavity mode hops are visible displaying Doppler-broadened profiles which correspond to F=1, 2 – F’=1’, 2’ transition (left part of the graph) and to F=2 – F’=1,2. The experimental data were taken with $^{87}$Rb isotope, so four Doppler-broadened profiles corresponding to F=1, 2 – F’=1’, 2’ transitions are observed. The frequency separation of resonances is about 0.81 GHz. The laser beam reflected from the exit window of the Rb cell together with the direct beam forms the standing wave in the cell. As a result the nonlinear resonances are superimposed on the
Doppler absorption resonances. They are observed at the small-scale tuning of the laser (Fig. 5).

**Fig. 3. The dependence of the output power on the LD current.** The LD current is changed by the symmetrical triangular wave. The red ellipses show the zone of the $^{87}\text{Rb}$ absorption.

**Fig. 4. The transmission of the Rb$^{87}$ cell on the PZT voltage sweeping.** The LD current is constant.
Fig. 5. The transmission of the Rb$^{87}$ cell at F=1, 2 - F'=1, 2 transitions. Two laser beams form the standing wave in the cell making the Doppler-free resonances visible.

Full-scale tuning of the ECDL-7910R is achieved by the synchronous sweeping of the piezo voltage and the LD current (Fig. 6). The PZT scan is set close to the maximum, while the current scan and the DC levels of the LD current and the PZT voltage are found experimentally to avoid mode-hops inside the full tuning range.

Fig. 6. The transmission of the Rb$^{87}$ cell at the synchronous scan of the piezo and the LD current.
Follow the way below, please, if the laser realignment is necessary.

1) Insert the Γ-shaped lever into the slot of the horizontal axle of the grating.

2) Find the direction in which the lever decreases the LD threshold. Gently press the lever up and down for this.

3) The clockwise rotation of the lock screw (Fig.1, pos.4) is applied if the motion of the lever down (i.e. the laser beam reflected from the grating goes up) reduces the threshold. The counter clockwise rotation is needed at the up-level position. Use a wrench number 4 to rotate the lock screw. Typically few degree rotation of the screw is enough to restore the operation of ECDL-7910R.

4) When the minimum of the threshold current is achieved, set if necessary the operation wavelength by tuning the horizontal screw (Fig.1, pos.5) which is accessible even in fully assembled optical unit.
Appendix. The circuits and the layout of ULDC200DP.

Fig. 7. The circuit of the power supply.

Fig. 8. The circuit of the current source.
Fig.9. The circuit of the internal temperature controller.

Fig.10. The circuit of the external temperature controller.

Fig.11. The circuit of the triangular-wave generator.
Fig. 12. The circuit of the high-voltage amplifier.

Fig. 13. The circuit of the meters and the pin assignment of the DHS-15 connector.
Fig. 14. The layout of the ULDC2006DP.
Common recommendations of the ECDL-7910R maintenance.

1. Do not try to change the laser beam collimation. In the case of laser diode degradation the module has to be replaced as a whole by a manufacturer.

2. Do not violate the procedures of the laser activation and disabling.

3. Do not reduce the LD temperature below the dew point. The LD temperature can be estimated using the TCR (temperature coefficient of resistance) of the thermistor: TCR = -4 %/°C.

4. Use an optical isolator to avoid unwanted reflections back into the laser.

5. Follow the golden rule: an ECDL as a part of an experimental setup must be switched on the last and switched off the first.

Specifications.

1. Wavelength 794.7 nm
   @ 68 mA, 101 mA

2. Output power 9 mW
   @ 101 mA

3. Continuous tuning range
   by PZT only 9 GHz
   by PZT+LD current 30 GHz

4. Coarse tuning range ±2 nm

5. Polarization linear vertical

6. Beam shape elliptical 5×1.5 mm²

7. Threshold current 55.5 mA

8. Operating current (D1Rb) 101 mA

9. Thermistor 20.8 kOhm

10. Optical head dimensions 56×50×33 mm³

11. Optical head weight 150 g

12. Electronic unit dimensions 260×210×70 mm³

13. Electronic unit weight 2.8 kg