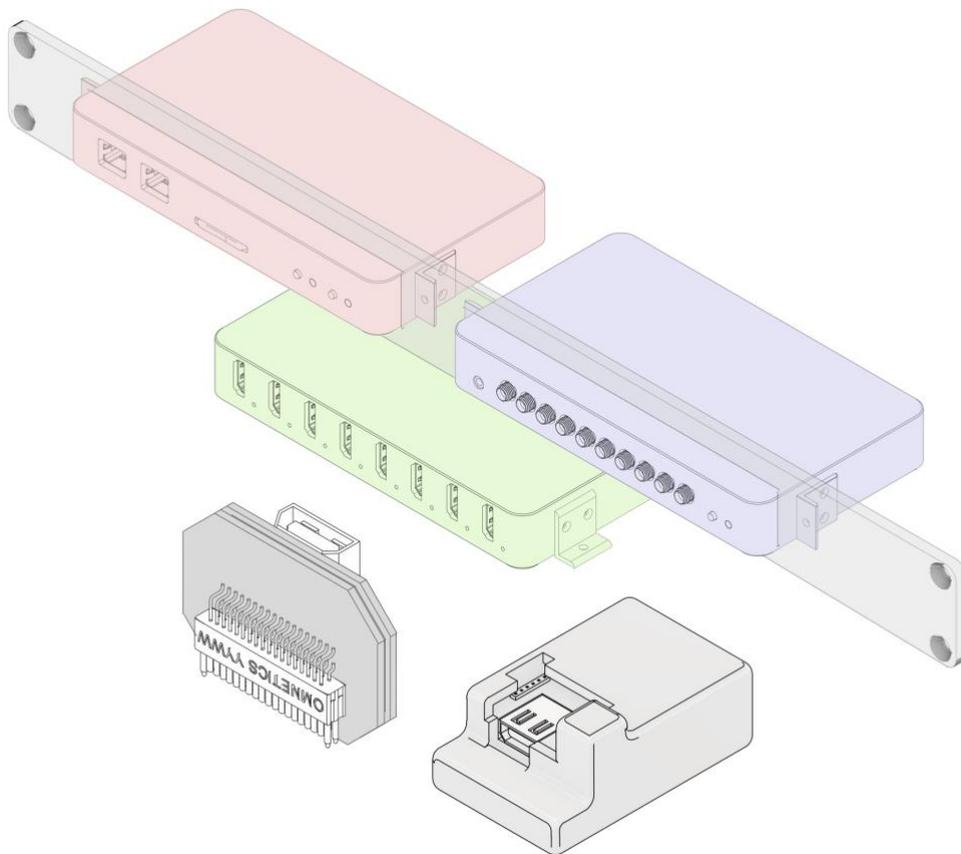


# SpikeGadgets

*Hardware Manual*



## Table of Contents

<b>Setup Guide</b> .....	<b>3</b>
<b>Hardware setup</b> .....	<b>3</b>
Computer Setup .....	5
Todes Software Installation .....	6
<b>Main Control Unit</b> .....	<b>7</b>
Controls and Indicators .....	8
<b>Environment Control Unit</b> .....	<b>11</b>
Controls and indicators .....	12
Inputs/Outputs .....	12
<b>Headstage Combiner Unit</b> .....	<b>15</b>
Controls , I/O, and indicators .....	16
<b>128 Channel Data Logging Headstage (HH128)</b> .....	<b>18</b>
Tethered mode .....	20
Untethered data logging.....	21
Start recording onto SD card .....	24
Transfer SD recording to your computer .....	24
Converting SD recording to .rec file.....	24
<b>32 Channel Lightweight Headstage (UH322)</b> .....	<b>26</b>
<b>Commutators (AC001 and PC001)</b> .....	<b>28</b>
<b>Camera Setup</b> .....	<b>29</b>
Allied Vision GigE cameras .....	29
<b>Troubleshooting</b> .....	<b>34</b>
60 Hz noise.....	34
Ground loops.....	35
Spurious crackling in signal .....	35
Magnetometer noise .....	36

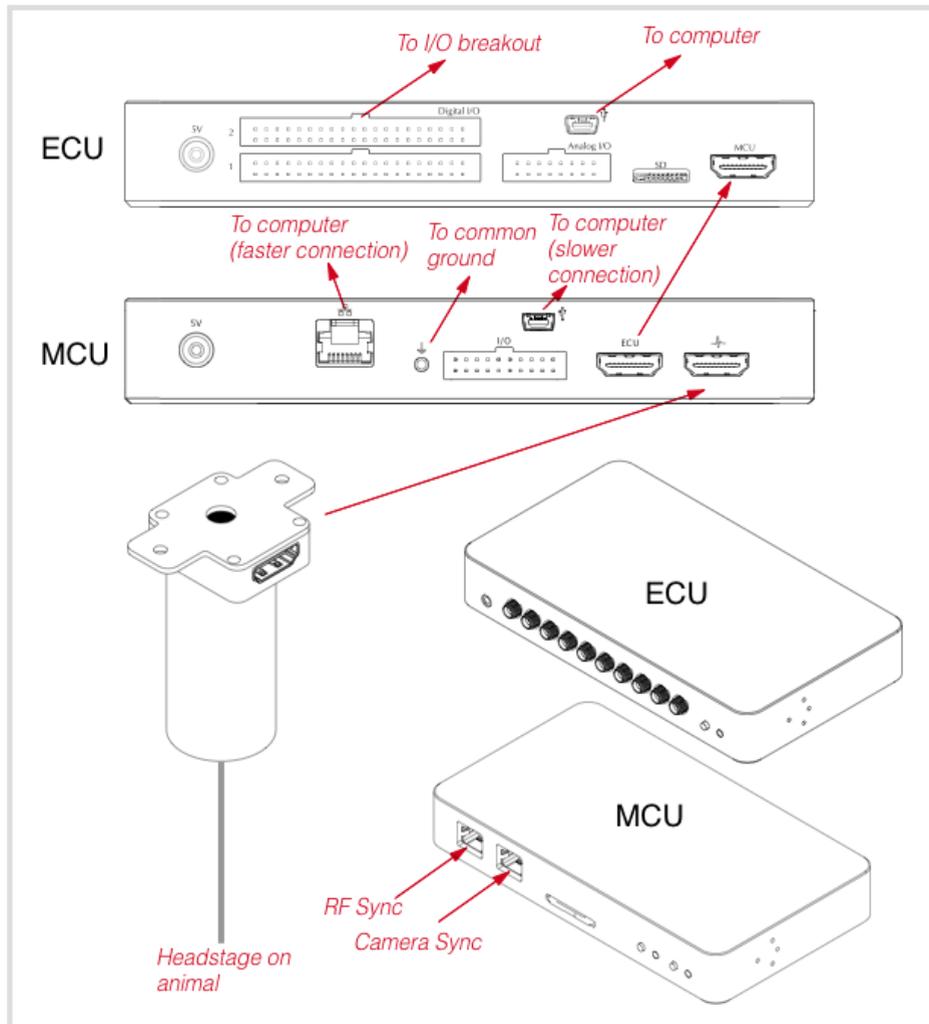
# Setup Guide

## Hardware setup

The most basic hardware configuration uses a Main Control Unit (MCU) and one headstage input. Using this simple configuration, users can stream neural data (up to 1024 channels) to a computer and collect digital events from up to six peripheral devices. For more advanced environmental monitoring and control, an Environmental Control Unit can be added, as pictured in Figure 1. For experiments involving freely-moving animals, a commutator is generally used between the headstage and the MCU to allow rotation without cable twisting. An HDMI cable is used between the headstage and the commutator, as well as between the commutator and the MCU. For setups involving non-mobile animals, users have the option to combine streams from multiple headstages using the Headstage Combiner Unit (HCU). The output of the HCU is plugged into the MCU as if it were one headstage.

