



miniLogger 32 headstage(ML32)



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MiniLogger 32



Introduction

The miniLogger 32 (ML32) is a miniaturized electrophysiology system designed for freely-moving recording experiments using mice and larger animals. The ML32 amplifies and digitizes 32 channels of neural data and either logs the data to an onboard microSD card in untethered mode or streams the data to the Main Control Unit (MCU), where it can be viewed in real-time on a local computer in tethered mode.

When recording in untethered mode, the ML32 functions under battery power and is controlled via radio frequency (RF) transmission from the MCU or Logger Dock. These RF signals are used to start and stop recording sessions as well as synchronize the neural data with environmental event data acquired to the local computer via the Control Unit. A single RF channel can also be used across many devices. This makes the ML32 ideal for high-throughput synchronized recording from multiple subjects, where a single RF signal can be used to initiate and end recording on many devices simultaneously.

The ML32 is divided into 2 components: 1) The ML32 processor top, which houses the battery, processor, and microSD storage, and 2) the ML32 base, which contains the Intan chip that amplifies and digitizes neural data.

The ML32 can be connected to the animal as a single unit, or the base alone can be installed. The processor top can be connected and disconnected from the base making it possible to install ML32 bases for long-term use on multiple animals, sharing one processor top between them. This also enables swapping between multiple processor tops on a single animal for longer sessions comprised of multiple back-to-back recordings.

This 2-component design also allows the ML32 base to be used for tethered recording, where the base is connected to an external processor such as the Headstage Combiner Unit (HCU) or Headstage Signal Converter (HSC) using a tether adaptor and ultraflexible HDMI cable. In this configuration the neural data is live-streamed via the MCU to the local computer using the Trodes application.

ML32 Specifications

Channel Count	32 channels
Connector from base to processor top	40-pin Hirose mezzanine connector
Connector from base to array	36-pin Omnetics with 4 guide posts
Sampling Rate	30 and 20kHz supported
Bit Depth	12-bit and 16-bit supported
Weight	7.2g
Sensors	3-axis accelerometer, 3-axis gyro
Radio synchronization range	~15 feet
Recording time	~70 minutes*

*Recording time is dictated by battery health, which slowly changes with use over time. This results in an expected but modest decrease in recording time.

