

USER MANUAL

SennsLite Software

Version 2.0

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1. Introduction

SennsLite is a research application for data collection with several sensor modalities seamlessly synchronized.

This software allows the user to record data from a single or multiple Bitbrain devices and sensor modalities simultaneously, synchronize the sensors and export the output to an interoperable format so that the researchers can perform their own analysis.

This document includes installation guidelines, an overview of the different operation modules (Recording module, Data Manager module, and Settings module) and a description of the exported data. For Ikon and Ikon Sleep EEG devices, the guide also covers IkonApp, a software module intended for home-based signal recording by participants, and other specific features that apply only to these devices. Finally, annexes are included for device-specific information and guidelines for contacting Bitbrain technical support.

1.1 CONNECTIVITY

Most of the Bitbrain EEG devices (Air, Diadem, Hero, Versatile) and other biosignal systems (Versatile Bio and Ring) transfer data to the recording station using a Bluetooth connection. The Ikon and Ikon Sleep EEG devices use Bluetooth Low Energy (BLE).

Versatile Plus devices support both wireless and wired communication: in addition to Bluetooth connectivity with internal SD card backup, these devices can also transmit data through a USB cable, providing a direct connection to the recording computer.

Important note: Devices with Bluetooth Low energy (BLE) modules (Ikon and Ikon Sleep) require Windows 11 for proper operation and connectivity stability. Please note that Windows 10 is no longer supported by Microsoft, and no further improvements to BLE performance are expected. For this reason, we strongly recommend using these devices only with Windows 11.

Note that Bluetooth connectivity does not guarantee that all data packages are received. For this reason, Ikon, Ikon Sleep and Versatile Plus devices include an internal SD card to store data. In the case of the other Bitbrain devices, they feature a slot for an external SD card. Storage capacity varies by device:

For Bitbrain devices that use external storage, the recording data are saved to an 8 GB SD card supplied by Bitbrain, and the use of the manufacturer-provided card is required to ensure proper operation and compatibility. Ikon and Ikon Sleep devices include an integrated 16 GB internal SD card, while Versatile Plus devices feature a 64 GB internal SD card.

1.2 SOFTWARE VERSIONS

SennsLite is available for Windows OS (10 or later, Windows 11 strongly recommended) and Linux (Ubuntu 22.04).

2. Windows Installation

Use the Windows installer provided by Bitbrain in the [Download Center](#) to set up the software on the selected computer. These are the steps to follow for a successful installation.

