Introduction

Congratulations on your purchase of X-Series products.

XDAQ systems from NeuroNexus provides the most input-output flexibility in a data acquisition system. XDAQ One and Core are capable of recording up to 1024 and 512 channels of neural and biological signals, respectively. Supported by Radiens software to feel confident in up to 1024 channels by viewing highly interactive probe-centric user interface and real-time signal metrics.

This “Quick Start Guide” is intended to provide a brief overview of the X-Series products and some of its basic functions.

IMPORTANT: Please check the NeuroNexus website at "https://www.neuronexus.com/products/xdaq-one/" and "https://www.neuronexus.com/products/xdaq-core/" for new updates about X-Series XDAQs.

Note: In order to ensure you have the latest version of the applications, please visit our downloads page at the link below.

https://www.neuronexus.com/radiens-allego-download-page/

For questions regarding operation of the system or if you have any issues with the , please email us at support@NeuroNexus.com. You can also call us at +1.734.913.8858.

What's in the Box

- X-Series unit
- AC Power Adapter for XDAQ One
- 5 V DC Adapter for XDAQ Core
- USB C interface cable
- Selected XR or XSR headstage amplifier(s) and headstage interface cable(s) that are specified in the order. For more information about our headstages please visit our website at "https://www.neuronexus.com/products/x-headstage/"

System Requirements

The computer system requirements include:

- Storage: SSD. Traditional magnetic hard disks may not be fast enough in some recording configurations
- USB 3.0
- CPU - Intel i7-6700k 4-core or equivalent
- 16GB RAM minimum

System Overview: X-Series One

Front Panel

Status LEDs

 SYS	Indicates whether the system has been detected by acquisition software.
 S1	When on, acquisition is on
 S2	When flashing, activity is being detected on DIN1/DIN2
 S3	When flashing, activity is being detected on DOUT1/DOUT2
 STIM	Shows stimulation pulse activity. System is in X3SR mode
 V1	Indicates VStim level is set to +/- 7 V
 V2	Indicates VStim level is set to +10/-4 V
 V3	Indicates VStim level is set to +4/-10 V
 Rec & Stim Headstages	Recording and Stimulating Headstages being used are connected here.
 GPIOs	Two I/Os each for Analog In, Analog Out, Digital In, Digital Out.

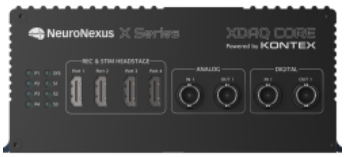
Back Panel

 Power Switch	Turns the system on or off when using an IEC 3-prong AC power cord.
 ESD Dip Switches	These switches control how electrostatic discharge is handled for SYS (recording system), P2-4 (headstage ports 2-4), and P1 (headstage port 1). Switch 1 circuit consists of a 1 nF capacitor to ground, and the switch 2 circuit is a 1nF capacitor in parallel with a 1 MΩ to ground. It is recommended to start with circuit 1 on only.
 GND	Isolated binding posts for grounding multiple components of the system.
 USB-PD	USB power delivery - A USB-C charger may be used to power the system instead of the standard IEC 3-prong AC power cord (20 VDC, 3.25 A minimum output).

 EXP1/2	XDAQ Expander units may be connected to these ports in order to provide additional GPIO connections.
 Audio Out	3.5 mm stereo jack to connect an audio device to hear signal activity.
 USB Data	Computer interface connection
 IO Port	DB25 interface for the XDAQ DB25 BNC Breakout Board for additional GPIO connections.

System Overview: X-Series Core

Front Panel



Status LEDs

	P1	Indicates whether a headstage is detected on the corresponding port.
	P2	Indicates whether a headstage is detected on the corresponding port.
	P3	Indicates whether a headstage is detected on the corresponding port.
	P4	Indicates whether a headstage is detected on the corresponding port.
	SYS	Indicates whether the system has been detected by acquisition software.
	S1	When on, acquisition is on
	S2	When flashing, activity is being detected on DIN1/DIN2
	S3	When flashing, activity is being detected on DOUT1/DOUT2
	Rec & Stim Headstages	Recording and Stimulating Headstages being used are connected here.
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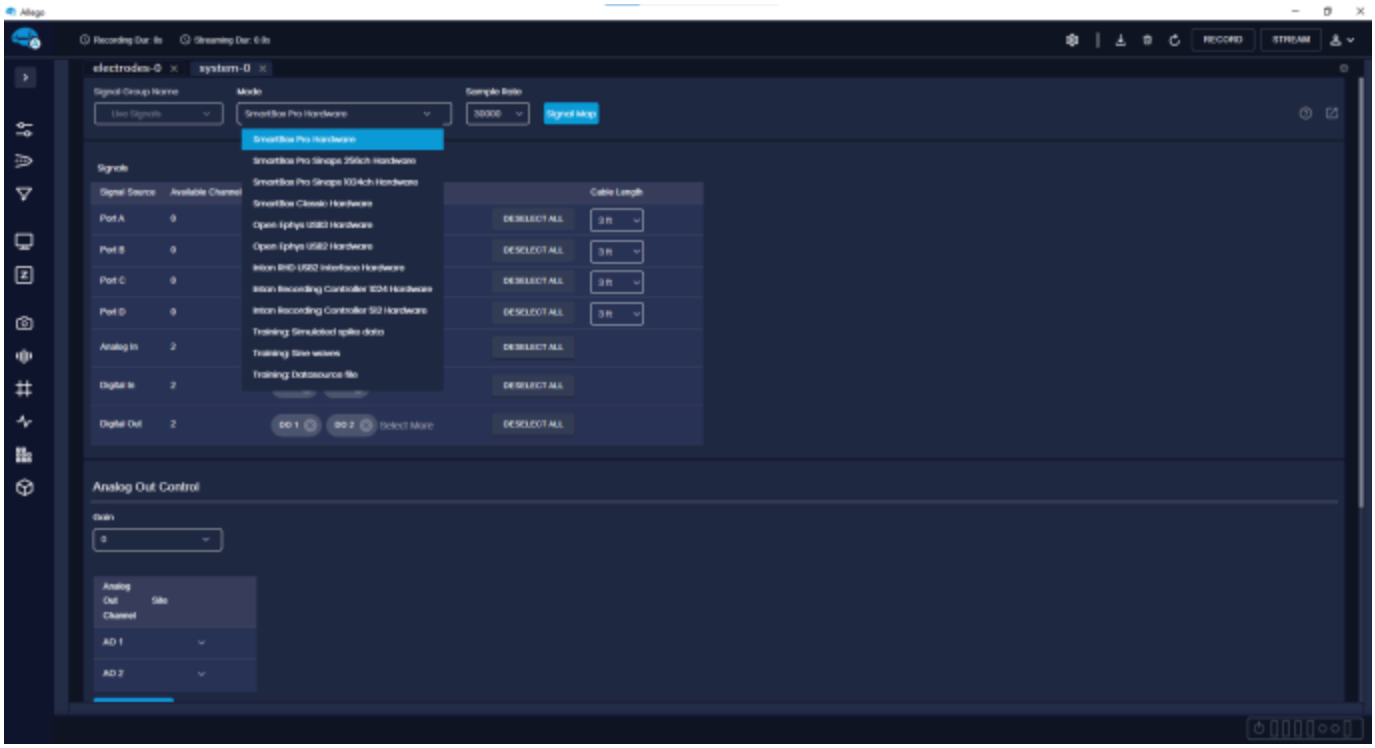
Back Panel

	USB-PD	USB power delivery - A USB-C charger may be used to power the system instead of the standard IEC 3-prong AC power cord (20 VDC, 3.25 A minimum output).
	EXP1/2	XDAQ Expander units may be connected to these ports in order to provide additional GPIO connections.
	Audio Out	3.5 mm stereo jack to connect an audio device to hear signal activity.
	USB Data	Computer interface connection
	IO Port	DB25 interface for the XDAQ DB25 BNC Breakout Board for additional GPIO connections.

Checking Hardware Connection

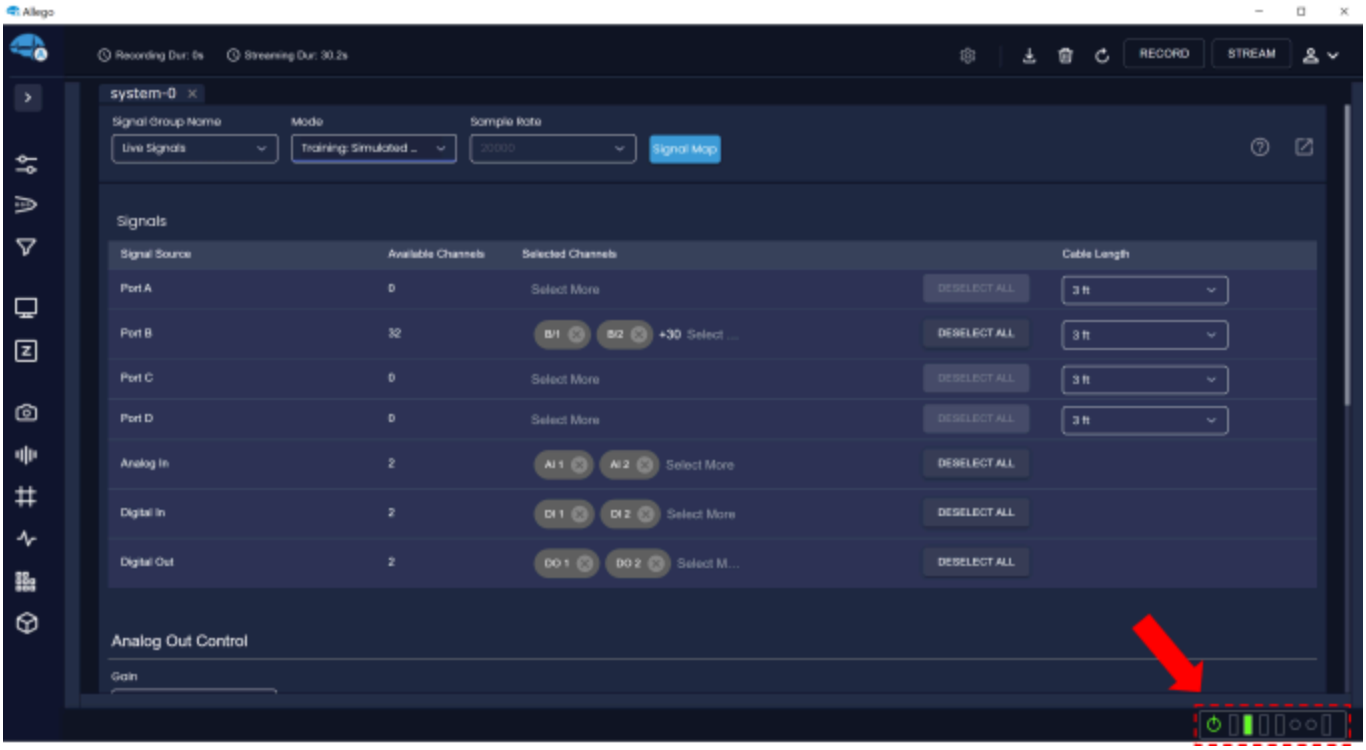
Navigate to the Dashboard and hit the System button. In the System tab, select connected X-Series product from the Mode dropdown.

Withthe XDAQ system on and connected to XR or XSR headstages, your software recognizes connected headstages automatically. If you are using SmartBox Pro family or a different Intan-based system, click on the Mode menu and select the appropriate option.

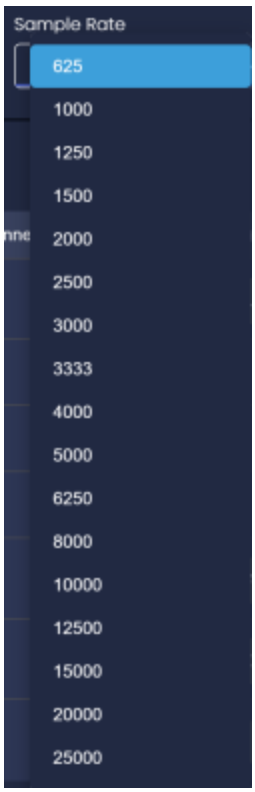


On the XDAQ outline, you can check the status of connected ports to the XR, or XSR headstages. Green light indicates which ports are in use.

TThe XDAQ Core and XDAQ One support simultaneous recording of up to 512 and 1024 channels across all four ports, respectively. For example, below shows the status of one 32 channel SmartLink headstage connected to port B.



The sample rate on the System view can be changed to values from 625 Hz to 30 kHz.



Download and Install Radiens Software Application

Radiens™ is the software suite designed to interface with the SmartBox Pro, Xseries, and other Intan-based acquisition systems, and can be used to review, visualize, and curate previously recorded data. The latest version of Radiens™ Apps can always be found on the Radiens™ page:

https://www.neuronexus.com/radiens-allego-download-page/

Once there, select the link for the appropriate operating system and then select “Download” to begin the transfer.

Windows

Launch the installer.

If you receive a warning against running an unrecognized app, select “More Info”, then “Run anyway.”

Allego will launch after the installation is complete.

macOS

Download the Allego installer.

Double-click the installer to launch.

Drag the Radiens App icon into the Applications folder.

Open the Applications folder by double clicking the folder icon.

In the Applications folder, double-click the Radiens App icon while holding down the control key (holding down the control key overrides the MacOS security check, which is only needed during the initial launch).

Allego will launch after the installation is complete.

On a Debian-based distro (Debian, Ubuntu, *buntu, Linux Mint, etc):

Download the .deb file

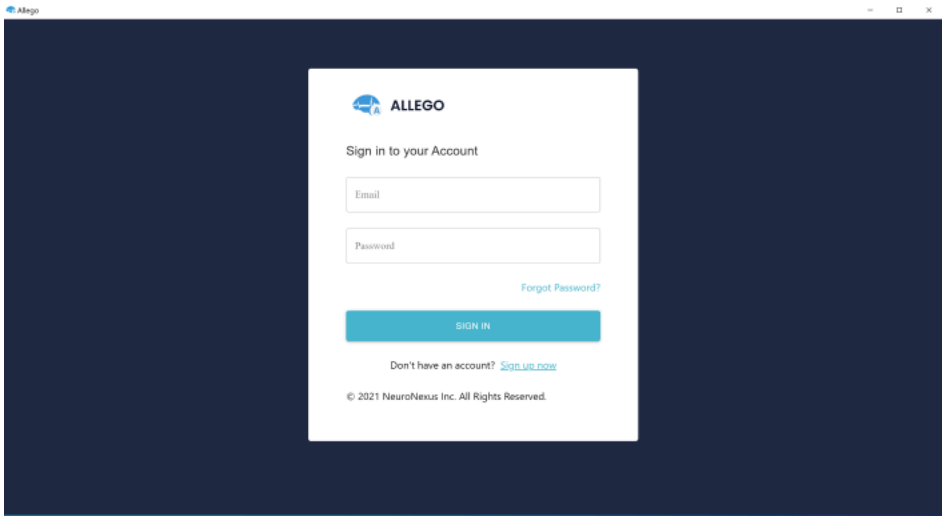
Run ‘sudo apt install <path to .deb>’

What is a Radiens ID

Your Radiens™ ID is your email address. Use the same Radiens™ ID to keep all your Radiens products associated with a single account. Radiens™ ID is essential for a secure and personalized experience with Radiens apps and services, and is required when you want to buy and use Radiens™ products.

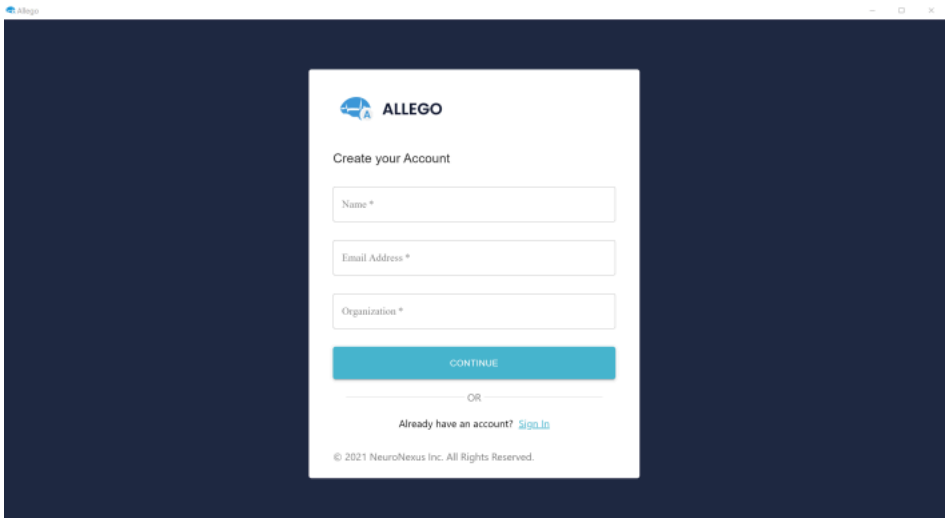
Create or Update Your Radiens ID

- Launch Allego. Once it has finished initializing , select Sign up now to create an account.

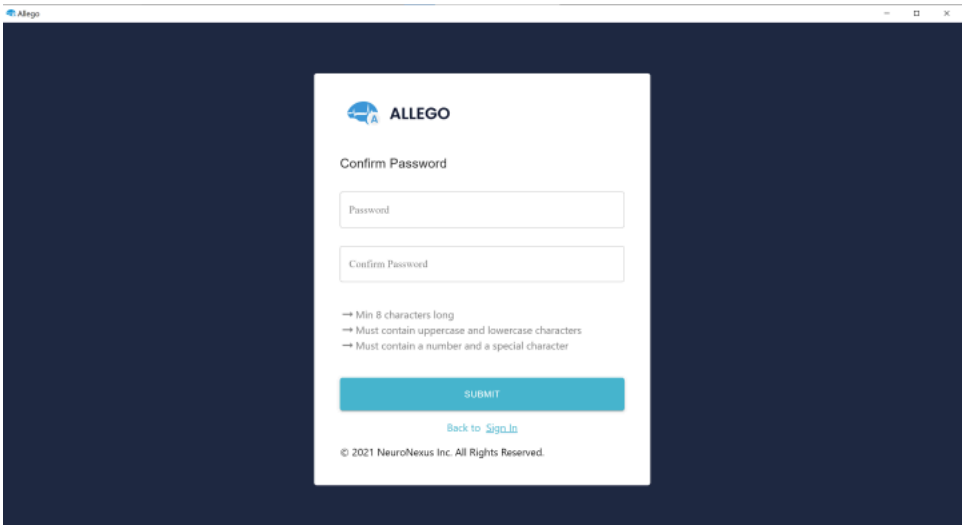


- On the Sign up now screen, create your account by providing the necessary information. Then select continue.

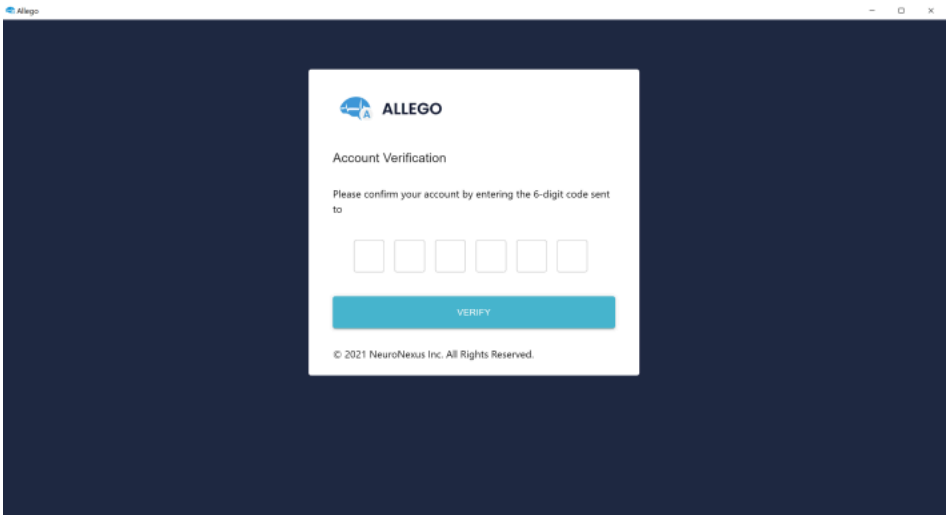
  Note: The email address that you enter will be your Radiens ID, so use a frequently used address that you will remember.



- On the new page, confirm password and submit.



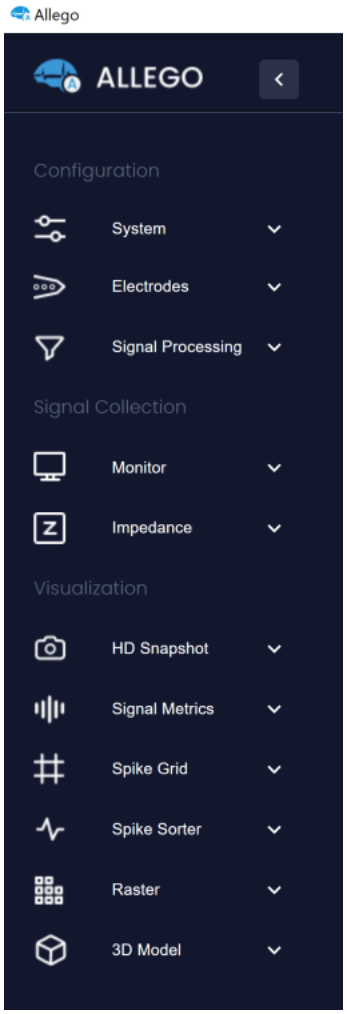
- You will receive a verification email with a 6-digit code to verify and confirm your account. You may have to wait for some time before receiving the email.



- Once you verify your account you should be able to login with the Email ID and password that you already created.

Module Drawer

On the left side of the display is the Module Drawer showing module icons. The drawer can be accessed by clicking the arrow button in the top left corner of the window.



The modules will now be displayed as a list. Clicking on an item will either open a new tab of the selected module or will bring an already opened tab into focus. Additionally, multiple tabs of the same type can be saved in the workspace, and all of them can be accessed from the module drawer. Creating tabs in a new window to extend the interface to other monitors can also be done easily. Right-clicking on a module will produce a context menu which allows the option of opening a new tab in a new window.