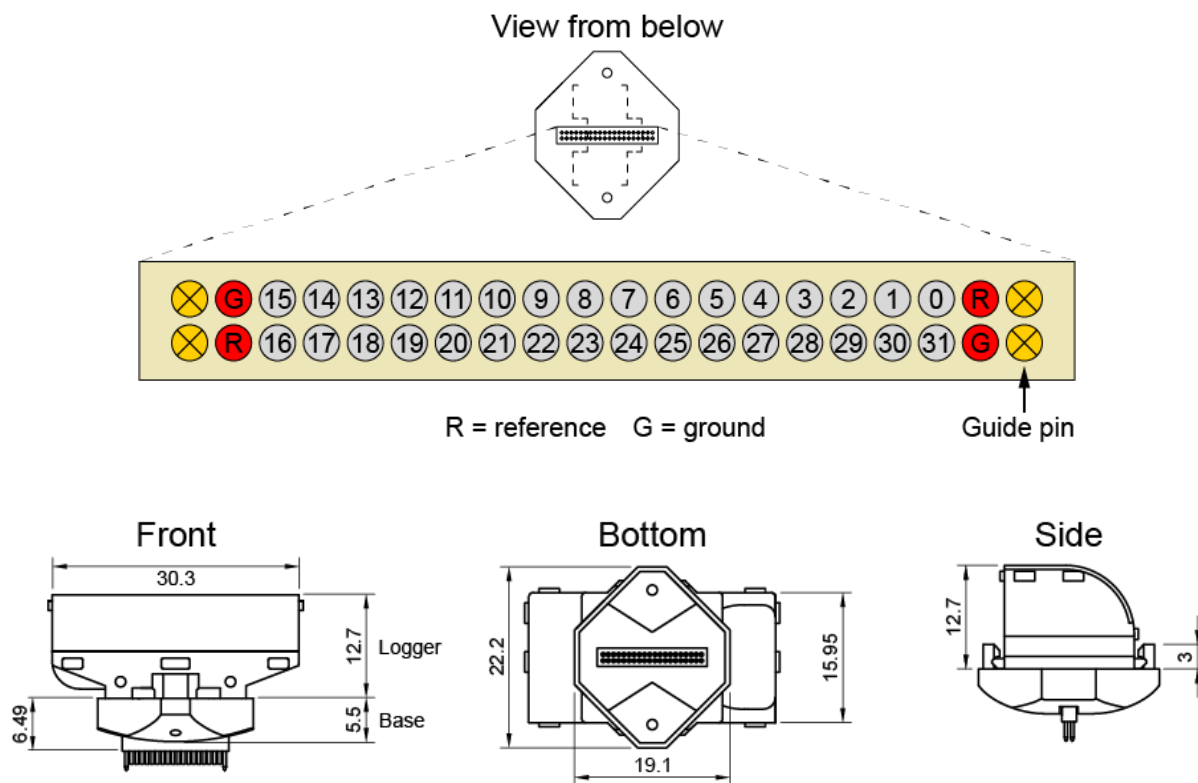


Figure 1 | ML32 headstage Omnetics connector pinout and dimensions (in millimeters). The processor top (Logger) and base are shown connected.

The Logger Dock

Introduction

The [Logger Dock](#) is a Control Unit, similar to the MCU, designed specifically to support data logging experiments using SpikeGadgets headstages, and is required for untethered recording with the ML32. The Logger Dock is used for battery charging and data extraction when using the ML32 and can also function as the Control Unit for untethered data logging experiments via RF control of the headstage. The ML32 connects to the Logger Dock via the docking cradle, which will be discussed in more detail under [Docking and Charging](#) below.



Logger Dock Primary Functions

Acquisition & Control: The Logger Dock is used in conjunction with Trodes to wirelessly start and stop untethered recording experiments and is also capable of recording environmental events via the Dock's 4 SPI inputs (3 digital and 1 analog).

Data Transfer: In addition to transferring ML32 data directly from the headstage to the local computer via the docking cradle, the Logger Dock is also equipped with a micro-SD slot for transferring data recorded using SpikeGadgets headstages with removable onboard storage ([HH128](#), [MSH](#), [NPH](#), etc.). In both cases, the Dock works in conjunction with the DataLoggerGUI application packaged with Trodes for extracting and merging data. More information about extracting and merging data using the DataLoggerGUI can be found [here](#).

Battery Charging: The ML32 processor top automatically begins charging when connected to the Logger Dock via the docking cradle, allowing the battery to begin charging while extracting and/or merging data.

Logger Dock Specifications

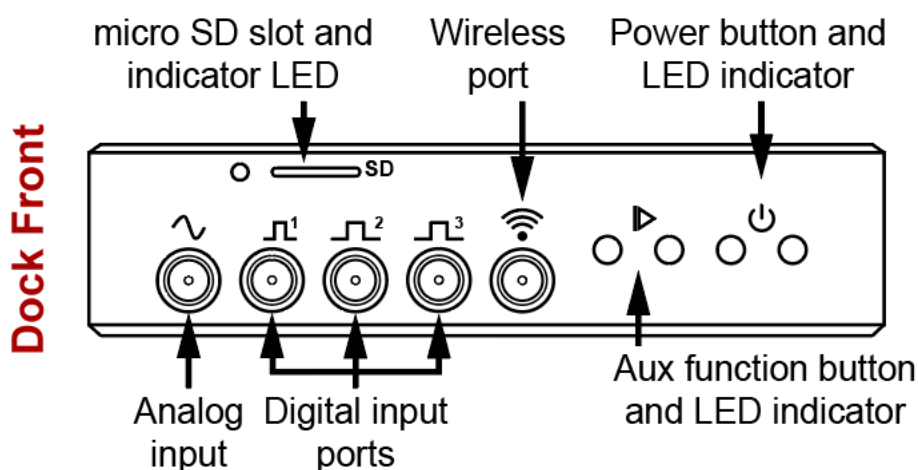
Dimensions	97 x 80 x 25 mm
Connection to computer	USB
Event input connection	SPI
Input Type	3 Digital, 1 Analog
Data upload speed	25 MBps
Power	5V linear connector

