SpikeGadgets

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128-Channel Data Logging Headstage (HH128)

Introduction

The 128-channel data logging headstage (HH128) amplifies and digitizes 128 neural channels and is capable of both streaming neural data to the Main Control Unit (MCU) via a cable (tethered mode) or logging it directly to a microSD card on the headstage (untethered mode). It is oriented horizontally for even weight distribution in the lowest profile possible to facilitate more natural animal behavior. The headstage also contains an integrated gyroscope, accelerometer, and radio receiver for synchronization during untethered recordings.
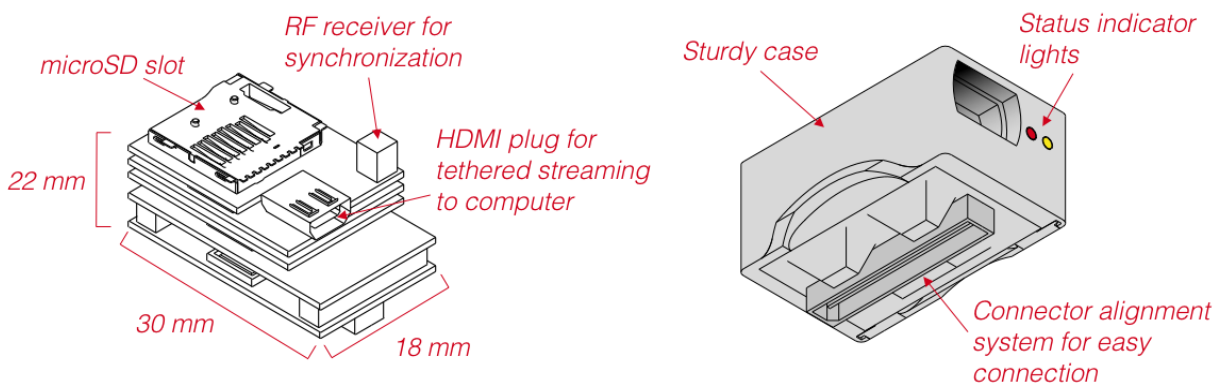

Figure 1 | 128-Channel data logging headstage (HH128) diagram. Dimensions and layout of PCB stack (left). Case, LED indicators and Lynx connector orientation (right).

HH128 Headstage Specifications

Channel count	128 Channels
Connector	
Headstage connector	160-pin Amphenol Lynx connector (11826-ADA).
Headstage Base connectors	160-pin Amphenol Lynx connector to two 70-pin Hirose DF40 connectors.
Weight	
Headstage only	12.9g
Headstage + Lynx adaptor board	17g
Headstage + Lynx adaptor board + 400mAh battery	26.9g
Dimensions	
Length	35mm
Width	22mm
Height	24mm
Data and Input Specifications	
Sampling rate	30 kHz or 20KHz
Bit depth	16-bit
Sensors	3-axis Accelerometer; 3-axis gyroscope
Input range	±5 mV
Data Logging	Full data-rate broadband data, 2hr 45min with 500mAh battery and 128GB SD card

Headstage Connection to Electrodes

The headstage utilizes an interlocking alignment system surrounding a high-density Lynx connector (Fig. 2) for simple and reliable docking. Simply grip the wing tip sides of the processor and gently pull straight up to remove or press straight down to connect.

Note: Connecting and disconnecting to an interface board should be done straight up/down. Do not try to connect at an angle and pry the headstage, as this may damage the connectors.

For a demonstration of connecting/disconnecting, see the following video:
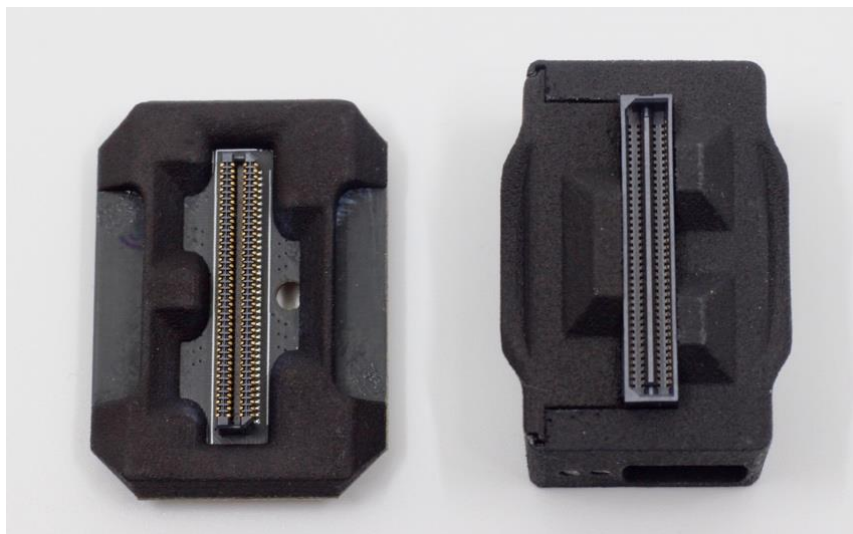
http://www.spikegadgets.com/downloads/HS128%20With%20EIB.mp4