CONFIGURATION

System: Configure signal sources, which ports will be used, sampling frequency, and D/A (Outputs)

The System module contains all the basic configuration options for how the recording system type should function and which recording system is being used. The Sample Rate can be set here, along with information on any connected headstages for each

port, analog and digital output control, triggering.

 Electrodes: Connected probe designs are selected, along with which port and SmartLink headstage will be used

The Electrodes module is where the headstage and probe types are defined for each port on the recording system. Here, one can enable and disable individual or groups of probe electrode sites, as well as arrange the voltage traces visualized in the Monitor tab. Wireframe models of NeuroNexus probes are shown here.

 Signal Processing: Create various filter types and combine them to create DSP groupings

The Signal processing module contains filtering options that will impact only visualized data, or both visualized and saved data.

SIGNAL COLLECTION

 Monitor: Shows the signals currently being streamed

The Monitor module is where biological data and peripheral device activity are visualized.

 Impedance: Impedance testing

Probe impedance can be measured at 1 kHz in this module.

VISUALIZATION

 HD Snapshot: Takes a high resolution still picture of signals for closer inspection

The HD Snapshot module provides the ability to visualize a waveform of a recorded signal using all captured data points. This results in a very accurate depiction of a signal of interest.

 Signal Metrics: Configure spike detection parameters and view key performance indicators/signal quality characteristics

The Signal Metrics module allows the user to characterize activity across electrode sites using several different metrics, such as mean and standard deviation. Probe geometry is used to visualize relationships between the activity recorded in different locations on the probe.

 Spike Grid: Set spike detection threshold using voltage or standard deviation of background noise from the mean. Displays detected spikes across all channels

The Spike Grid module allows the user to setup spike detection based on threshold types and values including amplitude threshold crossing or the standard deviation (SD) of background noise.

Spike Sorter: Grouping of the spikes into the clusters

Spike Sorter module groups detected spikes and extracts information like yield and signal-to-noise ratio from the streamed data.

Raster: Analyze spike trains of single neurons

The raster plot is a simple way to display spiking activity of neurons across all active channels over time.

3D Model: The interactive brain model with presentation of network activity

The 3D Model module is a powerful and unique way to visualize an experiment and any detected activity in real time. The probe design being used for the experiment can be positioned and visualized within a 3D brain of the chosen animal model.

Settings: Activate the software, set visual themes and set the recording file name and location

Software licensing, save paths, and various other features of Allego are configured in this module.

Status Bar

The Status bars are located at the top and bottom of the window.

At the top, it contains the Stream and Record buttons and provides current information on the recording and streaming duration. The Settings module is also accessible from here.

The connected headstage and channel count can be found on the bottom status bar as shown in the image below.

Save Workspace and User's Profile

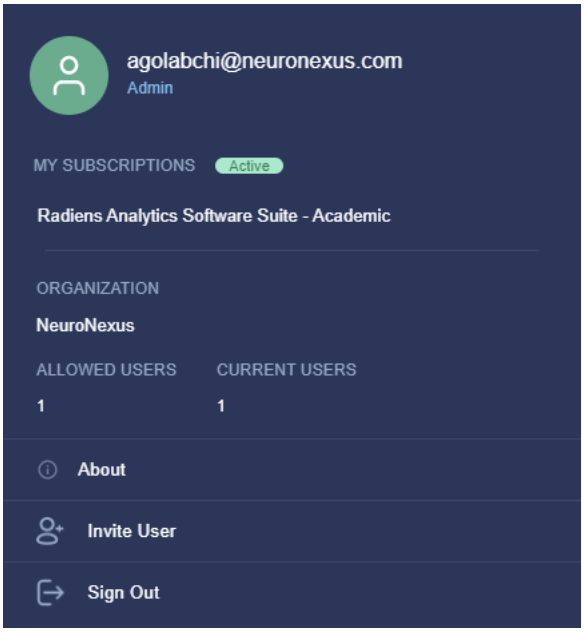
In the upper right area of the display, there are workspace buttons.

The Save Workspace button, , saves the current configuration of the workspace.

The trashcan icon, , will remove the selected window from the saved workspace.

The restore button, , will restore the tabs to their saved locations upon launching Allego.

User's profile, , is located at the top right corner of the Allego window. Subscription status and Allego version can be found in that section as shown below.



Dashboard Configurability

The module tabs in Allego are easily moved and repositioned by clicking on the tab header and dragging it to any other location on the Dashboard. Tabs can be viewed simultaneously via split screen or stacked together allowing them to be viewed like tabbed web browsers. Clicking and dragging the tab header around the display will provide a preview of the layout in real time.

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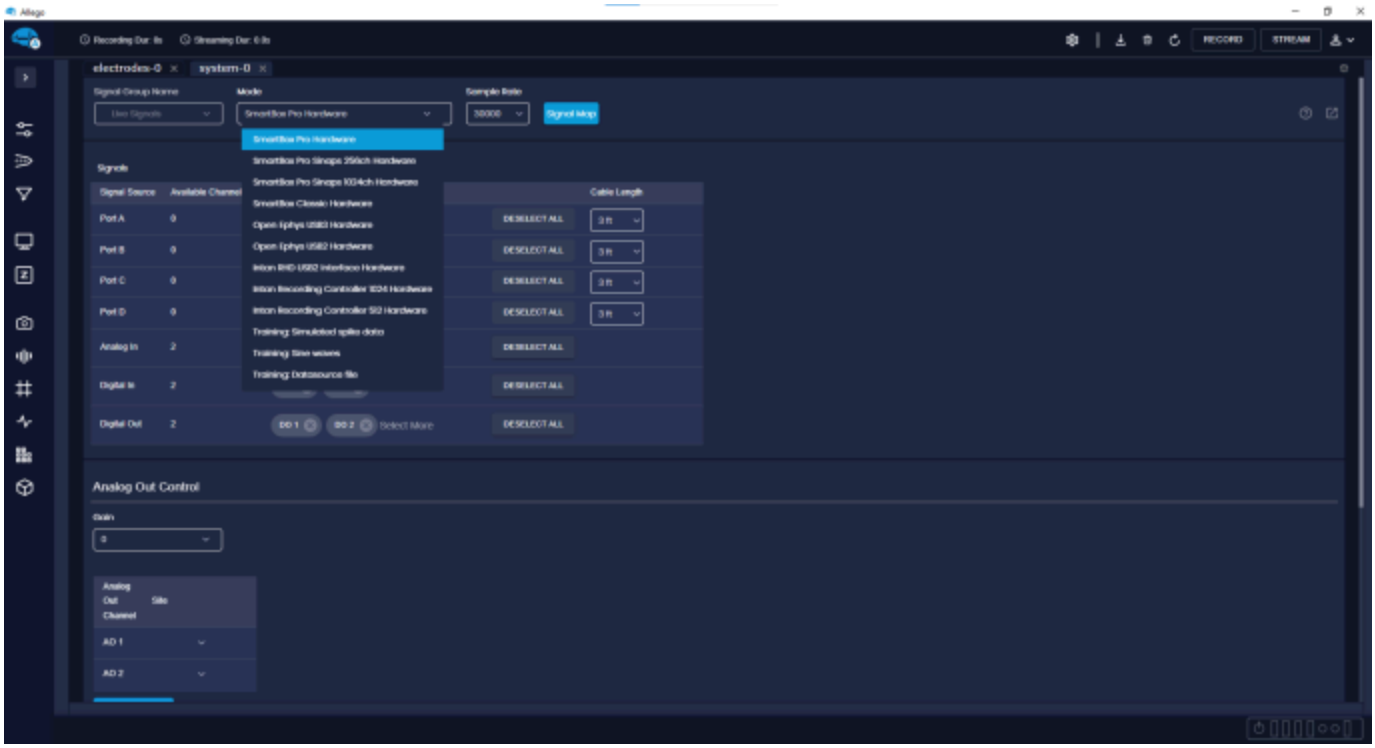

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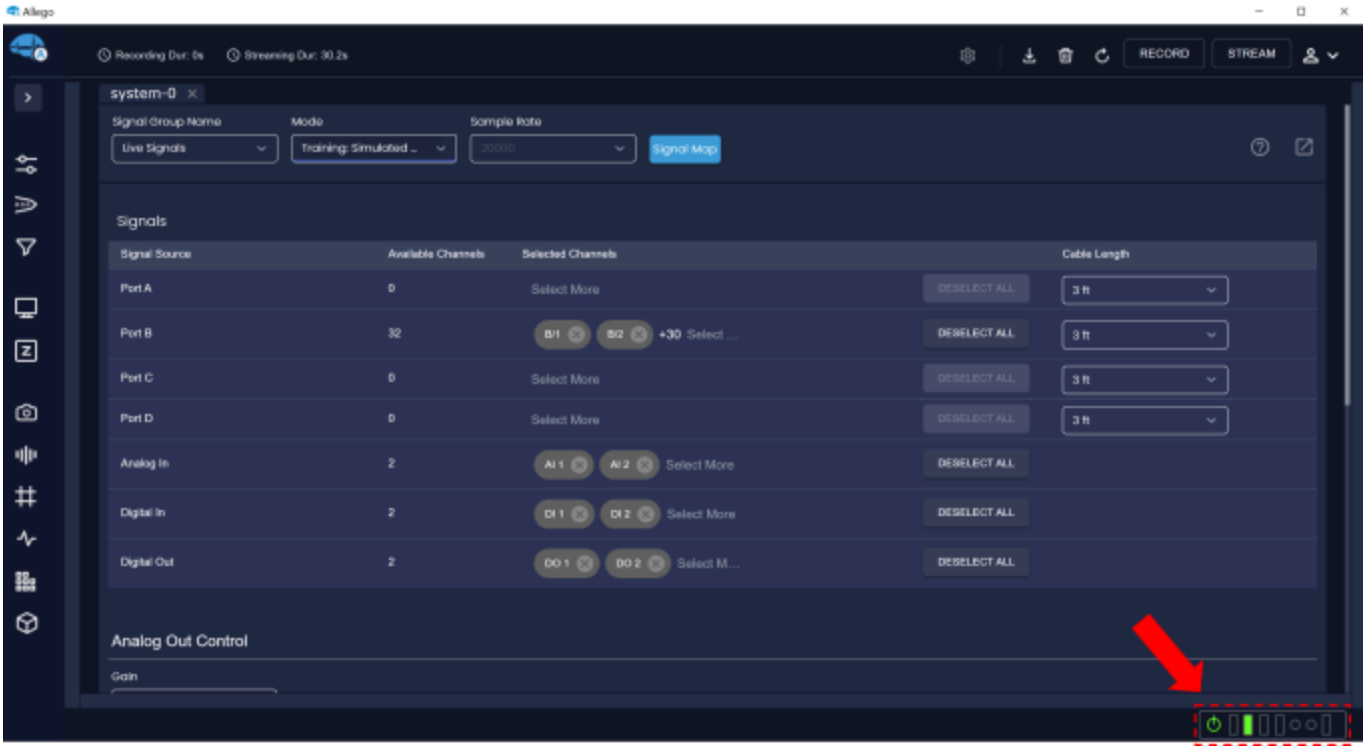

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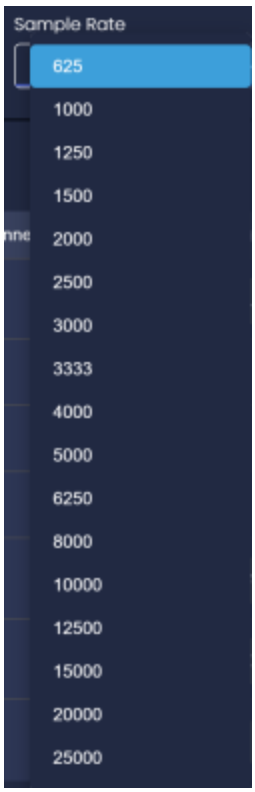
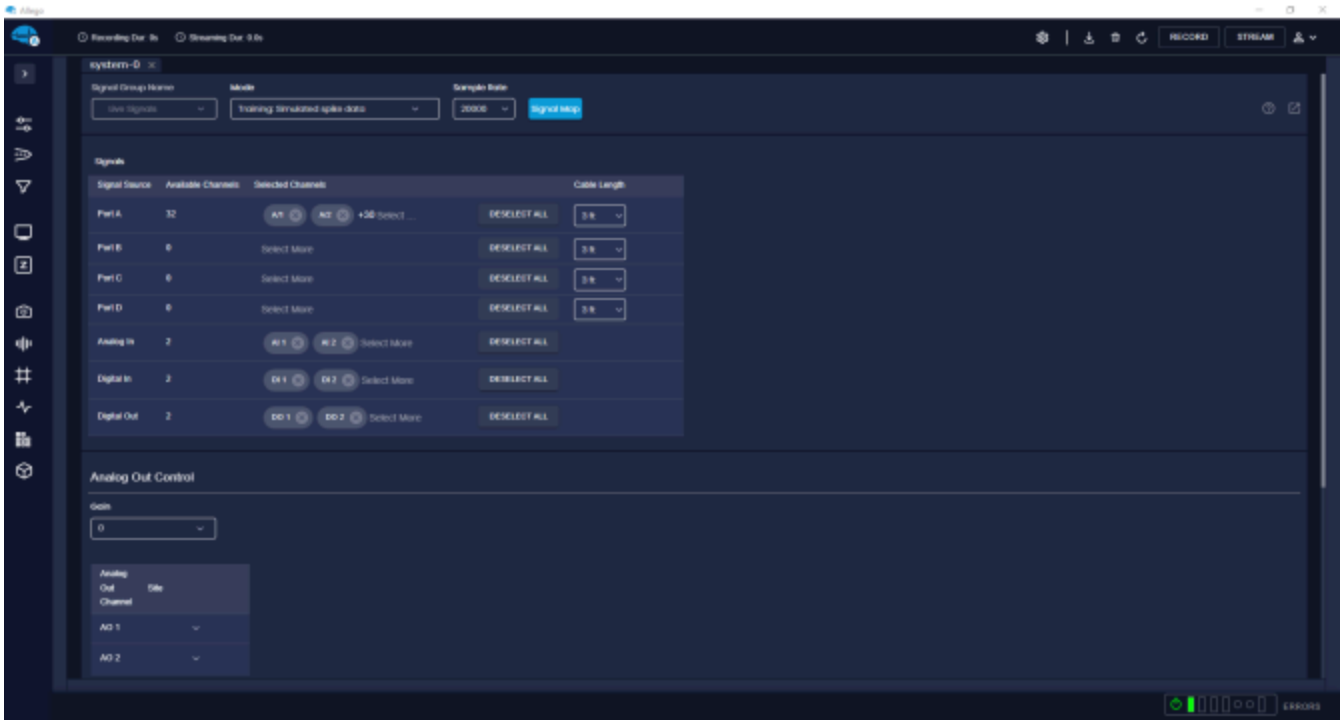
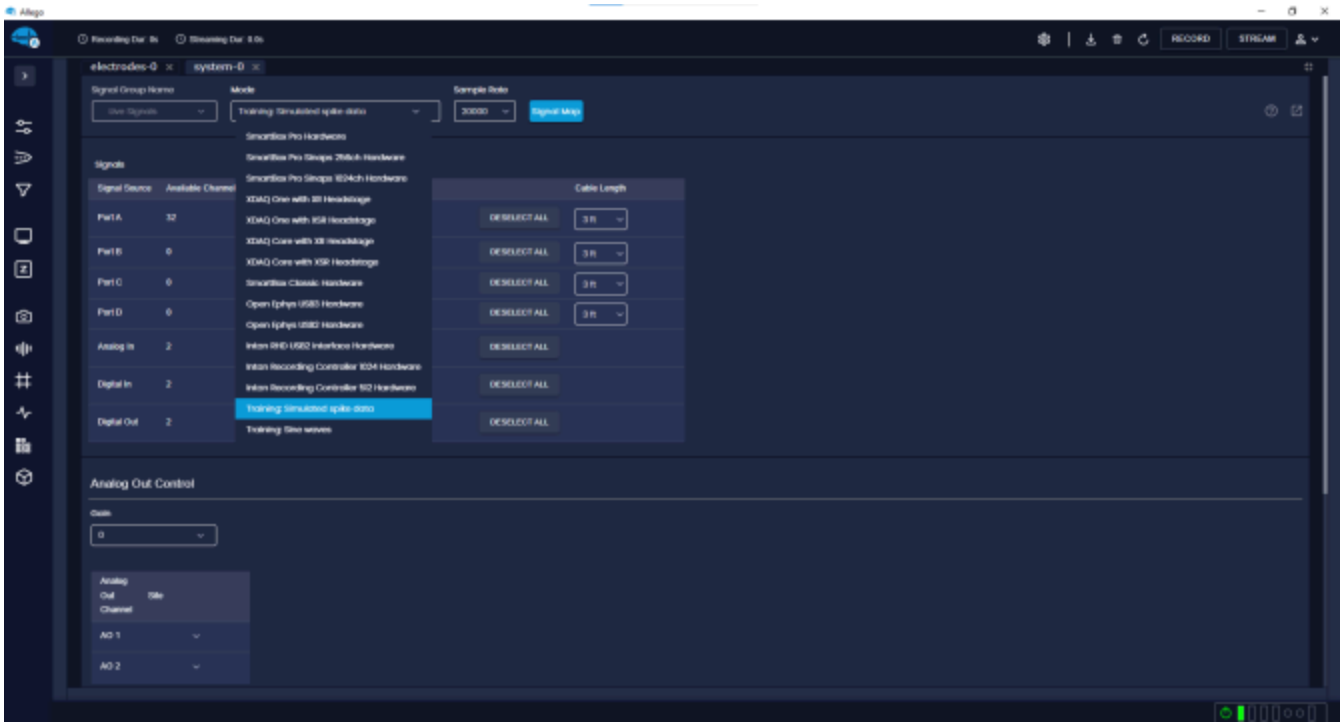


Training with Allego

To familiarize yourself with Allego before using it with X-Series product, select the System icon. From the Mode dropdown menu, choose Training: Simulated spike data. This mode simulates having a 32-channel headstage connected on Port A.



You may also test filtering options by choosing Training: Sine waves. Sine mode simulates a 64-channel headstage connected on Ports A and C.


Allego
RECORD
STREAM
electrodes-0
system-0
Signal Group Name
Mode
Training: Simulated spike data
Sample Rate
30000
Signal Map
Smartbox Pro Hardware
Smartbox Pro Sinapa 256ch Hardware
Smartbox Pro Sinapa 1024ch Hardware
XDAQ One with 32 Headstage
XDAQ One with RHA Headstage
XDAQ Core with 32 Headstage
XDAQ Core with RHP Headstage
Smartbox Classic Hardware
Open Ephys USB3 Hardware
Open Ephys USB2 Hardware
Intan RHD USB2 Interface Hardware
Intan Recording Controller 1024 Hardware
Intan Recording Controller 512 Hardware
Training: Simulated spike data
Training: Sine waves
Signals
Signal Source
Available Channel
Port A
32
Port B
0
Port C
0
Port D
0
Analog In
2
Digital In
2
Digital Out
2
Cable Length
DESELECT ALL
3 ft
Analog Out Control
Gain
0
Analog Out Channel
Title
AO-1
AO-2

What options do I have to power the XDAQ?

The XDAQ Core requires a 35 W USB-C PD power source with a required power specification of 12 V 3 A. It's worth noting that some power bricks may have limited driving capability, which can cause the XDAQ to be unable to lock in power, resulting in repeated clicking sounds. If this happens, try a different make or model.

The XDAQ One and AIO can be powered by the same external 35 W USB-C PD adapter or directly to a wall plug with an AC input range of 100-240 V. If both USB-C power and AC wall supply are active, the USB-C circuit will be disabled. It's important to ensure that the GND pin in the wall plug is properly grounded to earth.

If you prefer, you can power the XDAQ with batteries. Many USB PD-based power banks are available, but ensure that they meet the required 12 V 3 A specifications before use.

What do the XDAQ Status LEDs mean?

LED Indicators

SYS: ON - Program loaded

Flashing - Hardware Error

S1: ON - Acquisition on

S2: Flashing: Activities in DIN1 and DIN2

S3: Flashing: Activities in DOUT1 and DOUT2

STIM: ON - XDAQ in StimRecord (SR) Mode

V1: ON - VStim level set to +/- 7 V

V2: ON - VStim level set to +10/-4 V

V3: ON - VStim level set to +4/-10 V

Port1 | P1: ON - Headstage Detected

Port2 | P2: ON - Headstage Detected

Port3 | P3: ON - Headstage Detected

Port4 | P4: ON - Headstage Detected

Note:

- The flashing rate of S2, S3 LEDs doesn't not reflect true IO data rate. It is deliberately slowed for visualization purpose.
- Earlier models (prior to Nov 2022) of CORE front panel display S1 instead of SYS.

XDAQ Ports and Supported X-Headstages Explained

It's important to note that the XDAQ line supports not only Record (X3R & X6R) and Stim-Record (X3SR) X-Headstages, but also other Intan compatible headstages. Additionally, the number of enabled ports may vary depending on the purchased configuration.

XDAQ CORE

SKU: XDAQ-CORE_S16 - supports total of 512 Rec channels and 16 Stim-Rec channels

SKU: XDAQ-CORE_S32 - supports total of 512 Rec channels and 32 Stim-Rec channels

	Rec	Stim-Rec
Port 1	128ch	16ch (-S16) or 32ch (-S32)
Port 2	128ch	non-functional
Port 3	128ch	non-functional
Port 4	128ch	non-functional

XDAQ ONE

KU: XDAQ-ONE_R512_S64 - supports total of 512 Rec channels and 64 Stim-Rec channels

SKU: XDAQ-ONE_R512_S128 - supports total of 512 Rec channels and 128 Stim-Rec channels

SKU: XDAQ-ONE_R1024_S64 - supports total of 1024 Rec channels and 64 Stim-Rec channels

SKU: XDAQ-ONE_R1024_S128 - supports total of 1024 Rec channels and 128 Stim-Rec channels

	Rec	Stim-Rec
Port 1	256ch	32ch
Port 2	256ch	32ch
Port 3	256ch (-R1024)	32ch (-S128)
Port 4	256ch (-R1024)	32ch (-S128)

If there are ports on the XDAQ device that support additional channels than your current device supports, you may purchase and upgrade to support higher channel counts. It is generally more cost-effective to purchase the maximum number of channel counts upfront rather than upgrading at a later stage. However, note that it is not possible to upgrade XDAQ CORE, for example, to support driving 64 channels of Stim-Rec X-Headstages.