Control and Indicators

Power Button and LED Indicator: The rightmost button powers the Logger Dock on and off. Simply push the button to power the system on. Press and hold to power the system down.

Analog and Digital Inputs: The Logger Dock is equipped with 4 SPI inputs for acquiring signals from external devices to be synchronized with the recorded neural data (1 analog input, 3 digital inputs).

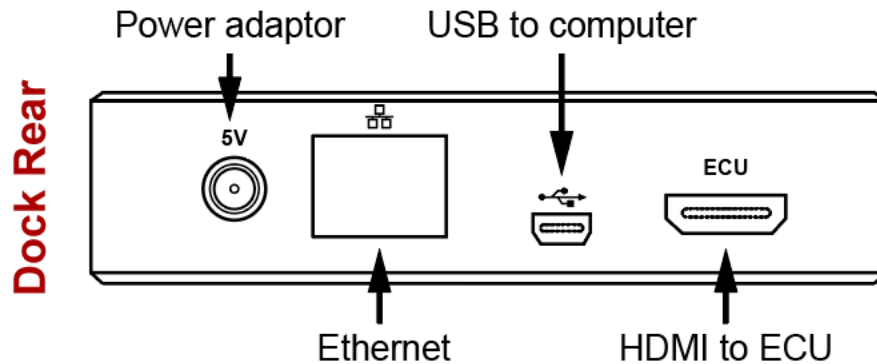
Analog input: 0-5V, 12-bit; **Digital input:** 0-5V (low = 0-1.5V; high = 3.5-5V).



Micro SD Slot and LED Indicator: The micro-SD card slot is used to enable SD cards for untethered recording experiments as well as import recorded data to the local computer. This is done using the [Data Logger GUI](#) application packaged with Trodes.

Wireless Port: The antenna included with the Logger Dock connects to the wireless port and transmits start and stop commands for untethered recording experiments. The antenna is needed to ensure maximum wireless range and should always be used when the dock is controlling data logger headstages operating in untethered mode.

Auxiliary Function Button: By default, the auxiliary function button is disabled, but can be reprogrammed to support custom applications using custom firmware. For more information about this, please contact support@SpikeGadgets.com.



Power Adaptor: The 5V jack for powering the Logger Dock. **Note:** The Logger Dock should only be powered using the 5V power supply provided with the unit. Other power supplies can damage the unit or produce unwanted electrical noise during recording.

Ethernet: The Logger Dock ethernet port of deactivated by default but retained for future applications.

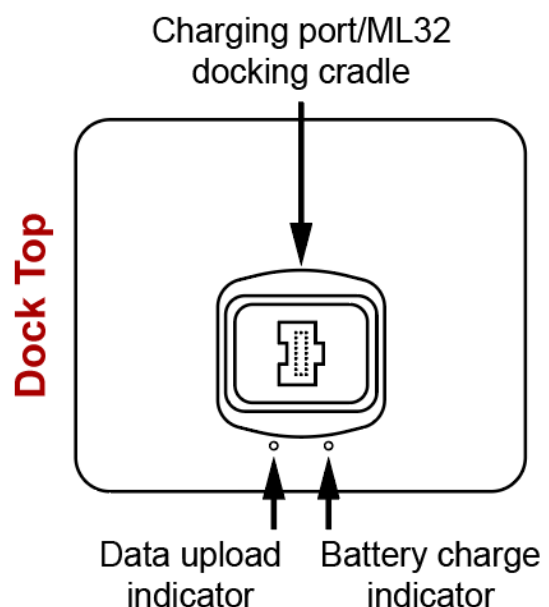
USB (to computer): The Logger Dock connects to the local computer via the mini USB 2.0 port. Once connected, the dock can be used to control untethered recording experiments via Trodes, and import untethered data recorded to SD via the Data Logger GUI.

