Neurologger®

The second generation - for mice and larger animals

Neurologger 2A

Infrared (IR) receiver for synchronization

3-D accelerometer

Connector for electrophysiological signals

4 neurophysiological channels with sampling rate up to 19.2 kHz for EEG, ECG, EOG, EMG, LFPs and neuronal activity.
3-D accelerometer
Infrared (IR) synchronization with external equipment.
The recorder weight in the most complete configuration is 1.71 g + ~1 g typical battery weight makes total weight 2.71 g.
The battery holder can add 0.63 g.

Neurologger 2A other variants

Only
3-D accelerometer,
256 MB memory,
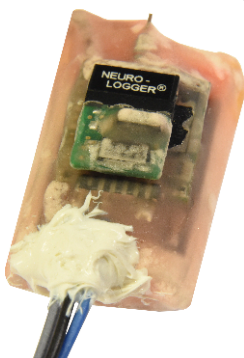weight 1.28 g

The lightest version:
electrodes are soldered
directly to the board,
clip connector for data
downloading, 1 GB,
weight 0.95 g

The same as before
but with the connector
for the electrodes,
weight 1.05 g

Micro board with
3-D accelerometer
is added, weight of
recording combination
1.61 g

Water-proof ECG recorder for marine birds
IR receiver is replaced by magnetic sensor.
Putting permanent magnet in the vicinity
of the sensor creates a label in the logger record.
Memory 1 GB, rechargeable battery 3.7V, 240 mAh.
The battery is sufficient for 4 days.
Total weight of encapsulated logger 20 g.

Neurologger 2B
Enhanced version with increased data rates

4 channels with sampling rate up to 33.3 kHz for sound and neuronal activity recording.
Single-channel 200 kHz mode for ultrasound recording.

Microphone
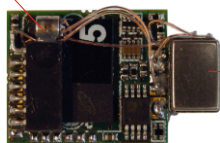
Contact microphone

Version for zebra finches, marmosets

Microphone

IR receiver

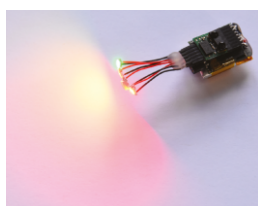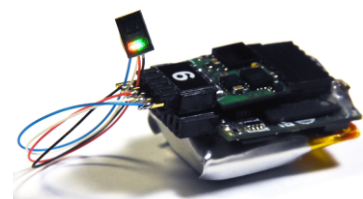Version for bats

Neurologger 2A/2B options complementing brain activity recording

4-channel optogenetic stimulator
Activates or suppress up to
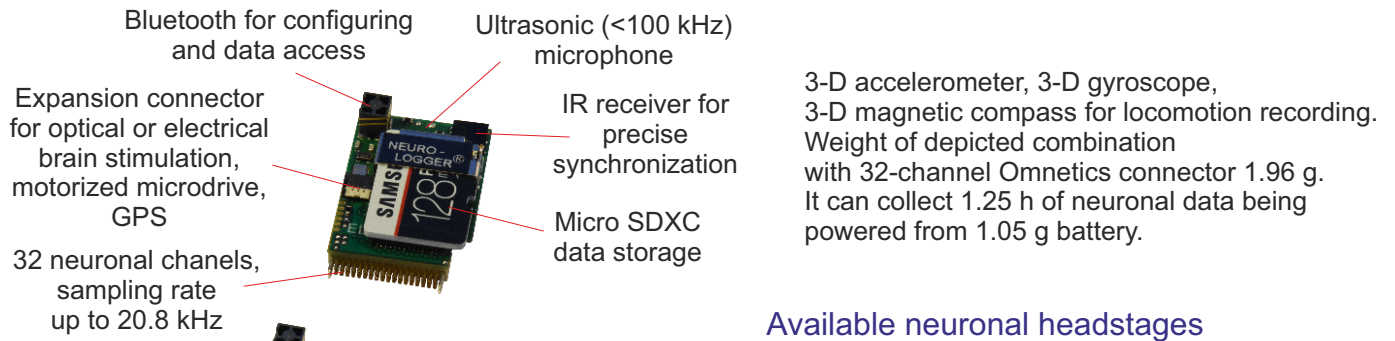4 brain areas independently
and wirelessly