All three control units require 5V power to function. Only use the included liar power adaptors, as some 'switching' type adaptors can introduce significant noise onto the recordings. The MCU has a separate ground input (2mm banana plug) which should be connected to a shared ground used by all components of the recording and behavioral environment. A central ground point should ideally be used by all devices to reduce the risk of ground loops.

**Figure 1**



Connection diagram for the MCU, ECU, commutator, and headstage. For setups using a combiner unit (HCU) the out/put from the HCU plugs directly into the MCU.

The MCU can connect to the computer using either USB 2.0 or ethernet. For Windows users that 1) Are recording from 128 channels or fewer, and 2) do not have sub-millisecond control latency requirements, we recommend using the USB connection for easy setup. For ethernet connection, set detailed setup instructions below.

## Computer Setup

The Trodes acquisition software will run on Linux (Ubuntu), Windows, and MacOS. Either USB or Ethernet source can be used and require different setup steps depending on the OS used.

### Ethernet (optional)

If you plan to use ethernet (UDP) to connect to the MCU, you will need a dedicated ethernet port on the computer for the MCU connection. Configure this port for IPv4 connection with the following address and subnet:

**Address:** 192.168.0.2

**Subnet:** 255.255.255.0

You also need to set the maximum transmission unit (MTU) for the connection to 9000 or more. Make sure there is no firewall active for this port (it may try to prevent a connection to the MCU). Next, adjust the size of the write/receive buffers used by sockets. For Ubuntu Linux, edit `/etc/sysctl.conf` (as root) and add the following lines:

```
net.core.rmem_max=8388607
```

```
net.core.rmem_default=8388607
```

```
net.core.wmem_max=8388607
```

```
net.core.wmem_default=8388607
```

For Windows, adjusting the size of receive buffers is done using a different procedure. To set the default size, edit (or create) the following DWORD registry keys (using 'regedit' program from the start menu run box) and restart Windows:

```
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Afd\Parameters]
```

```
DefaultReceiveWindow (REG_DWORD) = 8384512 (decimal)
```

*DefaultSendWindow (REG\_DWORD) = 8384512 (decimal)*

## **USB**

To use USB connection, you must install the FTD2XX driver. Follow directions in the 'comments' section for your OS here:

<http://www.ftdichip.com/Drivers/D2XX.htm>

On Ubuntu Linux, to connect to the MCU and ECU via USB, you must tell your OS how to handle SpikeGadgets hardware when it is plugged in. You only need to do this once. Run the following command (all on one line) to copy the udev rules file to your machine:

```
sudo wget https://bitbucket.org/mkarlsson/trodes/downloads/spikegadgets.rules -O /etc/udev/rules.d/spikegadgets.rules
```

Rules will be applied the next time you connect the hardware. If already connected, unplug and replug the USB cable. The .rules file is also distributed with the precompiled binary, in Resources/SetupHelp, and in the source repository, at Resources/Linux, so you can copy from there instead of using 'wget' if you want.

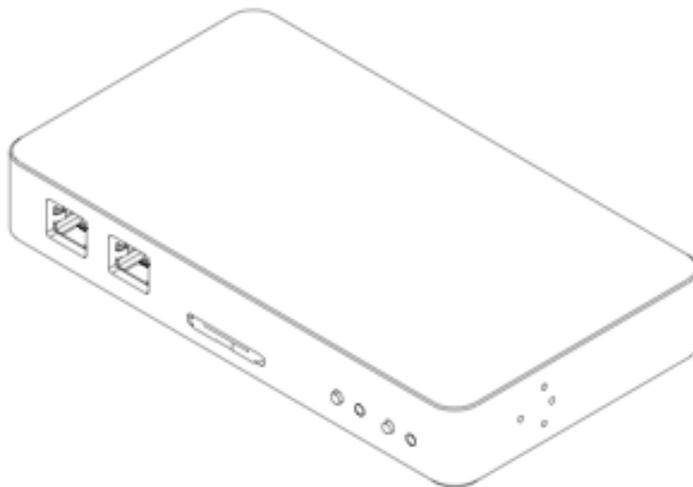
On Windows USB connectivity works without any extra setup. For MacOS, make sure you run the D2xxHelper program to prevent OS X 10.11 (El Capitan) claiming the device as a serial port.

## **Trodes Software Installation**

1. Download required multimedia plugins (linux only):  

```
sudo apt-get install gstreamer0.10-plugins-base  
sudo apt-get install gstreamer0.10-plugins-good
```
2. Download the latest release of the Trodes software suite here:  
<https://bitbucket.org/mkarlsson/trodes/downloads/>
3. Uncompress the downloaded folder and copy to a desired location on your machine.
4. Double-click on Trodes to run.

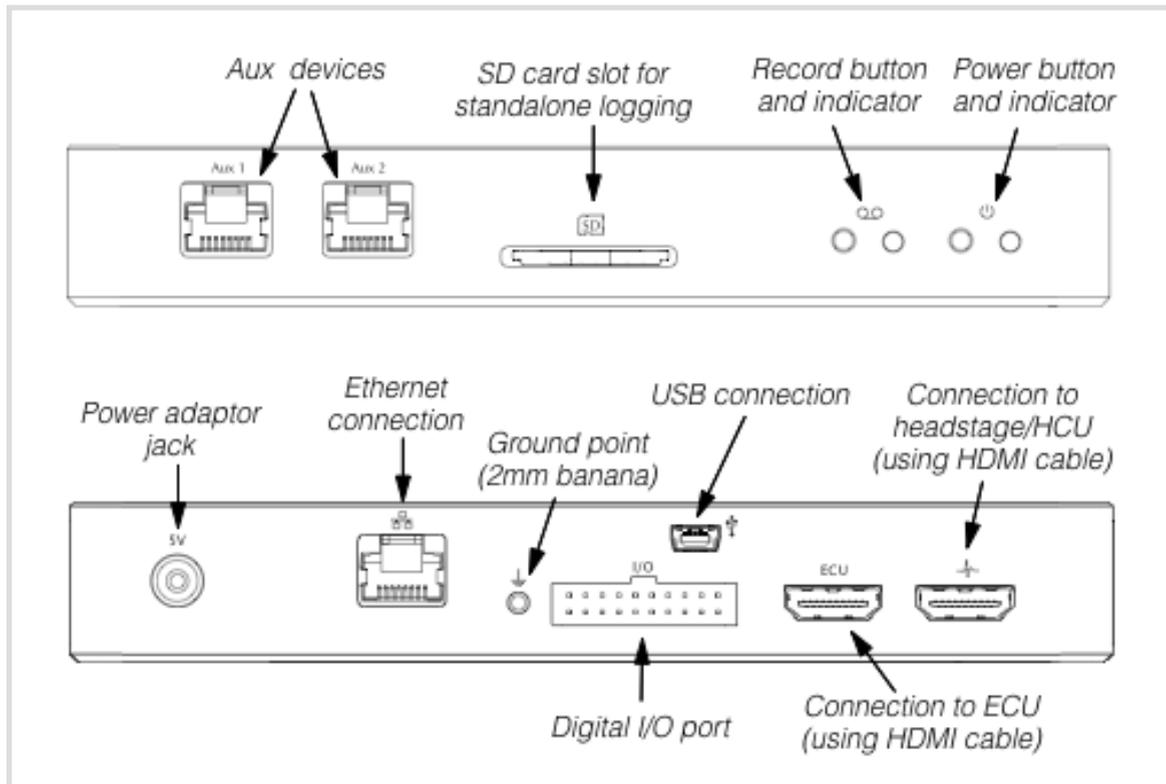
## Main Control Unit



The Main Control Unit (MCU) is the central controller of all SpikeGadgets hardware. It is designed to make electrophysiology experiments easy to execute but is also powerful enough to handle the most complex and cutting-edge applications. In its most basic operation, the MCU accepts digital data from our various types of electrophysiology headstages and streams the data to a computer via USB2.0 (up to 256 channels) or ethernet (up to 1024 channels). It also communicates with other SpikeGadgets devices, such as the Environmental Control Unit, and combines all data streams into a single stream. During autonomous mode, the system records data directly to an SD card, which can dramatically simplify the workflow for multi-system recording setups where multiple experiments are occurring simultaneously for high-throughput data collection.