1. Select the language to use during the installation.

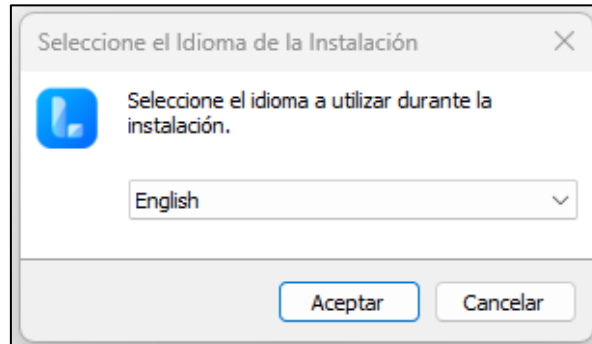


Figure 1. Language selection window for installation

2. Accept the license agreement.

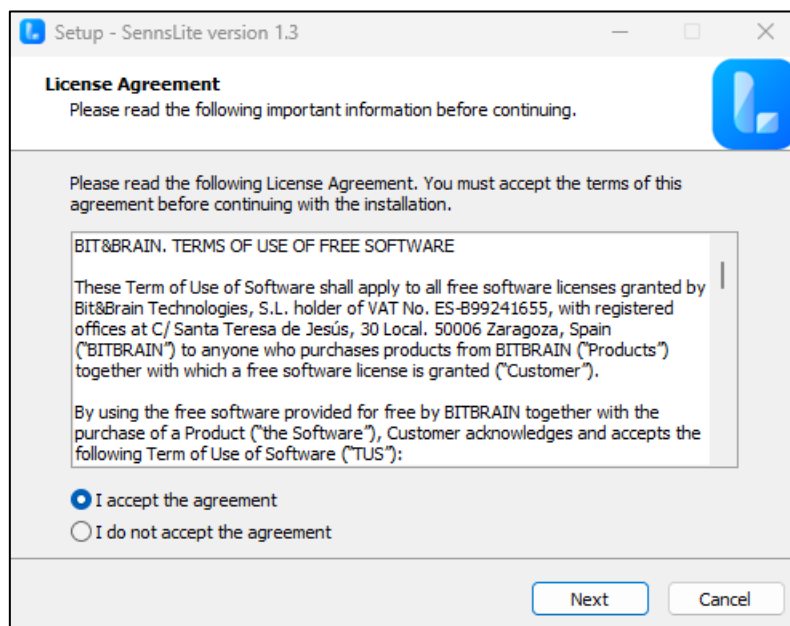


Figure 2. License agreement acceptance dialog box

3. Select where to install SennsLite.

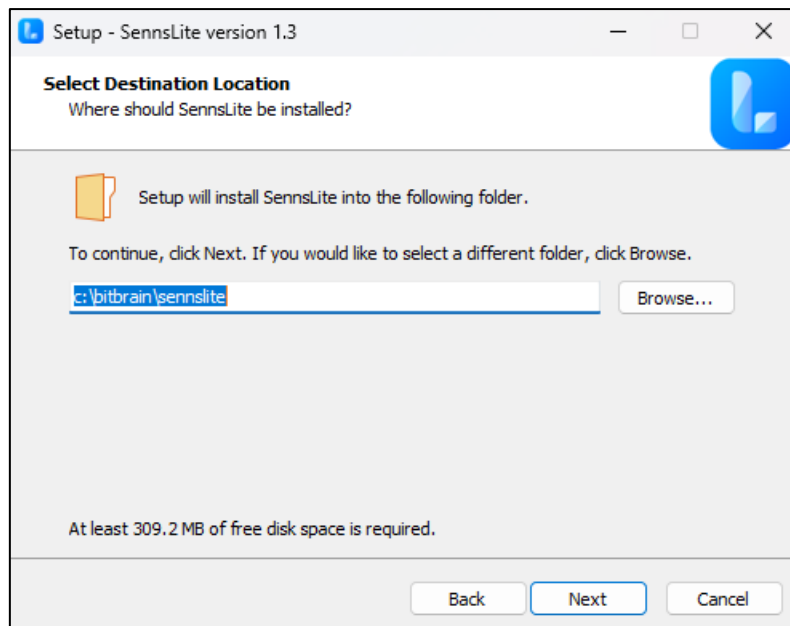


Figure 3. Window to select SennsLite Destination Location

4. Select where to place the program's shortcuts.

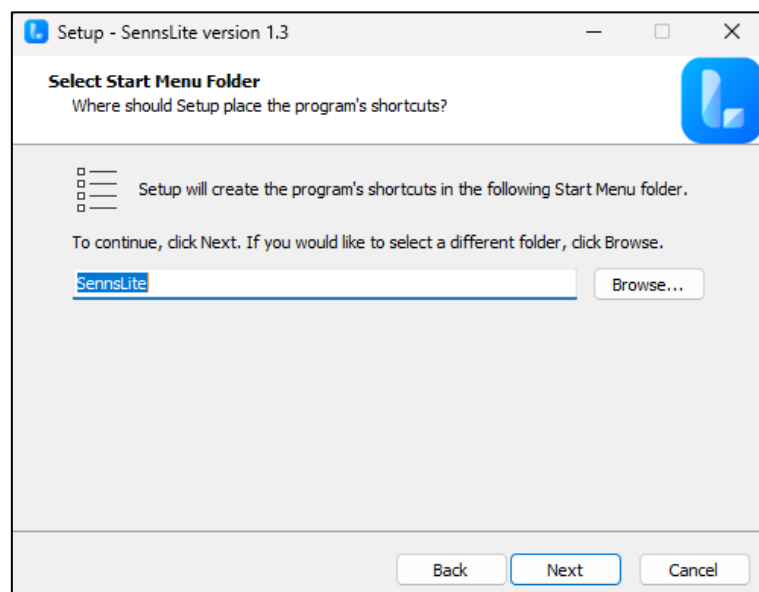


Figure 4. SennsLite shortcut placement screen

5. Confirm the previous settings to proceed with the installation of the software.

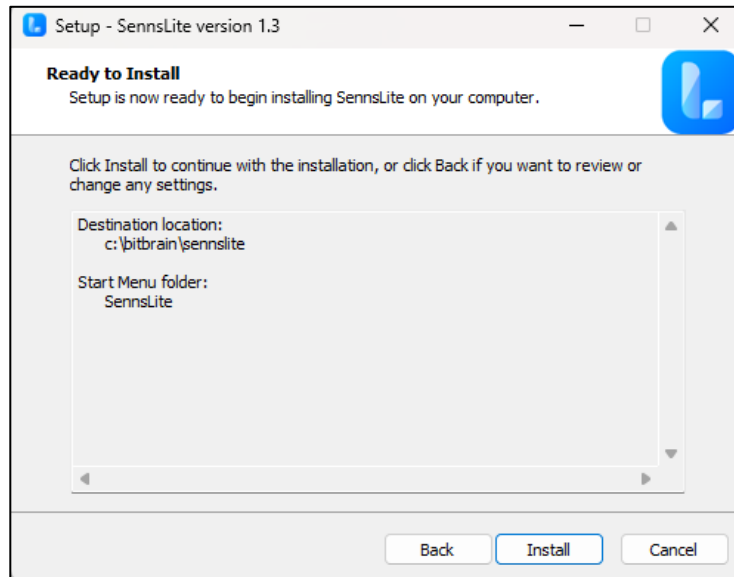


Figure 5. SennsLite installation window

6. After clicking install, the installation process takes place.

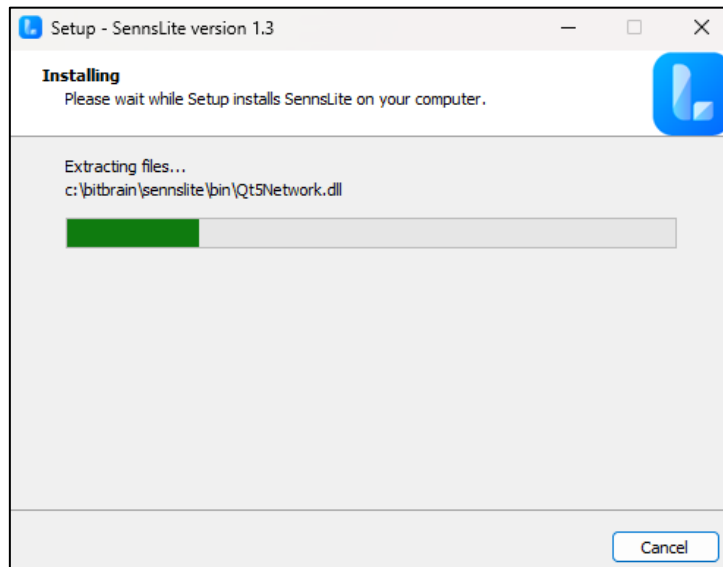


Figure 6. SennsLite installation in progress

7. The installation is finished, and the software can be used.

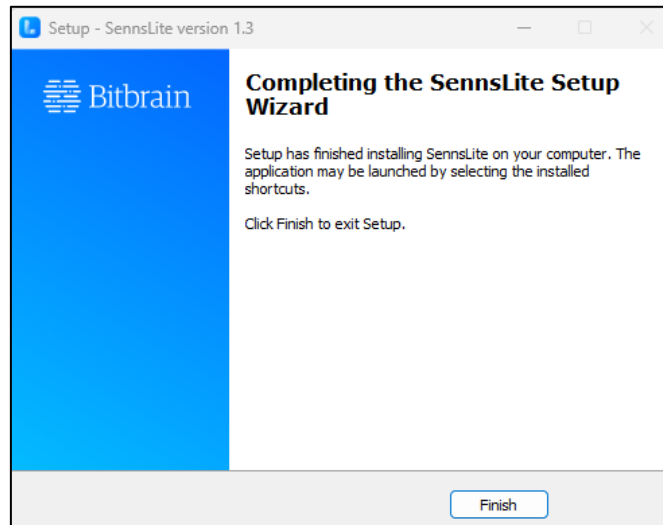


Figure 7. SennsLite installation complete

8. When SennsLite is launched for the first time, the user will be prompted to select the power line frequency according to the region where the system will be used from. Select 50 Hz or 60 Hz depending on the local mains power frequency.

Note: In most of Europe, Asia, Africa, and Australia the mains frequency is 50 Hz, while in North America and parts of South America it is typically 60 Hz. If unsure, please check your local electrical grid specifications.

