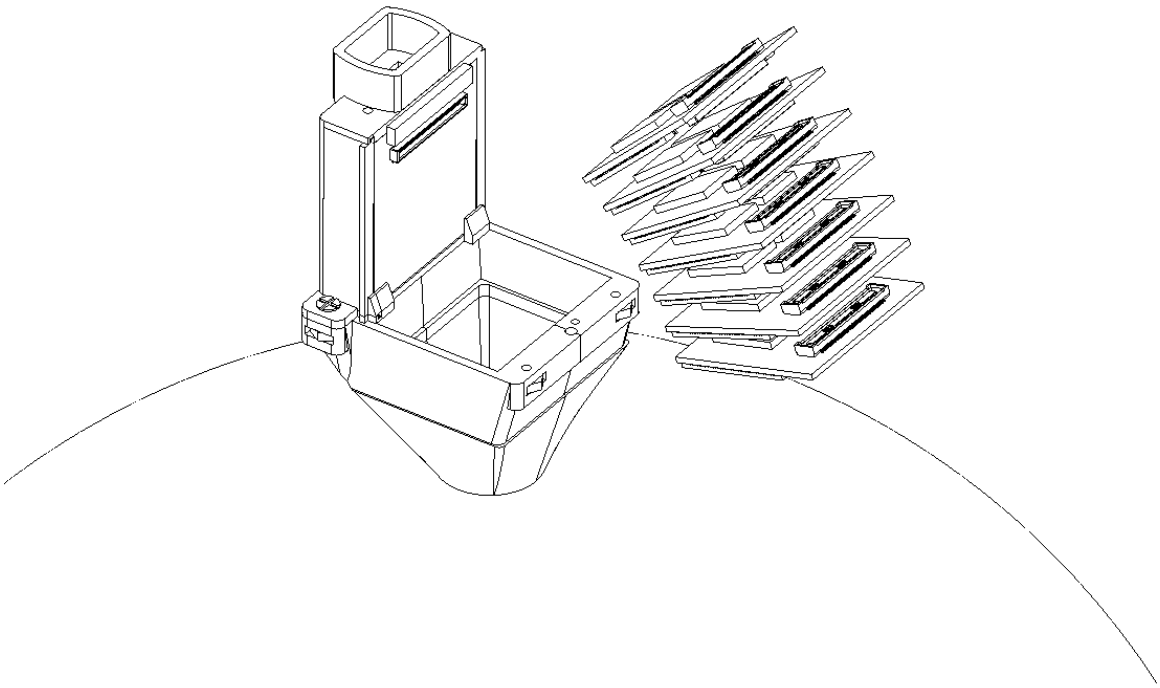
SpikeGadgets

Modular Stacking Headstage Manual



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Modular Stacking Headstage

System description

The modular stacking headstage (MSH) is a scalable, compact head-mounted electrophysiology system in which multiple recording modules can be combined in a modular fashion in increments of 128 to reach the desired number of channels. The MSH supports two acquisition modes: 1) standard computer-linked acquisition (via cable) for live access to the data, or 2) untethered data logging (via a battery) onto a removable SD card. In the untethered mode, data alignment to recorded environmental events is accomplished by aligning the times when a common radio signal was recorded by the separate systems. Because the system uses high-density connectors that are not robust enough for daily connecting/disconnecting, the system is designed to stay on the animal for the duration of the implant.

Specifications

Channel count	Scalable from 128 to 1024
Intended experimental applications	Freely moving, untethered data logging
Connector to electrode array/probe	Two Hirose FH43B-71S-0.25HW(99) connectors.
Sampling rate	30 and 20 kHz supported
Bit depth (ADC's)	16-bit and 12-bit supported
Input referred noise	2.8 µV RMS
Connector to MCU	Micro HDMI
Input range	± 5 mV
Dimensions	varies
Weight	varies
Battery life	varies
Sensors	3-axis accelerometer, 3-axis gyro
Radio synchronization range (during data logging)	10-20 meters

Hardware

The system utilizes an integrated field-programmable gate array (FPGA) to turn the headstage into a miniature programmable computer. This strategy provides many benefits for next-generation devices. Scalability and modularity are achieved by using the FPGA processor to flexibly communicate with a variable number (up to 8) of 128-channel recording modules. We use the integrated FPGA to control multiple chips and combine their outputs into one high-speed digital stream. This allows streaming of up to 1024 channels though a compact cable or logging the data directly to an SD card to avoid tethers altogether (up to 512 due to write speed restrictions on the SD cards).