The unit is compact, allowing it to be utilized in small spaces, and can be mounted to hardware with the included L-brackets. The brackets can be positioned in one of three orientations: forward, up, or down. When placed in the forward direction, the MCU can be mounted to the SpikeGadgets 19" rackmount plate.

**Figure 2**



*Front and back of the MCU, with all ports, controls, and indicators labeled.*

### Controls and Indicators

On the front face of the unit, there are two control buttons and two indicator lights. The button to the right is used to turn the system on and off. To turn on, push down once and release. To turn off, push and hold for two seconds. When turned on, if a headstage is plugged into the system and no errors occurred during initialization, the light to the right of the power button will turn green. If no headstage was detected or if an error occurred, the light will blink orange.

The second button is used to start and stop recordings to the SD card. If no card has been inserted in the SD card slot, then this button is inactive. Once a card is inserted, the indicator light to the right of the record button will turn green if the card's configuration was read without errors. Otherwise, the light will blink orange

to indicate an error. After the card has been inserted, push the record button and release to start recording. Push and hold for two seconds to stop recording.

## **Inputs/Outputs**

On the front face of the unit, there are two customizable jacks, labeled “Aux 1” and “Aux 2”, These jacks are there to allow custom modifications to the system, allowing peripheral devices to interact with the system. If you require custom interfacing with the unit, contact us for more information. By default, “Aux 1” is used to communicate with out radio synchronization transceiver for untethered headstages, and “Aux 2” is used to receive pulses from Allied Vision GIGE cameras when each frame is

The front face also has a slot for an SD card. To insert an SD card, slide a card into the slot until it clicks into place. To Remove the card, push in first and allow the internal spring mechanism to push the card out before pulling it out.

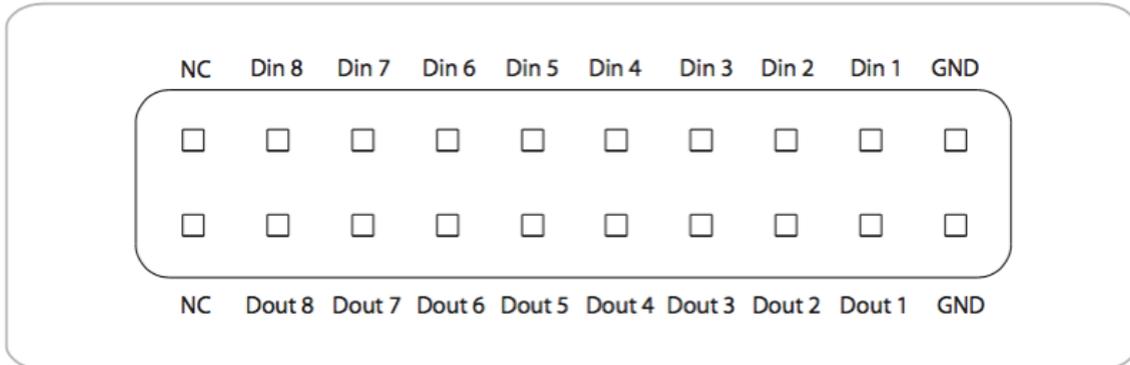
The back side of the unit contains the majority of the I/O. The power jack is located on the left side of the unit (looking from the back). Only use the included 5V power supply with this unit. Other supplies can either damage the unit or produce unwanted electrical noise during recordings.

Moving to the right, the next connector is an RJ45 ethernet connector. This is used to stream data out via gigabit ethernet. Make sure your ethernet cable is labeled “CAT5e” in order to stream at gigabit rates. The cable can either be plugged directly into a computers ethernet input, or to an ethernet network switch rated for gigabit speeds.

The third connector is for system ground. While not always necessary, grounding the system to the same ground used for all other hardware or to any shielding equipment often helps reduce electrical noise.

The fourth connector is a 20-pin header used to sample digital events from other hardware (Figure 3). By default, only Din pins 1-6 are turned on for digital event logging. If requested, this connector can also be configured for additional digital lines, including up to eight outputs with custom behavior (hardware synchronization, etc).

**Figure 3**



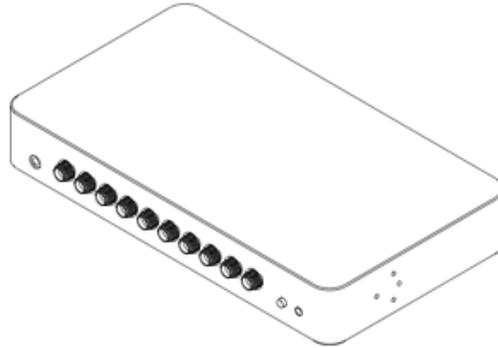
*Pin mappings for MCU digital I/O port. Douts 1-8 are turned off by default but can be enabled for custom applications.*

The fifth connector is an HDMI type A connector used for communication with the ECU. A standard off the shelf cable is used to connect the two units.

The connector farthest to the right is an HDMI type A jack, used to receive input from a single headstage or from the Headstage Combiner Unit. Signals from headstages without HDMI output must first be connected to the Headstage Combiner Unit. Headstages with the HDMI converter included, either directly on the headstage or in the cable, can plug directly into this jack. Headstage inputs are detected when the system is powered on. Make sure that the unit is reset after plugging in a headstage or the output from the Headstage Combiner Unit, otherwise the signals will not be properly detected.

The mini USB jack is used to stream signals to and from a computer if the ethernet connection is not used. The maximum number of channels that can be streamed via USB is 256. An FTDI USB driver will need to be installed on the computer (see installation instructions for Trodes above for more information).

## Environment Control Unit



The Environment Control Unit (ECU) is a powerful tool for controlling and recording the state of peripheral devices, such as lights, levers, beam breaks, lasers, audio cues, solenoids pumps, and synchronization signals from 3rd party hardware. The unit is equipped with 32 digital inputs, 32 digital outputs, 8 analog inputs, 4 analog outputs, stereo sound output, and a slot for an SD card to store audio playback files.

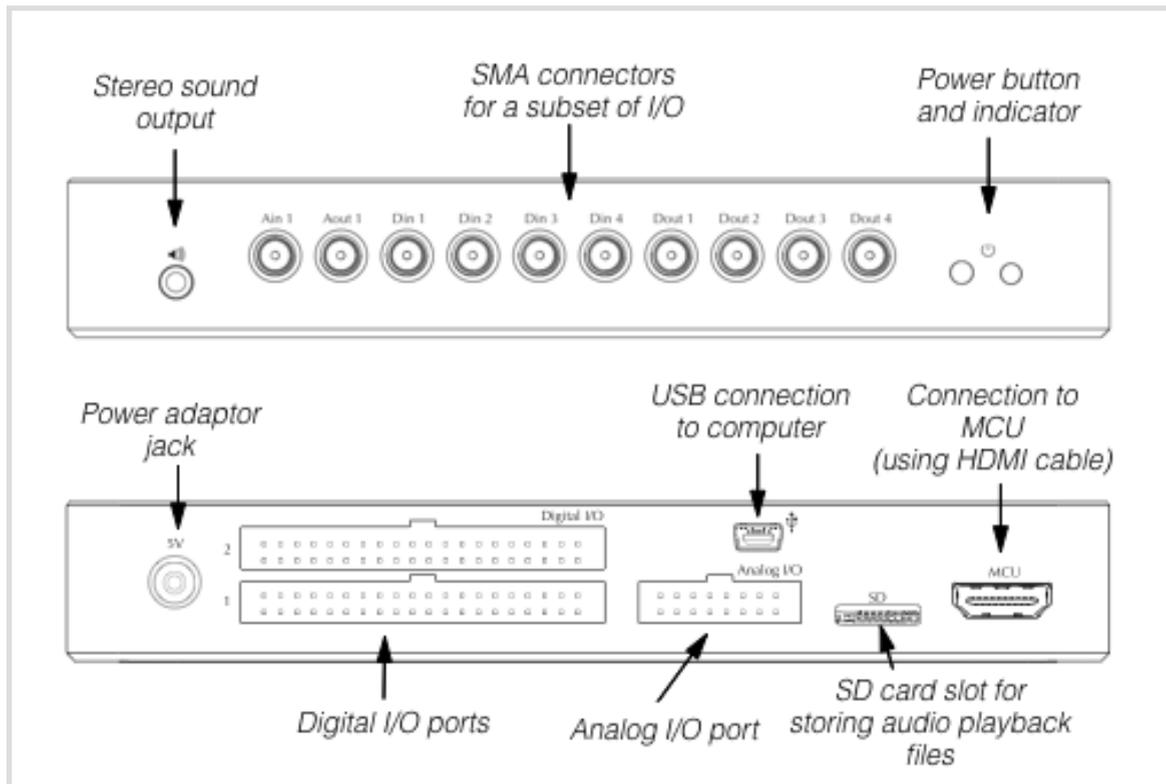
All digital and analog input channels are streamed to the Main Control Unit at a sampling rate of 30 kHz, and the information is combined with the neural data before being sent to the computer.

