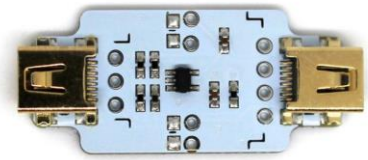
Electrodermal Activity (EDA) Sensor User Manual



ATTENTION
Please read this datasheet before
using your BITalino sensor

The information contained in this document has been carefully checked and were made every effort to ensure its quality. PLUX reserves the right to make changes and improvements to this manual and products referenced at any time without notice.

The word Bluetooth and its logo are trademarks of Bluetooth SIG Inc. and any use of such marks is under license. Other trademarks are the property of their respective own.

Please check your systems and sensors after receiving and before using it the first time to confirm if it contains all the ordered sensors, accessories and other components. Contact our support via e-mail at support@plux.info if there are any variations from your original order.

For regulatory information, please see the Regulatory Disclaimer at the end of this document.

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v.1.0

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1. General Information

1.1. General Description

The BITalino EDA sensor is capable of accurately measuring the electrical properties of the skin which changes. These changes are caused by alterations in sweat secretion and sweat gland activity as a result of changing sympathetic nervous system activity. The low-noise signal conditioning and amplification circuit design provide optimal performance in the detection of even the most feeble electrodermal skin response events

Together with our available EDA Analysis our OpenSignals (r)evolution software, one can easily extract overall statistics, basic spectral analysis, and extract typical event-related phasic features from the acquired sensor data.

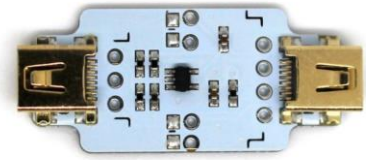


Figure 1: BITalino EDA sensor (standard version).

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered EDA sensor output acquired while being in a relaxed state. The raw digital sensor values received from the BITalino device ranged between 0 and 2^n-1 (n=sampling resolution) were converted into the original unit of measurement of this sensor (μS) using the transfer function found in section Transfer Function (Conversion Formula).

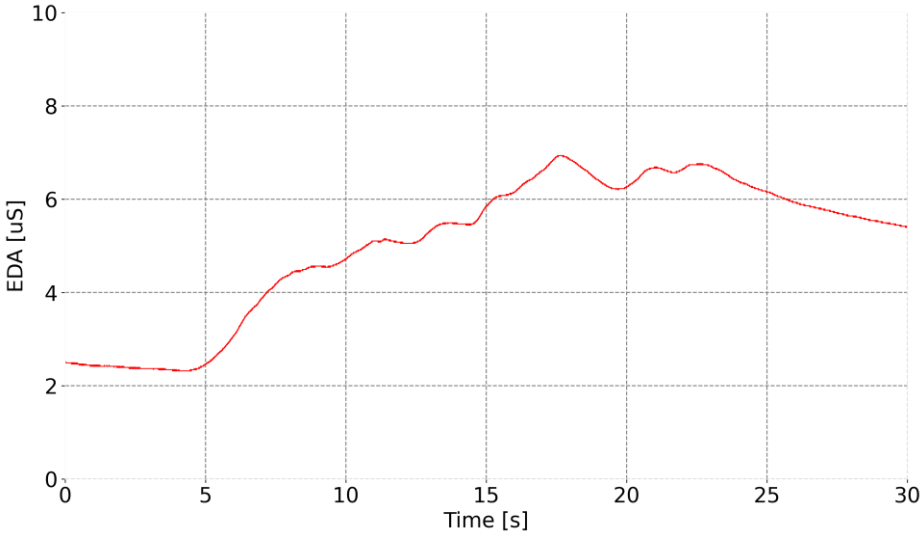


Figure 2: Typical unfiltered sensor output (while being in a relaxed state).

1.3. Sensor Specifications

> Bandwidth:	0-2.8Hz	**> Range:**	0-25μS (@VCC = 3.3V)
> Input Voltage Range:	1.8-5.5V	**> Consumption:**	±0.1mA
> Measurement:	continuous	**> Current:**	DC

1.4. Features

> Skin resistance measurement
> Pre-conditioned analog output
> High signal-to noise ratio
> Small form factor
> Raw data output
> Easy-to-use

1.5. Applications

> Life sciences studies
> Sympathetic nervous system monitoring
> Human-Computer Interaction
> Affective computing
> Psychophysiology
> Biomedical device prototyping
> Arousal detection
> Emotional cartography
> Physiology studies
> Relaxation biofeedback

1.6. Transfer Function (Conversion Formula)

The analog sensor signals acquired with BITalino devices are converted into digital values ranged between 0 and 2^n-1 (n=sampling resolution, usually 6-bit or 10-bit) and streamed in the raw digital format.