Please note that currently, it is not possible to drive both R and SR X-Headstages simultaneously. However, we may consider implementing this feature at a later stage depending on the level of interest from our users.

XDAQ Supported Headstages

In addition to the ultra-small X-Headstages, XDAQ also supports existing headstages that are compatible with Intan systems, such as those from NeuroNexus and Intan itself. However, an adapter is required to properly re-map the control and data signals to run these headstages and their corresponding accessories.

Fortunately, NeuroNexus offers adapters that allow X-Headstages to interface with existing controllers from Open-Ephys, Intan Controllers, SmartBox, and other similar systems. These adapters also enable XDAQ to use existing Intan-compatible headstages from Smartlink, Intan, and other compatible manufacturers.

NeuroNexus can easily provide adapters for other solutions not already supported. Contact us for more information.

XDAQ to Smartlink Adapter

To use NeuroNexus headstages with the XDAQ, simply connect the adapter to the HDMI ports and then use the Smartlink cable to link it up. This will allow you to use the NeuroNexus headstages directly with the XDAQ.

XDAQ to Intan RHS Headstage Adapter

To use the original Intan cables and headstages with the XDAQ, plug in this adapter into the HDMI ports. This will enable you to use the Intan RHS chips directly with the XDAQ. It's worth noting that each adapter has the capability to drive up to 2 Intan RHS chips.

XDAQ to Intan RHD Headstage Adapter

To use the original Intan cables and headstages with the XDAQ, simply plug in this adapter to the HDMI ports. This will allow you to connect the Intan RHD chips directly to the XDAQ using the original cables and headstages. Keep in mind that each adapter has the capacity to drive up to 4 Intan RHD chips.

X-Headstage to SmartBox Adapter

To use the X-Headstage, simply connect the adapter to it and then use the Smartlink cable to link it up with the SmartBox Pro. Depending on your needs, you can choose between two different finishes for the adapter. The Full Shell finish features a fully machined plastic body that completely encases the adapter and weighs 3.5 g. Alternatively, you can opt for the Min Size finish which utilizes adhesive and thermal wrap to protect the connections and weighs just 1.35 g.

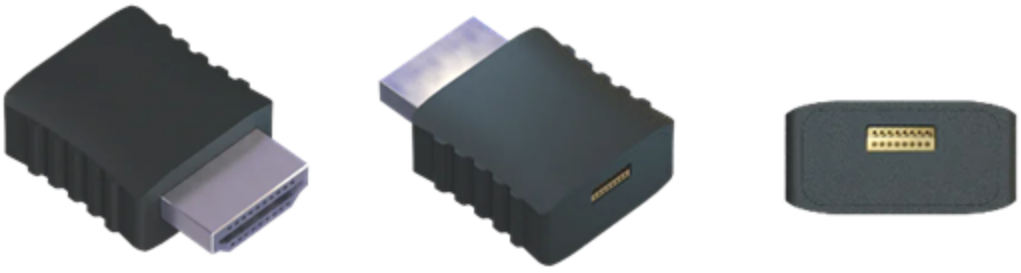
HDMI Cable to Intan System Adapter

Use this adapter to access the X-Headstage using NeuroNexus's HDMI X-cable solution. Then connect to Intan compatible acquisition box (Open-Ephys, Intan Recording Controller) via the SPI cable.

How do I use my old Intan headstages with XDAQ?

Use XDAQ to Intan RHD Headstage Adapter

or use XDAQ to Intan RHS Headstage Adapter.



How to run more than 4 headstages with the XDAQ

The XDAQ is specifically designed for high channel neural acquisition, and although each box only has four ports on board, it is possible to drive more than four headstages/animals at the same time by configuring each with a lower channel count.

For instance, each XDAQ ONE port has the capacity to support up to 256 channels of X3R/X6R Rec X-Headstage, and with four ports, the XDAQ ONE can simultaneously drive up to 1024 neural recording channels. To record from 16 or even 32 headstages/animals simultaneously, it is feasible to split the data and control lines into additional ports using an adapter. NeuroNexus can assist in the cost-effective production of this adapter.

Why can't XDAQ detect both X3R and X3SR headstages simultaneously?

The X3SR and X3R headstages utilize distinct control and communication protocols, making it impossible to control them concurrently. As a result, if you require additional recording channels while using the X3SR headstage, you will need to incorporate another X3SR headstage. Alternatively, if you are using X3R or X6R headstages, you should refrain from connecting an X3SR headstage. Running X3R and X6R headstages together is acceptable.

Why does XDAQ One offer 3 VStim compliance options?

The XDAQ has been designed to offer maximum flexibility and usability to researchers. In some cases, higher stimulation voltages may be required due to electrode impedance (where current I = VStim / Electrode Impedance). To address this, we've incorporated a feature that allows the box to supply up to 40% extra voltage limit on either the positive or negative terminal, while still maintaining safe limits for the SR X-Headstage.

There are three configurable options for this feature:

- +/- 7 V
- +10 V to -4 V
- +4 V to -10 V

If you're willing to sacrifice the potential lifetime of the XSR-Headstage (reducing it from 100 million cycles to 1 million cycles or less), we can customize the voltage output upon request at the time of order.

- +/- 7 V or (+/- 9 V)
- +14 V to -4 V
- +4 V to -14 V

What is the purpose of the ground ports in the back of the XDAQ

TruGround is an innovative feature that aids in the identification and establishment of the ideal grounding scheme for XDAQ acquisition hardware, thereby reducing noise in neural recordings.

In many instruments, digital and analog grounds are combined, leading to unintended paths for noise sources, making troubleshooting difficult. The XDAQ (models ONE and up) is designed with independent ground paths for three primary circuits: earth/shielding, digital system, and the animal. The earth ground is activated when the XDAQ is powered via the wall AC plug, which is grounded to earth. The XDAQ metal enclosure and cable connector shielding are also connected to earth ground. If powered using a USB-C brick, the wall plug's earth ground can be connected to the TruGround terminal's earth node. The digital ground is common to all electronics and integrated circuits, except for the amplifier and ADC responsible for electrophysiology recordings, which are optically isolated.

During initial setup or when the XDAQ is moved to a new location, users should experiment with different grounding options to achieve the optimal configurations for their specific environment. It's important to note that XDAQ provides two separate animal-side grounds, with Port 1 (P1) having a dedicated ground circuit, and Port 2-4 (P2-4) sharing one common ground circuit.

What is TruGround and how can it be used?

In many conventional system designs, there is usually only one ground node, which can lead to noisy electrical signals, especially in high-speed digital circuits that operate at 3 V or 1.2 V. In contrast, analog circuits that process signals from sensors typically deal with smaller outputs, on the order of 10 s mV or less. Electrophysiology signals, for instance, are usually in the range of 100s of µV or lower. Additionally, instruments powered by external AC supplies may not be properly earth grounded.

However, the XDAQ™ system incorporates TruGround, a unique feature that keeps ground nodes and corresponding electrical paths separate. The animal-side has individual grounds for signals and earth grounds, which connect to the connector shield and can be accessed from the ground panel at the back of the XDAQ™.

When conducting electrophysiology experiments and troubleshooting for noise, it is common to use a probe connected to the ground node and touch various surfaces to observe the noise response. But if the ground is not properly earth grounded, introducing noise into the system is a possibility. This practice may not be as effective

as one would expect, and in some rare cases, the noise in differential inputs can cancel out.

If your surgical procedure includes a Faraday cage around your implant, it might be better to connect the Faraday ground to the earth ground. In the X-Headstage™ and XDAQ™ solution, the earth ground is accessible via the connector shield on the X-Headstage™, and a pigtail can be soldered to the outer shield of the μHDMI connector to tap into the earth ground.

Moreover, the TruGround panel design at the back of the XDAQ™ makes debugging for noise more straightforward and logical. One can experiment with grounding the noise sources to the earth ground (provided the building has an earth ground), and then try different configurations between the ground nodes if necessary. The TruGround system includes two RC circuits for each ground node, which provide an ESD path to earth in case of charge buildup that creates static charges. Circuit 1 comprises a 1nF capacitor to ground, while circuit 2 is a 1nF capacitor in parallel with a 1 MOhm resistor to ground. KonteX™ recommends activating circuit 1 by default and experimenting with adding circuit 2 to the system to see if the ESD condition improves.

In summary, TruGround is a valuable design feature that makes noise optimization more manageable and logical, particularly in electrophysiology experiments.

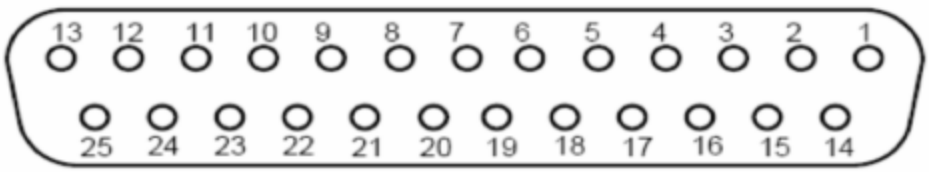
How to connect the XDAQ Expander to the XDAQ?

Below are the the steps to connect the XDAQ Expander:

- Connect the EXP1 port on the XDAQ to the EXP1 port of the Expander using an Ethernet cable.
- Connect the EXP2 port on the XDAQ to the EXP2 port of the Expander using another Ethernet cable.
- Power on the XDAQ either before or after plugging it into the Expander (The powering sequence of XDAQ is not critical and can be powered on before or after plugging in to the Expander).
- Turn on the software to begin using the XDAQ with the additional IO provided by the Expander.

XDAQ DB25 pinout

DB25 connector pinout for XDAQ ONE and CORE

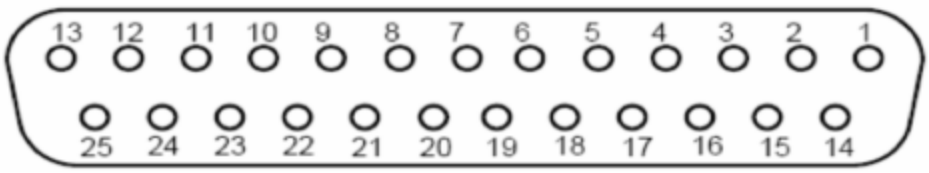


DB CONNECTOR PIN	SIGNAL
01	
02	DI 03
03	DI 05
04	DI 07
05	
06	
07	
08	
09	
10	DO 04
11	DO 06
12	DO 08
13	Mark Out
14	SYS GND
15	DI 04
16	DI 06
17	DI 08
18	
19	
20	
21	

DB CONNECTOR PIN	SIGNAL
22	DO 03
23	DO 05
24	DO 07
25	Sample CLK

XDAQ Expander DB25 pinout

DB25 connector pinout for XDAQ Expander



INPUT or OUTPUT DB CONNECTOR PIN	SIGNAL (DI or DO)
01	15
02	16
03	17
04	18
05	19
06	20
07	21
08	22
09	23
10	24
11	25
12	26
13	27
14	SYS GND
15	28
16	29
17	30
18	31
19	32
20	
21	

INPUT or OUTPUT DB CONNECTOR PIN	SIGNAL (DI or DO)
22	
23	
24	
25	

What are the main differences between XDAQ ONE and CORE?

XDAQ ONE and XDAQ CORE are both optimized tools designed by NeuroNexus. Both tools offer the ability to perform electrical stimulation. XDAQ CORE supports only up to 32-ch of XSR Headstage, while XDAQ ONE supports up to 128-ch of XSR Headstage. However, both tools support at least 512-ch of regular X-Headstage. When users are interested in running electrical stimulation experiments, XDAQ's recording capability is essentially limited to the number of channels in the SR X-Headstage. Thus, in the case of XDAQ CORE, users can only run either a 16-ch or 32-ch stimulation experiment (i.e. runs one X3SR32 Headstage) with each of the 16/32 amplifiers can be independently configured to deliver electrical stim pulses or record neural activities. In contrast, XDAQ ONE can support up to 128-ch switchable stimulation-recording experiment (i.e. runs four X3SR32 Headstages). If a stimulation experiment is not needed, then both ONE and CORE can support at least 512-ch of regular X-Headstages (or regular Intan RHD2000 series headstages), depending on how many units are plugged in.

In addition, XDAQ ONE has the following advantages over XDAQ CORE:

- XDAQ ONE has an advanced electrical design that isolates the sensitive animal signal from the rest of the system.
- XDAQ ONE includes dedicated and separated GND nodes for better noise optimization.
- XDAQ ONE includes an upgraded power design and can be powered by either USB-C PD or the built-in 25W worldwide AC power supply.
- XDAQ ONE has 3 selectable VStim compliance options (+/- 7 V, 4/-10, 10/-4), while XDAQ CORE has a fixed +/- 7 V Vstim compliance. The additional VStim compliance offered by XDAQ ONE provides additional current driving capability and may come in handy for those working with high impedance electrodes.

- XDAQ ONE includes 8 sets of digital IO and 2 sets of analog IO, while XDAQ CORE includes only 7 sets of digital IO and 1 set of analog IO. Both tools can increase the supported IO to an additional 24 sets of digital IO and additional 6 sets of analog IO with the XDAQ Expander.
- XDAQ ONE uses a heavy-duty aluminum enclosure (weighs ~3 kg) for optimal heat dissipation, while XDAQ CORE uses a standard aluminum enclosure (weighs ~0.85 kg), which runs a little bit warmer but works fine.

What is the difference between XDAQ Core, One, AIO?

The XDAQ Core is an entry-level device that facilitates both electrical stimulation and high-speed neural recording. It has the capacity to drive up to 512ch of recording X-Headstages or 32ch of stim-record X-Headstage (which can be upgraded to 64ch). However, it is impossible to connect both recording and stim-record X-Headstages simultaneously. Only one type of X-Headstage can be used at a time.

For those who require enhanced recording and stimulation performance, the XDAQ One is the ideal solution, with capabilities of up to 1024ch of recording X-Headstages or up to 128ch of stim-record X-Headstages.

NeuroNexus's flagship acquisition box, the XDAQ AIO, offers additional functionality for optogenetics, video/audio recording, and calcium imaging. Although it has a higher initial cost, users can purchase the base system and add functionality upgrades later.

How is XDAQ different than Open-Ephys Acquisition system?

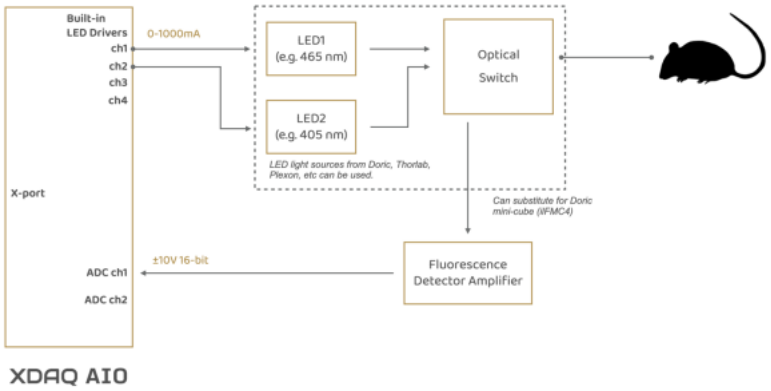
The Open Ephys acquisition box is a popular choice among researchers worldwide due to its high value and capable software.

However, NeuroNexus designed the XDAQ with multi-modal experimental needs in mind, offering both electrical stimulation and high-quality neural recording out of the box. The XDAQ line has been carefully tuned for improved electrical performance and uses an aluminum enclosure for enhanced durability and heat management. The XDAQ One and AIO models offer even better performance, with TruGround and electrically isolated animal ports. The XDAQ AIO also supports additional functionalities, including optogenetics, behavior video recording, and calcium imaging.

The XDAQ Core is priced similarly to the Open Ephys acquisition box but offers improved electrical performance and additional functionality for electrical stimulation. For those requiring a solution that supports a wider range of experimental needs and that can be scaled as research demands increase, the XDAQ AIO is an excellent choice. Note that AIO functionalities can be added after the base system is purchased, making it a highly flexible option.

How does XDAQ AIO perform photometry experiments. What additional equipments do I need?

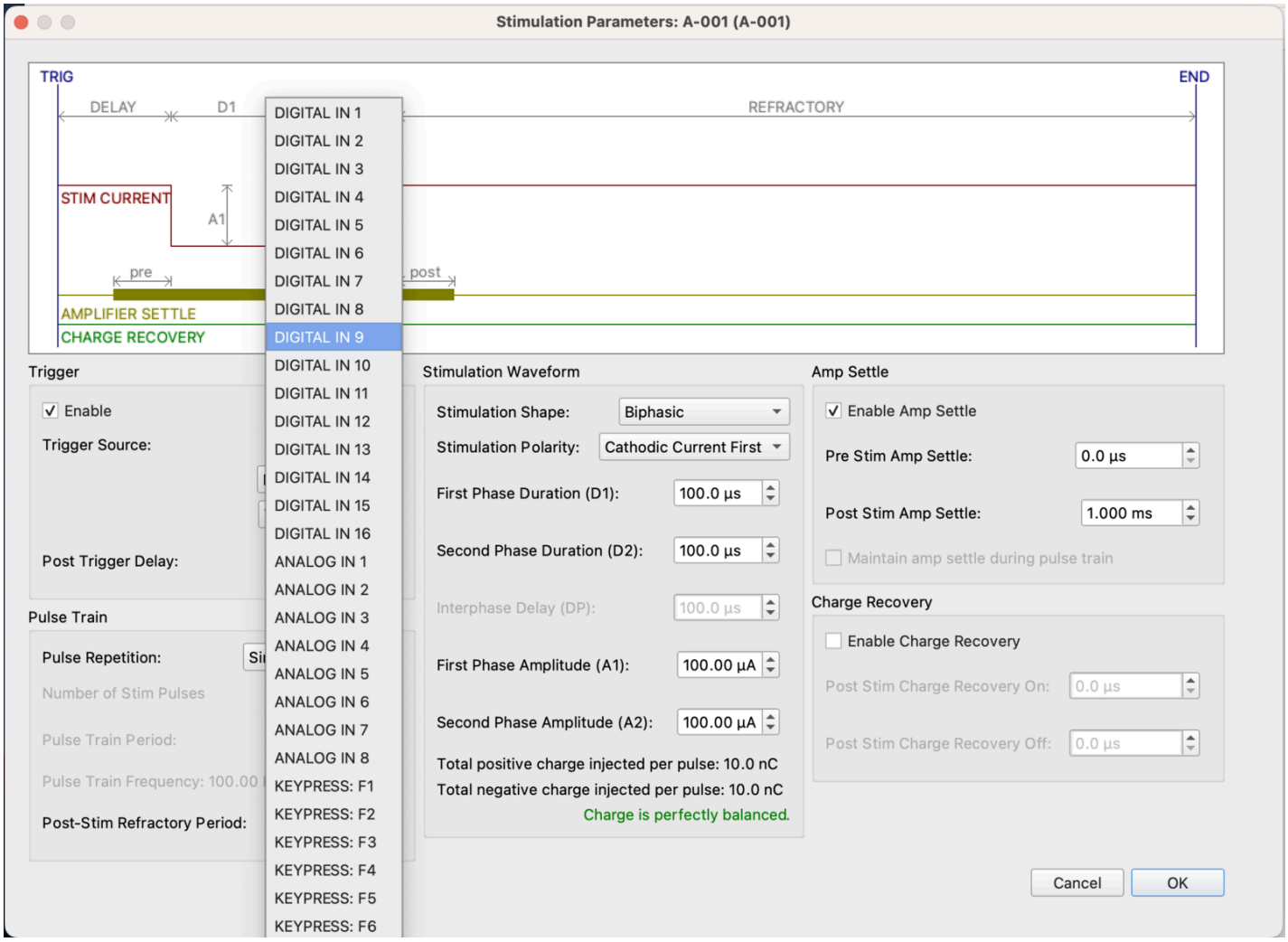
The XDAQ AIO is equipped with four independent LED drivers and two general-purpose ADC inputs. To conduct a photometry experiment, you'll need to connect external light sources with an optical switch and a fluorescence detector back to the XDAQ.