### **Features and specifications:**

\*32 digital inputs, 0-5V tolerant

\*32 digital outputs, 3.3V high voltage \*8 analog inputs, -10V to 10V range \*4 analog outputs, 0V to 10V range \*Stereo audio out, 44.4kHz sampling

**Figure 4**



*Front and back views of the ECU*

### Controls and indicators

On the front face of the unit (Figure 4), there is one control button and one indicator light. The button is used to turn the system on and off. To turn on, push down once and release. To turn off, push and hold for two seconds. Once the system is turned on, the indicator light will turn green. At that point, the StateScript control system and data streaming to the MCU is enabled.

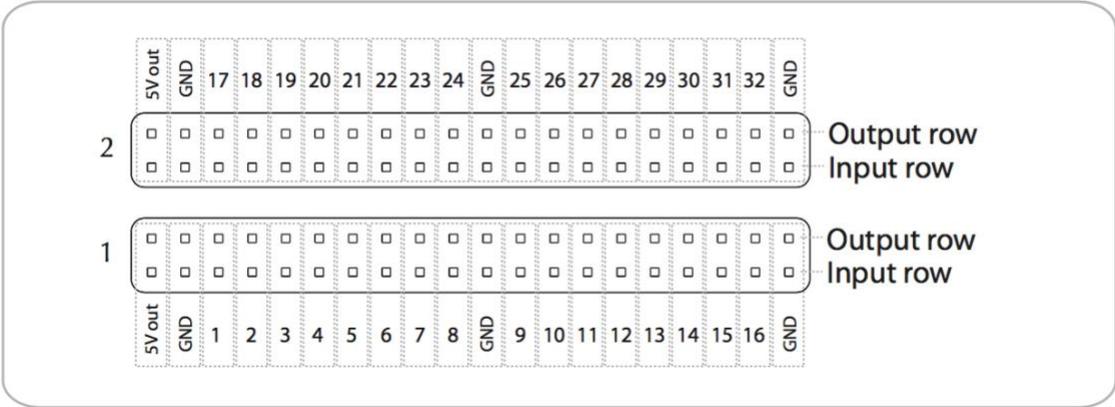
### Inputs/Outputs

On the front face of the unit, there are ten SMA connectors. These connectors duplicate a selected subset of the total I/O channels for convenience. Ain1 and Aout1 are analog input and output, respectively. Din(1-4) are four digital inputs,

and Dout(1-4) are four digital outputs. The front face of the unit also has a 1/8” audio jack for stereo sound output.

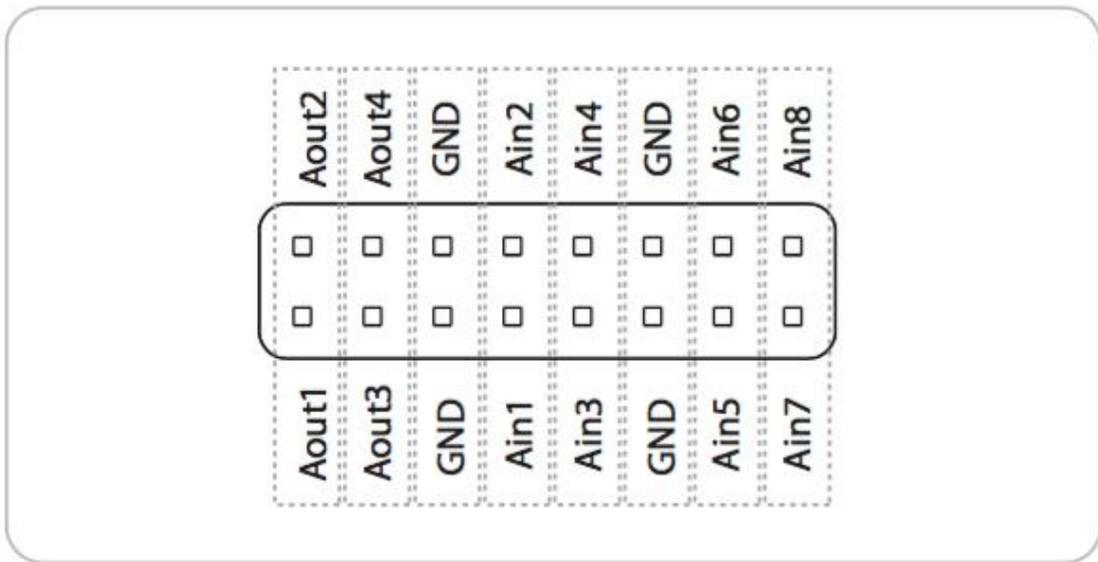
On the back face of the unit, all of the I/O channels are accessible via 0.1” pitch headers. The digital I/O pins are divided into two banks, where each bank contains 16 digital inputs and 16 digital outputs (Figure 5). The inputs will safely receive up to 5V inputs, but anything above 5.5V is not recommended. They use TTL gate logic, where inputs between 0-0.8V is a “low” logic state and inputs between 2-5V is a “high” logic state. If inputs are left floating (nothing connected) they are pulled down to a low state using a 47 kOhm pull-down resistor. The outputs use a 3.3V signal during the high state. These outputs are intended for logic output only and are not intended to drive large currents (XX mA combined maximum across all output pins). Our breakout panels use driver circuits that are capable of delivering larger currents.

**Figure 5**



*Digital I/O ports for the ECU. There are two ports, each with 16 inputs and 16 outputs, plus 5V out to power peripheral devices. The pin number mappings are shown above and below the ports.*

**Figure 6**



*Analog I/O port for the ECU. There are eight analog input pins (labeled AinX) and four analog output pins (labeled AoutX).*

The analog I/O channels are accessible from a 3rd smaller bank of pins (Figure 6). The input pins will digitize voltages between -10 V and 10V using a 12-bit ADC. The output pins can deliver voltages between 0-10V.

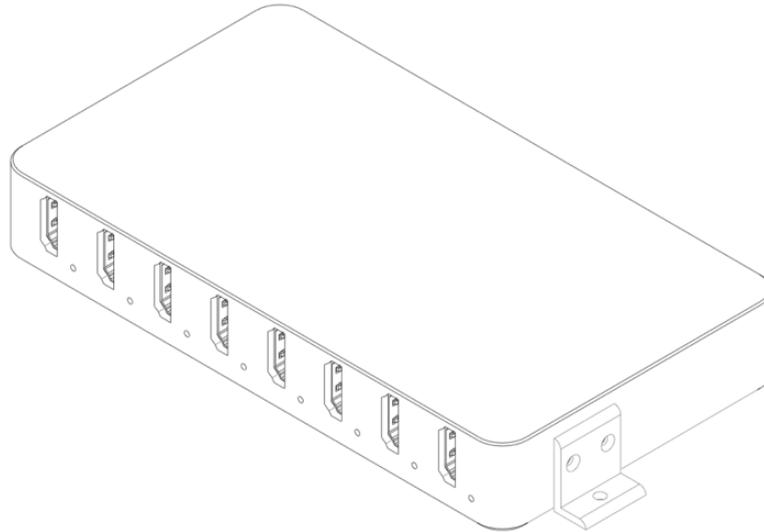
The unit must be connected to the Main Controller Unit (MCU) via the port labeled “MCU” in order to stream data alongside neural data.