Enhanced accelerometer board
16-bit 3-D accelerometer,
3-D gyroscope, 3-D magnetic
compass, altimeter, thermometer

Pulse oximeter
Records heart rate and
blood oxygenation (SpO2)
non-invasively

The third generation - multichannel neuronal recording in mice, rats, *etc.*

Bluetooth for configuring and data access

Ultrasonic (<100 kHz) microphone

IR receiver for precise synchronization

Expansion connector for optical or electrical brain stimulation, motorized microdrive, GPS

Micro SDXC data storage

32 neuronal chanels, sampling rate up to 20.8 kHz

3-D accelerometer, 3-D gyroscope, 3-D magnetic compass for locomotion recording. Weight of depicted combination with 32-channel Omnetics connector 1.96 g. It can collect 1.25 h of neuronal data being powered from 1.05 g battery.
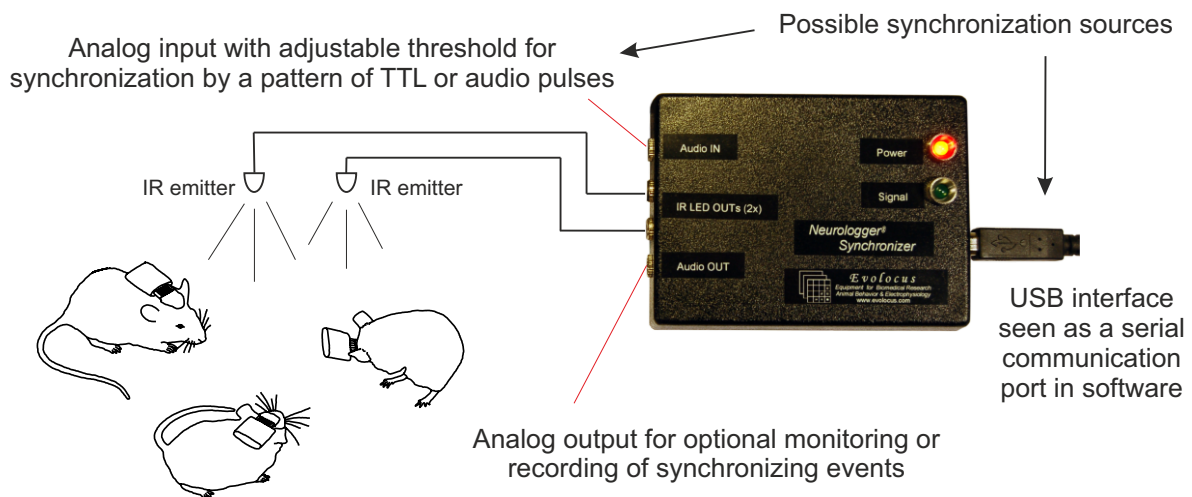
Available neuronal headstages

Ultrasonic recorder with 3-D accelerometer, 3-D gyroscope, 3-D magnetic sensor. Weight 1.29 g