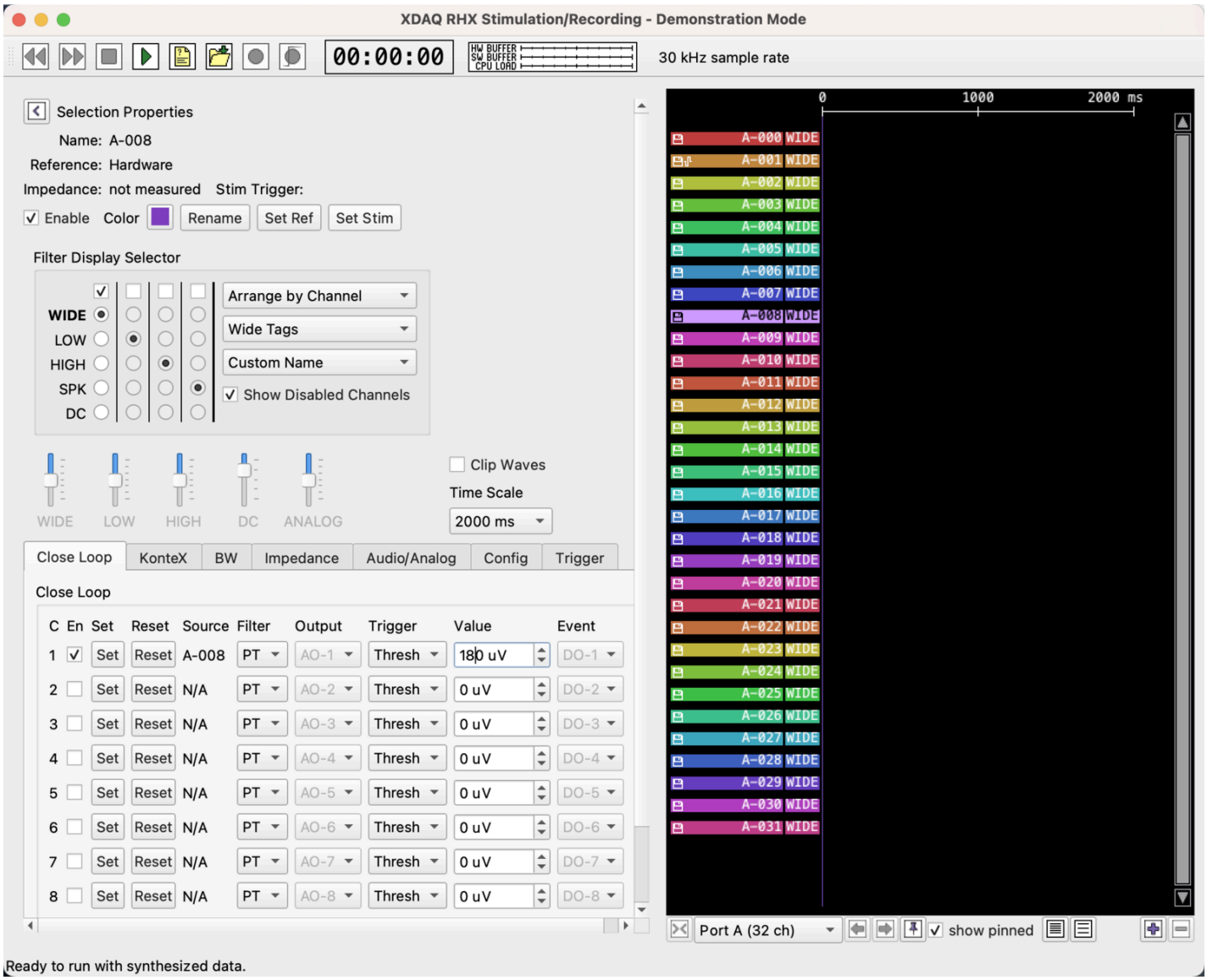
Simple close-loop Control with XDAQ

We have received many requests for close-loop control and it has been added to our XDAQ development list. While waiting for its implementation, we offer a rudimentary, threshold-based detection that is already available in the XDAQ for close-loop experiments. To demonstrate how it works, suppose we want to trigger an electrical stimulation to an electrode site (channel A-001) every time a specific channel (channel A-008) fires with spikes having an amplitude of 200µV or higher.

To use this detection, simply run the XDAQ RHX application from here. Start by setting up a stimulation pulse on A-001. Then, move the cursor to A-001 on the waveform window and click on the "Set Stim" button on the left panel. In the "Trigger" group box, enable the trigger by clicking on it and change the trigger source to "DIGITAL IN 9" or an available channel. Set the stimulation waveform to the desired parameters and click OK. This simple threshold-based detection can be used for close-loop experiments until more advanced options become available.



To enable close-loop control, first, navigate to channel A-008 on the waveform window. Next, select the "Close-loop Control" tab and enable Circuit 1 ("C1") by clicking "Set." Then, choose the appropriate filter from the dropdown list to Pass Through (PT). Set the trigger to Threshold "Thresh" and specify a value of 180 µV.



After satisfying the threshold condition, a digital out pulse will be generated on channel DO1. To utilize this output for controlling another device, connect a BNC patch cord between DO1 and DI9 on both the XDAQ and XDAQ IO expander. Note that the XDAQ supports only up to 8 Digital IN channels, hence DI9 must be used in this scenario. One can connect the patch cord to any other device that needs to be controlled, such as tone generation or drug delivery systems. This method ensures that the latency between threshold detection and digital out trigger remains less than 500 µs.

Is XDAQ upgradable. Can I add functionality down the road as needs arise?

Indeed, the XDAQ system is designed to be modular and upgradable, meaning that new functionalities can be incorporated at a later stage if supported. This can be accomplished through a firmware update or by installing new module cards.

Can I configure X-Headstage to interface with the electrode directly?

If you create your own electrode, we provide EIBs with a direct interface to the X-Headstage. Our current EIB offers can be customized to meet your specific requirements. Additionally, we offer adapters for commonly used connectors, which allows for easy and cost-effective replacement of broken pins while maintaining a smaller footprint than conventional designs. Contact us to learn more about our customizable EIBs and adapters.

Selecting and Configuring the X-Headstage

NeuroNexus currently offers three types of X-Headstages:

- X3R for recording with 32ch (x3R32) or 64ch (x3R64)
- X3SR for stimulation + recording with 32ch (x3SR32) or 64ch (coming soon)
- X6R for recording with 128ch (x6R128), 256ch (x6R256), and custom designs up to 384ch or 448ch.

To perform electrical stimulation related experiments, the X3SR is recommended. For a super small, high-channel (>128ch) headstage, choose the X6R. The X3R64 is recommended if budget allows, as it has the same footprint as the X3R32 and is currently the smallest headstage available. Note that the recording (R) and stimulation + recording (SR) X-Headstages cannot be used together at the same time.

System Connector

When configuring the X-Headstage, the choice of system side connector is crucial. The recommended option is the µHDMI connector due to its ease of use and affordability, and it can be used with low-cost, flexible HDMI cables.

Another option is to use the HDMI Cable to Intan Adapter along with the existing SPI cable to save costs.

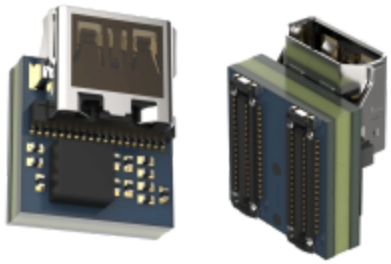
However, if you prefer the 12-pin Omnetics Intan connector, it can be configured at a higher cost. It's important to note that the 16-pin Omnetics connector used in Stim-Rec headstages is not currently offered, but it can be custom ordered upon request.

Armor Option:

The X-Headstage can be used without protective armor, but NeuroNexus offers several off-the-shelf armor designs for added protection. These include:

- N (naked)- No armor

  Option for the lightest weight



- M (mini)- Half armor covering top side only without accessory mounting feature

  Option for minimal structural protection

- S (screw)- Half armor covering top side only with accessory mounting feature

  Option with a locking mechanism for accessories

- IP (IP rated)- Full armor covering the entire X-Headstage with IP68 rating. IP configuration has no mounting feature

  Option for full armor shielding and added water resistance.

For those who prioritize minimal size and weight with added mechanical protection, the M armor is recommended. However, without the locking mechanism of the S armor, users must be careful not to disturb the connection interface before applying acrylic to secure the connection.

Note: All devices are coated with an ultra-thin layer of parylene-C coating.

Accelerometer

The X3R and X6R X-Headstages come with a 3-axis accelerometer installed to the auxiliary inputs of the amplifier circuits as a standard feature. However, the X3SR X-Headstage does not support an accelerometer.

Customization

NeuroNexus is committed to providing customized solutions to meet the unique needs of our clients. We offer a range of customization options, including connector-cable orientation, headstage body orientation, connector type, armor shape/material, and more. If you require further customization, please do not hesitate to contact us for more

details. Our team is dedicated to working with you to optimize our design to meet your specific requirements.

How do X3R, X3SR, and X6R headstages differ?

The X3 line consists of two headstage models: the X3R and the X3SR. The X3R is an ultra-small headstage capable of supporting 32 or 64 high-speed neural recordings. Meanwhile, the X3SR is a switchable stim-rec headstage that can accommodate 32 channels per chip and up to 64 channels per headstage. Both headstage models have a base dimension of 8.5 x 8.5 x 5 mm.

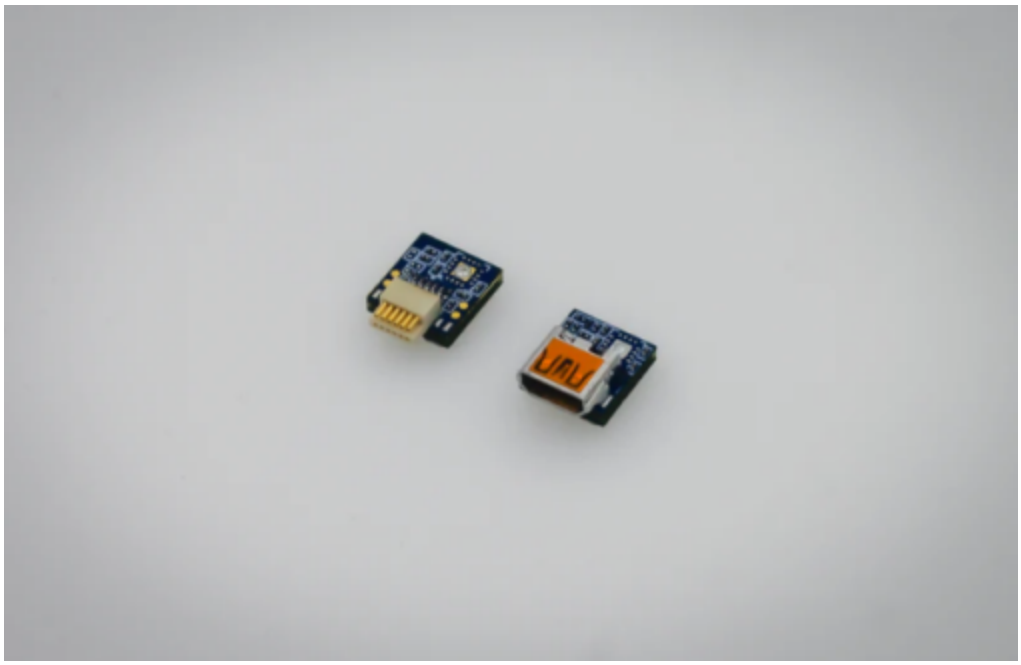
For high channel experiments, the X6R headstage is designed to start at 128 channels with a base dimension of 10 x 10 x 5mm. It can also be configured to drive up to 448 channels with a single cable. NeuroNexus is currently testing a headstage solution for a higher than 256 channel design.

The X3R is powered by the Intan RHD2132, while the X3SR is powered by the Intan RHS2116. On the other hand, the X6R is powered by the Intan RHD2164.

What connectors are used on the X-Headstage?

The X3 line (X3 Probe Interface) uses Molex PN: 5050663422 connectors, with a mating connector of Molex PN: 5050703422. The headstage on the X6 line (X6 Probe Interface) uses Panasonic PN: AXG144144A connectors, with a mating connector of Panasonic PN: AXG244144A.

What are the reasons behind X-Headstage™ using the µHDMI connector instead of the Omnetics connector?

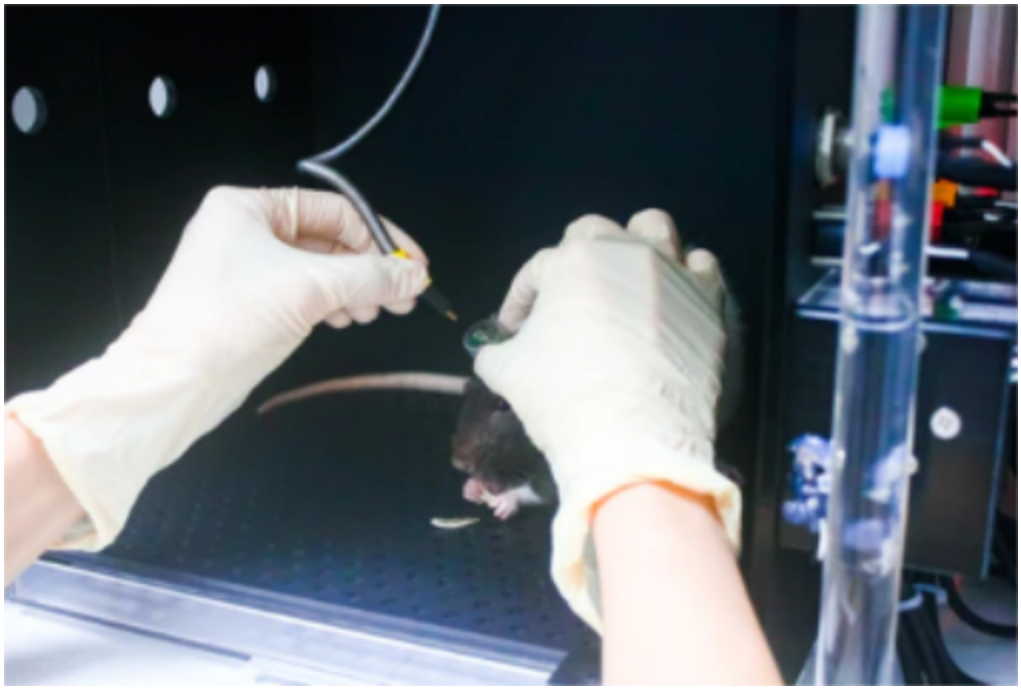


At NeuroNexus, we prioritize value-centric design, which involves carefully considering tradeoffs in our design decisions to achieve an optimal balance. While we aim to achieve the best performance, we also focus on creating designs that are practical and efficient. For example, when developing our X-Headstage™, we researched various commercially available connectors and compared them to Omnetics connectors, which are the standard choice for awake and behaving research in electrophysiology.

We eventually chose the µHDMI connector due to its availability, low cost, mechanical keyed orientation plug-in design, and sufficient number of pins. While it is not smaller or lighter than Omnetics connectors, it is still within the same size and weight range, and is not the limiting factor in overall minimization. The HDMI connector system is also widely used and has a well-tested mechanical connection.

One of the challenges researchers face daily is plugging in the animal for data collection, and Omnetics connectors can be difficult to use due to their small size and pin density. Mistakes during the plug cycle can damage expensive equipment or even cause the implant to fall off prematurely. Anesthetizing the animal to make the plug-in process easier is time-consuming and can impact animal performance in tasks related to learning and cognition. However, the µHDMI connector used in the X-Headstage™ makes the plug-in process straightforward and stress-free with its reliable lock-in feedback and keyed orientation. Compared to the 12-pin Omnetics alternative, data collection through the HDMI system is no longer like rolling the dice.

We also designed the X-Headstage™ signal circuit to be largely compatible with the standard HDMI system. This means that some cables from consumer electronics can be used with the X-Headstage™ and XDAQ™, which can reduce consumable part costs. Our HDMI cable is also as flexible as the blue Intan SPI cable, which is an important feature for practical and efficient designs.



Is X-Headstage's HDMI connector solution the same as ones used by NeuroNexus SmartBox Pro?

The X-Headstage is designed to work with consumer tech HDMI accessories, and we have carefully mapped the signal circuit to ensure maximum compatibility. However, it's important to note that NeuroNexus has a specific custom-made HDMI cable with a different signal pinout. While both cables may use the µHDMI connector, they are not compatible with each other.

Is the X-Headstage available with an Omnetics connector?

The X-Headstage can be configured with a 12-pin Omnetics connector, but we strongly recommend new users to consider using the µHDMI connector instead. It is simple to plug in and unplug and can take advantage of low-cost, flexible cables.

Is the X-Headstage compatible with NeuroNexus SmartBox Pro or other Intan-based digital control systems?

In most cases, a pin-remap adapter will be necessary for using the X-Headstage with other systems. We can produce adapters for other systems if the pinouts are provided. Please contact us for more details.

Adapters for the X-Headstage

The ultra-small connectors used in the X-Headstages™ may not interface directly with existing commercial electrodes. NeuroNexus offers out-of-the-shelf adapter designs for commonly used neural connectors, which not only ensures proper connectivity but also prolongs the lifetime of the headstage. Repeated use can cause wear and tear that can potentially damage the headstage, and using adapters can help mitigate this issue. By utilizing adapter designs, researchers can ensure proper compatibility and extend the lifespan of their X-Headstages™.

View the probe adapters here.

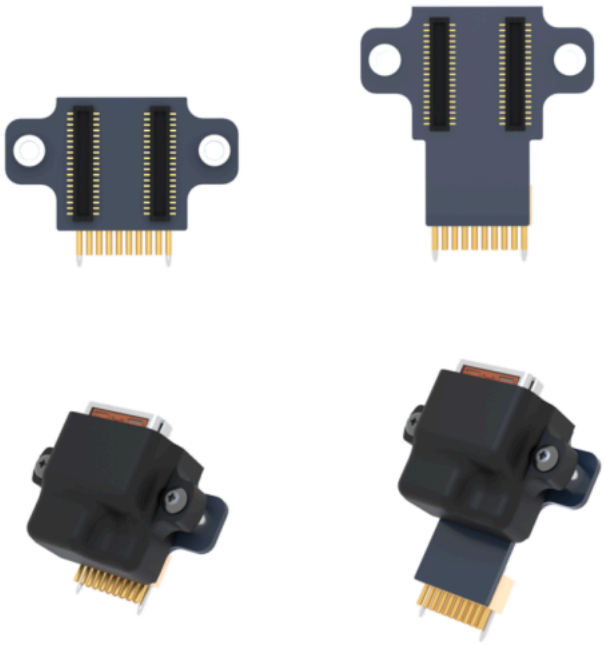
My electrode uses a different kind of connector than what is on the X-Headstage. Can I still use the X-Headstage?

If you use connectors commonly used in neuroscience, it's likely that we already have adaptors available. The X-Headstage is designed to be small, which is why we carefully chose these small industrial connectors. The adaptor-based approach has the advantage of allowing for easy replacement of broken pins while maintaining a smaller size than the conventional headstage design.

If you use commercial silicon or microwire electrodes, we recommend asking your probe vendor to support direct interfaces to the X-Headstage. We are happy to provide the necessary information to facilitate this.

Why are there two types of adapters (vertical design vs regular) for the same probe connector?

The regular adapter is designed with minimal footprint in mind. The vertical design moves the X-Headstage higher away from the skull and allows more space to pack in more implants.



X-Headstage to Other DAQs

To use X-Headstage with other data acquisition systems, such as those from different manufacturers, you may need to use an adapter. Currently, we offer adapters to be used with SmartBox Pro and Intan systems.

It's important to consult with us and to carefully test and validate the system before using it in experiments.

Is armor necessary for the X-Headstage?

While it is possible to use the X-Headstage without the armor, we recommend using it with the armor as it provides an additional layer of mechanical protection. This can help prolong the lifetime of the X-Headstage and reduce the risk of damage to the device.

Can I customize the shape or material of X-Headstage's protective armor?

Yes, please contact us for more information.

What are the weights of the various armor types?

Screw Armor (with screws): 0.24 g

Mini Armor: 0.20 g

IP Armor: 0.27 g

Adhesive adds about 0.10 g

The difference between Omnetics and HDMI connector armor designs is negligible.

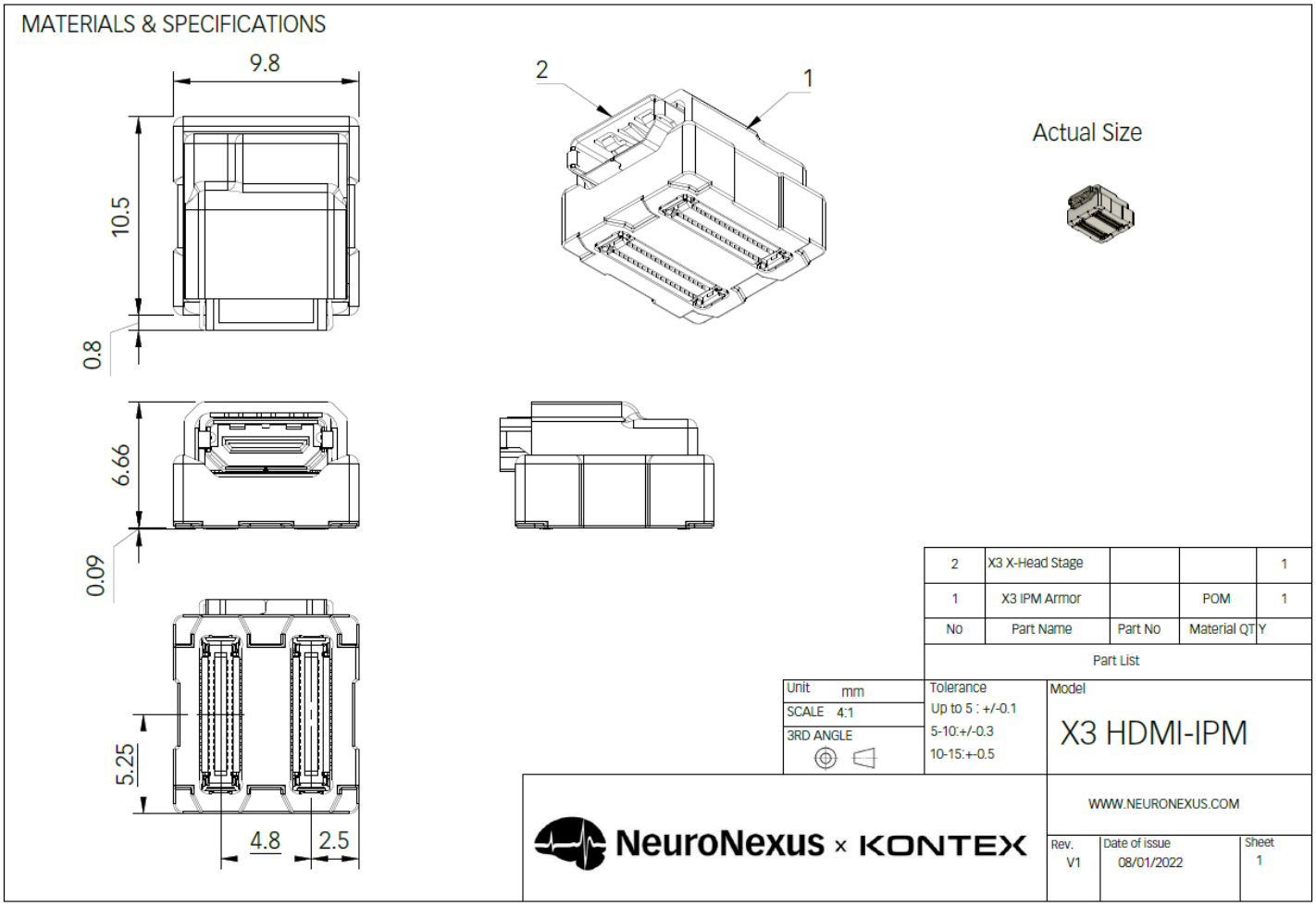
What is the purpose of the ears on the side of the standard armor?