HDMI (to ECU): The Logger Dock can be connected to a SpikeGadgets ECU via HDMI. This allows additional I/O channels to be used for untethered recording experiments controlled by the dock.

Docking and Charging

The Logger Dock supports untethered data logging experiments and is available with 2 different hardware configurations depending on the headstage(s) being used.

MiniLogger32 docking cradle: When using the MiniLogger32 (ML32), the Logger Dock is configured with a docking cradle for charging, data import and headstage control. Data recorded to the ML32 is imported using the DataLoggerGUI and can be merged with the environmental record recorded by Trodes.



When docked, the ML32 begin charging, and headstage settings can be changed via Trodes or the DataLoggerGUI.

Charge port (not shown): The charge port variant of the Logger Dock is used for charging batteries used to power headstages other than the ML32. When using a dock in this configuration, the front-facing micro SD slot is used to import untethered data recorded by the data-logging headstages listed above.

NOTE: Dock configuration is set during manufacture and is not readily changeable by the end-user. This is because internal hardware modifications are needed when changing docking configuration. Please contact support@SpikeGadgets.com for more information if your dock requires a change in configuration.

Data Upload Indicator: When docking the ML32, the data upload indicator turns blue to indicate the SD card is mounted. When exporting data, the indicator turns green.

Battery Charge Indicator: The battery charge indicator provides an easy readout of charge status. Red indicates the battery is charging; green indicates the battery is fully charged.

Logger Dock LED Indications

Indicator	Location	LED Pulse/Color	Meaning
Power	Front	Solid Green	Dock is powered on
Aux function	Front	Solid Red	Start command received from Trodes; Recording active
Battery	Top	Solid Red	Battery is charging
		Solid Green	Battery is fully charged
SD/Data Upload	Top/Front	Solid Blue	Mounted micro-SD card is detected/idle
		Flashing Green	SD data uploading to computer
		Flashing Red	Headstage/micro-SD card mounting/reading error (try unplugging and replugging)

Tethered Recording Using the ML32

Configuring the ML32 for Tethered Recording

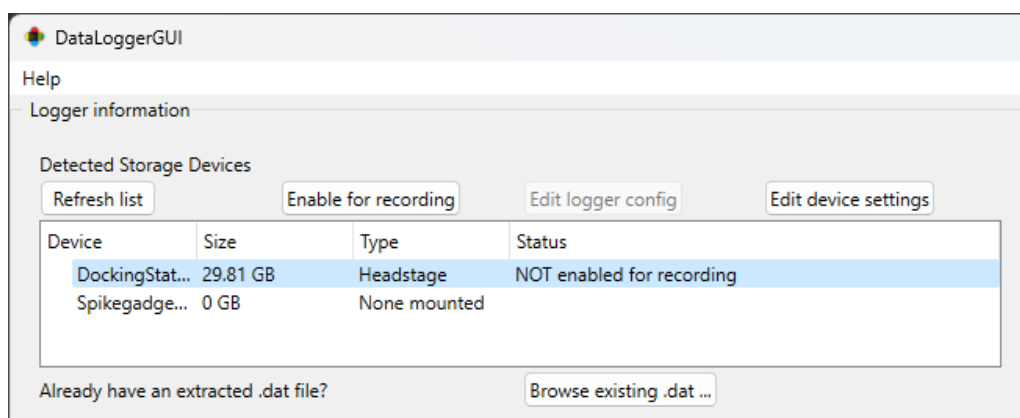
When using the ML32 for tethered recording, the ML32 Processor top is not used. Instead, the ML32 base is simply connected using the HDMI tether adaptor, which connects to the SpikeGadgets [Headstage Combiner Unit \(HCU\)](#) or [Headstage Signal Convertor \(HSC\)](#). In this configuration the HCU or HSC functions as the processor unit, which is then connected directly to the MCU via HDMI. This configuration can also be used with the SpikeGadgets General Purpose Commutator.