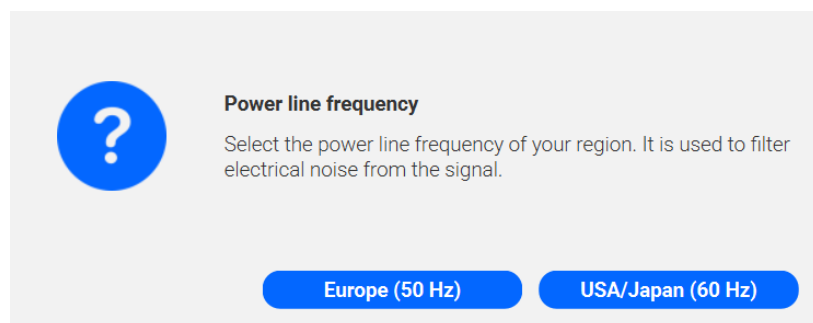


Figure 8. Power line frequency initial selector

3. Linux Installation

This section explains how to install and run SennsLite on Linux. The process is straightforward and only needs to be completed once on each computer.

First, download the required files for Linux (Ubuntu 22.04) provided by Bitbrain in the [Download Center](#). Then, extract the package into a local folder on your computer. Once extracted, you will find the SennsLite directory structure, including the release/base folder used in the steps below.

If this is the first time you are running SennsLite on a Linux machine, follow these steps:

1. Navigate to the installation directory

Open the folder where SennsLite was extracted and go to: release/base/main

2. Locate the installer script

Inside this folder, you should find a file called: installer.sh

3. Open a terminal in the folder

Right-click anywhere inside the release/base folder and select "Open in Terminal".

4. Run the installer

In the terminal, execute the following command: `'sudo ./installer.sh'`.

You will be prompted to enter a password. This is your Linux login password. This step installs the required components to run SennsLite on your system —primarily Qt and LSL dependencies—using the Ubuntu package manager.

Once the installation step has been completed (either just now or previously), SennsLite can be launched as follows:

1. Open a terminal in the same directory, following the steps explained previously.

If the terminal is no longer open, right-click inside the release/base/main folder again and select "Open in Terminal".

2. Start SennsLite

Run the following command: `'./lite_exec.sh'`

SennsLite will now start and is ready to be used on Linux.

Note: The installer.sh script only needs to be executed once per machine. For subsequent uses, you can directly run `./lite_exec.sh` to launch SennsLite.

4. Software Modules

The software has **three main** modules of operation:

- *Recording*: Allows the definition of the participant ID, destination folder, and the devices and signals to be recorded.
- *Data Manager*: Allows the export and visualization of recorded and synchronized data for further analysis. If SD card recording was previously enabled in the Recording Module, data from the SD card can also be imported through this window.
- *Settings*: Allows the configuration of specific application options, like export settings, user markers, LSL streaming and additional features specific to Ikon devices.

Three main buttons in the top-left corner of the initial screen of the software allow the navigation between these windows, as seen in Figure 9.

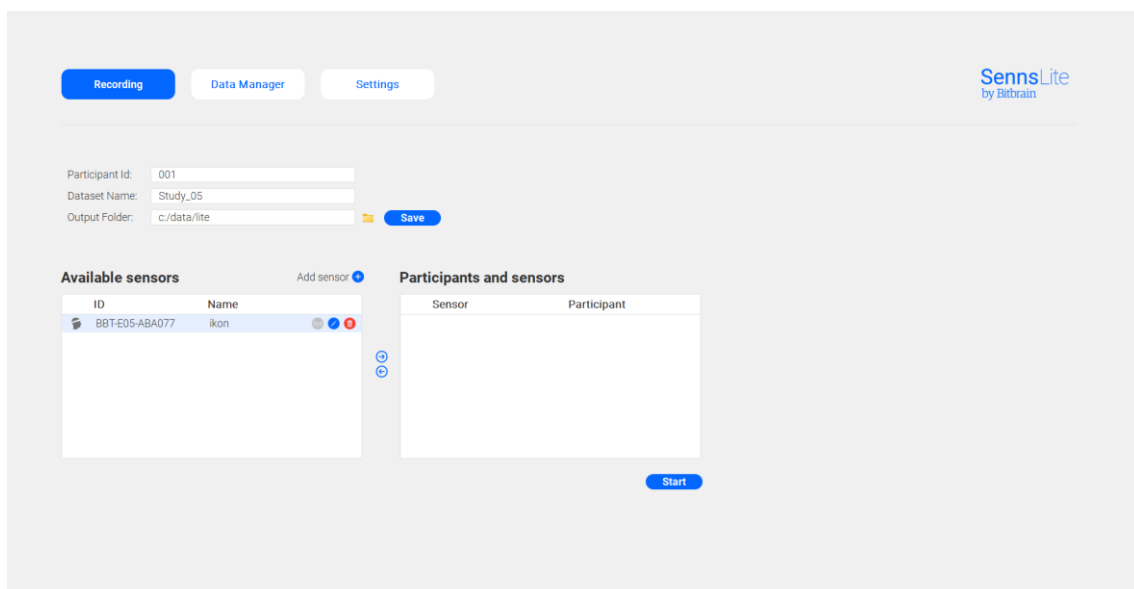


Figure 9. Initial screen of SennsLite software.

To perform a recording, three steps must be completed:

1. **Configuration**: Set up the participant and dataset IDs, as well as the output folder, and the devices from which to record. Also configure the settings of each device: serial number, signal types, ability to record in the SD card and to stream data through LSL.
2. **Data quality checking**: Review the data quality indexes before starting the actual recording. This helps to ensure that the device is placed correctly for obtaining data with the best possible signal quality. Currently, quality indexes are available for signals captured across all EEG devices and for additional biosignals recorded with the Ring device.
3. **Data recording**: carry out the task recording to save the data to disk.

5. Recording Module

5.1 STUDY CONFIGURATION

In the upper left part of the screen seen in Figure 10, there are three text boxes that need to be completed before starting any recording:

- Participant ID: Alpha-numerical ID.
- Dataset Name: Name of the folder where the dataset will be recorded.
- Output folder: Path to the folder where the dataset will be stored. **Important note: It is necessary to save recordings to a local drive rather than a cloud-synchronized folder, like One Drive, as it may interfere with the data import and export processes.**

The “Save” button allows to store the defined Participant ID, Dataset Name and Output folder settings.