The screw points on the X-Headstage serve as anchoring points to securely attach it to the adapter or even to use as an acrylic anchoring feature. It is not required to use ear type armor to utilize various accessories. The anchoring mechanism can be replaced with dental acrylic, which some users prefer due to its smaller footprint provided by the mini armor.

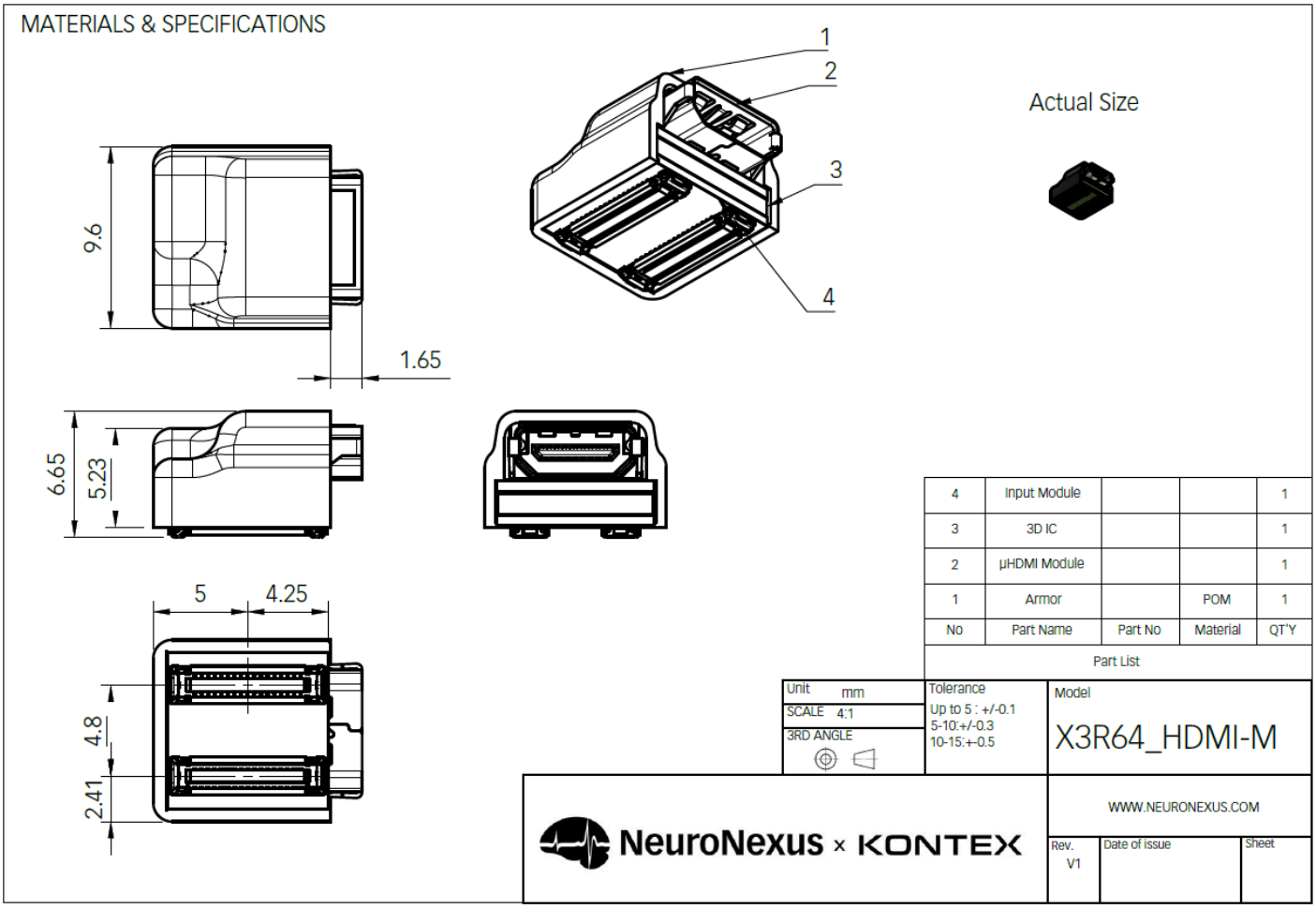
What screws are used in the S Armors?

By default, S Armors come equipped with an M1.2 3 mm captive screw. However, for users who use a remapper or cycle-extender, an optional 5 mm long screw should be used instead. For those who purchase a remapper or cycle-extender, NeuroNexus will supply the 5 mm long screw by default.

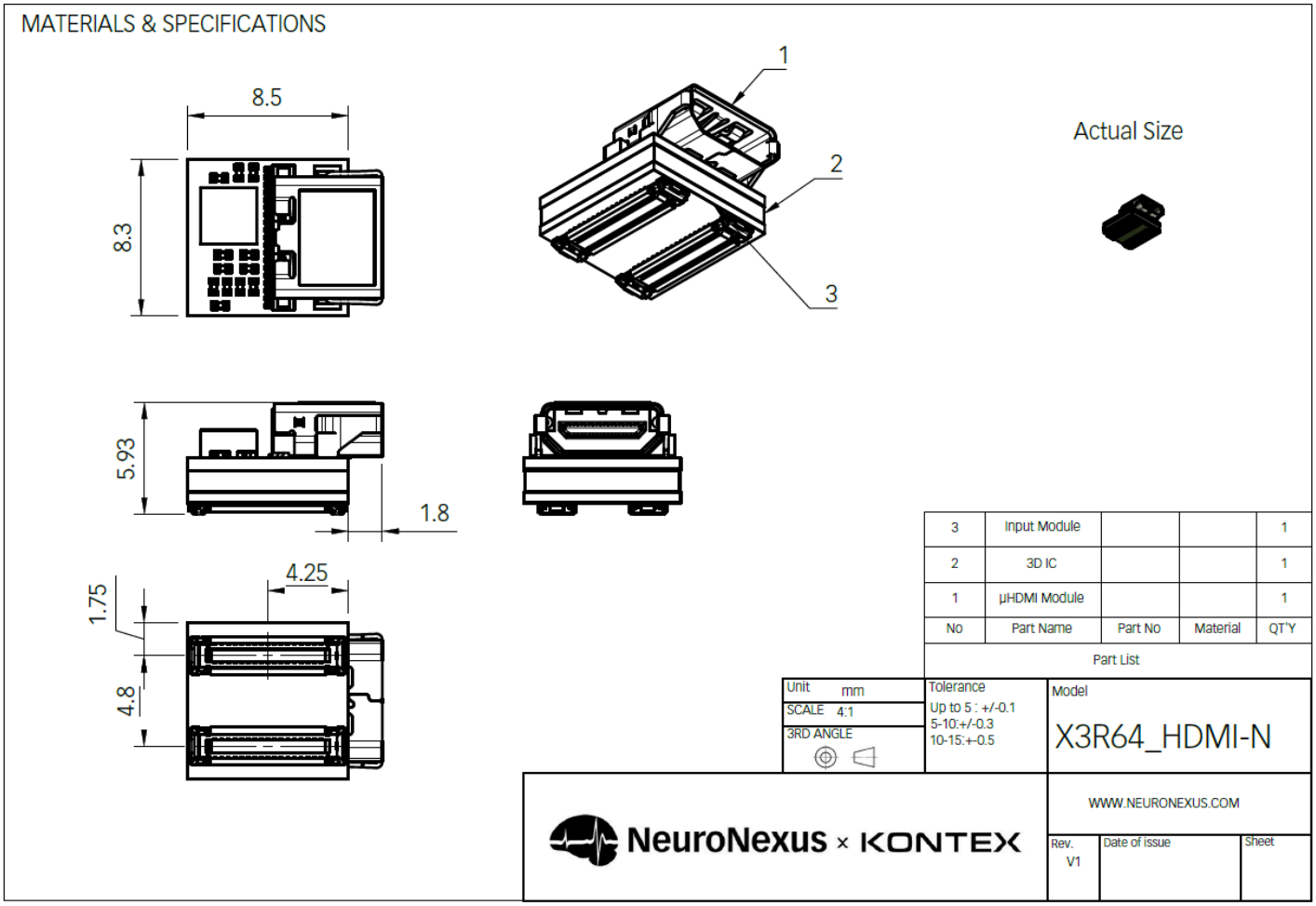
X3-HDMI-IPM


MATERIALS & SPECIFICATIONS
9.8
10.5
0.8
6.66
0.09
5.25
4.8
2.5
2
1
Actual Size
2 X3 X-Head Stage 1
1 X3 IPM Armor POM 1
No Part Name Part No Material QTY
Part List
Unit mm
SCALE 4:1
3RD ANGLE
Tolerance
Up to 5 : +/-0.1
5-10:+/-0.3
10-15:+-0.5
Model
X3 HDMI-IPM
NeuroNexus × KONTEX
WWW.NEURONEXUS.COM
Rev. V1
Date of issue 08/01/2022
Sheet 1

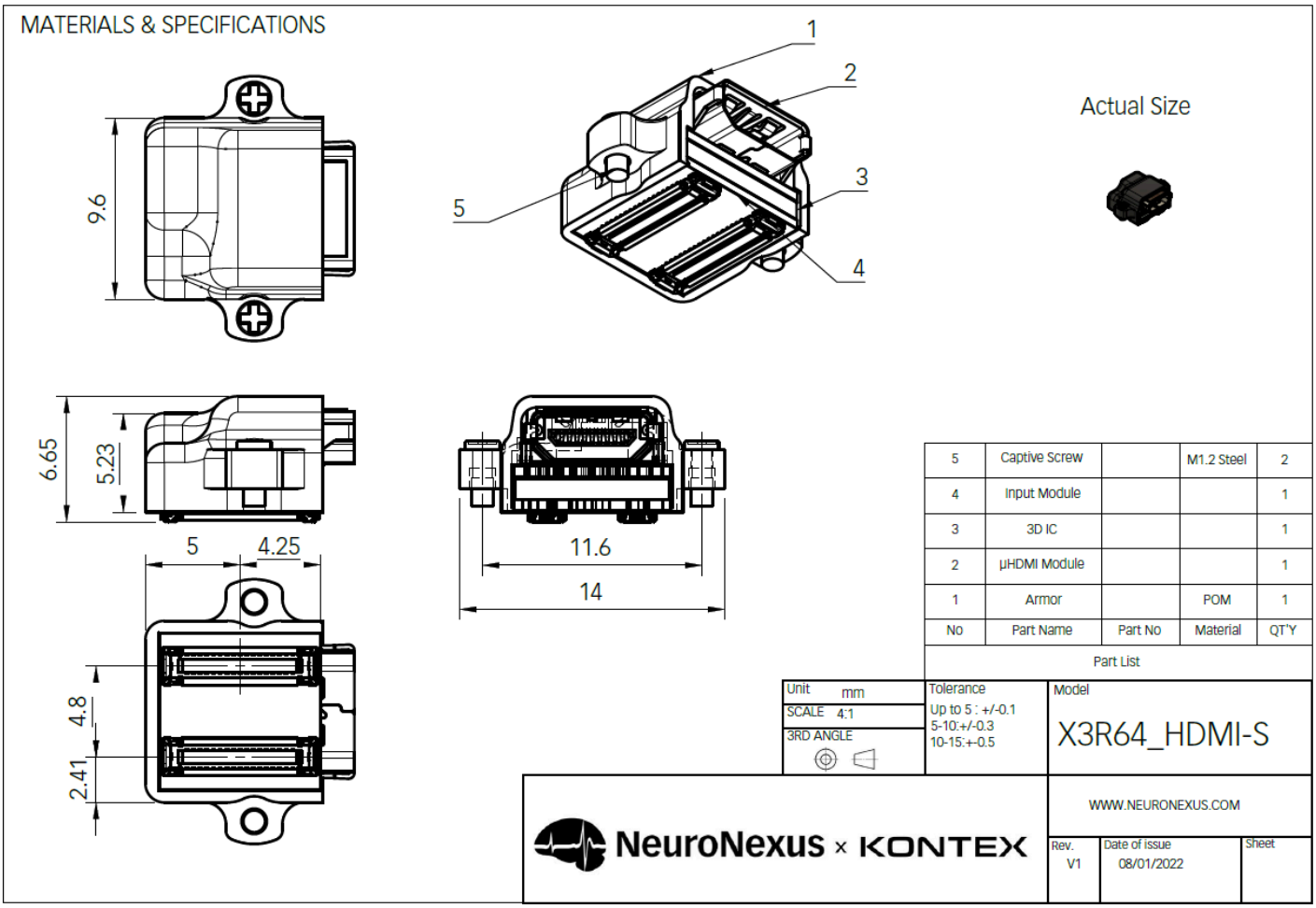
X3R64-HDMI-M


MATERIALS & SPECIFICATIONS
1
2
3
4
Actual Size
9.6
1.65
6.65
5.23
5
4.25
4.8
2.41
4 | Input Module | | | 1
3 | 3D IC | | | 1
2 | µHDMI Module | | | 1
1 | Armor | | POM | 1
No | Part Name | Part No | Material | QT'Y
Part List
Unit mm
SCALE 4:1
3RD ANGLE
Tolerance
Up to 5 : +/-0.1
5-10:+/-0.3
10-15:+-0.5
Model
X3R64_HDMI-M
NeuroNexus x KONTEX
WWW.NEURONEXUS.COM
Rev. V1
Date of issue
Sheet

X3R64-HDMI-N


MATERIALS & SPECIFICATIONS
8.5
8.3
5.93
1.8
4.25
1.75
4.8
1
2
3
Actual Size
3 | Input Module | | | 1
2 | 3D IC | | | 1
1 | µHDMI Module | | | 1
No | Part Name | Part No | Material | QT'Y
Part List
Unit mm
SCALE 4:1
3RD ANGLE
Tolerance
Up to 5 : +/-0.1
5-10:+/-0.3
10-15:+-0.5
Model
X3R64_HDMI-N
NeuroNexus × KONTEX
WWW.NEURONEXUS.COM
Rev. V1
Date of issue
Sheet

X3R64-HDMI-S

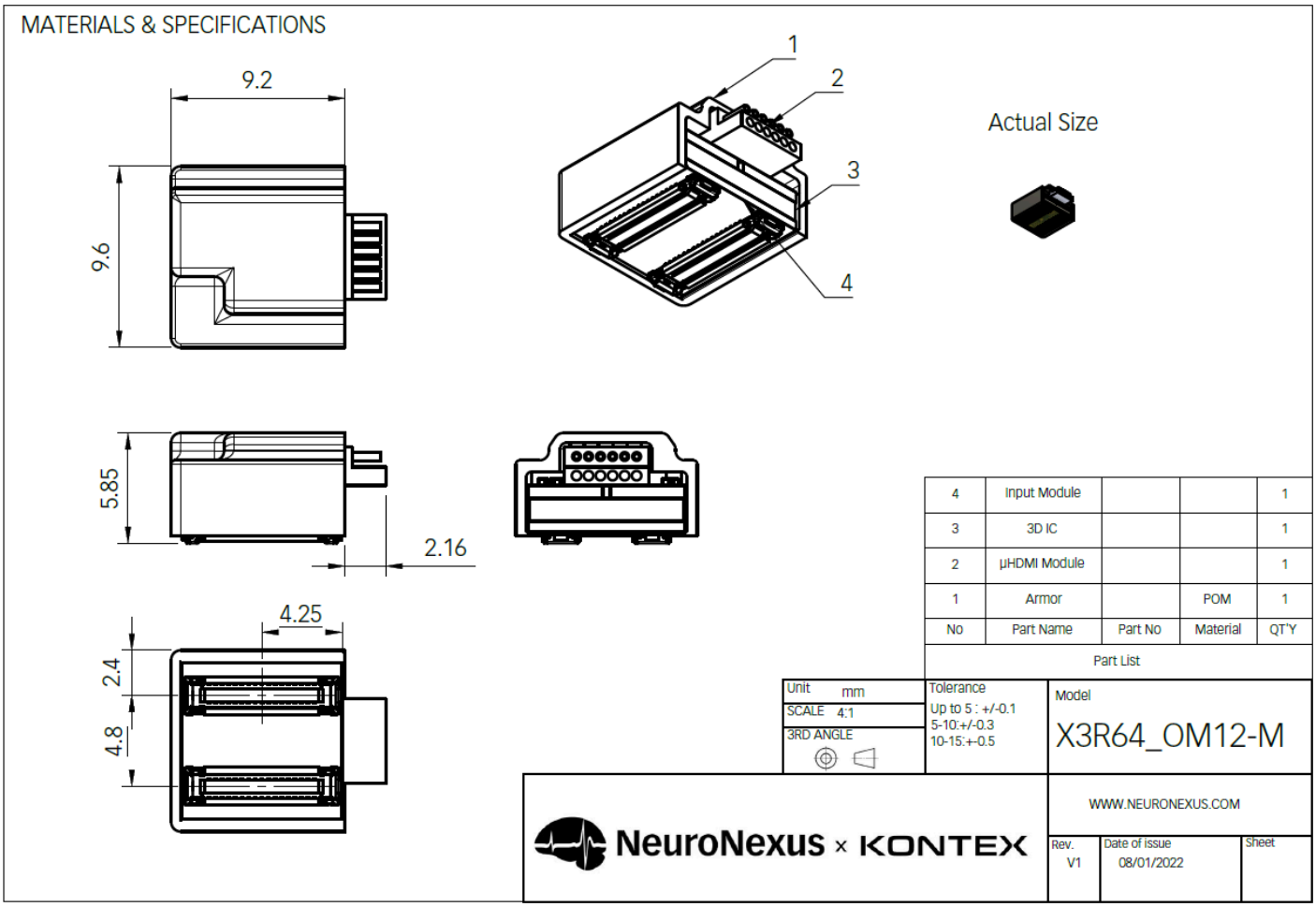


No	Part Name	Part No	Material	QT'Y
5	Captive Screw		M1.2 Steel	2
4	Input Module			1
3	3D IC			1
2	µHDMI Module			1
1	Armor		POM	1

Part List

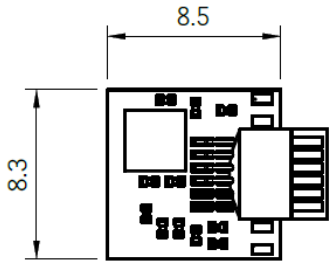
Unit mm SCALE 4:1 3RD ANGLE	Tolerance Up to 5 : +/-0.1 5-10:+/-0.3 10-15:+-0.5	Model X3R64_HDMI-S	
NeuroNexus × KONTEX		WWW.NEURONEXUS.COM	
		Rev. V1	Date of issue 08/01/2022
			Sheet

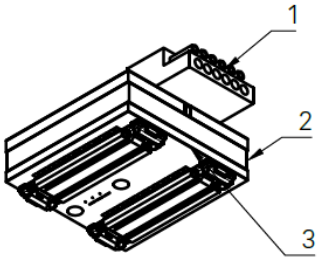
X3R64-OM12-M


MATERIALS & SPECIFICATIONS
9.2
9.6
5.85
2.16
4.25
2.4
4.8
1
2
3
4
Actual Size
4 Input Module 1
3 3D IC 1
2 µHDMI Module 1
1 Armor POM 1
No Part Name Part No Material QT'Y
Part List
Unit mm
SCALE 4:1
3RD ANGLE
Tolerance
Up to 5 : +/-0.1
5-10:+/-0.3
10-15:+-0.5
Model
X3R64_OM12-M
NeuroNexus × KONTEX
WWW.NEURONEXUS.COM
Rev. V1
Date of issue 08/01/2022
Sheet