In most applications, the original physical unit of the acquired EDA signal is preferred or required. The raw digital sensor samples can be converted back into microsiemens (mV) using the following formulas:

$$EDA(\mu S) = \frac{\frac{ADC}{2^n} \times VCC}{0.12} \quad (1)$$

$$EDA(S) = EDA(\mu S) \times 1 \times 10^{-6} \quad (2)$$

Valid sensor range: [0μS, 25μS]

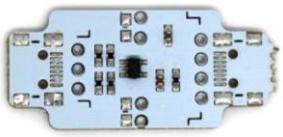
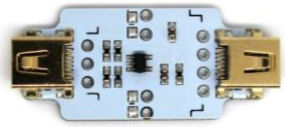
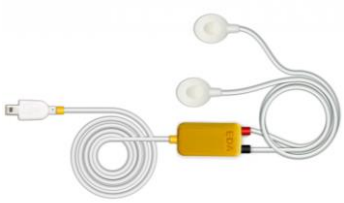
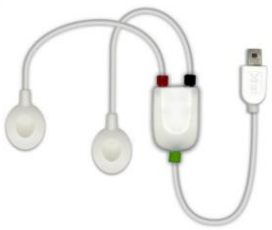
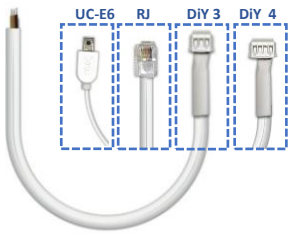
with:

	$EDA(\mu S)$	EDA signal in microsiemens (μS)
	$EDA(S)$	EDA signal in siemens (S)
	ADC	Value samples from the sensor/channel (digital value)
	n	Sampling resolution (default: 10-bit resolution (n=10), although 6-bit may also be found)
	VCC	Operating voltage (3.3V when used with BITalino)

1.7. Electrode Connections & Sleeve Color Meanings

The BITalino EDA sensor can be connected to electrode cables and open wire cables with different connection types, see Table 1.

Table 1: Possible connection types for the EDA sensor

Connection Type	**Self-assemble (none) / DiY (Molex Sherlock)**	**UC-E6**	**Assembled**
			
Electrode Cable	2-lead Self-assemble / DiY (10cm / 30cm)	2-lead (UC-E6) (10cm / 30cm)	Assembled 2 x 1-lead (10cm)
			
Open wires Cable	Self assemble + DiY / UC-E6 / legacy (RJ) (10cm / 30cm / 100cm)	UC-E6 (10cm / 30cm / 100cm)	Assembled 1 x UC-E6 (100cm)
			

The sleeve color meaning for the 2-lead electrode cable for the UC-E6 sensor connection version are described in Table 2.

Table 2: Sleeve color meanings for UC-E6 connection.

Sleeve Color	Red	Black
Electrode Cable (2-lead)	+	-

See section *2 Application Notes* for more information on where to place the electrodes and to connect electrodes cables for EDA acquisitions.

1.8. Physical Characteristics

The BITalino EDA sensor comes in a size of 12mm x 27mm (see Fig. 4).

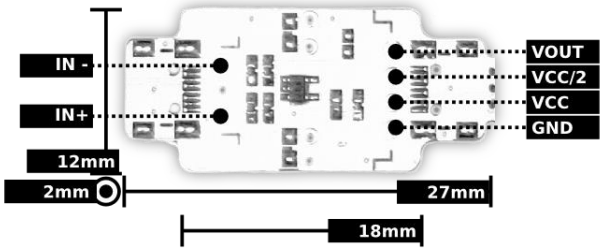


Figure 3: Physical characteristics of the standard EDA sensor.

2. Application Notes

The BITalino EDA sensor is designed to acquire the change of skin activity such as sweat with two measuring electrodes. One example is the placement of the electrodes on the anterior side of the hand on **two adjacent fingers** of interest (see Fig. 4). The electrodes are then connected to the sensor cable of the EDA sensor.

2.1. Electrode Placement/Sensor Placement

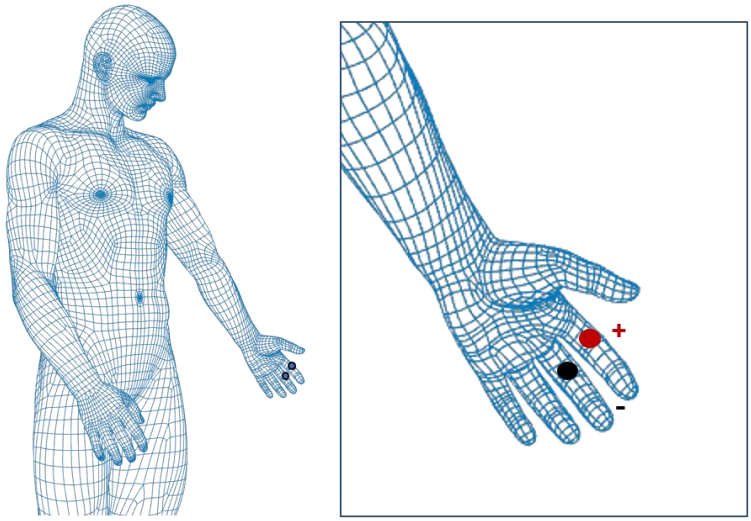


Figure 4: Example EDA placement I on the index and middle finger.

Possible electrode positions are listed in Table 1. The positive and the negative measuring electrodes can be positioned in either way.

Table 3: EDA electrode positioning.

	Positive Electrode (+) (red sleeve)	Negative Electrode (-) (black sleeve)
I	**Finger location 1**	**Finger location 2**
II	**Finger location 2**	**Finger location 1**

An example signal acquisition with the assembled version on the inside of the hand on two different locations is illustrated in Figure5.