Access to the stateScript environment can be achieved in one of two ways:

1. Via communication to the MCU routed to the ECU
2. Via direct communication to the ECU using the mini USB port. With direct communication, the ECU can act in standalone mode where a connection to an MCU is not required.

The StateScript environment has access to files placed on a micro SD card (inserted in the shown micro SD card slot). StateScript can play back audio files (.wav format) through the stereo 1/8” jack in the front face of the unit.

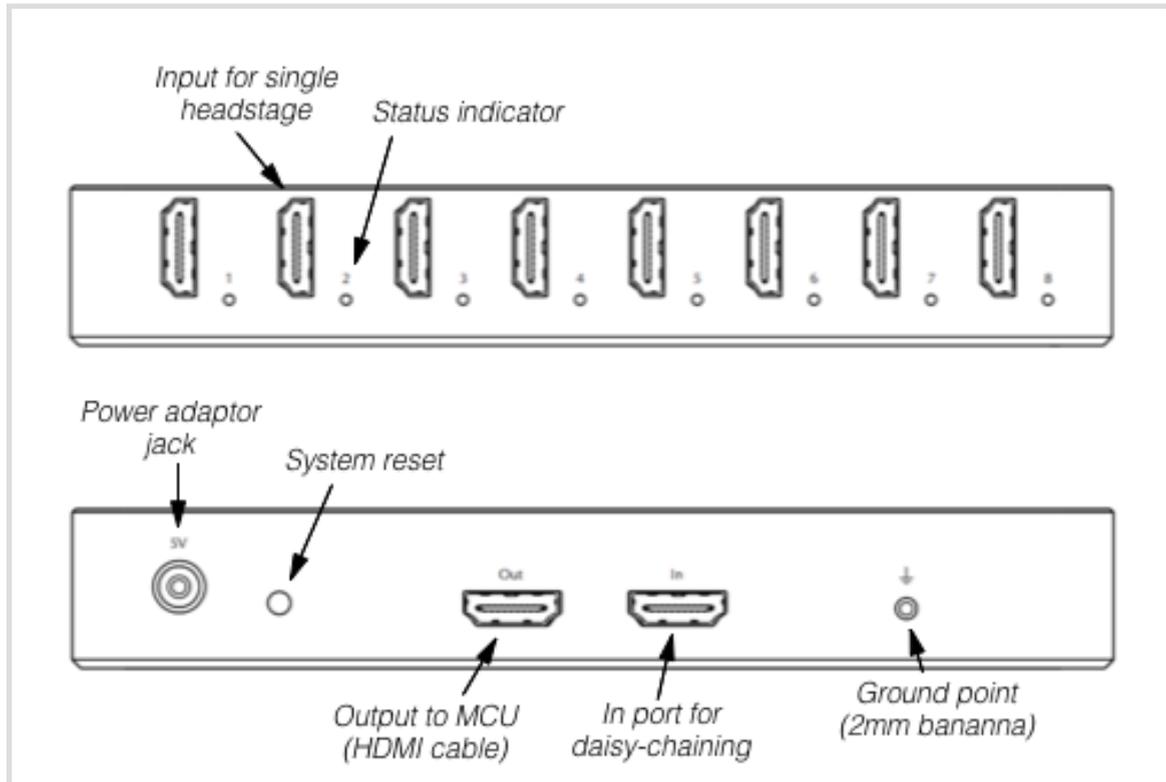
## Headstage Combiner Unit



The Headstage Combiner Unit (HCU) allows the data streams from multiple independent headstages to be combined into a single data stream. This ‘combined’ data stream is sent to the Main Control Unit (MCU) for further processing. The HCU allows up to 8 headstage streams to be combined, where the channel count for each headstage can be 32, 64, or 128 channels (1024 channel capacity). Furthermore, multiple HCU’s can be ‘daisy chained’ to allow even more headage streams to be combined.

The unit is compact, allowing it to be utilized in small spaces, and can be mounted to hardware with the included L-brackets. The brackets can be positioned in one of three orientations: forward, up, or down. When placed in the forward direction, the HCU can be mounted to the SpikeGadgets 19” rackmount plate.

**Figure 7**



*Front and back views of the HCU.*

### Controls , I/O, and indicators

On the front face of the unit, there are eight HDMI ports. Each port is used to connect to one headstage. Headstage channel counts can be either 32, 64, or 128. When a headstage is detected, an LED indicator to the right of the port will light up, color coded according to the headstage type. Green, yellow, and red corresponds to 32, 64, and 128 channels, respectively.

On the back side of the unit, there are two additional HDMI ports. These are not for headstage inputs. One is labeled “Out”. Use the included HDMI cable to connect the HCU to the MCU using this port. The “Out” port can also be used to daisy-chain multiple HCU’s. In this case, connect the “Out” port on one HCU to the

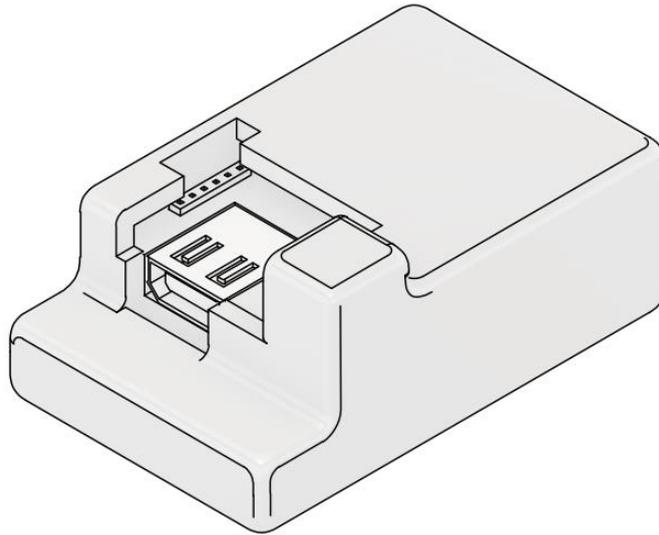
“In” port of a second HCU. The last HCU in the chain should use its “Out” port to connect to the MCU.

If any headstages are added or removed when the unit is powered on, the re-detect button may need to be pushed to recognize the new configuration. To prevent this button from being pushed accidentally, it is recessed inside the enclosure. The LED indicators on the front of the unit should be used to determine the current configuration. When the unit is first powered on, the configuration is automatically detected.

The unit is powered with the included 5V AC adaptor. Do not use other adaptors to power the system, as the wrong voltage may damage the electronics. Also, some power supplies cause unwanted noise to invade the neural recordings.

Finally, there is a grounding point on the unit, which is connected to the grounding point of the MCU. Generally, only one grounding point should be used at once to prevent ground loops.

## 128 Channel Data Logging Headstage (HH128)



The HH128 headstage amplifies and digitizes 128 neural channels and either sends data to the MCU (tethered mode) or logs it directly to a microSD card on the headstage (untethered mode). It is oriented horizontally, which means that the weight is distributed as low to the animal as possible. This headstage is intended to be left on the animal in between recording sessions, which makes daily plugging and unplugging (with micro HDMI connector) easy. It also contains an integrated 9-axis motion sensor and radio receiver for synchronization during untethered mode.