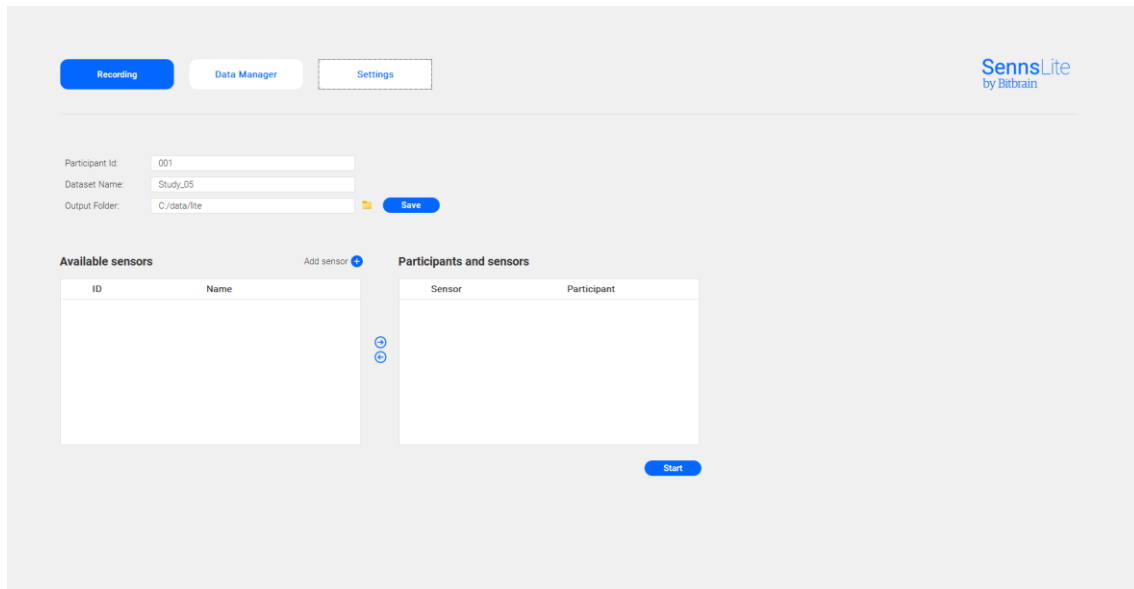


Figure 10. Recording Module

These three configuration parameters are mandatory and determine the output folder where the data is stored (see Section 7).

5.2 ADDING A NEW DEVICE

By clicking on the “Add sensor” button (see Figure 10), a screen will open (see Figure 11) to guide the user in the process of adding and configuring a new device. The following parameters must be configured:

- Type: Select the type of sensor from a dropdown menu.
- Name: Set a name to identify the device.
- Id: Type the serial number of the device.

- **Signals:** Select the signals to be recorded with the device. The signals available for recording depend on the inputs provided by the selected Bitbrain device. Refer to the corresponding User Guide for your device to identify the supported signal types and inputs. Please note that:
 - **Devices that share the Digital Input and Photodiode Input through a common connector only allow one of these inputs to be used simultaneously.** Consequently, when a photodiode is connected, Digital Input signals cannot be recorded, and vice versa.
 - **Only the selected signals will be recorded by the device, and it will not be possible to recover non-selected signals during recording or when exporting data.**
- **SD Card:** Enable the recording to the device's SD card.
- **LSL streaming:** Enable the streaming of data through LSL.
- **Settings wheel:** Provides amplifier information, including firmware version and internal SD card capacity. Only available for BLE devices (Ikon and Ikon Sleep). For the rest of the devices, this button will appear disabled.

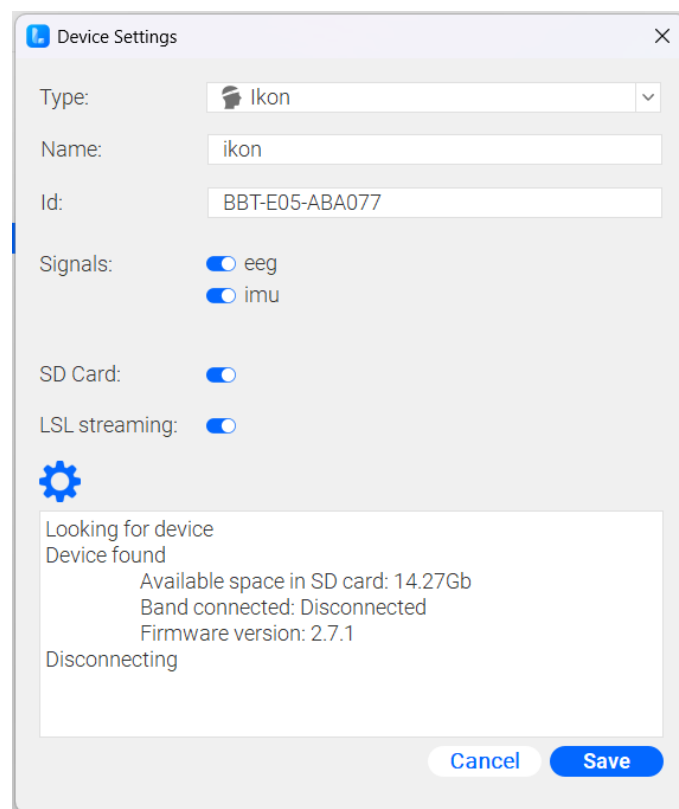


Figure 11. Device Settings window

Once the sensor has been configured, click on the “Save” button to continue.

The newly added device will then appear in the “Available sensors” list with its corresponding serial number that identifies it, as seen in Figure 12.