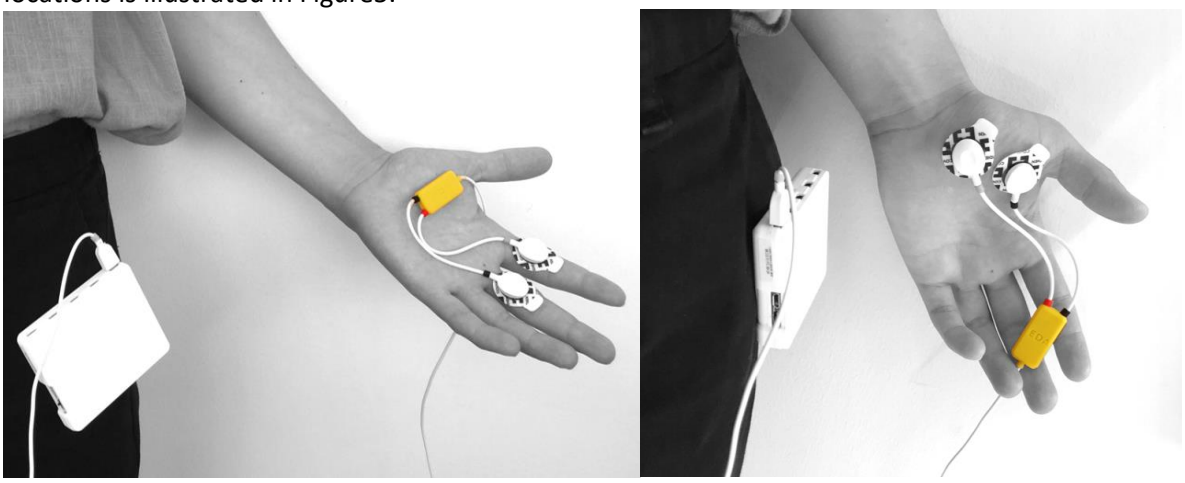


Figure 5: Example electrode placement of the assembled version on the anterior side of the hand on the index and middle finger (left) and below the thumb (right).

3. Using the EDA Sensor with BITalino & OpenSignals

The connection of BITalino EDA sensors is demonstrated with the three main Boards with Bluetooth (BT) connection. Notice, that the connection is the same for the Bluetooth low energy (BLE) boards.

3.1. Connecting the sensor to BITalino Systems (BT)

3.1.1. BITalino (r)evolution Board

The BITalino EDA sensor comes already connected to the BITalino (r)evolution Board.

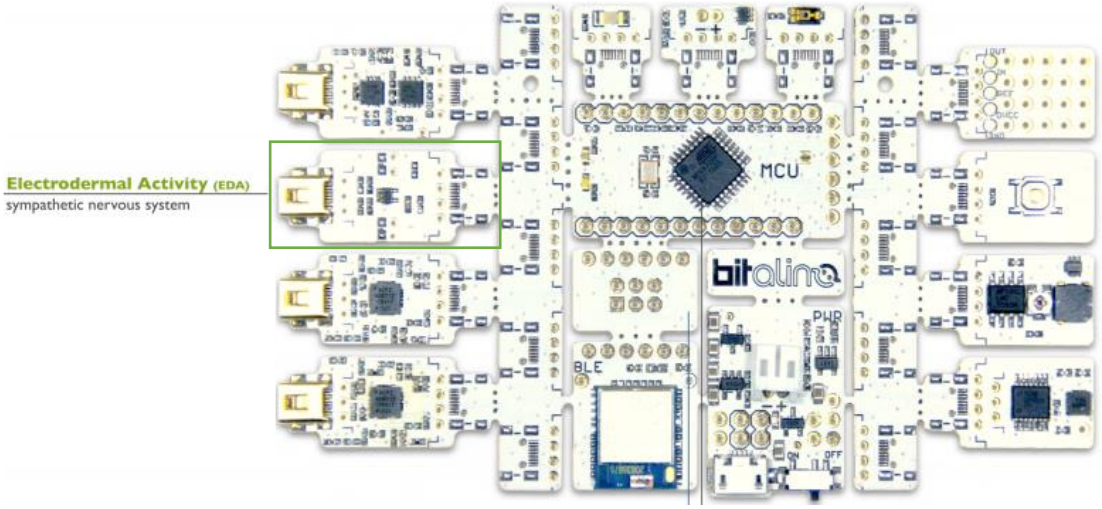


Figure 6: EDA compatible BITalino (r)evolution Board pre-connected to an EMG sensor with UC_E6 connector on one side.

3.1.2. BITalino (r)evolution Plugged

The BITalino EMG sensor (UC-E6 sockets) is compatible with all 6 analog input channels of the BITalino (r)evolution Plugged with a sensor cable with UC-E6 connectors.