### *HH128 Specifications*

Channel count	128
Connector to electrode array/probe	Two 70-pin Hirose DF40 connectors
Sampling rate	30 kHz
Bit depth (ADC's)	16-bit
Connector to system	Micro HDMI

Input range	± 5 mV
Dimensions	35mm × 22mm (footprint); 16.5mm height
Weight	9.2 grams
Sensors	3-axis accelerometer, 3-axis gyro, 3-axis magnetometer

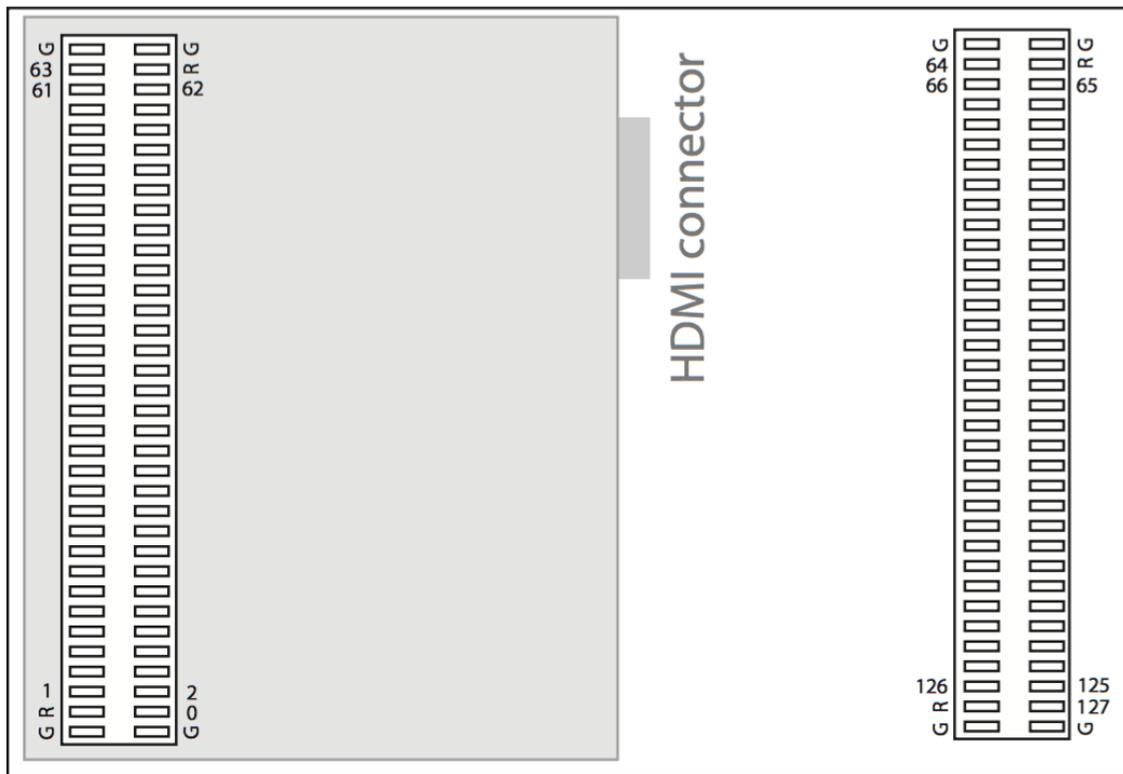
The headstage utilizes two high density connectors on the bottom face of the system (Figure 8). It is important to note that connecting and **disconnecting to an interface board should be done straight up/down**. Do not try to connect at an angle and pry the headstage off at an angle, as this may damage the connectors. To disconnect, insert a flat head screwdriver or similarly flat tool underneath the body next to one connector and turn the screwdriver to snap off the connector on one side. Then do the same thing on the other side. This procedure is best done when animals are anesthetized, so it is recommended to keep the system on the animal between recording sessions. For daily connecting/disconnecting on awake animals, we provide a hand tool to disconnect both sides simultaneously. For a demonstration of connecting/disconnecting, see the following video:

<http://www.spikegadgets.com/downloads/HS128%20With%20EIB.mp4>

The HH128 headstage is equipped with a 3-pin connector (Mill-max 1.27mm pitch) on the side. The outermost pins are route power and ground from the power source in order to connect an LED array for position tracking. The middle pin is a customizable I/O pin for peripheral device control.

The headstage is also equipped with two LED indicators on the top (visible through the case). These indicators are used to inform the user of system status (more details below).

**Figure 8**



*Hardware channel mapping of connectors on the bottom of the headstage. View is from the bottom up. Gray area showing the HDMI connector on top of headstage is shown to illustrate orientation.*

### Tethered mode

In tethered mode, an HDMI cable (with micro HDMI plug) is used to power the headstage and stream data to the MCU. Slide the cable into the kitten case until the connector is fully inserted. If the headstage is properly detected by the MCU, the MCU power indicator will turn green. Otherwise it will blink orange. Data streaming is started using the Trodes software or the record button on the MCU (in standalone mode).

Headstage settings can be modified using Trodes and will be saved onto the headstage after it is powered off and will also be applied to untethered recordings.

Settings can only be modified once a connection is made to the MCU from the computer, but not while data are actively streaming. On the HH128, the following settings are available and can be modified:

1. Auto amplifier settling. Set a signal threshold and the percentage of channels that need to simultaneously exceed this voltage threshold in order for a 'settle' command to be triggered. This is used to prevent extended amplifier ringing after large transient events occur (stimulation or physical bumping).
2. Smart Referencing (on/off). If the user intends to use digital referencing, then this setting is highly recommended. It eliminates temporal referencing error associated with the sequential nature at which channels are sampled.
3. 3-axis accelerometer (on/off)
4. 3-axis gyro (on/off)
5. 3-axis magnetometer (on/off). WARNING: this sensor can introduce significant noise onto the recording if you are using a long tether with high impedance ground. Looks for large transient pulses at about 10Hz frequency.

### [Untethered data logging](#)

The HH128 headstage utilizes a wireless link to communicate with the MCU. Start/stop commands and synchronization commands are sent through the wireless link.

#### **LED indications (untethered mode)**

- If the inserted SD card has no configuration file on it the red LED will blink slowly.
- If the inserted SD card is configured but not enabled (see above), the red LED will blink quickly.

- If the inserted SD card is enabled the yellow LED will be on solid until the headstage gets the start acquisition command from the wireless link. At that point the yellow light will turn off.
- Every time it receives a sync signal from the transceiver, the yellow LED will blink briefly (every 10 seconds).
- Once recording has begun, if a packet was not written to the SD card because the SD card was too slow, the red light will briefly flash. This is an important indicator when choosing an SD card brand to use, as some SD cards do not have adequate write speeds to support 128 channels writing at 30 kSample/sec. In general, dropping a packet once in a while is OK, but you will want to avoid cards that result in packet losses at high rates.

### **Prepare the card for recording**

We provide a set of helper programs to interface with the SD cards. Currently, these programs require a Windows operating system, and the programs are executed via the DOS command prompt. The programs can be downloaded here:

[http://www.spikegadgets.com/downloads/SDcard\\_filetransfer.zip](http://www.spikegadgets.com/downloads/SDcard_filetransfer.zip)

Download the compressed ZIP file and uncompress the folder in a desired location on your computer.

**Note:** to enable maximum write speed, the datalogger does not use a filesystem on the SD card. When you insert the card into your computer, do not allow the computer to format the card.

Open the Command Prompt as Administrator (right click on Command Prompt and choose “Run as administrator”). Then, navigate to the folder containing the SD card file transfer functions. Insert the Micro SD card into your computer (USB adaptors will usually work fine). Then, follow these steps:

1. Type “listDevices”

This program will list all the removable storage devices plugged into the machine. It may take up to a minute for your computer to see the SD card after you have plugged in into your machine. Keep running

the listDevices program until the drive is shown. When it does, it will list the card as 'PhysicalDriveN', where N depends on how many removable devices there are. Make sure you identify the correct number! This number will be referred to as 'N' below.

**Note:** if you never see the card, there may be a permissions issue. In windows, you need admin permissions to run these programs (see above).