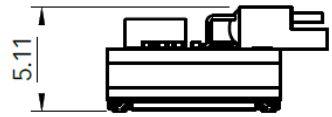
X3R64-OM12-N

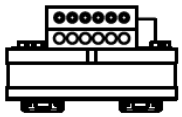
MATERIALS & SPECIFICATIONS

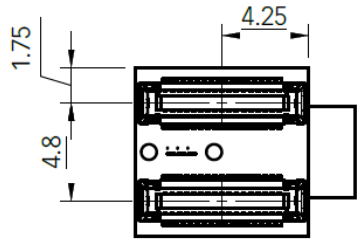




Actual Size





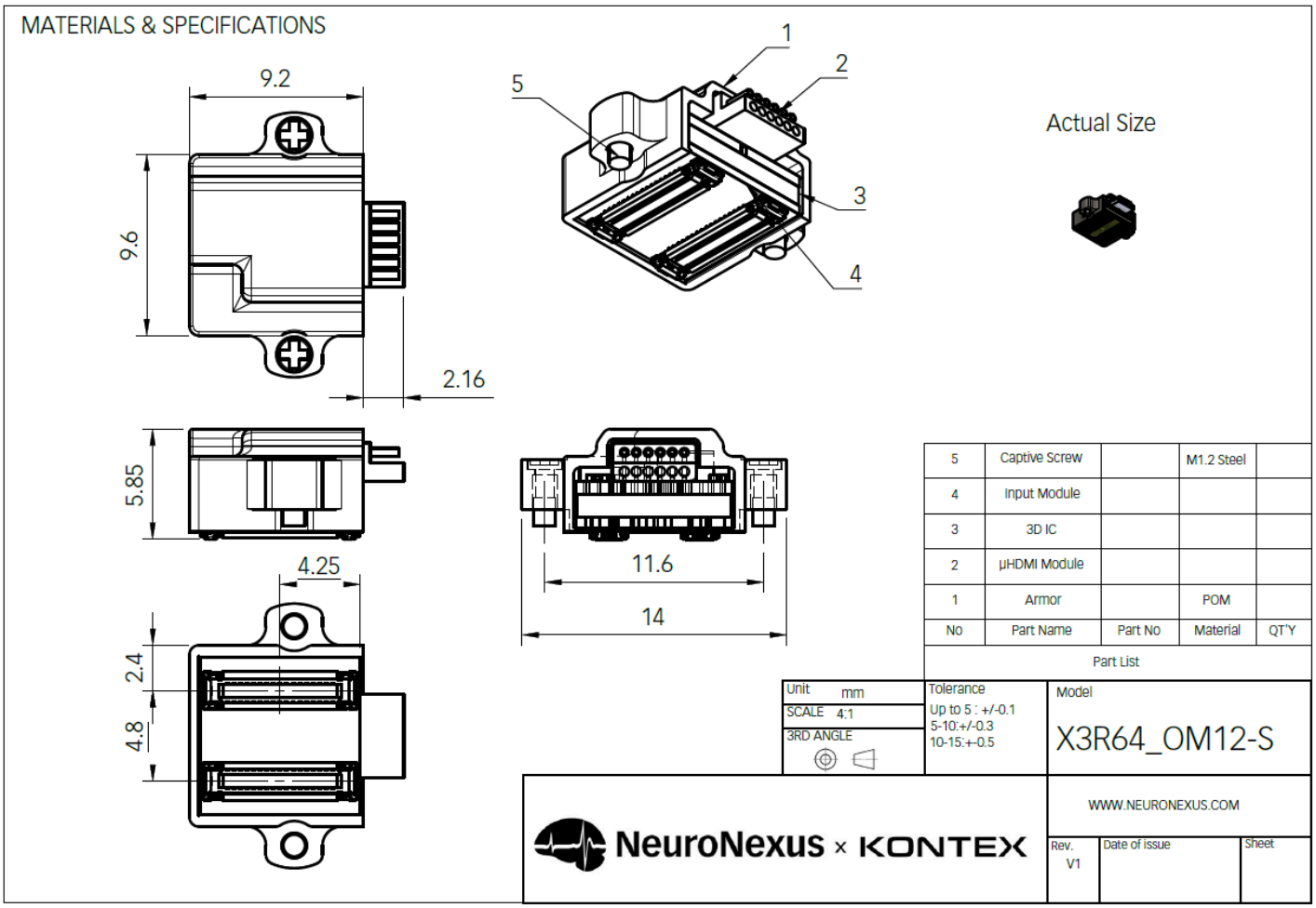


No	Part Name	Part No	Material	QT'Y
3	Input Module			1
2	3D IC			1
1	Om12 Module			1

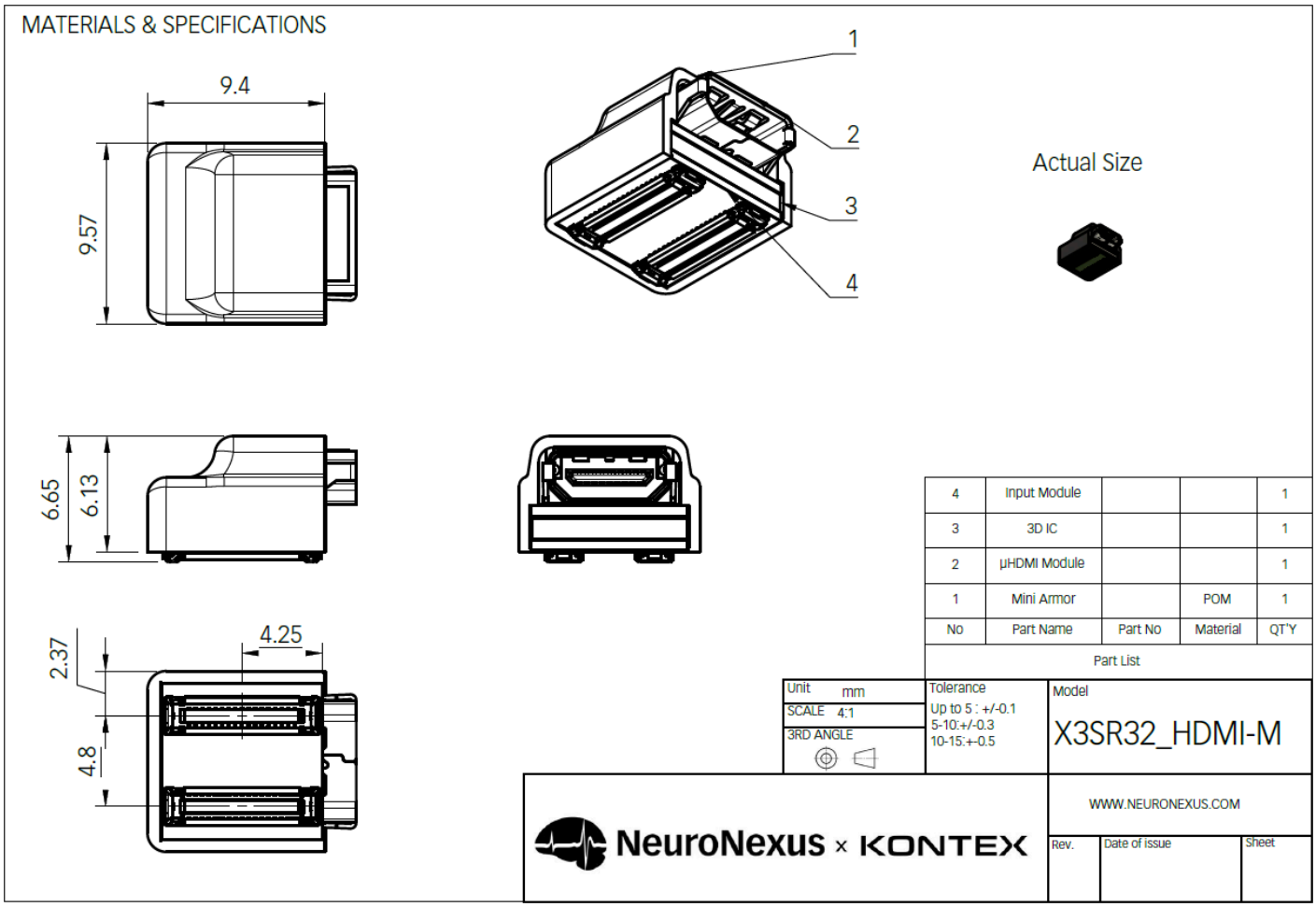
Part List

Unit mm SCALE 4:1 3RD ANGLE	Tolerance Up to 5 : +/-0.1 5-10:+/-0.3 10-15:+-0.5	Model X3R64_OM12-N	
NeuroNexus × KONTEX		WWW.NEURONEXUS.COM	
		Rev. V1	Date of issue 08/01/2022
			Sheet

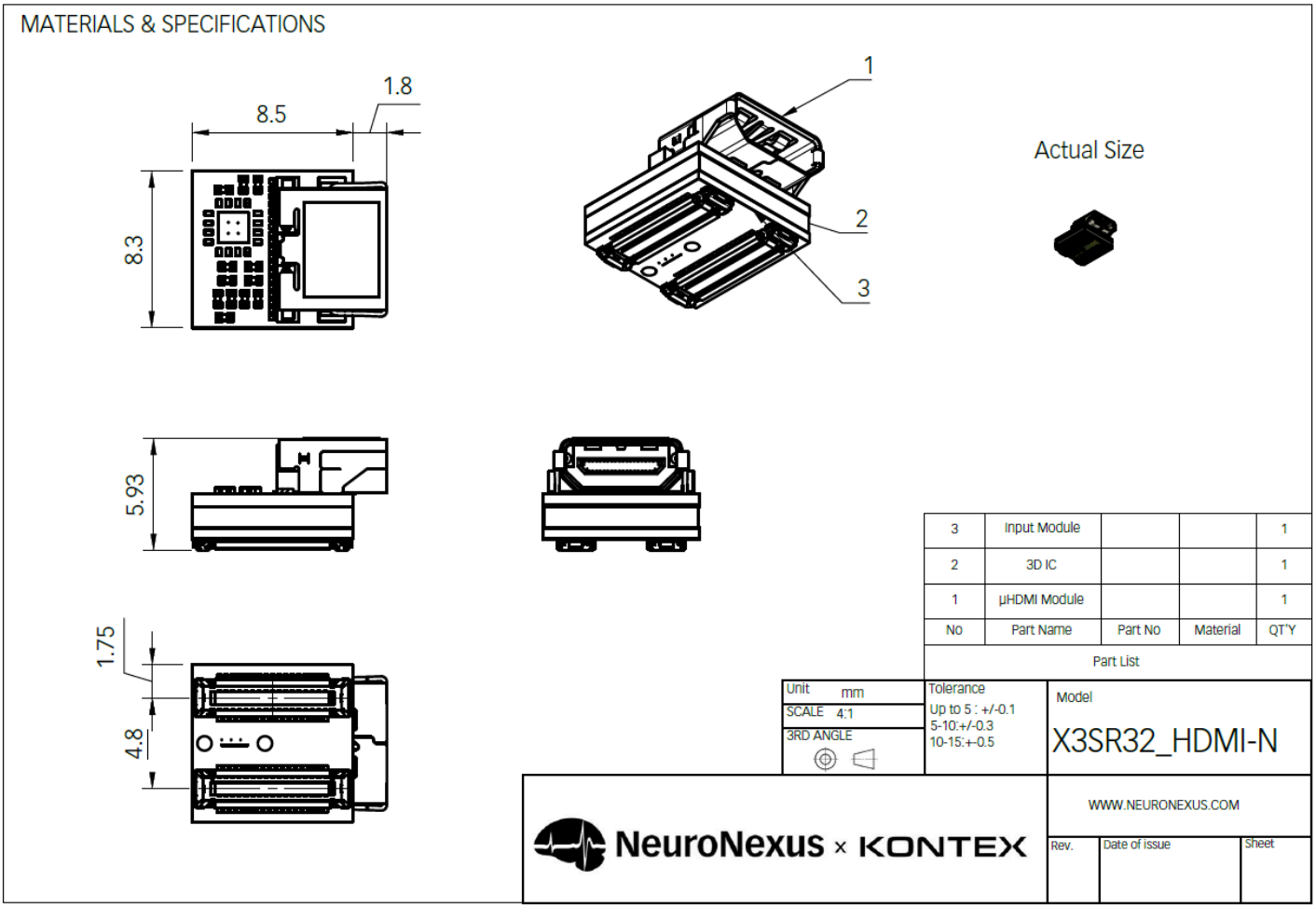
X3R64-OM12-S


MATERIALS & SPECIFICATIONS
9.2
9.6
2.16
5.85
4.25
2.4
4.8
1
2
3
4
5
11.6
14
Actual Size
5 Captive Screw M1.2 Steel
4 Input Module
3 3D IC
2 µHDMI Module
1 Armor POM
No Part Name Part No Material QT'Y
Part List
Unit mm
SCALE 4:1
3RD ANGLE
Tolerance
Up to 5 : +/-0.1
5-10:+/-0.3
10-15:+-0.5
Model
X3R64_OM12-S
NeuroNexus x KONTEX
WWW.NEURONEXUS.COM
Rev. V1
Date of issue
Sheet

X3SR32-HDMI-M



X3SR32-HDMI-N



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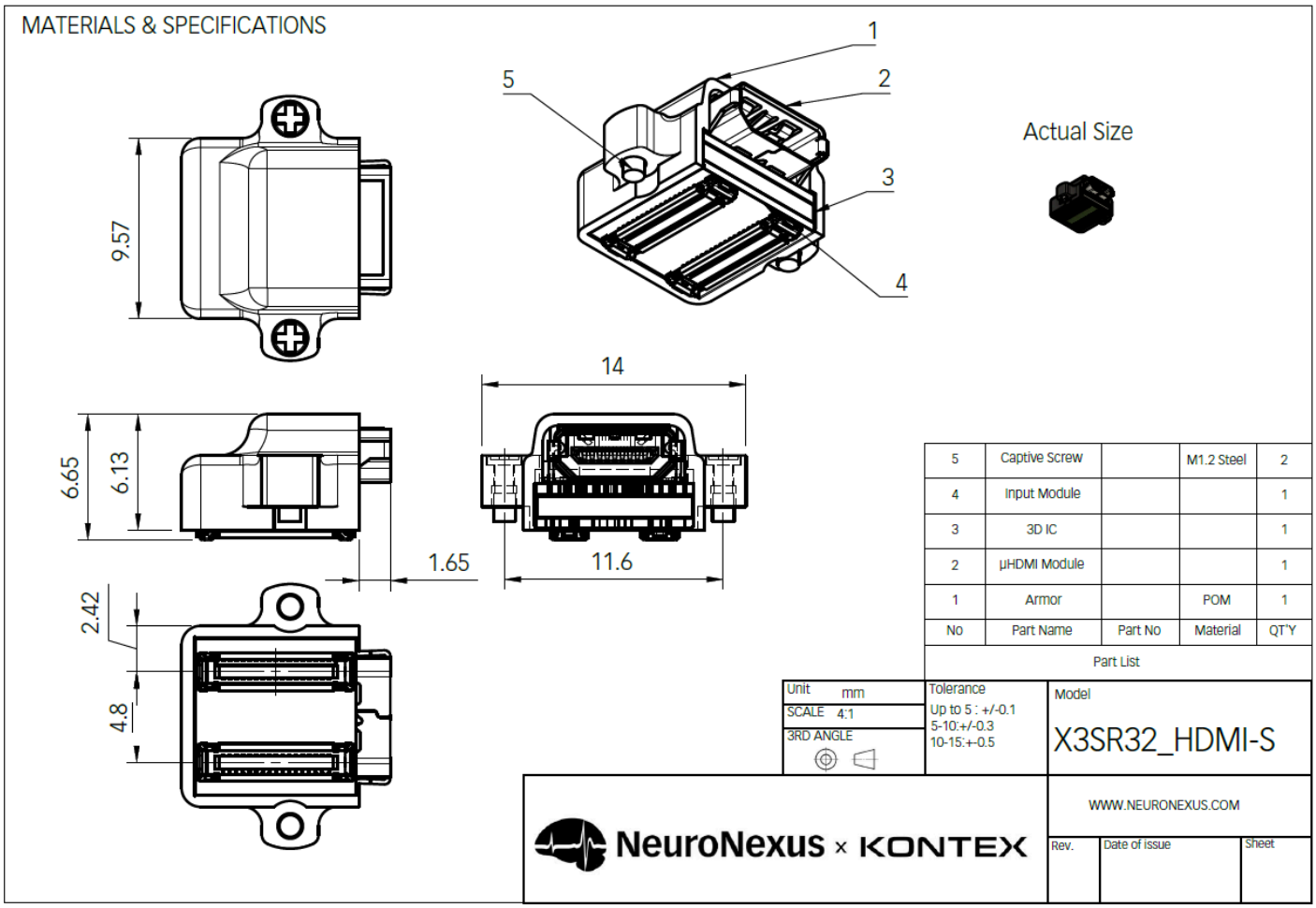
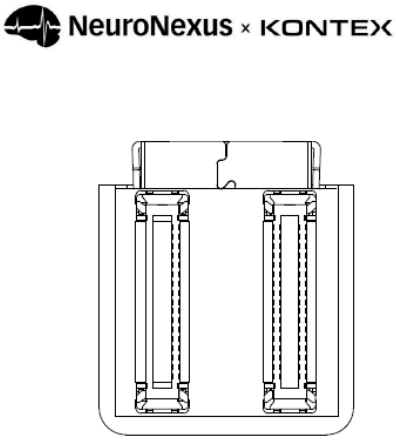
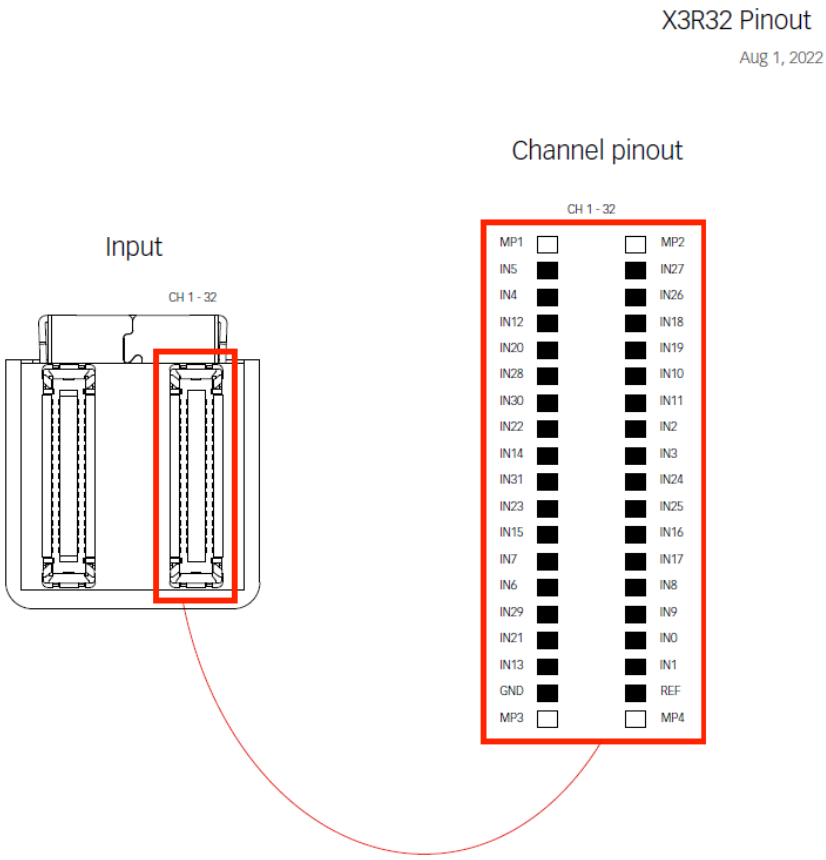


Where do I find the pinout of X-Headstage or its adapters?

If you need access to the mapping, pin out, spec sheet, engineering drawing, 3D models, or any other technical documentation for the X-Headstage that is not available on our knowledge base, please contact us and we will be happy to provide it to you.

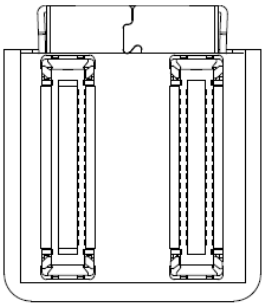
X3R32 Pinout



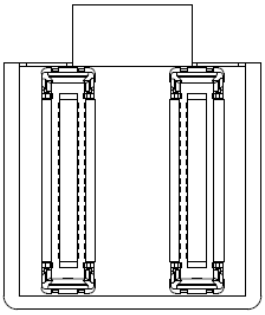


X3R64 Pinout

NeuroNexus × KONTEX



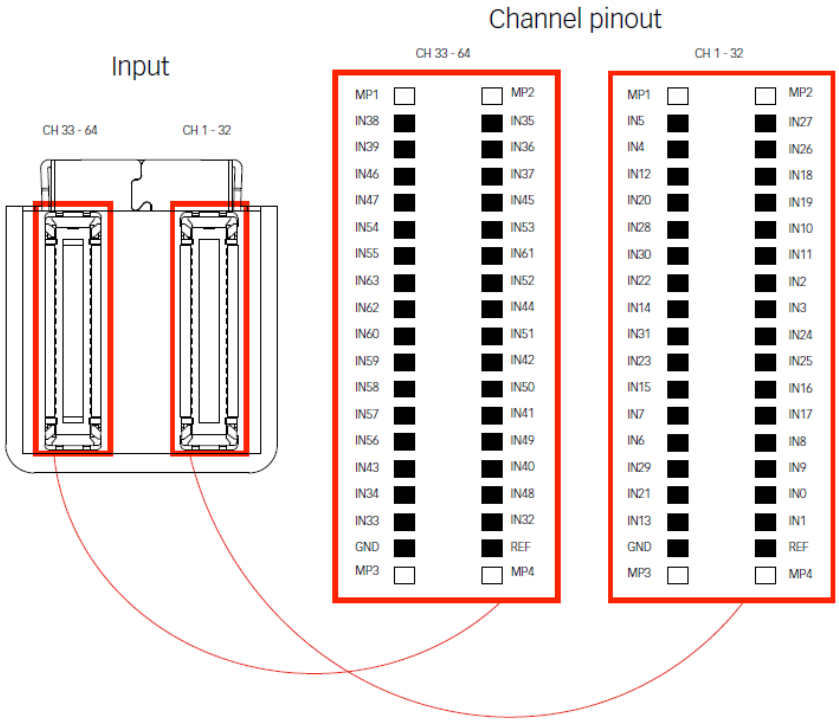
µHDMI



12pin Omnetics

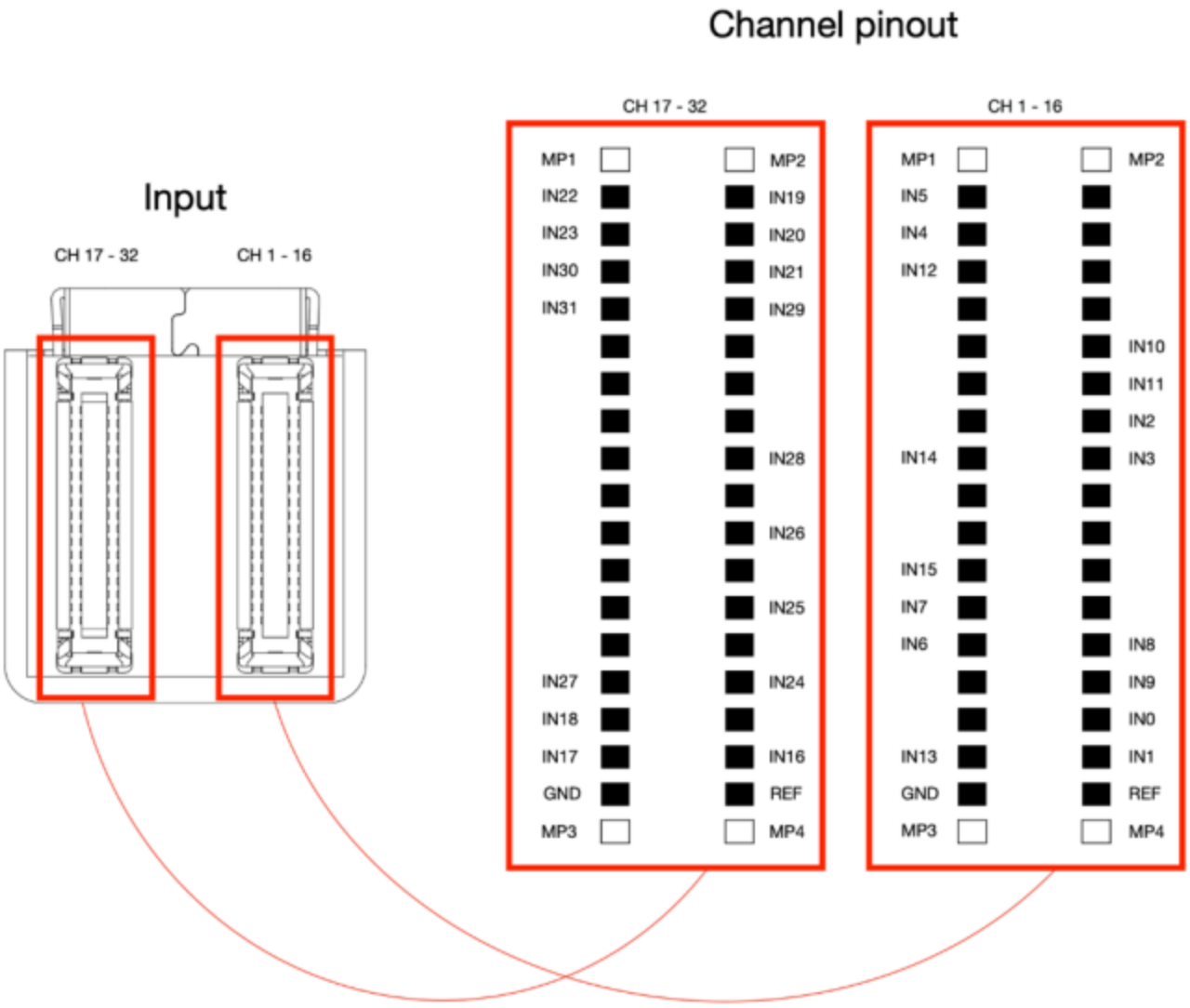
X3R64 Pinout

Aug 1, 2022



X3SR Pinout

The X-Headstage is manufactured using advanced packaging technology, which means that there are multiple ICs inside each chip. For example, the X3SR32 contains two Intan RHS2116 dies, with each die connected to one of the two X3BtB connectors. This configuration maintains compatibility with other X3 series chips, but it means that only 16 out of 32 channels (34 channels if including GND and Ref) are activated. The pinout map is available on the X3SR32 section, along with other related resource files.



