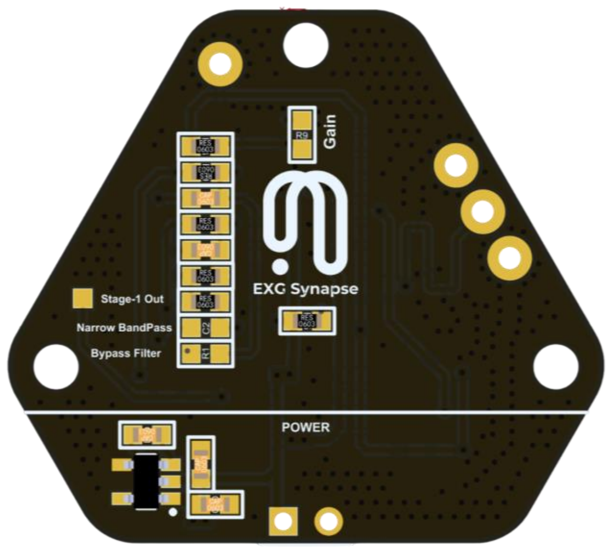
Product Reference Manual



Description

Neuphony EXG Synapse is an innovative, hexagon-shaped chip designed for recording high-quality biopotential signals from various regions of the body, including the heart (ECG), brain (EEG), eyes (EOG), and muscles (EMG). Serving as a robust analog-front-end (AFE) biopotential signal-acquisition board, the Neuphony EXG Synapse can seamlessly integrate with a range of microcontroller units (MCUs) or single-board computers (SBCs) equipped with an analog-to-digital converter (ADC). Compatible platforms include popular options such as Arduino UNO & Nano, Espressif ESP32 and more.

This versatile device also interfaces effortlessly with dedicated ADCs like the Texas Instruments ADS1115 and ADS131M0x, expanding its compatibility and flexibility for diverse applications. The Neuphony EXG Synapse empowers users to explore and capture publication-grade biopotential signals, making it a valuable tool for researchers, developers, and enthusiasts in the field of bioelectronics and health monitoring.

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Features

1. Comprehensive biopotential signal compatibility, covering ECG, EEG, EOG, and EMG, ensures a versatile solution for various physiological monitoring applications.
2. Neuphony EXG Synapse offers customizable gain and filter bandwidth settings for precise signal configuration.
3. Enjoy flexibility with an optional bypass of the bandpass filter, allowing tailored signal output for diverse analysis.
4. Seamlessly pairs with any MCU featuring ADC, expanding compatibility across platforms like Arduino, ESP32, STM32, and more.
5. Seamless Python/LSL compatibility

Specifications

1. **Input Voltage:** 3.3V
2. **Input Impedance:** 20 GΩ
3. **Compatible Hardware:** Any ADC input
4. **Biopotentials:** ECG EMG, EOG, or EEG (configurable bandpass) | By default configured for a bandwidth 1.6Hz to 47Hz and Gain 50
5. **No. of channels**: 1
6. **Electrodes**: 3
7. **Dimensions**: 30.0 x 33.0 mm
8. **Open Source**: Hardware

Input Signals

Default Frequency Range:

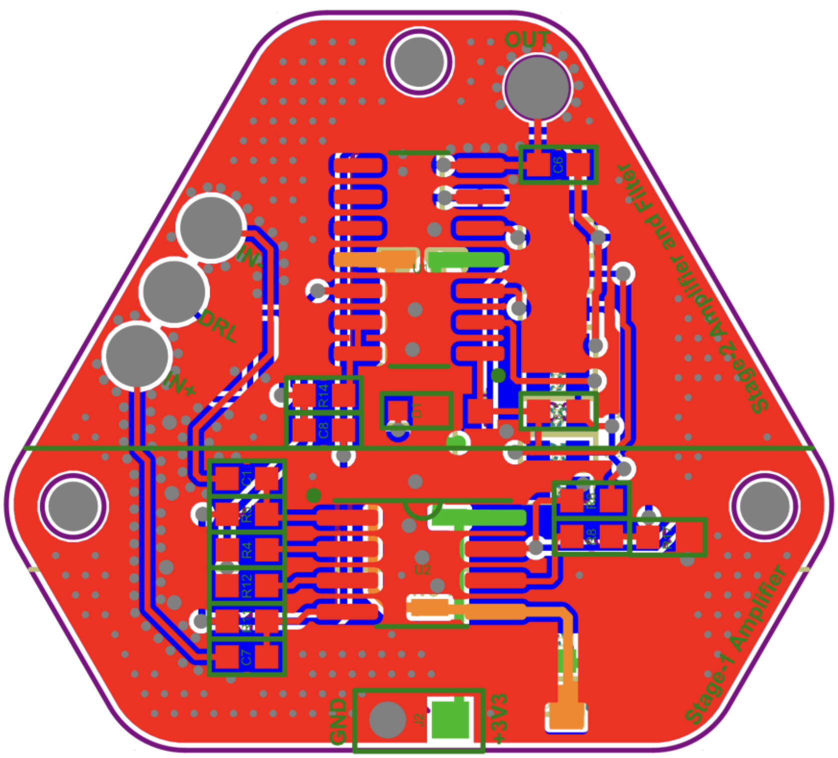
1. ECG Frequency Range: 0.5 - 40Hz
2. EMG Frequency Range: 75 - 150 Hz
3. EEG Frequency Range: 0.5 - 47.5 Hz
4. EOG Frequency Range: 0.5 - 15 Hz

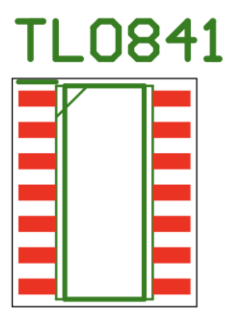
Absolute Maximum Ratings

Description	Min	Typ	Max	Unit
Input voltage from 3V3 pad	1.8	3.3	5.5	V
Operating Temperature	-40	25	85	°C

Recommended Operating Conditions for Neuphony EXG Synapse's input voltage is 3.3V

