Battery-powered optogenetic stimulator receives controlling signals from computer in real time through infrared (IR) link. This stimulator can be configured wirelessly to generate desired pattern of stimulation.

**Optogenetic stimulation system**

- IR emitter
- Controlling module
- Neurologger with optogenetic stimulation
- Ultralight optogenetic stimulator
- USB

**Ultralight battery-powered optogenetic stimulator**

- Only 0.59 g including battery and one light emitter
- Ideal for small laboratory animals (mice, rats, etc.) and songbirds (zebra finches, canaries, etc.)
- Supports up to 4 independently controlled light emitting diodes (LEDs)

**Neurologger 2A/2B with integrated 4-channel optogenetic stimulator**

- Records brain activity (4 channels up to 33 kHz sampling) together with activation or suppression of up to 4 brain areas
- Designed for use with mice, rats and other laboratory animals

**Optogenetic stimulator capabilities**

Stimulating capabilities of ultralight and integrated with Neurologger 2A/2B wireless optogenetic stimulators are similar. Their key features are:

- **High illuminating power.** Even with the lightest battery the peak LED input power is ~1 W.
- **Stable light output** (maximal deviation 1.5%). The light output does not degrade with battery discharge. It also does not depend on animal orientation and movements, contrary to systems exploiting energy harvesting.
- **No potentially dangerous high-intensity electromagnetic waves like in the energy-harvesting systems.**
- **Independent control of several stimulators** attached to different animals in one environment.
- **Reliable wireless connection** between stationary controlling module and head-mounted stimulators.
- Direct transmitter-receiver visibility is not needed. Digital noise-free signal processing.
- Stimulating power is adjusted with 1% step.
- Continuous and pulse stimulation is possible. In pulse stimulation ON/OFF periods are adjusted in large ranges and with a small step.
- **Power is adjusted in up to 4 channels individually and wirelessly in each stimulator.**
- **Individual ON/OFF control of up to 4 channels in each stimulator.**
- Simple control from popular environments (Matlab, Python, LabView, etc.) through USB serial port emulation.
- Direct control through analog/digital input from other equipment.
Maximal duration of experiment with ultralight optogenetic stimulator

Longevity of experiments with batteries of different capacity and weight was estimated for ultralight single-channel optogenetic stimulator in two modes:

- Waiting for incoming commands without stimulation.
- Optogenetic stimulation with 10 ms ON / 90 ms OFF schedule with 25% of maximal output power.

Stimulator consumes 345 μA in waiting mode and on average 5.5 mA in the above-mentioned stimulation mode.

<table>
<thead>
<tr>
<th>Battery capacity (mAh)</th>
<th>Battery weight (g)</th>
<th>Total weight (g)</th>
<th>Duration of waiting mode (days)</th>
<th>Duration of stimulation (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.36</td>
<td>0.59</td>
<td>1.45</td>
<td>2.18</td>
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<td>20</td>
<td>0.63</td>
<td>0.86</td>
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<td>1.28</td>
<td>4.83</td>
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<td>50</td>
<td>1.58</td>
<td>1.81</td>
<td>6.04</td>
<td>9.09</td>
</tr>
</tbody>
</table>

Solid black line shows luminous flux approximation error. It is below 1%. Dotted cloud around this line (±0.5%) represents discretization error caused by 1% step of power adjustment. The total error is always below 1.5% in the displayed range of battery voltages.

*Minimal battery voltage that is capable to keep stable LED output depends on illumination intensity configured. It is expressed in % of maximal possible output derived from fully charged (up to 4.15 V) lithium-polymeric battery. If LED output is set at 75% of maximal value, the minimal battery voltage allowed for the output stabilization will be 3.76 V. This border is marked by a vertical dashed line. For outputs 50%, 25%, 10% and 5% the minimal voltages will be 3.37, 2.98, 2.75 and 2.67 V respectively. Chart is plotted for blue LED (460 nm, 1W input peak power) powered from a source with the output impedance 577 mΩ.

Light output maximal deviation 1.5% in the range of battery voltages from 2.6 V to 4.15 V*

Included software allows easy configuration and control of ultralight wireless optogenetic stimulator.

Provided code examples are helpful for integration of optogenetics into different behavioral experiments.