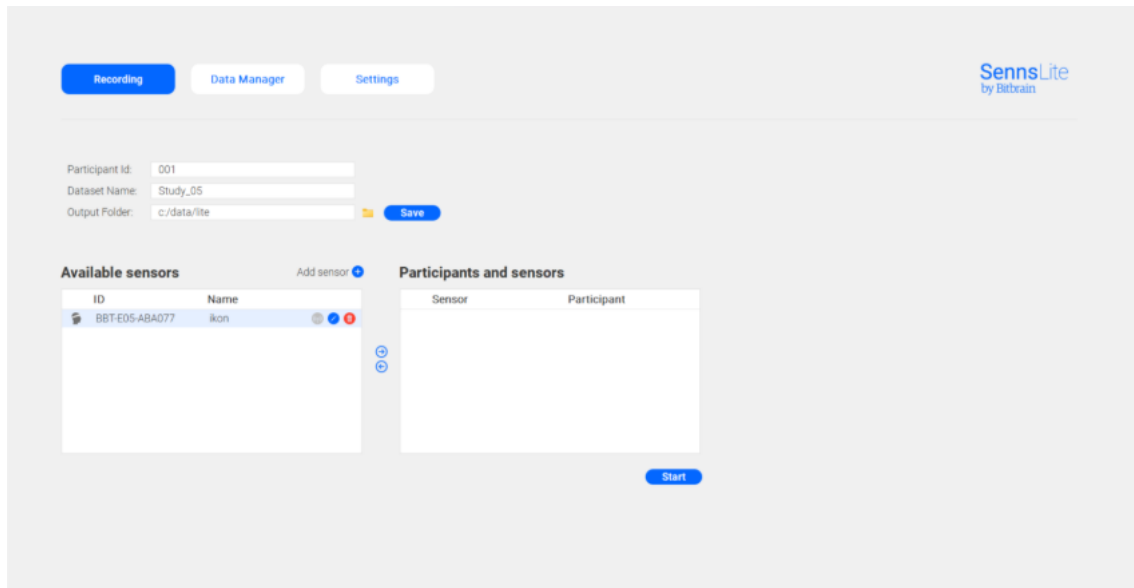


Figure 12. Sensor added to the “Available sensors” list

The buttons next to each sensor in the “Available sensors” list, allow the following actions:

- Pairing of the Bluetooth device: this step is mandatory (only once in a computer) for the standard Bluetooth devices, both in Windows and Linux. **It is not needed in Ikon or Ikon Sleep as it uses a BLE connection and therefore this button appears disabled.**
- Edit the device settings.
- Remove the device from the list.

Once the configuration is set and the sensor is added, select the device from the “Available sensors” list and transfer it to the “Participants and sensors” list using the horizontal arrows, allowing it to be included in the upcoming recording session, as seen in Figure 13. Additional sensors and participants can be defined and saved, enabling recordings with multiple devices and/or participants within a single session. For more detailed information on how to do this, see Section 10.

Once configured, click on the “Start” button to proceed to the “Sensors checking” window.

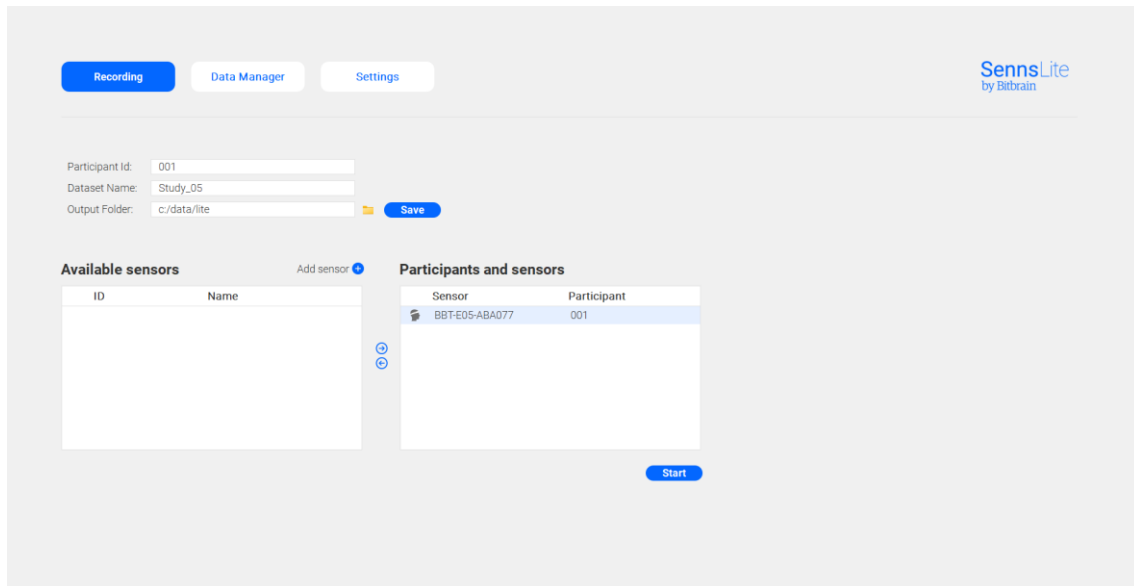


Figure 13. Selected device in the "Participants and sensors" list

5.3 VERSATILE PLUS EEG DEVICE-SPECIFIC SETTINGS

5.3.1 Data Acquisition Modes

Versatile Plus EEG devices provide several acquisition modes that allow users to balance wireless mobility, acquisition latency, sampling rate requirements and data storage options. Depending on the selected configuration, data can be transmitted wirelessly, stored locally on the device, or transferred through a direct USB connection:

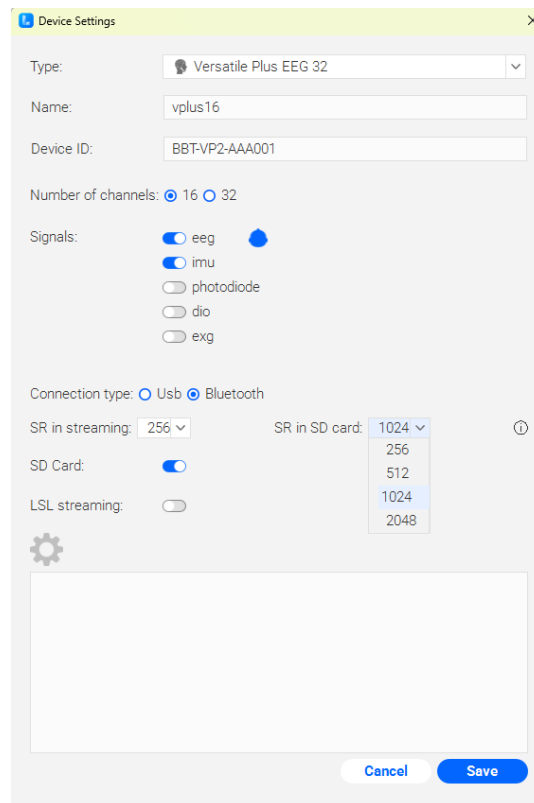


Figure 14. Device Settings window for Versatile Plus devices

- **Bluetooth Only**

In this mode, the amplifier streams data wirelessly to the acquisition computer through Bluetooth. Data is recorded directly on the computer and no backup copy is stored on the device's internal memory. This mode supports sampling rates of up to 256 Hz, making it suitable for standard EEG studies where moderate sampling rates are sufficient. Its main advantage is the ability to perform fully wireless acquisitions, allowing unrestricted participant movement and greater flexibility in experimental setups.