3D Print the X-Headstages

The X-Headstage is remarkably small, which opens up the possibility of new techniques, such as embedding the headstage with the electrode. To facilitate this, users may find it helpful to 3D print the X-Headstage prior to ordering to simulate a mock surgery.

We provide CAD models for most of our products, which can be found on this knowledge base. Please note that the model may vary depending on the specific configuration. If the 3D model you require is missing, please do not hesitate to contact us.

3D Model of X3R Headstage

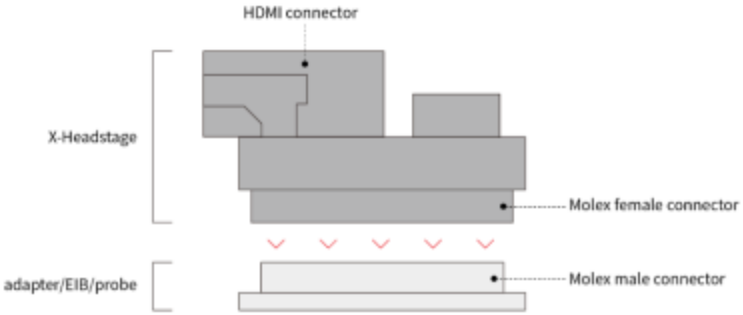
- X3R-HDMI-M
- X3R-HDMI-N
- X3R-HDMI-S
- X3R-OM12-M
- X3R-OM12-N
- X3R-OM12-S
- X3R64-HDMI-IPM
- X3R64-HDMI-N
- X3R64-HDMI-M-ACC
- X3R64-HDMI-S-ACC

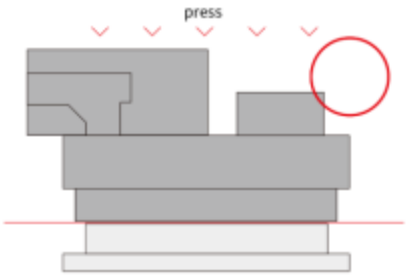
3D Model of X6R Headstage

- X6R-HDMI-N
- X6R128-HDMI-M
- X6R256-HDMI-M (step file)
- X6R256-HDMI-M (STL file)
- X6R256-HDMI-N

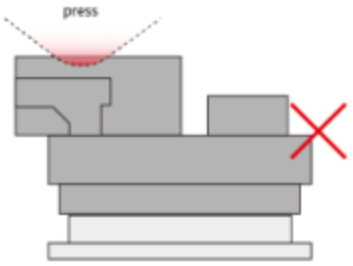
Handling the X-Headstage

Handling the X-Headstage™ properly is essential to ensure its longevity and reliability. To connect the EIB/Probe/Adapter, align the two units directly on top of each other and apply equal force along the entire area. A satisfying lock feel indicates that the connectors are plugged in correctly. It is important to establish a good connection before screwing the X-Headstage™ with standard armor into an adapter. Following these guidelines will help ensure the X-Headstage™ is properly handled and functions optimally.

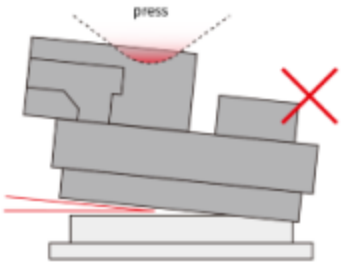




push the whole connector evenly in parallel

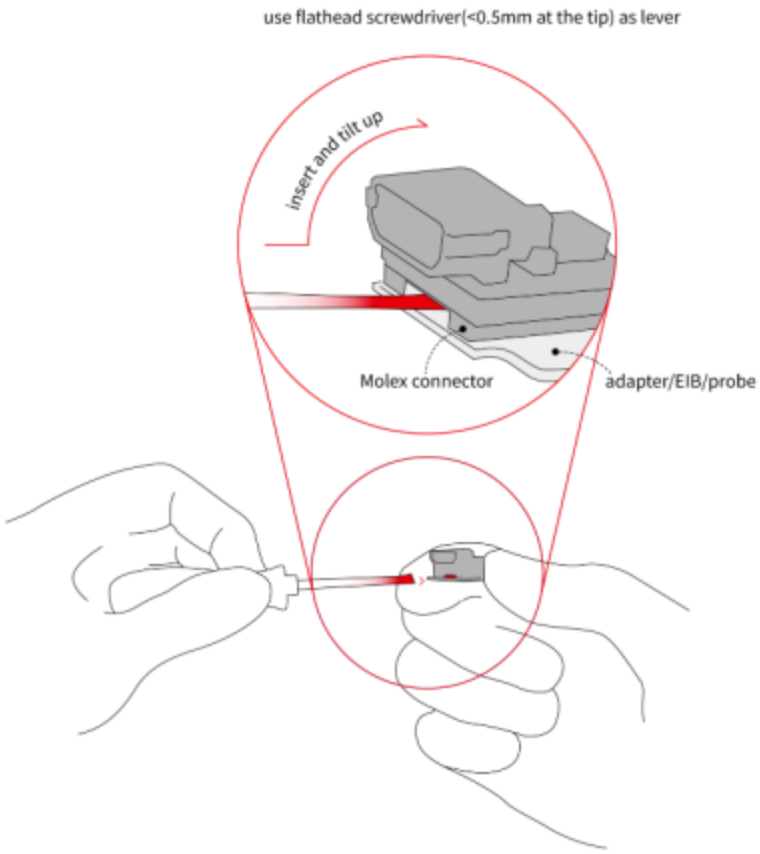


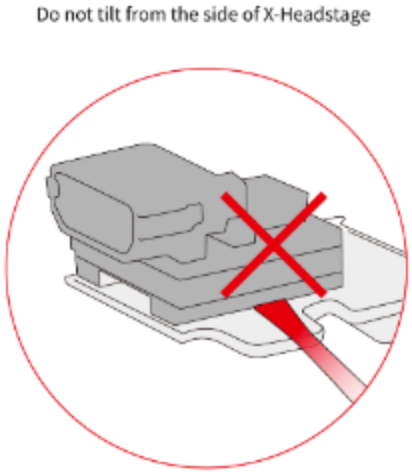
DO NOT push the only end of connector



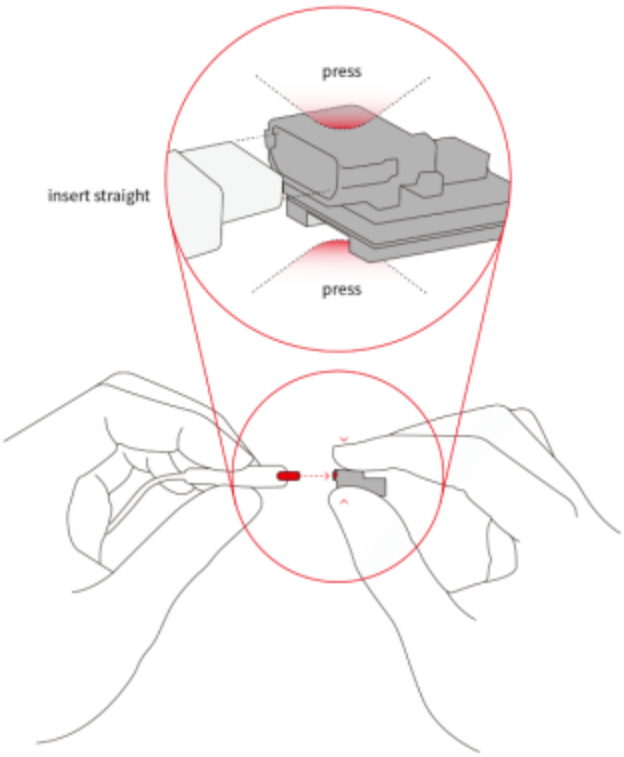
DO NOT push when the connector is not parallel

To detach the EIB/adapter from the X-Headstage™, use a small flat screwdriver and tilt the EIB or probe boards away from the X-Headstage™ either from the top (HDMI or Omnetics connector) or bottom side. It is important not to push the EIB/probe along the side (the long side) to avoid damaging the connectors. Following this procedure will help ensure safe detachment of the EIB/adapter from the X-Headstage™.





When plugging in the cable to the X-Headstage™, it is important to exert some pressure over the HDMI/Omnetics connector to minimize any tear between the stacks of PCBs in the X-Headstage™. This is especially crucial for X-Headstage™ models without armor protection. Proper handling of the connector will help ensure the longevity and reliability of the X-Headstage™.



Is there a proper way to plug and unplug connectors from X-Headstage?

When plugging and unplugging the connector, it is recommended to do so along the long side of the connector. If the connectors are properly plugged in, you should feel a satisfying lock. It's important to ensure a good connection is established before screwing the X-Headstage with standard armor into an adapter.

To unplug the EIB/adapter from the headstage, use a small flat screwdriver to push the EIB or probe boards away from the X-Headstage from either the top or bottom side (the short side). Do not push the EIB/probe along the side (the long side).

How do you recover X-Headstage from dental cement?

Dental acrylic is commonly used to secure implant materials on the skull. To recover the X-Headstage™ and electrode at the end of the experiment, the headstage must be separated from the acrylic, typically after the brain has been perfused and extracted. Acetone is effective in softening and dissolving dental acrylic, and leaving the extracted implant in acetone overnight will soften the acrylic sufficiently for it to be peeled and broken off from the X-Headstage™. To avoid particles from clogging the connector pins during the soaking and detaching process, it is recommended to apply a thin layer of Vaseline around the XHS probe connectors during the embedding step. Additionally, during the application and dissolving stage, it is advisable to connect the cable to prevent any accidental dripping of acrylic into the connector.

Embedding X-Headstage™

To protect the connector region, connect both probe connectors in the X-Headstage™ and cover them.

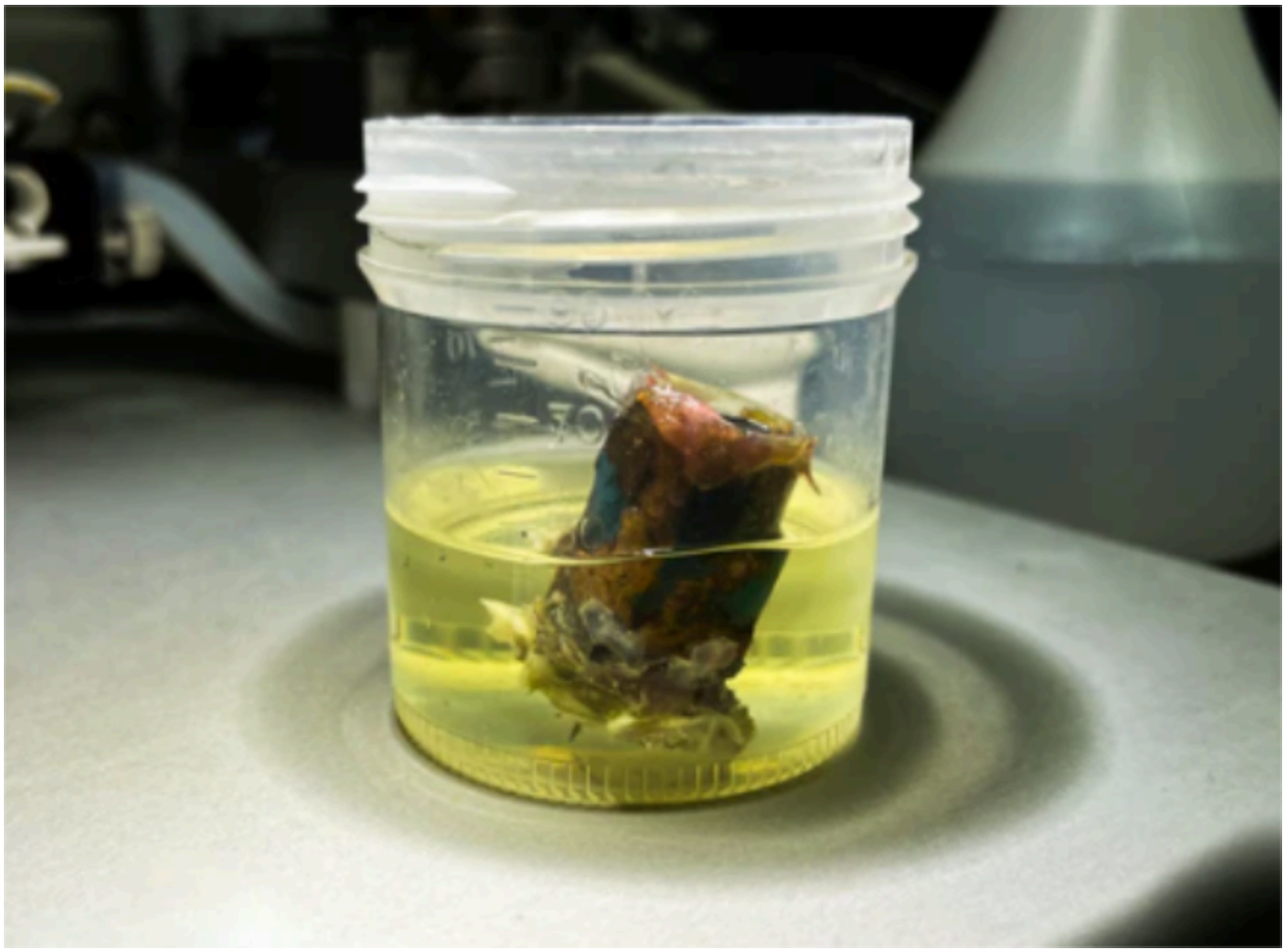
Apply a thin layer of Vaseline around the X-Headstage™'s probe connectors during the embedding step to prevent particles from clogging the connector pins.

During the acrylic application phase, either plug in a cable to the X-Headstage™ system connector (HDMI or Omnetics), or protect the connector to prevent any accidental dripping of acrylic into the connector.

Some users have recommended using a segment of a syringe tube as a container and outer barrier for holding the dental acrylic. Once the X-Headstage™ and electrode have been anchored, place the tube around the implant and pour the acrylic in the tube to hold and protect the entire implant. The tube also serves as a handling point, making it easy to plug in the cable for data collection.

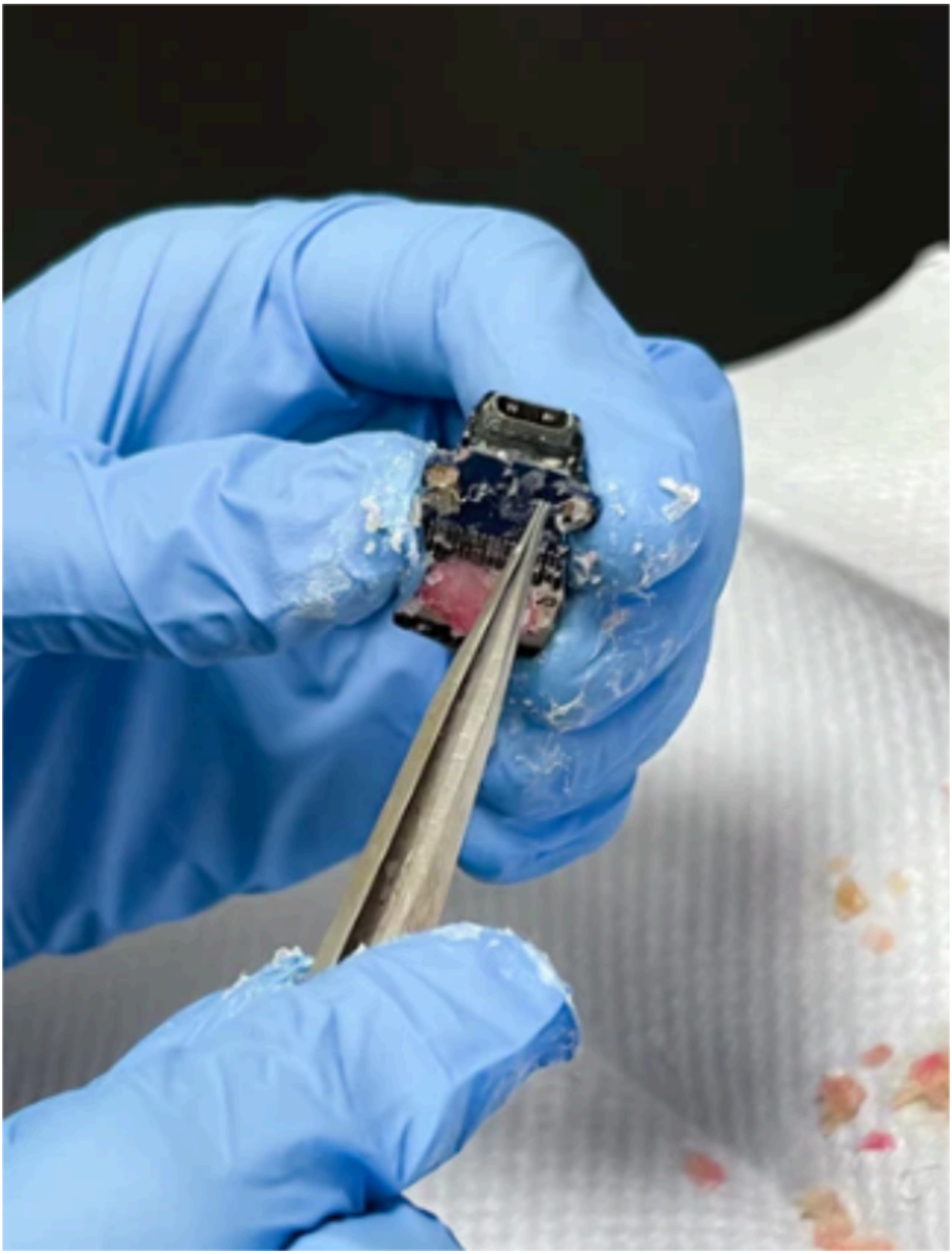
Recovering X-Headstage™

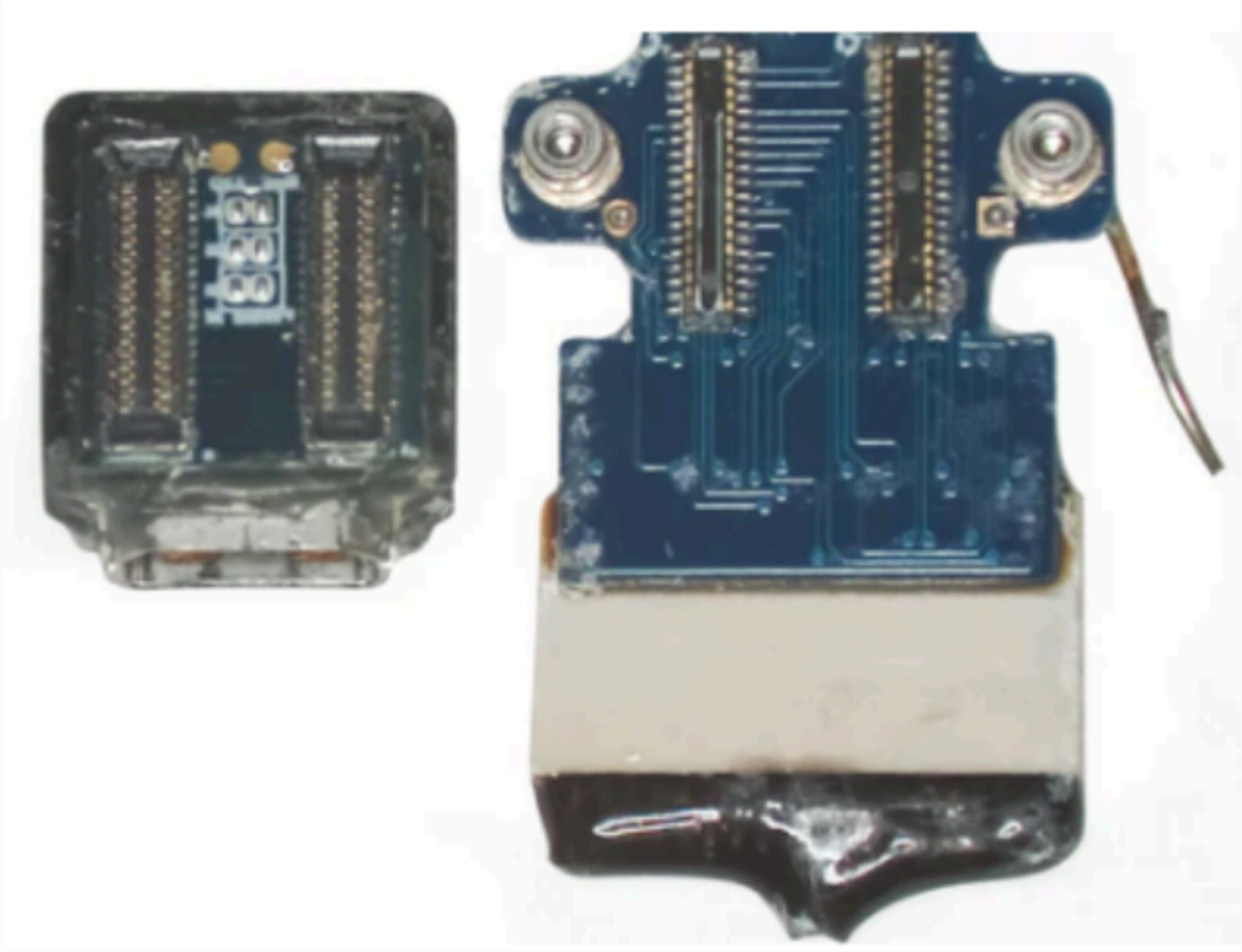
To soak the extracted implant in acetone, suspend it in the center of a beaker or jar. Cut an old HDMI cable and attach it to the lid of the jar by drilling a hole. Feed the cable through the hole, and then apply epoxy or glue to secure it. Fill the jar with acetone, making sure that the liquid is just below the HDMI connector. To prevent acetone vapor from leaking into the connector, apply a thin layer of Vaseline around the joint. Allow the implant to soak overnight.