Board Topology / Layers

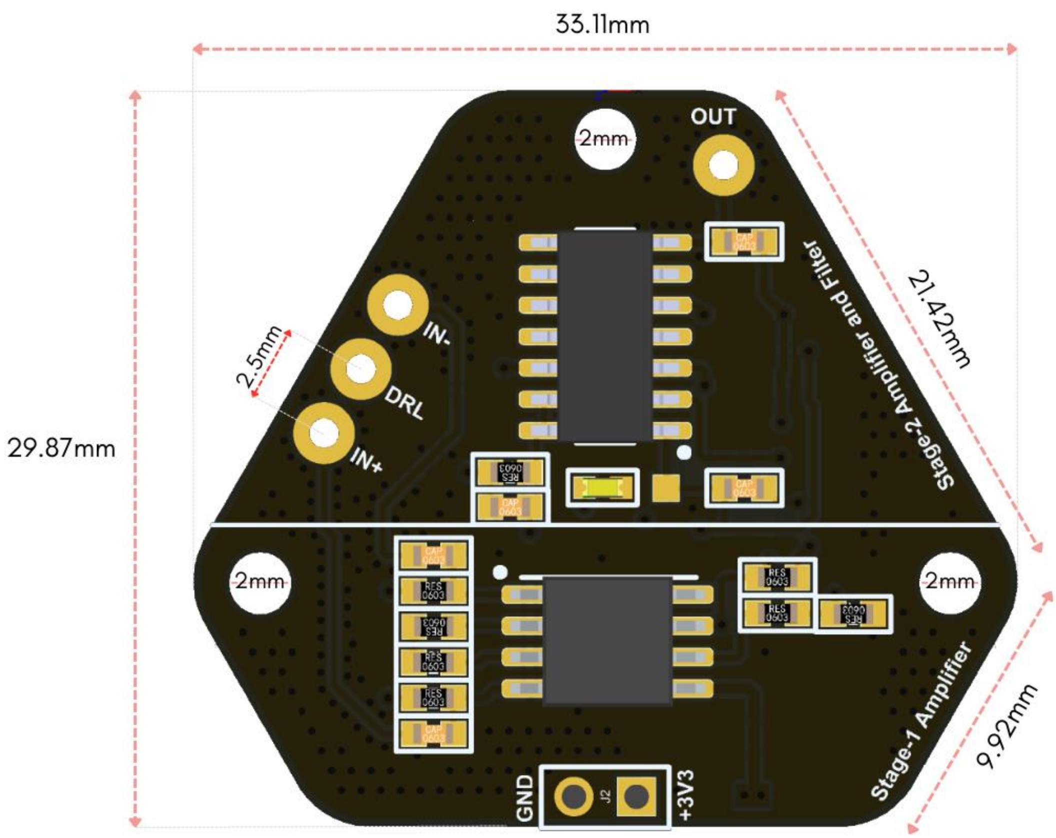




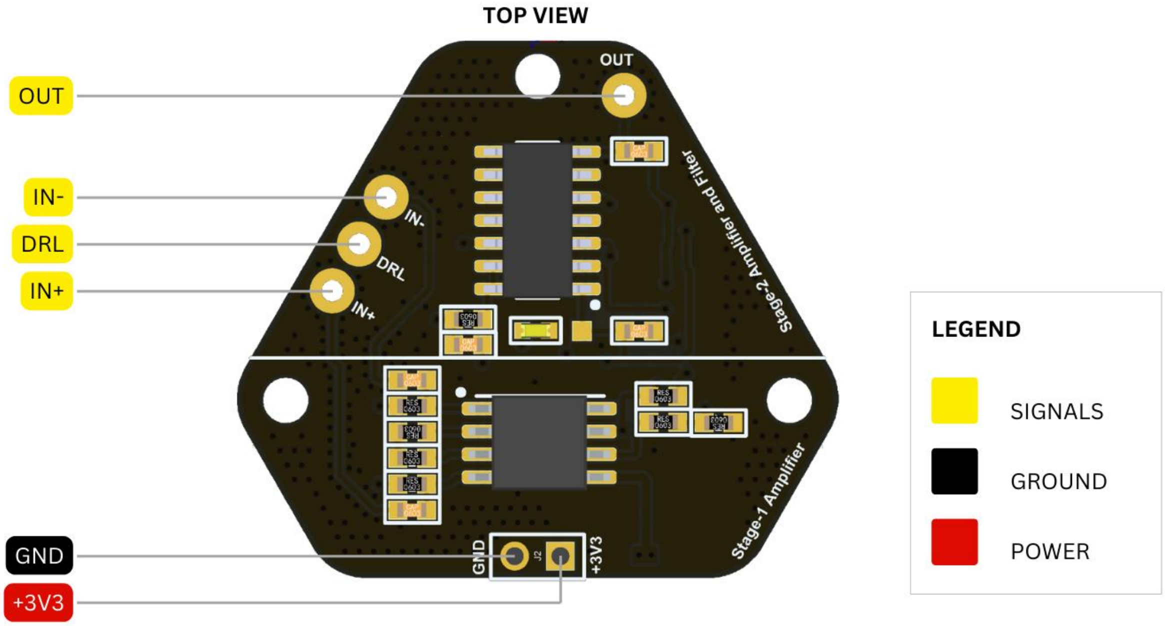
Layer	Name	Material	Thickness	Constant	Board Layer Stack
	Top Overlay				
	Top Solder	Solder Resist	0.010mm	3.5	
1	TOP	CF-004	0.035mm		
	Dielectric1	Core-042	0.500mm	4.8	
2	BOTTOM	CF-004	0.035mm		
	Bottom Solder	Solder Resist	0.010mm	3.5	
	Bottom Overlay				
Total board thickness:			0.590mm		

1. 2 Layer Board with 0.6mm thickness
2. Minimum clearance – 0.15mm
3. Minimum track width – 0.15mm
4. Vias drill minimum diameter – 0.25mm
5. Overall minimum diameter – 0.5mm