Figure 2 | Lynx connector with surrounding interlocking alignment elements. Left: Headstage Lynx connector board top-view. Right: Headstage logger bottom-view.

The HH128 headstage is equipped with a 3-pin connector (Mill-max 1.27mm pitch) on the top. The outermost pins route power and ground from the power source in order to connect an LED array for position tracking. The middle pin is currently unused.

The headstage is also equipped with two LED indicators visible on the side of the headstage case that provide the user with system status indications.

Figure 3 | Side view showing LED indicators to the right of the HDMI port and Mill-max polarity designations indicated by plus (+) and minus (-), where power (+) is the pin closest to the HDMI port.

NOTE: The newest HH128 cases do not have polarity markings, but the pin designations remain the same.

LED Status Indicators

Upon powering on the HH128 headstage, the Yellow and Red onboard LEDs will blink simultaneously once to indicate the headstage is powered on.

Headstage Status Indicators
Following the startup blink mentioned above, the headstage will blink in different patterns or colors to provide status indications

LED Color	Pulse type	Meaning
Red and yellow	Simultaneous Blink	Headstage powered on
Red	Fast (4Hz) blink	SD card is not enabled for recording
	Breathing	SD card is full; recording stopped
	Random blip during recording	Dropped packet(s). If it happens often, consider upgrading to an SD card with faster writing speed.
Yellow	Fast (4Hz) blink	SD card is being erased
	Slow (2 Hz) blink	SD card mounting error. Often resolved by removing SD, re-enabling & re-inserting SD.
	Breathing	SD card mounted and enabled; ready to record
	4x blinks	Recording has started

NOTE: When the MCU and headstage are configured for untethered recording and the RF transceiver is connected to the MCU, the headstage's yellow LED will blip intermittently. This is expected behavior resulting from the MCU transmitting periodic commands to the headstage.

SD Card Setup

Before a SD card can be used for untethered recording in data logging mode, it must be enabled. This can be done either using the Logger Dock or MCU (running firmware 3.19 or later). To do this, first place the microSD card into the card reader slot on the Dock or MCU (an adaptor is required when using the MCU).

MCU: With the SD card mounted in the card reader slot, hold down the left button on the front of the MCU. This will cause the left LED to rapidly flash red, indicating the card is

being enabled. The button can be released when the LED turns green. MCU firmware version 3.19 or later is required.

IMPORTANT NOTE: SD cards should only be inserted into the MCU when being read or enabled, and should be removed following the action. This is because SD cards cannot be read or enabled using the MCU while streaming, and streaming cannot be initiated while an SD card is inserted.

Enabling SD via the Logger Dock using the DataLoggerGUI

1. Once your SD card has been inserted into the Logger Dock or MCU, open the DataLoggerGUI application from the Trodes application directory.

2. Your SD card should be listed under "Detected Storage Devices." If you do not see your device listed, hit the refresh button.

3. Hit the "Enable for recording" button to enable your SD card.

Preparing to Record

In tethered mode, an HDMI to micro HDMI cable is used to power the headstage and stream data to the MCU (pictured right). Once connected via micro HDMI, if the headstage is properly detected by the MCU, the MCU's power indicator LED will change from blinking amber to solid green. Data streaming is controlled by the Trodes application via the MCU. More information about this can be found in the [Trodes wiki](#).

Headstage settings are modified using Trodes and saved to flash memory on the headstage for recording in untethered mode. To modify settings, the MCU connection to your computer must be enabled in Trodes, but streaming should not be initiated. Settings cannot be saved to the headstage while streaming data.

Figure 4 | Micro HDMI to HDMI right-angle cable for connecting to the MCU while taking tethered recordings and updating headstage settings for untethered recording.

Connecting your MCU to your computer via Trodes is done under the Connection dropdown in your Trodes Workspace:

Connection > Source > SpikeGadgets > USB **OR** Ethernet

The following HH128 settings can be modified under the Settings dropdown menu in your Trodes Workspace (Figure 5):

- **Auto Settle –** Large transient electrical events (caused by electrical stimulation, physical bumping, etc.) can cause extended amplifier ringing. The Auto settle function resets the amplifiers when this occurs and allows you to set a voltage and channel count threshold for triggering the reset.