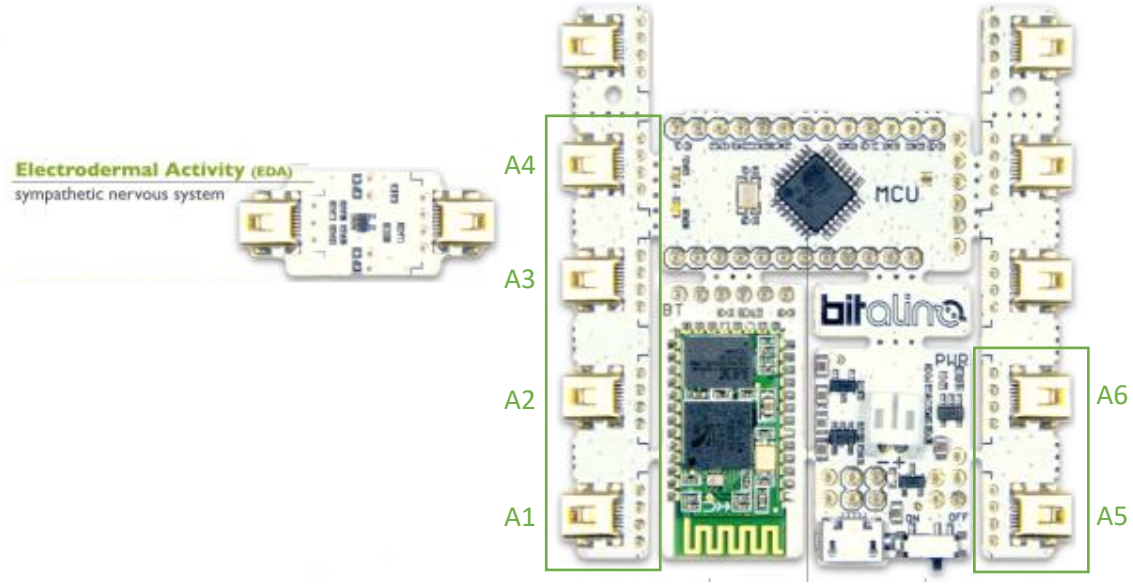


Figure 7: BITalino (r)evolution Plugged with possible connection ports (marked in green) for the EMG sensor (UC-E6).

3.1.3. BITalino (r)evolution Freestyle

The BITalino EDA sensor (no connections or Molex Sherlock plugs) is compatible with the BITalino (r)evolution Freestyle.

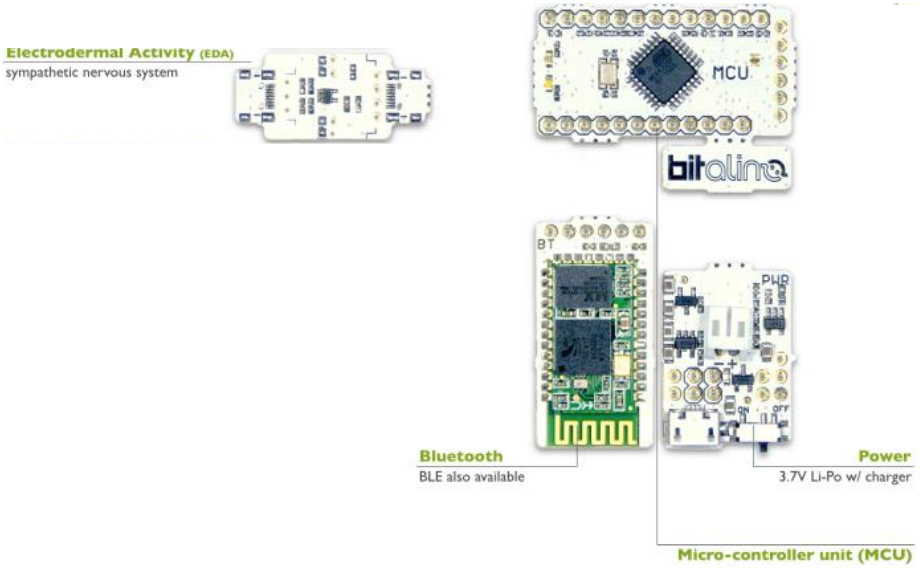


Figure 8: BITalino (r)evolution Freestyle with the possible connection ports (marked in green) for the EDA sensor (without connections) using the Molex Sherlock plugs and sockets or self-mounted cables.

3.1.4. BITalino (r)evolution Core (assembled)

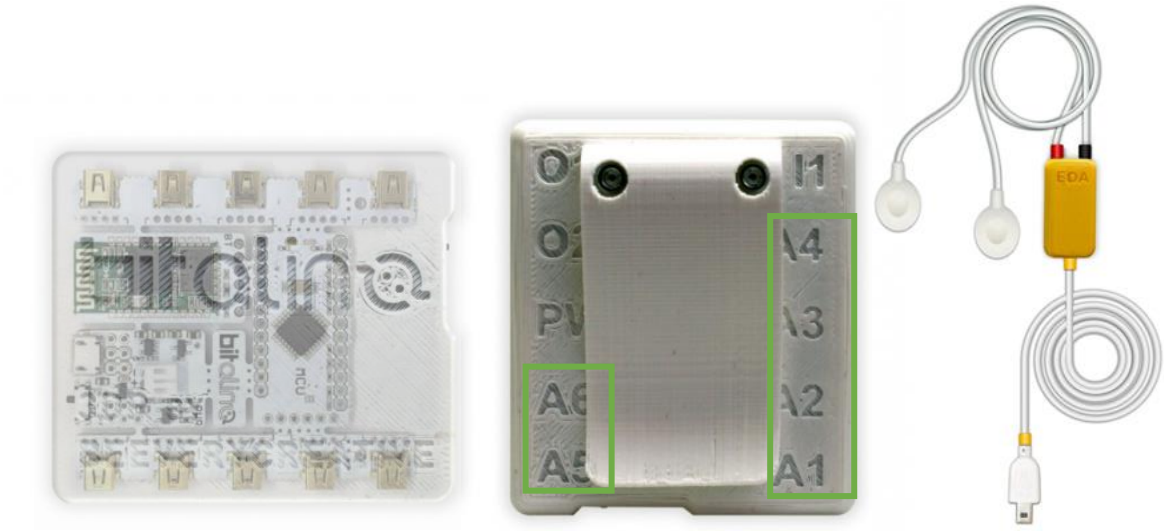


Figure 9: BITalino (r)evolution Core (assembled) and the connection ports for the EDA sensor (assembled) marked in green.