- **Bluetooth + Internal SD Card**

In this mode, data are simultaneously streamed via Bluetooth and stored on the device's internal SD card. This configuration combines high participant mobility with local data storage, providing protection against potential packet losses caused by temporary wireless communication interruptions. Bluetooth transmission is used primarily for real-time streaming, while the complete recording is stored locally on the amplifier's internal SD card.

This mode supports configurable sampling rates of up to 2048 Hz, making it the preferred option for studies requiring high temporal resolution while maintaining high participant mobility. **Please note:** Data stored on the internal SD card is not automatically included in exported recordings. To import the SD card data, the device must be first connected and accessed from the software. Otherwise, any exported data will correspond only to the data received and recorded via the Bluetooth connection. For additional information about data import and export procedures, please refer to Section 7.

- **USB Acquisition**

In USB mode, the amplifier is connected directly to the acquisition computer through the Isolator¹ and the provided USB cable. Data is transferred through the wired connection and recorded directly on the computer.

This mode supports sampling rates of up to 1024 Hz and is particularly suitable for long-duration recordings (the acquisition is not limited by the device battery life) and latency-critical applications. The wired connection minimizes transmission delays and timing variability.

Important: The amplifier determines its acquisition mode at power-on, depending on whether a USB connection is detected at that moment. To ensure the device starts correctly in USB mode, always follow this connection order:

1. Ensure the amplifier is powered off

¹ **Important:** When using a Versatile Plus EEG device connected via USB (data acquisition, data transfer, or battery charging), always use the supplied Isolator accessory. The Isolator provides electrical isolation between the amplifier and the computer, helping protect the device from electrical noise and power surges. For detailed information about the Isolator and its correct use, please refer to the Versatile Plus EEG User Manual.

2. Connect the Isolator to the computer and to the amplifier
3. Power on the amplifier

If the amplifier is powered on before the Isolator is connected, it will start in Bluetooth mode and will not switch to USB mode even if the USB connection is established afterwards. In that case, the amplifier must be powered off and on again with the USB connection already in place.

Please note: using the USB mode does not enable to use the internal SD card recording.

Summarizing, the maximum sampling rate depends on the selected acquisition mode:

Table 1. Maximum Configurable Sampling Rates by Versatile Plus Acquisition Mode

<i>Acquisition Mode</i>	<i>Maximum Sampling Rate</i>
<i>Bluetooth Only</i>	256 Hz
<i>Bluetooth + Internal SD Card</i>	2048 Hz
<i>USB Cable</i>	1024 Hz

When selecting the sampling rate, users should consider the requirements of the application. Sampling rates of 256–512 Hz are sufficient for most EEG studies, including cognitive neuroscience, BCI applications, neurofeedback, and general electrophysiological research. Higher sampling rates may be beneficial for applications involving precise timing analysis, high-frequency signal components, or advanced offline processing.

As a general recommendation, users should select the lowest sampling rate that adequately captures the signals of interest, as this reduces storage requirements and processing time without compromising data quality.

5.3.2 Digital I/O (DIO) Port

Versatile Plus EEG devices include a configurable Digital Input/Output (DIO) port that enables event marking and synchronization with other devices.

The DIO port can operate either as Digital Input or as a Digital Output. The appropriate configuration depends on whether Versatile Plus is receiving synchronization signals from external equipment or acting as the source of synchronization events:

- **Digital Input Mode:** When configured as a Digital Input, the DIO port can receive trigger signals from compatible accessories and external equipment. Received events are recorded together with the physiological data, allowing accurate synchronization between the acquisition and external events occurring during the experiment. Typical accessories and applications include, for example: a button box, a pedal, a TTL cable, etc.
- **Digital Output Mode:** When configured as a Digital Output, the DIO port generates TTL pulses that can be received by the digital input of another device using a TTL cable. These output triggers can be used to synchronize with other Bitbrain devices or external acquisition systems, enabling sample-level alignment between recordings.

In detail, the digital output signal consists of pulses every 30 seconds, with the pulse length randomly changing between 125 ms and 250 ms (short and long pulses, respectively). Each pulse is randomly short or long, so the train writes out a pattern as it goes. That pattern acts like a fingerprint: any short stretch of it is unique. Two devices can match fingerprints and line up their clocks exactly.

5.4 DEFINE CUSTOM LAYOUT (ONLY APPLIES TO VERSATILE & VERSATILE PLUS EEG DEVICES)

In the **water-based EEG devices** (Versatile 8, 16, 32, 64ch; Versatile Kids 16, 32ch and Versatile Plus 16, 32ch) an icon with the figure of a head will appear next to the “EEG” signal button, as indicated in Figure 15.

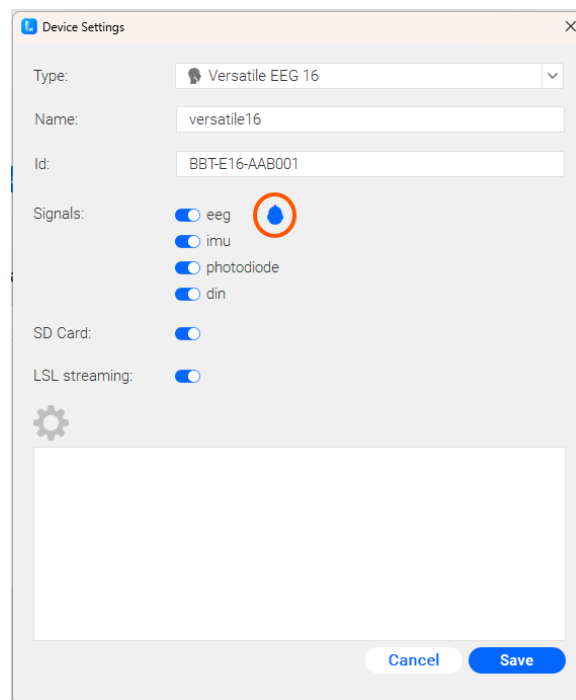


Figure 15. Device Settings window for Versatile and Versatile Plus EEG devices

This functionality allows the user to define the EEG sensor placement and visualization. Specifically, it enables the definition of the sensor positions on the head according to the international 10/10 electrode positioning system for EEG recording, as well as the selection of the order in which EEG channels are displayed in subsequent windows (“Sensor checking” and “Study in process”). Channels can be visualized either ordered by anatomical brain regions or ordered sequentially by sensor number.