  IMPORTANT NOTE: Auto settle channel threshold should always be set to a value greater than zero. Failure to do this can result in high amplitude noise "ticks" occurring at a 500ms interval across all neural data channels.

- **Sampling Sequence Correction (on/off) –** Eliminates temporal referencing error associated with the sequential nature of how channels are sampled. It is highly recommended to turn this on when using digital reference.

- **3-axis accelerometer (on/off) –** The accelerometer range is +/- 2g, encoded in signed 16-bit integers. This means each step is 2/32767g or 0.000061g.

- **3-axis gyro (on/off) –** The gyro range is +/- 2000 degrees/second at 16 bits, or 0.061deg/sec per step.
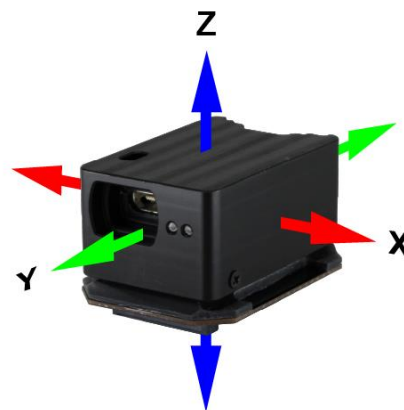
Initiating a Tethered Recording

1. Open Trodes and create a new Workspace "From Scratch" under the Create/Edit Workspace menu or open the Workspace you have already created.

2. Once you have opened your Workspace, connect your headstage to the MCU via HDMI, and link your MCU to Trodes using the "Connection" dropdown menu by selecting: Source > SpikeGadgets > USB OR Ethernet

3. Begin streaming by clicking "Stream from source" under the Connections dropdown menu.

4. Create a new recording file by selecting "New recording" under the File dropdown menu.

5. Set your recording directory using the file explorer pop-up window.

6. Begin recording by hitting the record button.

7. To end your recording, hit the pause button, and disconnect your stream.

Untethered Configuration and Recording

The HH128 headstage can be used in untethered data-logging mode to record neural data directly to an onboard microSD card without the need of a cable tether. It does this under battery power by receiving wireless communication from the control unit (MCU or Logger Dock). The MCU or Logger Dock sends start/stop and synchronization commands to the headstage via radio frequency (RF) wireless link. This guide will cover recording using the MCU.

Figure 5 | HH128 logger and base with mounted battery and micro HDMI battery connector.

NOTE: When taking an untethered data-logger recording with your headstage, you must ensure that both the headstage and control unit are set to the same Radio Frequency (RF) channel and sampling rate, with RF session ID mode turned on.

Preparing your Headstage for Recording:

1. Open Trodes and create a new Workspace "From Scratch" under the Create/Edit Workspace menu or open the Workspace you have already created.

2. Connect your headstage to the MCU via HDMI, and link your MCU to Trodes using the "Connection" dropdown menu by selecting: Source > SpikeGadgets > USB OR Ethernet.

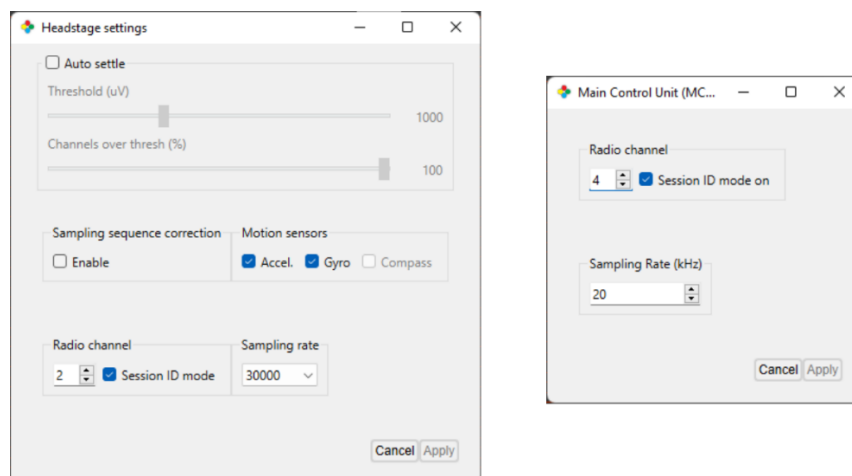   • Your SD card should not be inserted into your headstage yet.