16-channel Hirose 0.35 g

32-channel Hirose 0.44 g

16-channel Omnetics 0.46 g

32-channel Omnetics 0.67 g

Scalable architecture: from 16 to 256 channels

Neurologger 3 64 channels

Neurologger 3, 256 channels
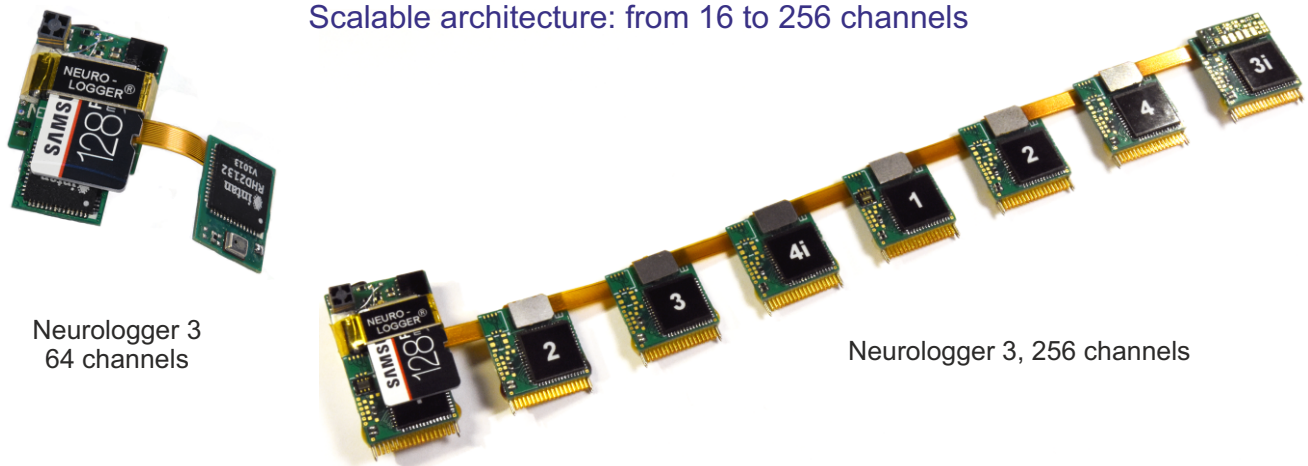
Neurologger Synchronizer

The tool for precise synchronization of Neurologgers of all generations with external equipment

Analog input with adjustable threshold for synchronization by a pattern of TTL or audio pulses

Possible synchronization sources

IR emitter

IR emitter

Audio IN

Power

Signal

IR LED OUTs (2x)

Neurologger® Synchronizer

Audio OUT

Evolocus
Equipment for Biomedical Research
Animal Behavior & Electrophysiology
www.evolocus.com

USB interface seen as a serial communication port in software

Analog output for optional monitoring or recording of synchronizing events

Standard serial interface is supported in Matlab, Labview, Python and all classical programming languages. We provide Matlab examples illustrating interaction with Neurologger Synchronizer. Analog input with adjustable threshold also can be used with a push button. Pressing on this button will initiate transmission of a predefined pattern of IR pulses to the Neurologgers. Software for conversion of Neurologger data to Matlab and other environments is provided.