The BITalino EDA sensor (assembled) is compatible with all 6 analog input channels of the BITalino (r)evolution Core (assembled) with a pre-connected sensor cable.

3.2. Configuring the Sensor in OpenSignals

3.2.1. OpenSignals (r)evolution (Windows, macOS, Linux)

Open the OpenSignals (r)evolution device manager to access and configure your BITalino device.

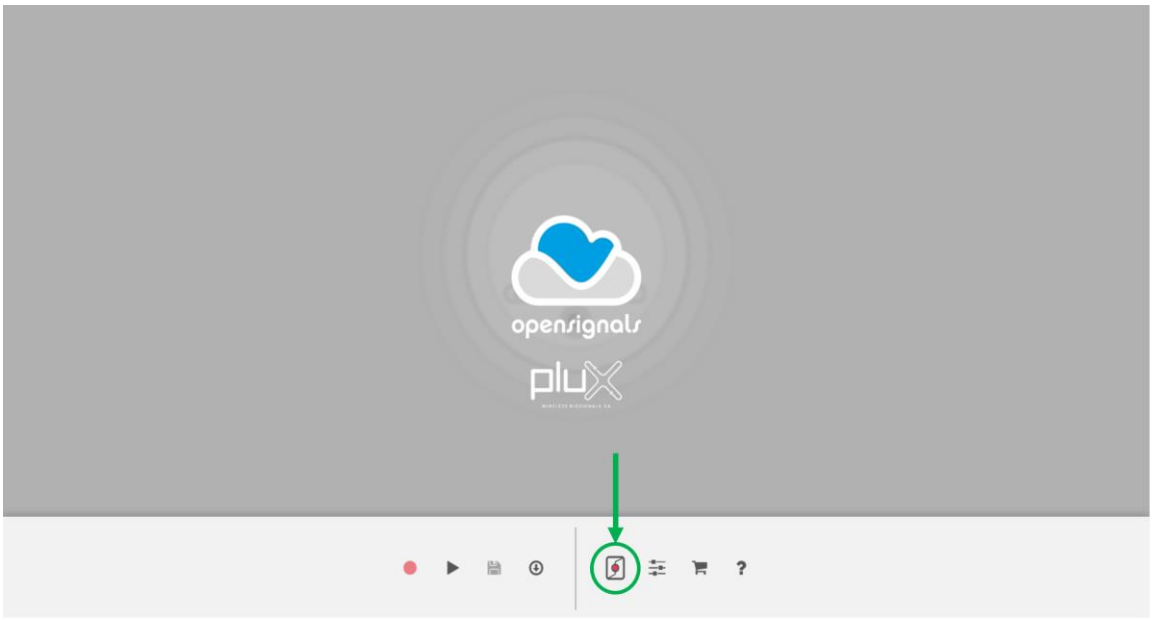


Figure 10: Access the OpenSignals (r)evolution device manager.

Select the device you intend to use for acquisition by clicking on *ENABLE button on* the device panel in the OpenSignals device manager. The device is activated for acquisition if the *ENABLE* button is blue.