2. WriteConfig N FILENAME

where N is defined above. **Make sure you use the correct number!**

**This is a low-level write command and choosing the wrong number can direct the writing to your hard drive.** FILENAME is the name of the configuration file for the number of channels your headstage has. For example, a 128 channel headstage uses "config128.cfg" which is included in the file transfer folder. This function is used to write a new configuration to the SD card. This configuration defines the operating parameters of the headstage when it is untethered from the computer and logging to the SD card. The config file has 32 line entries (referring to the 32 channels of each input module), where each entry is a sequence of 8 numbers (0's or 1's, referring to up to the 8 possible input modules). A line entry on row 3 of 00000011 means that the 3rd channel of input modules 1 and 2 are on. In most cases, all 32 entry lines will be the same, unless you want to ignore some channels that you do not want to log. This step is done once per card.

3. CardEnable N

This program is used to enable the SD card for recording. Once a card has been used to record data, it must be enabled again. This is to ensure that data is not overwritten before it has been extracted onto your computer.

Now you are ready to record data on the card!

### Start recording onto SD card

1. Connect the transceiver antenna into the first auxiliary connector on the front of the MCU, then power on the MCU and (optionally) the ECU.
2. Insert the SD card into the SD slot of the headstage
3. Contact a 3.7 V battery using the battery adaptor plugged into the HDMI connector
4. Start Trodes and open a workspace with no neural channels configured (like ECUonly.trodesconf).
5. Connect to the MCU and start streaming. This will send a signal to the headstage to start recording onto the SD card.
6. Open a log file in Trodes and start recording the MCU/ECU environmental data.

### Transfer SD recording to your computer

When you have finished your recording session, you will need to transfer the data on the SD card to the computer. Plug the SD card into the computer as done above. Now, type:

```
extract N
```

This will download the data from the SD card and save it in a temporary file called 'data.dat'.

### Converting SD recording to .rec file

Once you have extracted the temporary .dat file from the SD card, you will need to convert the file into a format that is used by the Trodes suite. This means that a proper header needs to be appended to the beginning of the file the contains information about the contents. There are two ways to do this:

1. If you do not need to combine the data with a simultaneous environmental recording from the MCU and ECU, then the helper program (included in the Trodes software suite) called "sdtorec" will

simply add the desired workspace info to the output file. From the command line, use the following syntax:

```
sdtorec -sd [SDRECORDING.dat] -numchan [NUMCHANNELS] -mergeconf [WORKSPACE.trodesconf]
```

2. If you need to combine the data with a simultaneous environmental recording from the MCU and ECU, then the helper program (included in the Trodes software suite) called “mergesdrecording” will merge the neural recording from the SD card with the environmental recording taken using Trodes. From the command line, use the following syntax:  

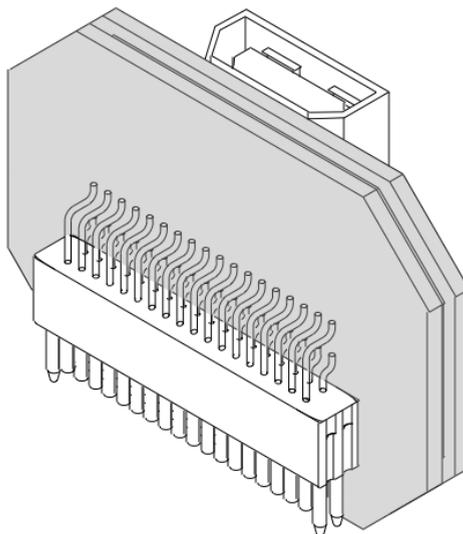
```
mergesdrecording -rec [ENVIRONMENTALRECORDING.rec] -sd [SDRECORDING] -numchan [NUMCHANNELS] -mergeconf [WORKSPACE.trodesconf]
```

Here is an example for the following setup:

- 1) 128 channel headstage with 9-axis sensor and RF sync receiver included
- 2) ECU and MCU data to merge with SD log

```
PATH/TO/TRODES/mergesdrecording -rec PATH/TO/ECU/RECORDING/myRecording.rec -sd  
PATH/TO/RECORDING/sdFile.dat -numchan 128  
-mergeconf 128_Tetrodes_ECU_Sensors.trodesconf
```

## 32 Channel Lightweight Headstage (UH322)



The 32-channel upright headstage (UH32) is our flagship small-animal headstage. It amplifies and digitizes 32 neural channels, all in a low-profile and low-weight package. Combined with our low-torque commutator, this is the perfect tool for freely-behaving mice. Like the HH128, it uses an HDMI cable to stream out data. But it does not have a processor onboard, so it requires either our commutator with built-in signal processor or our HCU to process the data stream.

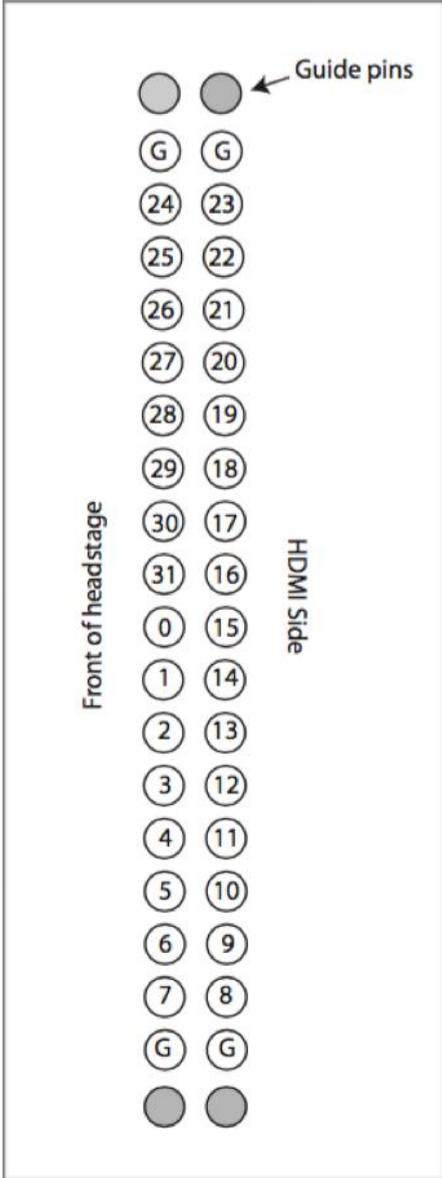
### *UH32 Specifications*

Channel count	32
Connector to electrode array/probe	Omnetics 36-pin with 4 guide pins
Sampling rate	30 kHz
Bit depth (ADC's)	16-bit
Connector to system	Micro HDMI
Input range	$\pm 5$ mV
Height	11.45mm

Weight	1.8 grams
--------	-----------

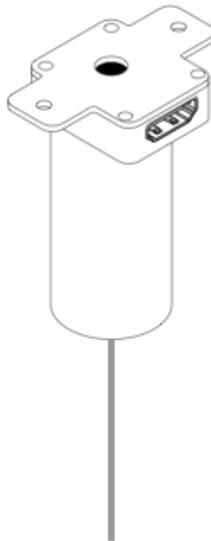
The UH32 headstage uses a 36-pin Omnetics connector to interact with electrode arrays and probes. See Figure 9 for the hardware pin mapping.

**Figure 9**



*Hardware pin mapping for the UH32 headstage. The perspective is looking up into the Omnetics connector pins from the bottom of the headstage.*

## Commutators (AC001 and PC001)



SpikeGadgets slip ring commutators come in two types. The first type is the AC001 commutator, which is specialized for mice carrying the UH32 headstage. It has low enough mechanical resistance for mice to turn it, and it has a 4mm diameter hole through the middle for a separate optical fiber, stimulation line, or drug delivery tube. It utilizes a built-in processor to convert the digital signals from the headstage to a more robust protocol before going through the slip rings. The rotating portion is equipped with two light indicators that display current connection status to the headstage. When powered by the MCU, the red light will blink if no connection to a headstage is made. Once a headstage is successfully connected and initialized, all lights turn off.