Figure 6 | Headstage and MCU RF channel, sampling rate and session ID mode

Notice the discrepancy between the headstage and MCU sampling rate and RF channel values in the figure above. These need to be aligned before initiating an untethered recording.

3. Under the "Settings" dropdown menus, set the MCU and headstage RF channel and sampling rate to the same values and select the session ID mode checkbox for both (Fig. 6):

   MCU: Settings > MCU Settings…

   Headstage: Settings > Headstage Settings…

4. Apply your settings above, then save your Workspace. This Workspace can be used later as the basis for the Workspace used to merge your neural and environmental data.

Initiating an Untethered Recording:

1. Connect your RF transceiver to the Aux 1 port on the front of the control unit you are using.

2. Disconnect your headstage from the MCU, connect the headstage to battery power, insert your SD card into the headstage and power the headstage on.

   • For more information about preparing your SD card, see SD Card Setup above.

2. Open Trodes and create a new Workspace with channel count set to zero. This Workspace will be used to acquire the environmental record.

3. If you are using an Environmental Control Unit (ECU), make sure this is connected to your control unit via HDMI. Your ECU must also be added to your Workspace by selecting "ECU" from the Hardware Devices dropdown menu, then clicking "+Add Device."

4. Open your Workspace, connect to your MCU, and set your MCU RF channel and sampling rate to match the settings you previously applied to your headstage, also making sure Session ID mode is checked.

5. When you are ready to begin recording, select "Stream from source" from the Connections menu. This will trigger the headstage to begin recording.

6. To initiate recording with the MCU, select "New Recording..." from the File dropdown menu and select your recording directory.

7. Hit the red "record" button to begin recording your environmental record with the MCU.

8. To end your recording, hit the pause button, and disconnect your stream.

IMPORTANT NOTE: The headstage will start recording when you begin streaming with the MCU, but the MCU will **NOT** start recording until you create a new recording file and hit the record button in Trodes. The same holds true for ending your recording; the MCU recording can be ended or paused using the interface buttons, but the headstage recording is ended by disconnecting your stream.

Synchronization

Synchronization between the environmental record recorded by Trodes on your local computer and the neural data recorded to SD on the headstage is done via a radio signal sent at regular intervals (10-second intervals for most setups). This signal is transmitted from the SpikeGadgets control unit that acquires your environmental data and connects to your computer. Trodes connects to this control unit to display and save the environmental data during the recording session. Any video recordings taken using the Camera Module in Trodes are set up the same way they would be for tethered recording.

Importantly, the neural data being recorded to SD cannot be accessed during recording. Once the recording session is done, there will be 2 data files that need to be merged. One data file contains the neural data and is saved to the headstage SD card, the other contains the environmental data saved to your computer. These two files will be aligned using the synchronization signals saved to both files and will be merged using the DataLoggerGUI.

Transferring and Merging Data

In order to merge your data files into a single .rec file you will need the following:

1. The file containing the recorded neural data from the headstage SD card.

2. The file containing the environmental data recorded to your local computer by Trodes.

3. A Trodes Workspace file to append to the merged file.

   NOTE: This is NOT the Workspace file used to record the environmental data, but rather a Workspace that contains both environmental record settings as well as probe and channel setting as if the recording were taken in tethered mode. If desired, the initial Workspace created when preparing your headstage for recording can be adapted for this purpose.

Merging recorded data using the DataLoggerGUI and Logger Dock:

1. Power down the headstage, remove the SD card and insert it into the Logger Dock.

2. Open the DataLoggerGUI application found in the Trodes application folder.

3. The Logger Dock will be listed under the Detected Storage Devices with storage size, type and SD card status listed.

4. Under Extract, select your .rec file and corresponding Workspace .trodesconf file, and set your extracted data directory.

5. Hit START.

More information about merging your data files can be found in the data extraction subsection of the DataLoggerGUI documentation in the Trodes Wiki.

Items Included with Shipment

Item	Description
HH128 Data Logger Headstage	128-channel data logger with amplification, digitization, and SD data storage
HH128 Data Logger base	Hirose to Lynx connector board
45" HDMI A-D Cable (HDMI to micro HDMI)	HDMI tether for connecting headstage to MCU
128-Channel Signal Test Board	PCB routing single input to all headstage channel for signal testing

About SpikeGadgets

SpikeGadgets is trying something new. Our hybrid approach is to design and sell powerful hardware that interfaces with an open-source software platform supported by a large community of scientists and developers. Our goal is to support the efforts of the open-source community in a commercially-sustainable way.

Technical Support

If you would like technical support, please email us at support@spikegadgets.com.