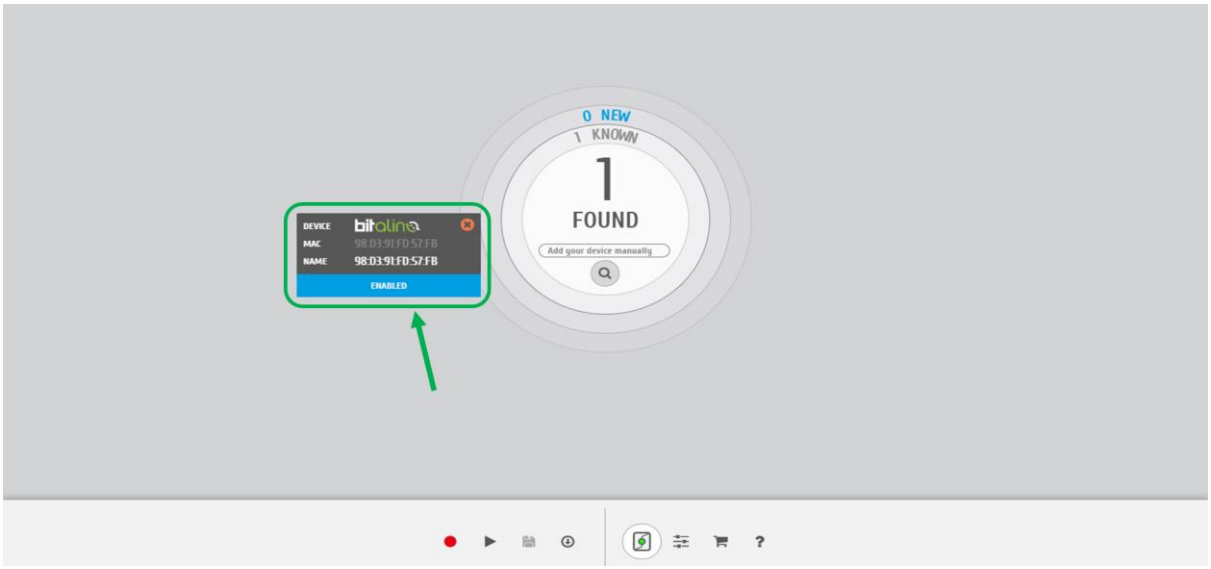


Figure 11: Enabling the device for acquisition.

Click on the BITalino logo to access the available settings. Select the channel your sensor is connected to and select the *EDA* from the dropdown menu highlighted in the next screenshot.

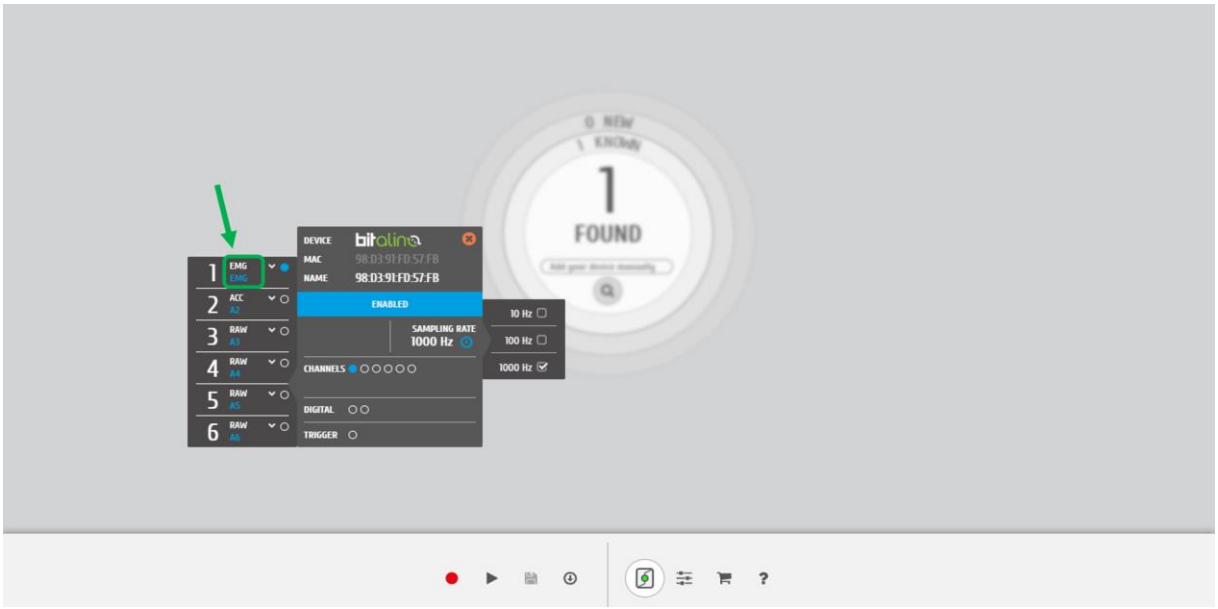


Figure 12: Set the channel type of the channel you have your EDA sensor connected to, to *EDA.*

Activate the channel for acquisition by clicking on the circle next to the channel type (must be blue). If not done before, follow the instruction available in section *2 Application Notes* to learn how to apply the sensors and *3.1 Connecting the sensor to BITalino Systems* to learn how to connect your device to your BITalino device. Click on the record button in the OpenSignals main interface whenever you're ready for your acquisition.