The second type of commutator is the PC001. This slip ring commutator is specialized for rats carrying the HH128 headstage or any other headstage with a processor onboard. It can be used for headstages processing up to 1024 channels of neural data. Like the AC001, it has low mechanical resistance and has a 4mm diameter hole through the middle for a separate optical fiber, stimulation line, or drug delivery tube. Unlike the AC001, it is electronically passive, and therefore has no indicator lights.

## Camera Setup

The Trodes camera module can currently accept video feed from most USB web cams. Time stamping individual frames occurs in software and may have a fair bit of jitter (depending on the speed of the camera compression, USB connection, and decompression). For more precise time stamping using hardware sync pulses, the camera module also supports Allied Vision GIGE cameras. We have tested the MAKO G 125C in many settings. With this camera, contact us for the required adaptor that connects the sync pulses from the camera to the AUX 2 input of the MCU (see Figure 1).

### Allied Vision GigE cameras

Before they can be used with Trodes, the Allied Vision GigE cameras need to be configured to send out sync pulses, to use the preferred resolution, etc. You can do this configuration on any computer running the AVT VimbaViewer software (Linux or Windows). You will probably also want to have VimbaViewer running on your rig machine as well, so that you can adjust settings as necessary (e.g. exposure, gain, etc).

Plug your PoE (power-over-ethernet)-compatible GiGe router into wall power.

Connect an ethernet cable from one of the powered ports to your camera (not all ports on the router may provide power!). Connect another ethernet cable from any port to the network port on your PC. We recommend using a different router and port for the camera than the MCU, so that the two are operating on completely different networks.

### Set the IPv4 settings for the Ethernet port to:

**Address:** 169.254.100.1

**Netmask:** 255.255.0.0

**MTU:** 9000

## **If you are having trouble**

VimbaViewer is currently used to program settings onto the Allied Vision cameras. VimbaViewer can be downloaded here: <https://www.alliedvision.com/en/products/software.html>

### **On Linux**

Follow their release notes (i.e. run their install.sh script, then log out and log back in). Run Vimba Viewer by double-clicking on Vimba Viewer program. If you get an error that no transport layers can be found, re-running the Install script, and then logging out and back in seems to help.

### **On Windows**

install the included drivers and double-click on the VimbaViewer program to start. Note: installing VimbaViewer on windows is known to conflict with pvAPI, which is used by Trodes to connect to the Allied Vision cameras. If you are using Windows, we recommend installing VimbaViewer on a different computer (not a rig machine) in order to program settings into the camera.

If your camera is detected, an icon for the camera should appear in the start window. When you right-click on the camera name, you should get the options: Open CONFIG MODE, Open READ ONLY, Open FULL ACCESS. Click on the camera (or right-click and choose "Open FULL ACCESS"). If your camera is not detected, it is possible that the IP address is blocked. Try incrementing the last digit in the address, i.e., 169.254.100.2 and so on.

Now go through and set the following settings; leave the rest at the factory default. (All settings are applied immediately, there is no need to 'save' your work):

### **Video settings**

Set the frame rate to 30fps, which seems to be the max for the Mako camera.

Acquisition

AcquisitionFrameRateAbs → 30

The following settings control exposure time (in ms, capped by frame rate), onboard gain, and manual white balance settings. Depending on your lighting conditions, tracking LED use, etc, you may want to adjust these. Manual white balance is highly recommended if you are using colored LEDs for tracking.

## Controls

Exposure

ExposureTimeAbs → 30000

GainControl

Gain → 8

Whitebalance

BalanceWhiteAuto → Off

BalanceRatioSelector → Red; BalanceRatioAbs → 1.9

BalanceRatioSelector → Blue; BalanceRatioAbs → 3.0

**Warning!** If you set the Exposure Time too high, you limit your frame rate and the camera sync will be too slow!

## Digital outputs

The (internal) strobe signal is configured to output a 1ms pulse at the start of each frame exposure. We route this signal to SyncOut1.

## IO

Strobe

StrobeDuration → 1000 (1000us = 1ms pulse)

StrobeDurationMode → Controlled

StrobeSource → Exposing

SyncOut

SyncOutSelector → Syncout1 (indicate which output we want to set up)

SyncOutSource → Strobe1

## **ImageFormat**

PixelFormat → RGB8Packed

Lastly, you need to save these settings to a 'UserSet' on the camera so that they will survive after power off. There are 3 available slots: 'UserSet1', 'UserSet2' and 'UserSet3'. The 'Default' UserSet contains the factory settings. We'll use 'UserSet1'

Set UserSetSelector to UserSet1 (this tells the camera where you want to save the config, in the next step)

Execute the UserSetSave command (click on [COMMAND], then click 'Execute' in the popup window)

Set UserSetDefaultSelector to UserSet1. This tells the camera that you want it to load UserSet1 on power up.

To test that your settings were saved, unplug and re-plug the camera, wait for it to reappear in the camera list, and make sure the changes you made above were preserved.

To make sure camera sync pulses are being recorded, open a workspace file in Trodes that displays the 8 digital in/out lines of the MCU. When you start streaming data, you should see 1ms pulses on the 8th digital input line.

Press the 'Video' button to open up the camera module. In the source menu, you should see an entry for your Allied Vision camera if it is detected. Click on it to start streaming from the camera.

## Troubleshooting

### 60 Hz noise

Often, electrical noise is due to 60Hz hum originating from AC power or equipment running on AC power. Eliminating 60Hz noise can be challenging, especially with complex setups. Here are a few things to consider:

1. AC/DC adaptors are a common source of 60 Hz noise, especially the “switching” kind. Try unplugging all AC/DC adaptors in the room to see if the noise problem is eliminated.
2. If you are using a laptop to run the Trodes software, the computer’s power adaptor may be a source of noise. Try running the computer from battery to see if the noise is eliminated.
3. Try turning off all light sources in the room, or any equipment with motors or pumps (fans, hoods, refrigerators, etc).
4. If your recording environment is small enough, enclosing the environment in copper mesh shielding will block electromagnetic noise. Make sure that the shielding is electrically coupled to building ground. Plug the same ground into the “ground” input of the Main Controller Unit. Copper mesh should be approximately 16 strands per square inch with .25mm wire. Here is link to a tested copper mesh:  
<https://www.twpinc.com/wire-mesh-material/copper/16-mesh-copper-70>
5. For head-fixed setups, a common source of noise is the metal apparatus used to restrain the animal. The apparatus needs to be properly grounded. This same ground should be plugged into the “ground” input of the MCU.

## Ground loops

Ground loops arise when there are multiple paths to ground. These loops can occur at multiple places in the setup.

1. If you are using more than one headstage simultaneously, do not use a separate ground for each headstage. All should share a single ground point (skull screw or bath).
2. When connecting the ECU or MCU to the computer via USB, make sure the computer is on the same ground as the MCU ground point input. If this is not the case, a ground loop may occur. We recommend using a USB opto-isolator to decouple from the computer's ground. Here is a link to a tested product:

<http://www.mouser.com/search/ProductDetail.aspx?R=0virtualkey0virtualkeyUSB-ISO>

## Spurious crackling in signal

Non-regular noise events can have many causes. Here are a few things to check:

1. Static discharge. If your behavioral environment is enclosed with plastic material that does not have antistatic properties, you may see random-looking noise events on the recording. Static can also build up on micro drive protective cones (if made of plastic) and on the cables. A useful tool to reduce static is antistatic spray.
2. Digital loss because of poor signal transmission. This can be caused by long or unshielded cables. Try trading out the cables along the path from the animal to the MCU to eliminate the problem.
3. Flakey commutator. If noise events occur when the commutator is rotating, then slip rings may need adjustment. Please contact us for assistance.

### Magnetometer noise

Some of our headstages are equipped with motion sensors, such as the HH128. One of these sensors, the 3-axis magnetometer, emits magnetic pulses approximately 10 times/sec. These pulses can add noise to the recording if there is high impedance to ground. A long cable going to the MCU with thin internal gauge wires may cause this condition. For long cables, we recommend using a separate, large diameter wire alongside the HDMI cable to provide a low-impedance ground.