After soaking the extracted implant in acetone overnight, the solvent in the jar may become murky with particles settling at the bottom. Carefully remove the implant from the jar and start peeling off the softened acrylic until the EIB or probe PCB is exposed and can be removed. You may need to soak the implant in acetone again if the acrylic is not soft enough to be peeled off easily.

If you notice any residual particles on the connector after removing the softened acrylic, you can clean it by gently spraying a stream of acetone. Be sure to use a gentle stream to avoid damaging the connector.





Allow the X-Headstage™ to air dry completely before testing. To verify its functionality, use the impedance test module and brainwave simulator. The headstage should be able to perform measurements and recordings at the appropriate level. If everything checks out, your X-Headstage™ is now ready for another round of experiments!

Notes regarding the reliability of the connectors used on the X-Headstage

The X-Headstage employs ultra-small board-to-board connectors commonly used in the PC industry. While manufacturers rate these connectors at 50 cycles, our testing has shown that they can withstand over 200 cycles. While reliability concerns have been raised by some companies that have used this type of connector, our design addresses these concerns in several ways.

First, the X-Headstage is designed to be embedded with the electrode, which improves signal quality and makes daily plug-ins easier. As a result, we expect the plug and unplug cycle to occur only after each chronic experiment, meaning one mating cycle every 3-4 months or longer. Even with a conservative rating from manufacturers, this means the X-Headstage can be used for well over 10 years.

Second, the X-Headstage uses an adapter-based solution to interface with standard neural connectors such as those from Omnetics. Since the X-Headstage is attached only once to the adapter and securely locked with screw armor, the plug-unplug cycle limitation does not apply to the actual connectors on the X-Headstage. Moreover, when Omnetics connectors eventually fail, it is much more economical to replace the adapters instead of the entire headstage.

We designed the X-Headstage with throwaway adapters that serve as the primary interface with the electrode side. If an adapter does break, it can be easily replaced with a new cycle extension adapter.

NeuroNexus's technicians and engineers, based in the electronics manufacturing hub of Taiwan, are well-trained in complex electronics repair. We offer repair services to replace the entire connector modules of the X-Headstages for a fee. Although we cannot guarantee every repair will be successful due to eventual decay at the solder joints, NeuroNexus will attempt the repair and fully test the repaired X-Headstage. If the repair is unsuccessful, you will not be charged. For more information, please see our repair and service policy.

Repair & Service

If you encounter any problems with your X-Headstage™, the most common issue is broken connectors due to mechanical wear. If you need to send your X-Headstage™ back for repair, we will replace the input and output modules with brand new components. Please contact us for more information about pricing.

If your X-Headstage™ has been embedded, it is important to ensure that all soft tissues have been removed and it is free of any biological contamination before sending it back. Please note that due to the challenging conditions the headstages are used in, and the limitations of repairs in general, we cannot guarantee that all repairs will be successful. We will determine if the X-Headstage™ can be repaired upon receipt and inspection. If the repair is unsuccessful, you will not be charged. However, please note that you will be responsible for the round trip shipping costs.

What chips are used in the X3 and X6 series X-Headstages?

The X3- and X6- series X-Headstages are built around Intan Technologies ASIC and NeuroNexus utilizes advanced chip packaging technologies to incorporate multiple ICs within each chip. Here are the specific configurations:

X3R32 - 1 RHD2132

X3R64 - 2 RHD2132

X3SR32 - 2 RHS2116

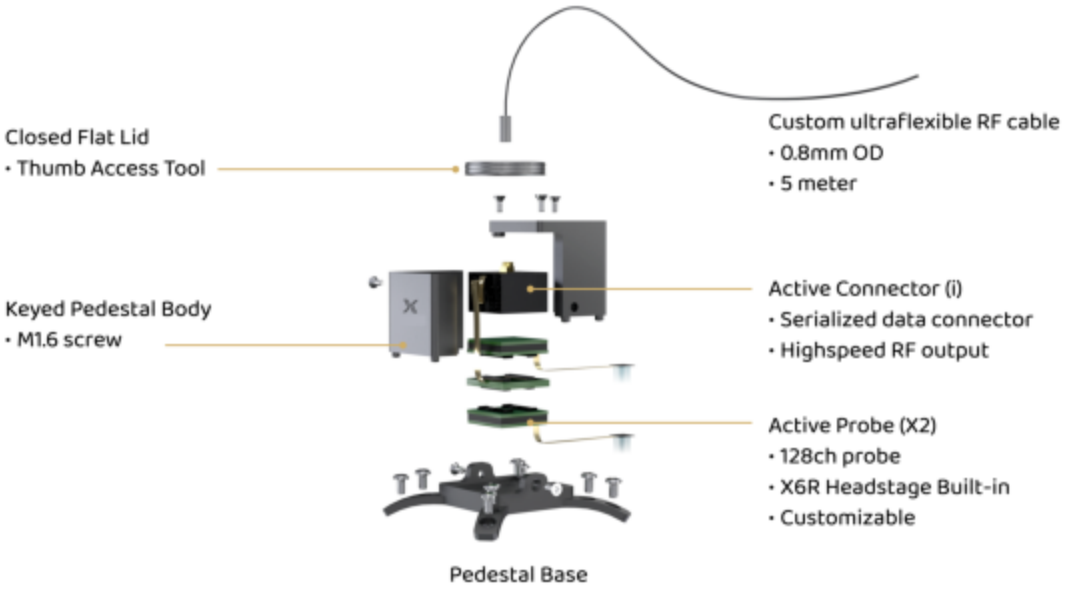
X6R128 - 2 RHD2164

When using the X-Headstage with certain Open Source applications, multiple chips may appear in the graphical user interface (GUI) due to the presence of these multiple ICs.

Can X-Headstage be used for non-human primate experiments?

The X-Headstage™ is adaptable for use in non-human primate (NHP) experiments and is compatible with various pedestal or chamber designs commonly used in such experiments. At NeuroNexus, we are working on developing specific solutions for NHP experiments using the X-Headstage™.

If you would like more information on how the X-Headstage™ can be used in NHP experiments or our specific solutions for NHP experiments, please do not hesitate to contact us. We would be happy to provide more details and discuss how the X-Headstage™ can benefit your research.



Notes regarding the reliability of the connectors used on the X-Headstage

The X-Headstage uses ultra-small board-to-board connectors commonly found in the PC industry. These connectors typically have a cycle rating of around 50 cycles according to manufacturers, but in testing, NeuroNexus has found that they can withstand over 200 cycles. While other companies have experienced reliability issues with this type of connector, NeuroNexus's design differs in several ways that make reliability less of a concern.

Firstly, the X-Headstage is designed to be embedded with the electrode, which improves signal quality and makes daily plugins effortless with the easy-to-use HDMI connector. As a result, plug and unplug cycles are expected to occur only after each chronic experiment, when the electrode board is removed from the X-Headstage. This means that there will only be one mating cycle every 3-4 months or longer. Even with conservative manufacturer ratings, this means a usage time of well over 10 years.

Secondly, the X-Headstage uses an adapter-based solution to interface with standard neural connectors, such as those from Omnetics. Since the X-Headstage is attached only once to the adapter and is securely locked with screw armor, the plug-unplug cycle limitation does not apply to the actual connectors on the X-Headstage. When the Omnetics connectors eventually fail, it is much more economical to replace the adapters rather than the entire headstage.

Additionally, NeuroNexus designed throw-away adapters that serve as the primary interface with the electrode side. If they break, simply replace the cycle extension adapter.

Lastly, our technicians and engineers are well trained in complex electronics repair. We offer repair services to replace the entire connector modules of the X-Headstages for a fee, which can extend the lifespan of your headstage investment. While we cannot guarantee that every repair will be successful, we will attempt the repair and fully test

the repaired X-Headstage. If the repair is unsuccessful, you will not be charged. See our repair and service section for more information.

Do I need to use XDAQ system to use the X-Headstage?

No. The X-Headstage™ can indeed be used with any existing Intan compatible controllers, including those from Intan, Open-Ephys, and others. The X-Headstage™ is designed with a micro HDMI connector, which is easy to plug in and can leverage NeuroNexus's low-cost, ultraflexible cable solution.

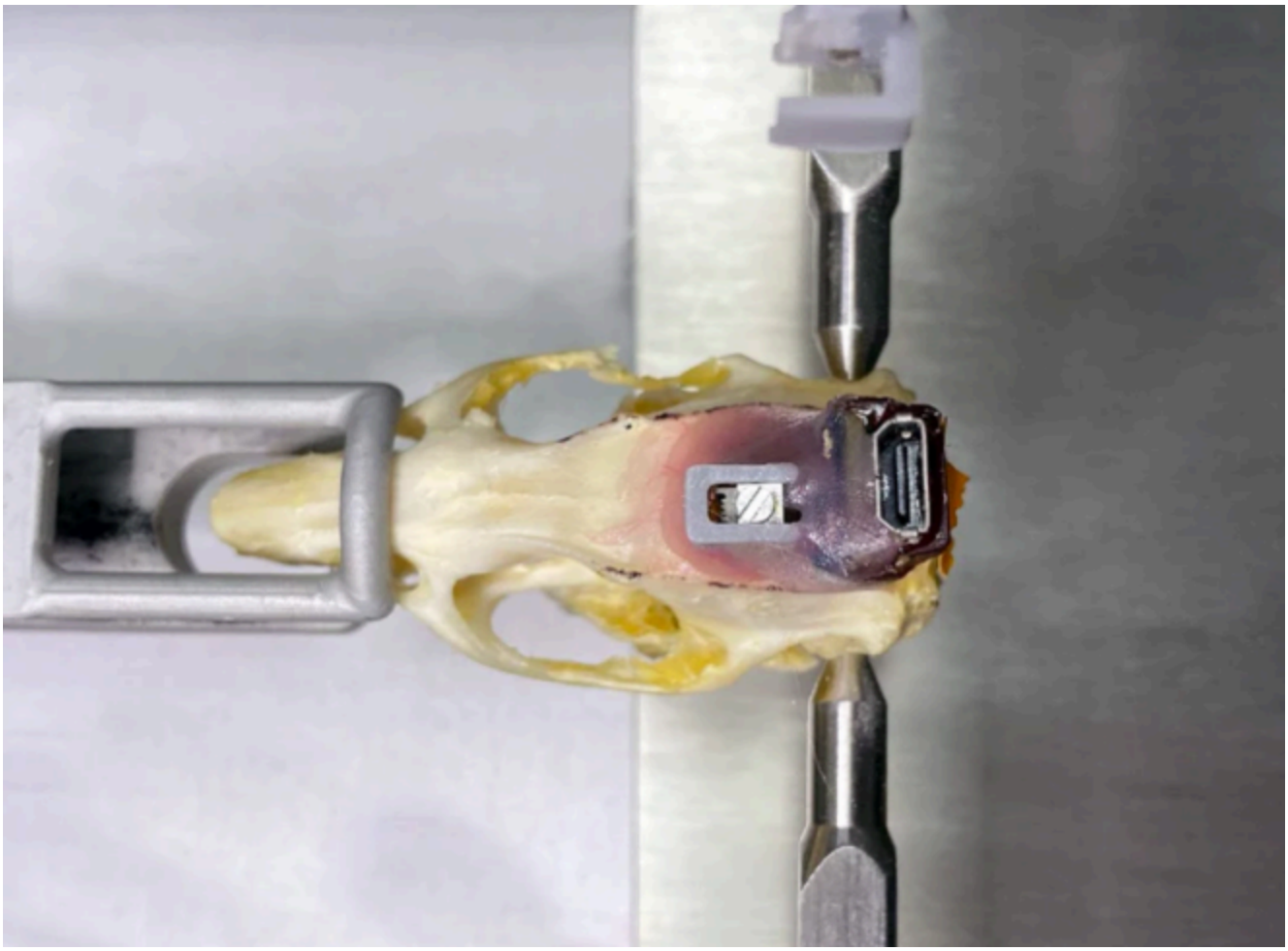
NeuroNexus provides adapters to interface the micro HDMI connector with Intan's 12-pin or 16-pin connector to their system. Alternatively, you can configure the X-Headstage™ with Omnetics connectors and use an existing cable solution. It is worth noting that the micro HDMI connector offers the flexibility of supporting both xR (record only) and xSR (switchable stim and record) headstages.

If you are interested in learning more about available adapters and accessories, please do not hesitate to contact us.

Are tracking LEDs available with X-Headstage?

Yes, tracking LEDs can be installed to an adaptor. Contact us for more information.

X-Headstage™ + Electrode vs Active Probe



The ultra-small size of an X-Headstage™ offers several advantages, including the ability to embed it together with an electrode to create an active implant. An active implant is a neural interface with integrated electronic circuitry for amplification, filtering, multiplexing, etc. Such implants offer robust noise rejection against motion artifacts and generate a cleaner signal with a lower noise floor.

NeuroNexus Technologies now offers probes with integrated Intan chips, but these electrodes are more expensive and disposable. In contrast, the X-Headstage™ solution is a cost-effective alternative. It is designed and validated to be reusable, and when

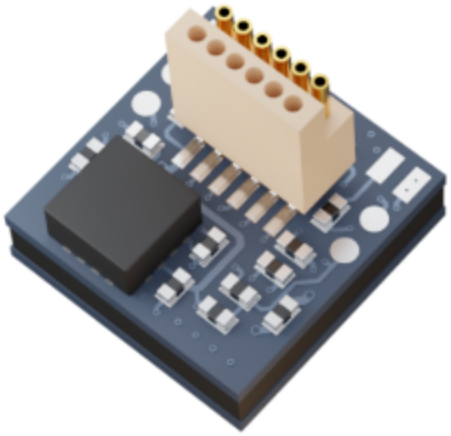
purchased in bulk, its unit price can be lower than that of a conventional headstage despite its better performance and specifications.

The X-Headstage™ with an electrode installed is even smaller than the active silicon probes available in the market. Its heart is a SiP (system in package) like chip package specifically designed for more efficient component integration. To adapt silicon probes to work with the X-Headstage™, the probe board can be replaced with smaller, cheaper connectors that mate with the X-Headstage™.

The X-Headstage™ offers an opportunity for researchers to transform their passive implants into active designs. With NeuroNexus's ecosystem of connectivity accessories, the X-Headstage™ solution enables more flexible implant possibilities, such as accessing multiple implants in different regions through a single cable solution.

Can I place, or implant, the X-Headstage horizontally on the skull?

Yes, design like the below is possible. Contact us for more information.



Dental cement accidentally got into the board to board connector, what do I do?

If you encounter residue on the X-Headstage, try submerging it in acetone for a few hours and then use a cotton-less swab to remove it.

How is X-Headstage different than Intan's RHD/RHS-2000 chips?

The X-Headstage utilizes a chip package that is specifically designed for the X-Series and is based on Intan's frontend ASICs. This chip package enables multi-die integration, as well as the use of interposer technology to route IOs across the top and bottom of the chip. This design provides for more efficient integration of components, allowing us to achieve an ultra-small headstage that has improved functionalities, such as more channels, while still maintaining the proven acquisition performance of the Intan chips. In summary, the X-Series chip package enables us to maximize the capabilities of the Intan frontend ASICs in order to create an advanced and efficient headstage for high-speed neural recording.

How is X-Headstage more cost-effective than headstages offered by other vendors?

We strongly believe that the X-Headstage is a superior solution compared to other headstage designs in the market. One of its standout features is its ultra-small size, which makes it more flexible and compatible with a wider range of surgical procedures. Additionally, the X-Headstage is capable of transforming passive probes into active designs, improving noise rejection and signal acquisition quality.

The X-Headstage features an adapter-based design that allows it to interface with commonly used probes with connectors such as Omnetics. Traditional headstage designs often encounter problems with bent or broken pins, which renders the entire headstage unusable. With the X-Headstage, it is easy and cost-effective to replace a broken pin without having to replace the entire headstage.

Furthermore, our X-Headstages are designed to be repairable. Even with the armor installed, we are able to replenish broken X-Headstages with new connectors while reusing the expensive amplifiers. Contact us for more information on repair and service costs and conditions. Overall, the X-Headstage is a reliable and flexible solution that offers superior performance and ease of use for high-speed neural recording.

How much current can x3SR headstage deliver?

The x3SR headstage is equipped with constant current stimulators capable of delivering currents ranging from 10 nA to 2.55 mA over a 14 V compliance range. It is important to note that the deliverable current is highly dependent on electrode impedance.

In cases where a higher compliance is required to deliver more current due to high impedance, the x3SR can support an 18 V compliance at the expense of reduced lifetime. According to Intan Technology, with the higher compliance, "each stimulator circuit begins to fail after many stimulation pulses, typically in the range of 30,000 to 1 million stimulation pulses. After degradation, the positive current output will be too low, often zero. This is a permanent hardware failure that cannot be reset by power-cycling the device."

Therefore, while the x3SR can support a higher compliance to meet specific experimental needs, it is important to be aware of the potential consequences and limitations of doing so. Careful consideration should be given to the specific requirements of each experiment and the potential impact on the lifespan and performance of the headstage.

Why is the SR X-Headstage not detected in the Open-Ephys GUI?

At present, the Open-Ephys GUI only supports the Recording type headstage, which means that the software is not able to detect the SR X-Headstage. However, NeuroNexus is currently in the process of developing its own unified software that will support various data sources such as neural recording, stimulation, video streaming, etc. This software will be part of the XDAQ line.

What kind of stimulation pattern can be delivered by the X3SR headstages?

X3SR can be programmed to deliver a wide variety of stimulus pattern with pulse timing as fine as 33.3 µs. When driven by XDAQ, our software allows delivery of biphasic, triphasic, burst pulses with amplitude ranging from 10 nA to 2.55 mA.

I don't see the ground and reference access pads available on the X-Headstages. Is that correct?

The X-Headstage features GND and REF inputs, with external pads removed to minimize its footprint. However, these signals can still be accessed through the EIB or the sensor.

I have the OpenEphys or Intan Controller with the blue or purple Intan SPI cables, can they still be used with the X-Headstage?

Our recommendation for connecting the X-Headstage is through the use of HDMI connectors/cables due to their ease of use, low cost, and flexibility. However, if you prefer to use your existing cable system with Omnetics connectors, the X-Headstage can be configured accordingly. You may also consider using adapters to interface between HDMI and Omnetics connectors.

Is accelerometer sensor available for the X3SR stim X-Headstage

X3SR headstage does not support 3-axis accelerometer sensors.

What is the advantage of implanting or cementing the X-Headstage with the electrode?

The X-Headstage can improve signal quality and longevity by firmly cementing the headstage and electrode to the skull, reducing mechanical strain and minimizing motion artifact. Direct plug-in/out of the headstage can cause disturbance to the sensitive neural interface, but this can be reduced when the X-Headstage with a μHDMI connector is embedded with the electrode. This allows for easy and safe plugin without anesthetizing the animal, increasing data collection throughput.

What probes or electrodes are compatible with X-Headstage?

The X-Headstage can accommodate most high (1-5 MOhm) or low (1-100 kOhm) impedance electrodes, whether commercially available or homemade. However, it is important to note that high impedance electrodes may not be suitable for stimulation experiments, as the X3SR has a compliance stim voltage of 14 V. To ensure optimal results, it is recommended to condition the electrode by lowering its impedance through techniques such as electroplating or activation before proceeding with stimulation experiments.

Can I purchase a longer HDMI cable?

We recommend keeping the cable as short as possible to maintain optimal signal quality. If the HDMI cable is sufficient for the behavior experiment, hook up the acquisition system with a computer close the animal, and Remote Desktop into the control computer could be a way to increase distance.

Alternatively, if the animal needs to cover a bigger space and thus needing a longer cable, contact us for a custom solution.