Each 128-channel module utilizes two Intan Technologies' RHD2164 chips to record neural signals with lower than 1 μV resolution, up to 30 kHz sampling rate, and 2.4-2.8 µV RMS typical input-referred noise. The modules are daisy-chained in the stack where each module claims a subset of the available digital communication lines to/from the FPGA and passes the rest along to the next module in the stack.

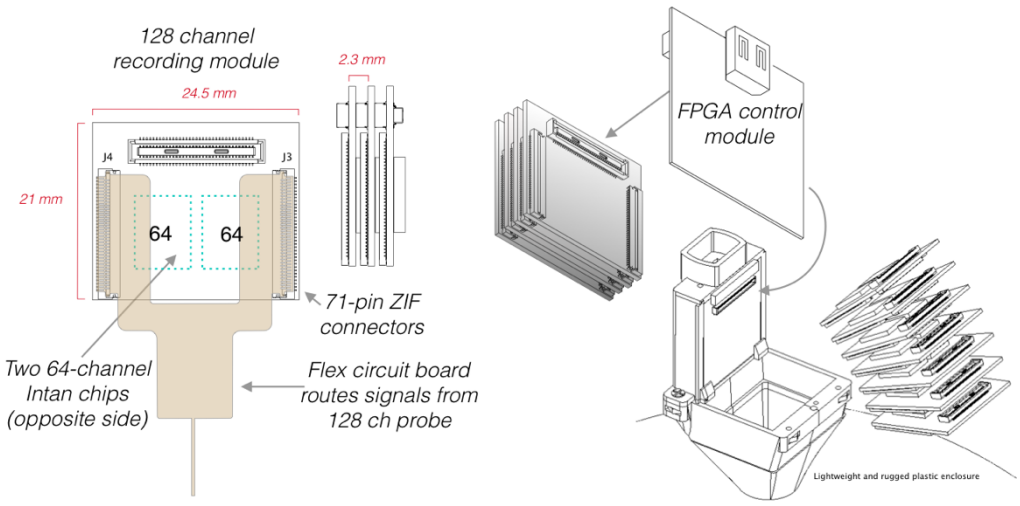

Figure 1- 128-channel module diagrams

The MSH is intended to be used in conjunction with high density silicone/polymer probes or ECog arrays to record from many sites in the brain. It enables high density stacking of multiple 128-channel recording modules. The 128-channel module uses two high density 71-pin zero-insertion force (ZIF) connectors to connect to the probe. The probe interface to these connectors is a flexible printed circuit board (single-sided FPC) with the illustrated dimensions below. For more detailed information about the FPC requirements, see the Hirose datasheet for the FH43B series connector.

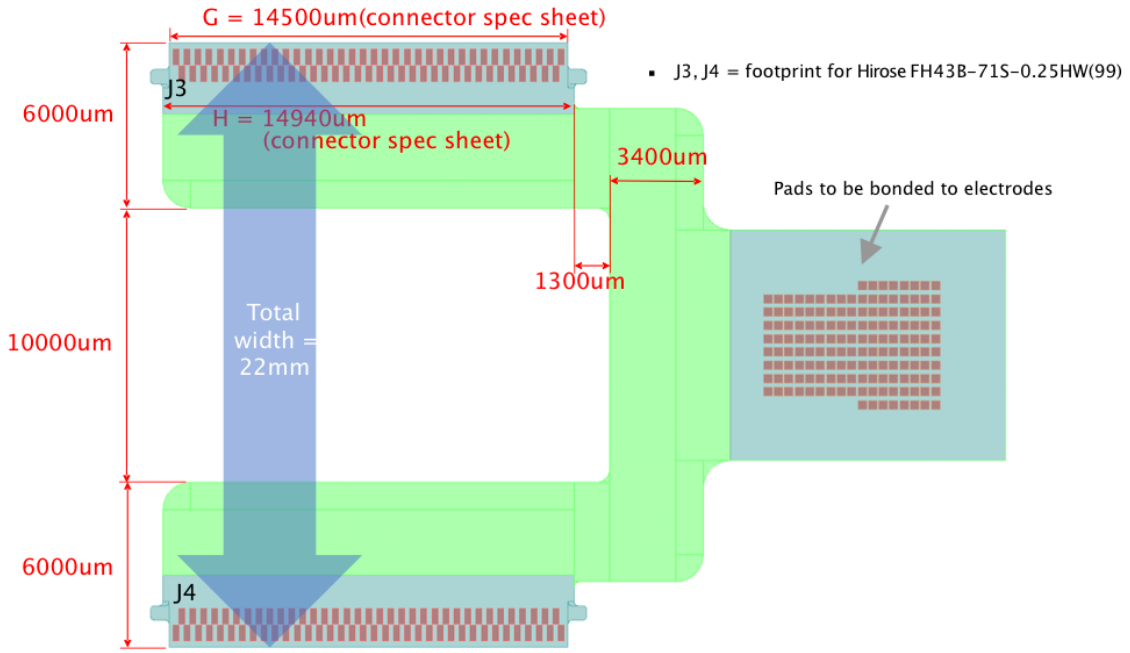

Figure 2- Flexible PCB routing the channels between the probe and the 128-channel modules