For more information about setting up tethered recordings using Trodes, please see the [Trodes Wiki Quickstart Guide](#).

Untethered Recording Using the ML32

Configuring the ML32 for Recording

1. Power on the Logger Dock and connect the ML32 via the docking cradle.
2. Open the DataLoggerGUI application found in the Trodes installation directory.
3. The Logger Dock and any other USB connected Control Unit such as an MCU will be listed under the Detected Storage Devices menu. If the connected devices are not listed, clicking 'Refresh List' will scan for recognized devices.



4. Select the Docking Station to highlight the device being prepared for recording.
5. Before the ML32 logger configuration can be edited, the headstage must be enabled for recording by clicking the 'Enable for recording' button while the headstage is selected. The SD card should ONLY be enabled once recorded data has been extracted. Enabling the SD card will allow the data to be overwritten.

NOTE: The headstage must be enabled for recording between each recording session. This helps ensure that recorded data is not accidentally overwritten before it has been extracted.

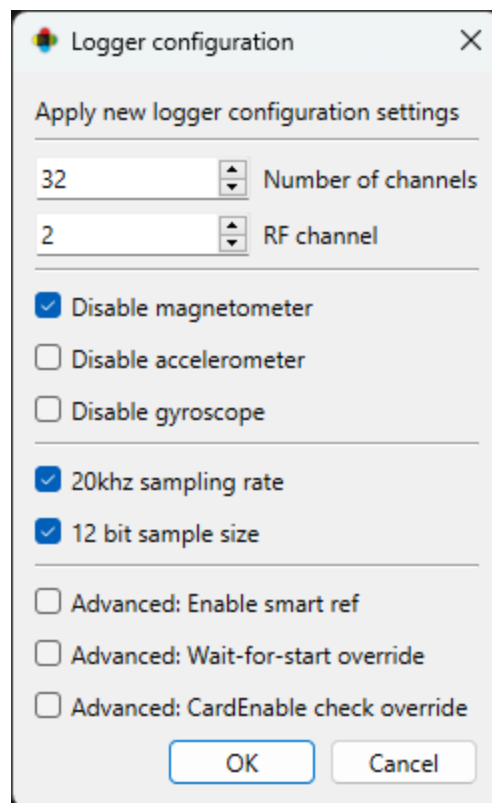
6. Once the headstage has been enabled, the headstage is configured using the Edit logger config popup menu.

By default, the radio frequency (RF) channel used to control the headstage is set to 2. This must match between the headstage and control unit. The magnetometer is disabled by default, as the ML32 is not equipped with a magnetometer.

Enabling Smart Referencing is strongly recommended when using digital reference. Smart Ref corrects the very small (microsecond scale) sequence sampling error inherent to the functioning of the Intan digitizer/amplifier used to acquire data.

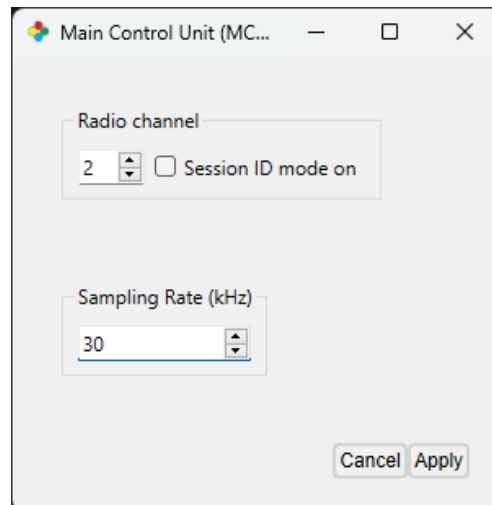
Enabling Wait-for-start override causes the headstage to automatically begin recording when the processor top and headstage base are connected rather than waiting for a start command from the Control Unit. The headstage will still record RF sync signals from the control unit once streaming is initiated, but to avoid recording start-time confusion it is recommended that this feature be used in situations where merging neural data with an environmental record is not needed.