Dimensions



Pinout



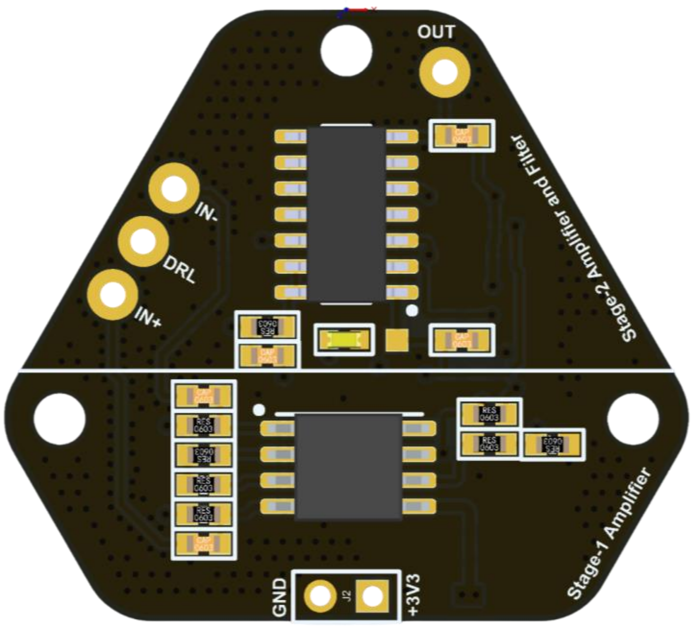
Pinout for Neuphony EXG Synapse

Pin	Type	Description
OUT	ANALOG	Anlog output
IN-	ANALOG	Negative analog input
DRL	ANALOG	Right Leg Drive
IN+	ANALOG	Positive analog input
GND	POWER	Ground
+3V3	POWER	+3V3 Power Rail

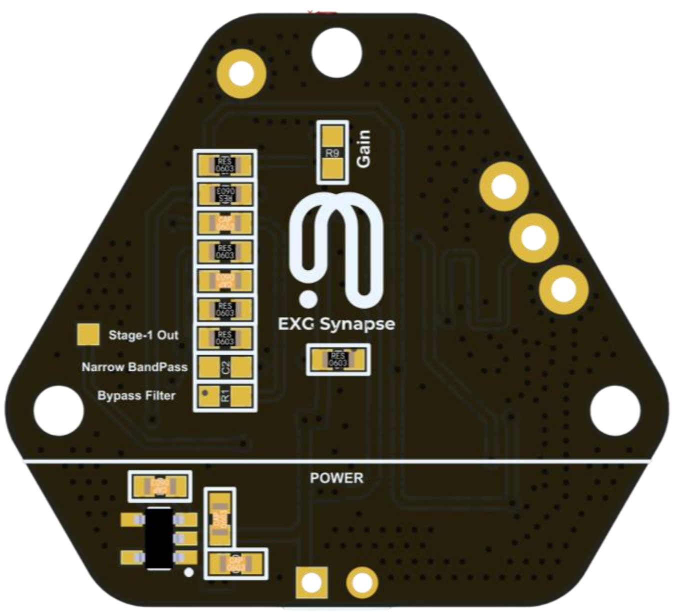
Pin description for Neuphony EXG Synapse