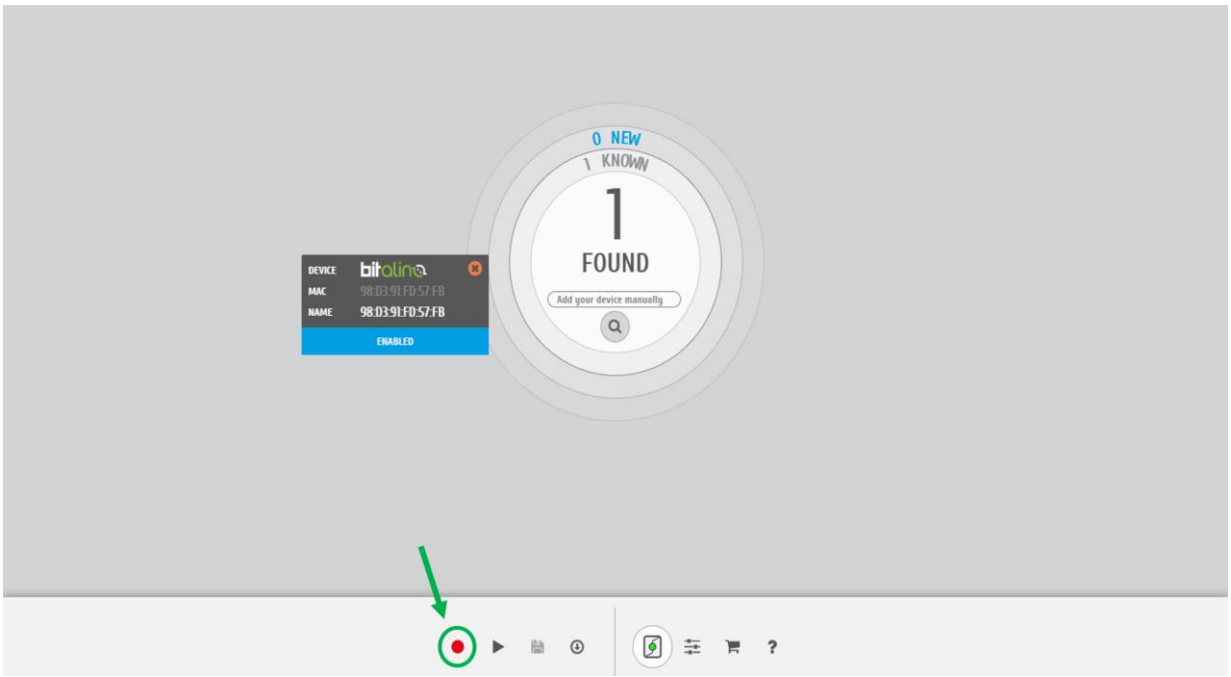


Figure 13: Start the acquisition whenever you're ready.

4. Scientific Publications Using the EDA Sensor

The following scientific is only a small selection extracted from the list of available publications using BITalino. Please visit the following website to access the entire up-to-date list:

https://bitalino.com/en/community/publications

Publications

Hugo Plácido da Silva, André Lourenço, Ana Fred and Raúl Martins, "BIT: Biosignal Igniter Toolkit", in Computer Methods and Programs in Biomedicine, vol. 115, no. 1, pp. 20-32, 2014

Roberta Bortolla, Marco Cavicchioli, Joaquim Soler Rivaldi, Juan Carlos Pascual Mateos, Paul F. M. J. Verschure and Cesare Maffei, "Hypersensitivity or hyperreactivity? An experimental investigation in Borderline Personality Disorder", in Mediterranean Journal of Clinical Psychology, vol. 1, no. 8, pp. 1-17, 2020

Ali Rizwan, Najah Ali, Ahmed Zoha, Metin Ozturk, Akram Alomaniy, Muhammad Imran and Qammer Abbasi, "Non-Invasive Hydration Level Estimation in Human Body Using Galvanic Skin Response", in IEEE Sensors Journal, vol. 9, no. 20, pp. 4891 - 4900, 2020

Claudia Quaresma, Madalena Gomes, Heitor Cardoso, Nuno Ferreira, Ricardo Vigário, Carla Quintão and Micaela Fonseca, "GNEUROPATHY: Validation Process at Clinical Environment", in In Proc. of the 12th Int'l Joint Conf. on Biomedical Engineering Systems and Technologies (BIOSTEC), pp. 275-279, 2019

Anastasija Rastovic, Maud Pélissier and Emmanuel Ferragne, "The perception of swear words by French learners of English: an experiment involving electrodermal activity", in Anglophonia, no. 27, 2019

Joana Pinto, Ana Fred and Hugo Plácido da Silva, "Biosignal-Based Multimodal Emotion Recognition in a Valence-Arousal Affective Framework Applied to Immersive Video Visualization", in In Proc. of the IEEE Engineering in Medicine and Biology Society Annual Int'l Conf. (EMBC), 2019

Amir Hasanbasic, Mustafa Spahic, Dino Bosnjic, Haris H adzic, Vedad Mesic and Omar Jahic, "Recognition of stress levels among students with wearable sensors", in In Proc. of the Int'l Symposium INFOTEH-JAHORINA (INFOTEH), pp. 1-4, 2019

Roberta Bortolla, Marco Cavicchioli, Marco Cavicchioli, Marco Galli and Cesare Maffei, "A comprehensive evaluation of emotional responsiveness in borderline personality disorder: a support for hypersensitivity hypothesis", in Borderline Personality Disorder and Emotion Dysregulation, vol. 8, no. 6, pp. 1-16, 2019

Carmen Camara, Honorio Martin, Pedro Peris-Lopez and Muawya Aldalaien, "Design and Analysis of a True Random Number Generator Based on GSR Signals for Body Sensor Networks", in Sensors, vol. 9, no. 19, pp. 2033, 2019

Diana Batista, Hugo Plácido da Silva, Ana Fred, Carlos Moreira, Margarida Reis and Hugo Ferreira, "Benchmarking of the BITalino biomedical toolkit against an established gold standard", in IET Healthcare Technology Letters, pp. 1-5, 2019

5. Safety & Maintenance

5.1. Safety Instructions

Please read the following safety instructions **before** using your *BITalino* system with the EDA sensor to prevent any damages or problems with the user, test persons and/or *BITalino* devices. Violations of these instructions can lead to inferior signal quality and/or damages to the *BITalino* system and user.