CardEnable check override allows a recording to be initiated without first enabling the headstage for recording. **WARNING: this feature should be used for testing purposes ONLY!** Initiating a new recording without first extracting the previously recorded data WILL result in the previously recorded data being overwritten.



7. The Control Unit and Trodes Workspace RF channel and Sampling rate settings must match the headstage settings for proper headstage control and post-experiment merging of data.

- When using the Logger Dock for experimental control, dock settings are configured using the 'Edit device settings' popup menu. RF mode should be set to 1 when using the ML32.
- When using the MCU for experimental control, the MCU settings are configured using Trodes under the Settings dropdown menu shown right (Settings > MCU Settings...). The RF Session ID mode checkbox should be unchecked.



8. Once Headstage settings have been configured, the ML32 can be undocked and connected to the logger base. Connecting the base and top which will power on the ML32.

ML32 LED indications

Color	Pulse	Meaning
Red	4Hz Blinking	SD card not enabled
	1Hz Blinking	SD error
	Solid	No Intan chip recognized
	Blip during recording	Dropped packet(s)
	Breathing (when docked)	Processor top connected to Dock
	Breathing (untethered)	SD card full
Blue	3 blinks	Recording Start pulse received
	4Hz Blinking	SD card mounting
	Breathing	Ready to record; waiting for RF start command from MCU
	blip every 10 seconds (when recording)	RF sync pulse received

Initiating Untethered Recording

1. Connect your [RF transceiver](#) to the control unit.
 - **MCU:** Connect the transceiver to the Aux 1 port on the front of the MCU using HDMI.
 - **Logger Dock:** Connect the transceiver using the wireless SPI port on the front of the Logger Dock.
2. Connect the ML32 logger top to the base and connect the headstage to the implanted array.
2. Open Trodes and create a new Workspace with channel count set to zero. This Workspace will be used to acquire the environmental record. For more information about workspace creation, please visit the [Trodes Wiki](#).
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 and connect to your control unit via the "Connections" Dropdown menu.
 - When using the MCU, make sure the MCU RF channel and sampling rate match the settings you previously applied to your headstage. Session ID mode should be turned off (unchecked). This is done under the "Settings" dropdown menu shown on the previous page.
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 in Trodes, 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.
8. To end your recording, hit the pause button and disconnect your stream.

IMPORTANT NOTE: When recording untethered, the headstage starts recording when you begin streaming with the control unit, but Trodes will **NOT** start recording until you create a new recording file and hit the record button. 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.

Merging with Environmental 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 storage.
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 the headstage channel count setting as if the recording were taken in tethered mode. One easy way to create this file is to edit the workspace file used for acquiring environmental data; simply set the channel count to 32 rather than 0.

Merging Data with the DataLoggerGUI:

1. Disconnect the ML32 logger top from the logger base, and dock the headstage on 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. You should see your headstage onboard storage listed here. Click to highlight this data source.
4. Under Extract, select your environmental .rec file and corresponding Workspace .trodesconf file, and set your extracted data directory.
5. Hit START.

NOTE: If you would like to extract the data without merging with environmental data, simply uncheck “merge logger data with environmental data” in the DataLoggerGUI interface.

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

Additional Resources

For information about getting started with your SpikeGadgets recording system, please visit the [Trodes Wiki](#), which contains additional information and resources covering many basic and advanced topics about using SpikeGadgets recording systems. For new users, a good place to start is the [Quickstart Guide](#).

Additional information and [documentation](#) about all our [products](#) and [software](#) can be found on our [website](#).

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.