Board Diagrams

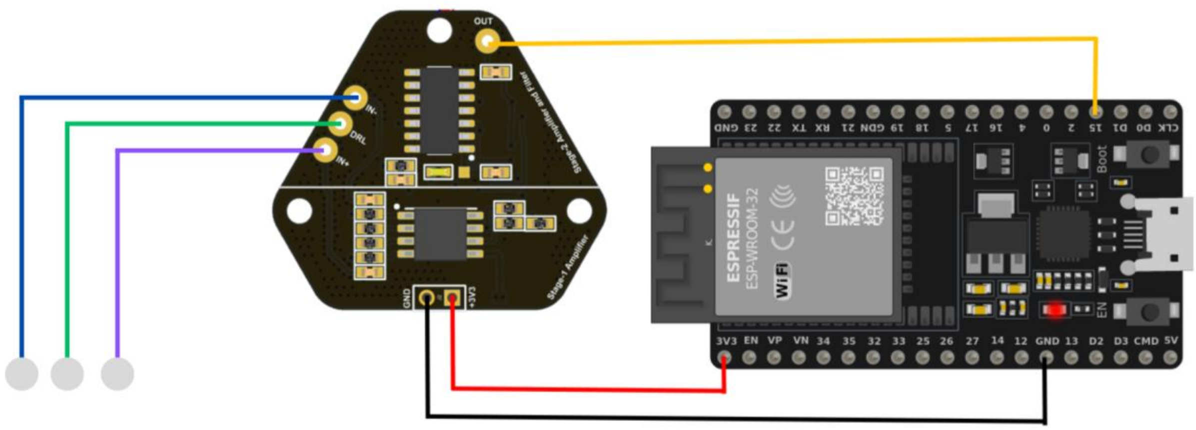
Top View



Bottom View



EXG Circuit



Getting Started

i. What is EXG?
ii. Brief about EXG Synapse
iii. Hardware and Software Requirements
iv. Assembly of Connectors
v. Any configuration on the PCB (gain, filter width)
vi. Power Supply Connection
vii. Electrode Connection
viii. Connections with esp32
ix. Flashing Code
x. Skin prep
xi. Electrode Placement
xii. Visualizing data using LSL

(Above steps will be explained in detail)

Possible Configurations

i. Configurable Gain

Default Gain Configuration: The default gain in the first stage amplification is set to 50. This value is established to provide a baseline performance in typical use cases.

User-Configurable Gain: To accommodate diverse application scenarios, users have the flexibility to configure the gain according to their specific requirements. This customization is achieved by placing a desired resistance at the designated location, R9.

Gain Formula: The gain (G) is determined by the following formula: G = R9/10k

Where:

- *G* is the gain of the amplification stage.
- *R*9 is the resistance value placed at the configurable location.
- 10*k* is the default resistance value.

By manipulating the value of *R*9, users can finely tune the amplification gain to suit the unique demands of their intended application. This level of customization ensures optimal performance and versatility in the amplification process.

ii. Bandpass Filters bandwidth

Default Bandpass Filter Configuration: The bandpass filter is implemented as a 2nd order Butterworth filter, offering a default high pass frequency of 1.6Hz and a default low pass frequency of 48.228Hz. These preset values are selected to cover a wide range of applications effectively.

User-Configurable Low Pass Frequency: For users desiring customization, the bandpass filter allows the adjustment of the low pass frequency. This is accomplished by manipulating the capacitance of C2, a capacitor placed in parallel with C3.

Capacitance Options: To simplify user adjustments, a set of capacitances is provided: 0.5uF, 3nF, 0.2uF, and 0.1uF. Each of these capacitances results in a specific low pass cutoff frequency when combined with C3 in parallel.

- A capacitance of 0.5uF yields a low pass cutoff frequency of 19.6Hz.
- A capacitance of 3nF results in a low pass cutoff frequency of 47.52Hz.
- A capacitance of 0.2uF leads to a low pass cutoff frequency of 27.84Hz.
- A capacitance of 0.1uF produces a low pass cutoff frequency of 34.10Hz.

The bandpass filter design employs the characteristics of a 2nd order Butterworth filter, ensuring a smooth frequency response within the specified range

iii. Bypass Bandpass Filter

Bypass Option for Direct Data Access: For enhanced flexibility, users have the option to bypass the bandpass filter and access data directly. This bypass feature allows users to streamline their signal processing by circumventing the filtering stage when it is not required for their specific application.

Activation of Bypass: To enable direct data access without bandpass filtering, users can engage the bypass option. This can be achieved through a designated control or switch in the circuit.

Streamlined Signal Path: By choosing to bypass the bandpass filter, users can obtain raw data without undergoing the frequency filtering process. This is particularly useful when a specific application demands unaltered or unfiltered signal information.

Versatile Integration: The bypass capability is designed to seamlessly integrate with the bandpass filter circuit, offering users the flexibility to tailor the signal processing approach based on their unique requirements. Whether opting for the bandpass filter or the direct data path, users can adapt the system to suit the demands of their specific applications.

Reference Documents

(Links to github and other useful documents like ESP manual)

Certification

OSHWA Certification is currently under process

Licenses

Hardware	CERN-OHL-S2.0
Software	MIT
Documentation	CC-BY-4.0