- ! The user should always keep the device and its accessories dry.
- ! The user must turn off the *BITalino* device and contact Technical Support if the system or accessories reach uncomfortable temperatures.
- ! The user should not use the *BITalino* device in noisy environments (environments with microwaves and other similar equipment). Doing so will lead to noise increase in the acquired signals and Bluetooth connectivity issues.
- ! The user must not use the device near the fire or in potentially explosive atmospheres, such as atmospheres with flammable gas.
- ! The user should only use the detection surfaces or other approved accessories purchased from PLUX or by a PLUX agent.
- ! The user should inspect the sensors on a regular basis to ensure that they remain in good working order.
- ! The user should stop using the *BITalino* device if experience any kind of discomfort or skin irritation.
- ! Do not use the system on persons with allergies to silver.
- ! The user should dispose detection surfaces after using the *BITalino* device. Detection sur- faces are single-user and disposable. Reusable electrodes should be reused by the same user. Do not use reusable electrodes on several users.
- ! The user must not place the device in the microwave.
- ! The user must not insert objects into the holes of the device.
- ! The user should not open the *BITalino* device or its accessories. The repair of the same should be only done by properly authorized PLUX personnel.
- ! The user should make sure the cables do not obstruct the passage of people.
- ! The user should use the sensor cables with extreme caution to avoid risk of strangulation.
- ! The user should keep a safe distance between the *BITalino* device and other devices to ensure their proper functioning.
- ! The user should only send the device to repair to qualified PLUX personnel.

- ! The user should not immerse the sensors or the *BITalino* device, nor clean with liquid or abrasives.

- ! The user should handle the *BITalino* device with caution and not expose the device or accessories to high accelerations and vibrations.

- ! *BITalino* devices should not be used in patients with implanted electronic devices of any kind, including pace-makers, electronic infusion pumps, stimulators, defibrillators or similar.

- ! Do not apply electrodes over damaged or irritated skin.

- ! Do not use your device while charging its internal battery.

5.2. Transportation and Storage

Please follow these recommendations to ensure safe transportation and storage of your *BITalino* equipment and sensors to prevent any damaging of your system.

The *BITalino* equipment and sensors should be stored in the original box in a dry place when those are not being used.

- Relative humidity: up to 95% with no condensation
- Ambient temperature: 10°C to 30°C
- Atmospheric pressure between 500hPa and 1060hPa

Whenever the equipment needs to be transported, it should be placed in the original box, since this was designed and tested to ensure the equipment and accessories are securely stored.

Take care while handling the transportation of the system and avoid dropping it, since the device is not shock-proof and should not be placed under stress or sudden acceleration.

5.3. Cleaning

Please follow these cleaning instructions to prevent any damage of the system or the user because of conducting cleaning methods that may cause any damage.

- The *BITalino* and sensors should be visually checked before each use and cleaning process to ensure that no mechanical damage occurred.

- The *BITalino* equipment and sensors (including the cables) should be cleaned with a slightly damp cloth or suitable absorbent paper, ensuring no liquid enters the equipment of sensors. Do not use detergent or any type of cleaning liquid as these may damage your equipment and/or sensor.

- Do not clean or re-use detection surfaces (electrodes). They are only suitable for single use, and should be disposed of after usage except indicated otherwise.

6. Ordering Guides, Regulatory & Legal Information

6.1. Ordering Guide

Please follow the following ordering guide when submitting orders of EDA sensors to orders@plux.info. If no specification is provided, the standard version of the sensor will be delivered.

Electrodermal Activity (EDA)

SKU Reference	PLUX Code	UPC
SENS-EDA-NC / SENS-EDA-UCE6) / BUNDLE-EDA-UCE6	810121207 / 810121208 / 810121252	**641945958904/ 641945958782/ 785614264955**
Description		
Electrodermal Activity (EDA) / Electrodermal Activity (EDA) UC-E6 / Assembled Electrodermal Activity (EDA) Sensor		

Electrodes & Accessories

For a full list of available and compatible electrodes, please visit the BITalino store.

6.2. Guarantee of Quality & Warranty

BITalino sensors have three months quality guarantee from the date of purchase. PLUX guarantees that the system, sensors and accessories will be free from material or manufacturing defects for the mentioned time periods following date of purchase.

If PLUX receives notification of any such defects within the guarantee period, it will repair or substitute with the same unit\model, any products with proven defects at no cost to the client. During the repair period PLUX promises to provide a temporary replacement under the same specification. Repairs will be carried out at PLUX's premises after the equipment has been received.

6.3. Warranty Voidance

Usage of the device that is not in accordance with the handling instructions indicated in the manual, or use with accessories other than those manufactured by PLUX will invalidate the warranty of your devices.

Be careful when connecting your BITalino devices, sensors and/or accessories to any third party device including the usage of the 3rd party connection components that are available for BITalino systems as **the usage of these components will void the electrical warranty of your BITalino device and sensors and, if not indicated otherwise, the warranty of the 3rd party system you're connecting to the device**. Check the electrical specifications of both systems you want to connect to prevent any damage of the user(s) or the systems.

In the case of warranty voidance, the same applies that we expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.

6.4. Contact & Support

Contact us if you are experiencing any problems that cannot be solved with the information given in the BITalino documentation.

Please send us an e-mail with precise information about the error occurrence, device configuration, and, if possible, screenshots of the problem to support@plux.info.

6.5. Regulatory Disclaimer

BITalino products are intended for use in life science education and research applications; they are not medical devices nor are they intended for medical diagnosis, cure, mitigation, treatment or prevention of disease. we expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.

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