The FH43B connector pins route the channels in a specific pattern that dictates each channel's assigned hardware address, starting at 0:

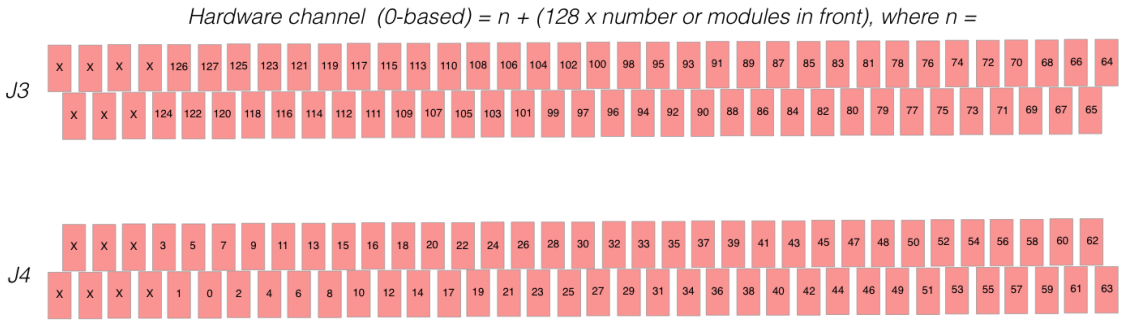

Figure 3- MSH channel map to hardware

Grounding/Referencing

A common reference line is attached to a single point on the system, which serves as the reference for all channels. This reference is tied to system ground by default. No grounding or referencing is performed using any pins on the FH43B connectors to the probes; rather a separate wire is used to connect the reference point to the final termination board in the stack.

Tethered recording

In tethered mode, an HDMI type A to type D plug is used to power the headstage and stream data to the MCU. Signals can be routed through SpikeGadgets commutator to prevent cable twisting. To connect, slide the HDMI cable into the headstage case opening 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 initiated using controls within the Trodes software.

Untethered data logging

For untethered recordings, power (3.7 – 5V) must be supplied through the HDMI connector on the system using the SpikeGadgets power adaptor. Typically, a 3.7V rechargeable lithium battery is used. Also, a microSD card that has been formatted using the SpikeGadgets Logger Dock must be inserted into the SD card slot of the headstage. Once power is supplied, a set of possible LED indication patterns on the headstage signify system state:

LED indications (untethered mode)

Light Color	Pulse	Meaning
Red and yellow	Blink	Headstage powered on
Red	Fast blink (4 Hz)	SD card is configured but not enabled
	Slow	No configuration on the SD card
	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.
	Solid	No Intan chips detected OR a gap in the stack is detected (i.e. a bad board)
Yellow	Fast blink (4 Hz)	SD card is being erased after power on.
	Slow breathing	Standby. System is ready to record and is awaiting start command via radio.
	Slow breathing transitions to four blinks (2 Hz)	Recording has started after start command is received
	Blink (every 1 second) after recording has begun.	Sync signal from the transceiver received.

When the headstage enters Standby mode after initialization, a radio-based start signal must be emitted either from the SpikeGadgets Main Control Unit (MCU) or the Logger Dock. This signal is emitted when acquisition is started using the Trodes Software commands. Trodes is used to record the environmental signals—Digital (on/off) events, analog signals, video, etc.—which are aligned and merged with the neural data during postprocessing.

Configuration

Headstage settings can be modified using Trodes when the headstage is in tethered mode and connected to the MCU. Settings are saved onto the headstage, making them persistent after power shut off, and are applied to subsequent tethered and untethered recordings. Settings can only be modified once a connection is made to the MCU from the computer, but not while data is actively streaming. On the headstage, the following settings are available and can be modified:

- **Auto amplifier settle after large artifacts** 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).
- **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-axis accelerometer** (on/off)- data logging version only
- **3-axis gyro** (on/off)- data logging version only
- **Sampling rate (20 kHz or 30 kHz)**
- **Sample bit depth (12-bit or 16-bit)**
- **Radio channel for synchronization**- data logging version only
- **Synchronization mode**

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.