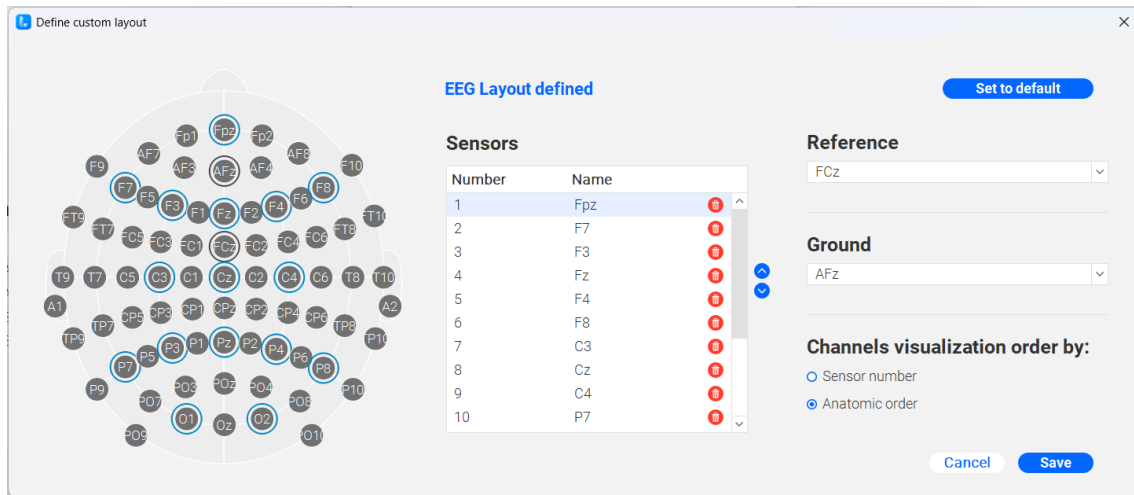


Figure 16. Custom layout definition window in Versatile and Versatile Plus EEG devices

Clicking the blue head icon (circled in Figure 15) opens a window titled "Define custom layout" (Figure 16) that contains several interactive components:

- The head illustration on the left shows all the available positions in the cap, according to the EEG international positioning system. The ones that are circled in blue represent those that are selected as recording sensors, and the ones that are circled in grey represent the reference and the ground.
- The "Sensors" list displays the selected recording EEG sensors. The "Number" corresponds to the one found in each cable of the sensors' bundle, and the "Name" represents the position that each one occupies in the cap.
- The reference and ground sensors that appear on the right side of the window cannot be changed, except in the Versatile Kids, where the reference sensor can be reassigned using the dropdown menu.
- The "Channel visualization order" allows the user to choose how to visualize the selected EEG signals in the display of the following window ("Sensors checking").

A default layout is established according to the 10/10 and 10/20 international system for EEG recording; however, it can be changed based on the desired configuration of the sensors in the cap. This allows for a fully customizable arrangement of sensors in Versatile EEG devices.

The default EEG layout and visualization parameters are set once the device is added, but they can be adjusted through the following actions:

- The blue up and down arrows next to the sensors' list (see Figure 16) can be used to move the names to occupy the corresponding position set in the cap.
- The blue "Set to default" button seen in the top right corner of Figure 16, allows the user to directly set the default parameters for the sensors' layout and the channels visualization order.
- The reference and ground sensors that appear in the right side of the window seen in Figure 16, cannot be changed, except in the Versatile Kids, where the reference sensor can be reassigned using the dropdown menu.

- To remove a sensor from the list, click on the red trash-can button associated with that sensor.
- Then, to add a new sensor, the desired location can be directly selected on the head illustration by clicking on the available position. The sensor can then be adjusted using the up and down arrows, as mentioned above, to match the corresponding cable number.
- The effect of the selection in “Channel visualization order by:” will only be visible in the next windows “Sensors checking” and “Study in process” as its function is to reorganize the displayed EEG signals independently of the physical sensor positions on the cap.
 - When “Anatomic order” is selected, the software arranges the signals by anatomical region only for visualization: from left to right, frontal sensors are at the top, followed by fronto-parietal and parietal sensors, then temporal and temporo-parietal sensors, and finally the occipital sensors at the bottom of the signal display. **This only affects the order of visualization of the signals in the display. The correspondence between the sensor number (on the cable) and the electrode position on the cap according to the international system will not be affected.**
This grouping only places signals from nearby brain regions together, making visual inspection and signal quality checking easier and more intuitive.
 - When “Sensor number” is selected, signals are displayed in ascending order according to their assigned sensor numbers, starting from 1 up to the last sensor available on the Versatile or Versatile Plus EEG device.

The EEG layout properties established when clicking on the “Set to default” button, will set the “Channel visualization order” to “Anatomic order”, ensuring that, no matter how the sensors are positioned in the cap, the signals will be visualized from the front to the back, from left to right. It will also set the sensors’ position to the recommended EEG layout for each device, which can be checked in Bitbrain’s Help Center.

Once the layout is set, click on the “Save” button to continue.

5.5 COMPUTER SETTINGS FOR RELIABLE DATA ACQUISITION

To help prevent interruptions during data acquisition, SennsLite verifies several computer settings before a recording is started.

The following conditions are checked:

- The computer is connected to a power source
- Sleep/Hibernation modes are disabled.
- Automatic operating system updates are paused (Windows only).

These settings help reduce the risk of acquisition interruptions caused by battery depletion, loss of Bluetooth connectivity due to hibernation, or unexpected system updates and restarts during data recording:

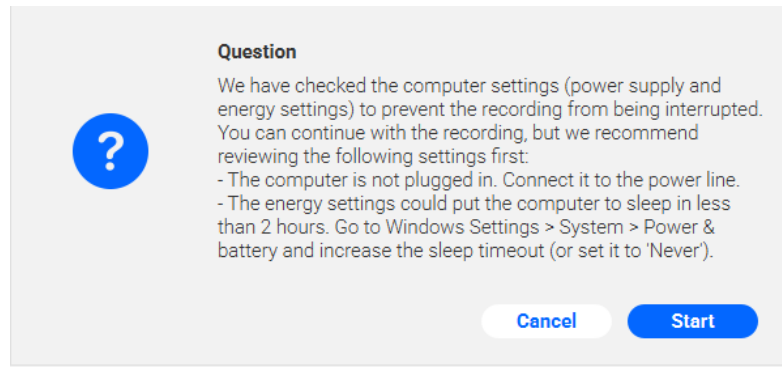


Figure 17. Computer Settings for Reliable Data Recording

Important: For all Bitbrain devices except Ikon Sleep, these checks are advisory only. If one or more recommended settings are not met, SennsLite displays a warning message before the recording starts, but the acquisition can still be initiated.