Comparison of three generations of Neurologgers®

	Neurologger 1	Neurologger 2A/2B	Neurologger 3
Primary usage	EEG, EMG and LFPs recording in large animals: marine mammals, ruminants	EEG, EMG and LFPs recording in mice and larger animals; ECG, vocalization recording including ultrasonic	Multichannel neuronal recording in mice and larger animals; vocalization recording including ultrasonic
Number of channels	**8 differential channels**	**4 channels** freely assigned to two referent electrodes; from them one can be used for temperature recording	**16, 32, 64, 96, 128, 192, 256 channels** with one referent electrode; or 16-128 differential channels; up to 3 channels for temperature
ADC resolution	10 bit; 2x oversampling in low-frequency modes	10 bit; 2x-8x oversampling in low-frequency modes	16 bit
Sampling rate	8 channels up to 800 Hz; or 2 channels up to 10 kHz; or 1 channel 20 kHz; higher sampling rates by request	**Version 2A:** 4 channels up to 20 kHz **Version 2B:** 4 channels up to 33.3 kHz; or 1 channel up to 200 kHz	Number of channels: Maximal rate 16: 40 kHz; 32: 20.8 kHz; 64: 10.4 kHz; 96: ~7 kHz 128: 5.2 kHz; 192: ~3.5 kHz; 256: ~1.5 kHz Starting from 32 channels: free selection of channel sequence; selected channels can be sampled more often than others
Locomotion recording	Optional analog 3-D accelerometer occupies three channels	Optional 3-D accelerometer; optional 3-D accelerometer, 3-D gyroscope, 3-D magnetic compass, altimeter	3-D accelerometer, 3-D gyroscope, 3-D magnetic compass
Vocalization recording	-	Optional microphone and contact microphone are connected to neurophysiological channels; optional dynamic range expansion	Dedicated 12-bit 200 ksps microphone ADC works simultaneously with neuronal 16-bit ADC; optional dynamic range expansion; attachment of a microphone to one 16-bit channel is also possible
Expansion possibilities	Asynchronous serial bus up to 1.5 Mbps (UART) and digital input/output lines at the main CPU can be custom programmed by request.	Dedicated communication controller with different peripheral interfaces is connected to 8 Mbps synchronous bus (SPI). It can be custom programmed by request. Current expansions include: 4-channel optogenetic stimulator, heart rate and blood oxygenation (SpO2) sensor.	Inter-integrated circuit (I2C) communication bus 400 kbps makes possible chained connection of multiple custom-developed peripheral devices. Development of the following peripheral units is planned or will be done by request: optical and electrical brain stimulators, motorized microdrive, GPS. 32-ch version has 3 auxiliary analog inputs and one digital output.
Data memory	Micro SD high-capacity (4-32 GB) memory card	Soldered memory chip 1-2 GB	Micro SD high-capacity (4-32 GB) or extended capacity (64-256 GB, Micro SDXC) memory card
Maximal memory filling speed	30 kBps (2 channels, 10 kHz)	300 kBps (1 channel, 200 kHz)	1.77MBps (32 channels 20.8 kHz, sound 125 kHz, motion sensors 580 Hz)
Maximal recording duration	Limited by the battery	1 GB will be filled when 4 channels are sampled with the frequency: 100 Hz: 20 days 17 h 400 Hz: 5 days 4 h 1600 Hz: 1 day 7 h 9.6 kHz: 5 h 10 min 19.2 kHz: 2 h 35 min 33.3 kHz: 1 h 29 min One channel at 200 kHz: 59 min 39 s 3D accelerometer increases volume by 50% in low-frequency modes.	In most cases limited by the battery. 128 GB card is sufficient for recording during 20 hours in the highest data rate mode listed above. If only 32 channels are sampled with the frequency 15.625 kHz, 128 GB is sufficient for 31 hours.
Current consumption	~5.5 mA in EEG mode	**Version 2A:** 1.5 - 4.3 mA, mode-dependent; In EEG mode with 3D accelerometer. 2.0 mA **Version 2B:** in high-frequency modes	11-25 mA, mode-dependent; All neuronal modes ~25 mA.
Logger size (w/o battery)	36x31x6 mm	From 18x15x3 mm to 22x15x8 mm	From 20x15x6 mm to 24x15x8 mm
Logger weight (w/o battery)	**5.31 g**	**0.95 - 1.71 g**, version-dependent	**1.29 – 1.96 g**, version-dependent
Recommended batteries and their weights	Lithium-polymeric 3.7V 240 mAh 9.0 g rechargeable battery will be sufficient for 1 day 19h. Non-rechargeable 3.6V 1200 mAh 8.9 g LS14250 will be sufficient for 9 days.	A couple of non-rechargeable Zn-Air 1.4V batteries ZA 10 (75 mAh), ZA312 (175 mAh), ZA13 (305 mAh) with the weights per pair 0.635, 1.02, 1.66 g respectively will be sufficient for 1, 2 and 4 days of EEG recording. Lithium-polymeric batteries, for instance 3.7V 12 mAh 0.38 g GM300910, also can be used.	Lithium-polymeric 3,7V 20 mAh, 0.63 g 40 mAh, 1.05 g 50 mAh, 1.58 g Will provide duration of neuronal recording of 15 min, 1 h 15 min and 2 h 15 min respectively.