Since Ikon Sleep is intended for overnight recordings, these requirements are mandatory. The recording cannot be started until the computer is connected to an external power source and the required settings have been satisfied. The following message or similar will appear until the requirements are met:

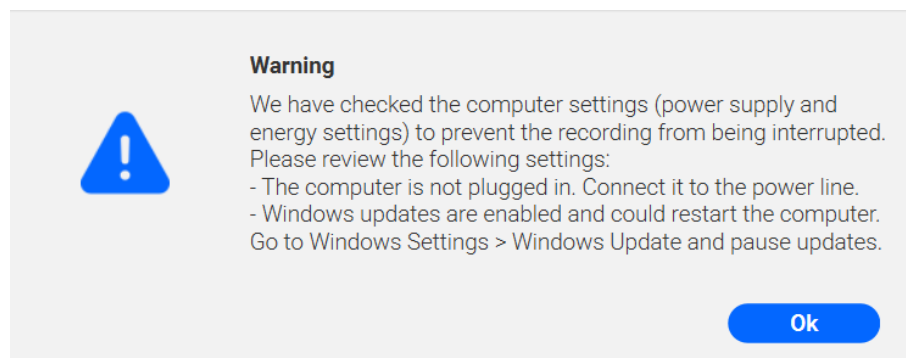


Figure 18. Computer settings to prevent interruptions during data recording with Ikon Sleep EEG

Before conducting an overnight study, users should verify that automatic updates are paused and that all power-saving features that may suspend system operation have been disabled.

These requirements help ensure continuous data acquisition throughout the night and minimize the risk of incomplete or corrupt recordings.

Note: This warning is displayed whenever the required computer settings are not met, even if Offline Recording (Ikon Sleep + SD Card)² has been enabled in Settings. The requirements must always be satisfied to start a recording session.

² To learn more regarding this functionality, please refer to Section 13.1

6. Data Recording

6.1 DATA QUALITY CHECKING

After pressing the “Start” button in the Recording module (Figure 13), the quality of the registered signal must be verified through the indicators for each type of sensor.

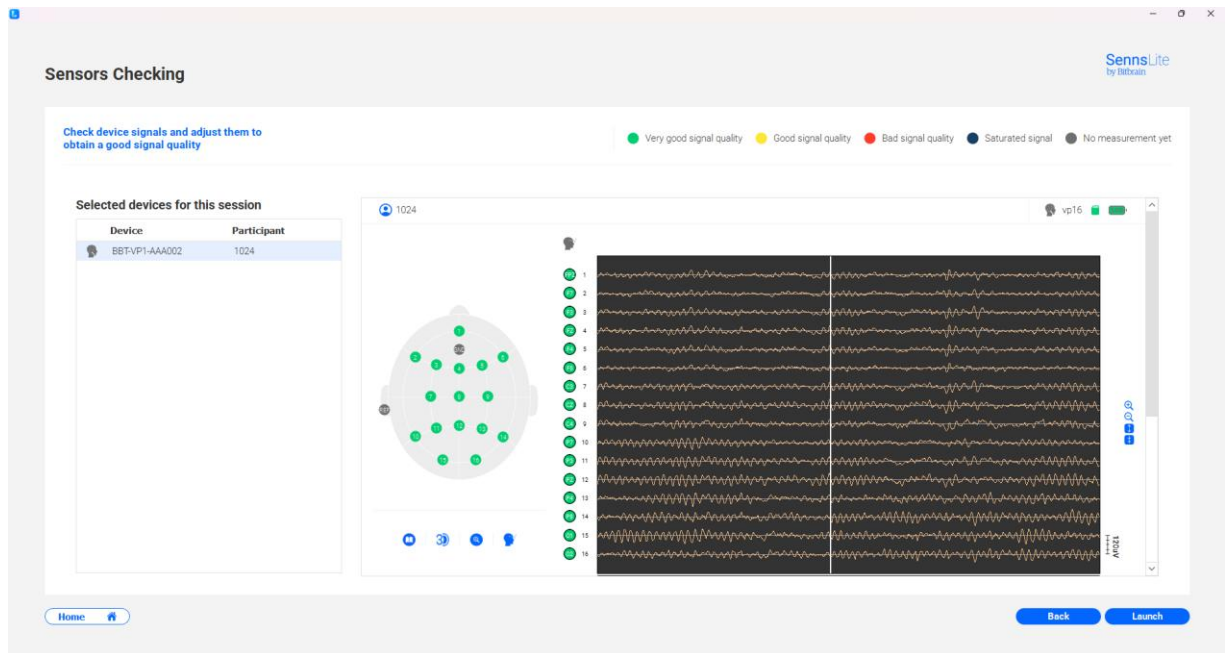


Figure 19. Sensors checking window

As shown in Figure 19, the icons in the upper right corner of the signal viewer indicate the status of the SD card, connection and battery:

- **SD card & connection feedback**
 - **Green circle (Device connected):** The recording in the SD card was not enabled in the Device Settings window and the device is correctly connected.
 - **Red circle (Device disconnected):** The recording in the SD card was not enabled in the Device Settings window and the device is disconnected.
 - **Green SD card icon (Device connected and recording on microSD):** The recording in the SD card was enabled in the Device Settings window, and the signal is being received and recorded to the SD card correctly.
 - **Crossed SD card icon (Not streaming but a record on microSD card was started):** The recording in the SD card was enabled in the Device Settings window, the recording started on the SD card, but no signal is currently being received. This is typically because the device is out of Bluetooth range or the connection has been lost.
 - **Gray SD card icon with a blinking red cross:** The recording in the SD card was enabled in the Device Settings window, but data is not being written to the SD

card. This can occur if the SD card is missing, incorrectly inserted or not properly detected by the device. This status only applies to devices with an external SD card and does not affect Ikon or Ikon Sleep devices.

- **Battery status:** Displays the current battery level of each amplifier as a percentage (%). This value is updated according to the charge level reported by the device.

Important note: When the battery level becomes low, the amplifier battery indicator will turn red. In this situation, it is recommended to stop the recording and recharge the amplifier before continuing, as continuing to record with a low battery may compromise the integrity and quality of the session data.

The icons on the right side of the signal viewer allow the user to adjust how the signals are displayed (Figure 19):

- The magnifying glass buttons allow the user to zoom in or out, making the signals appear wider or narrower.
- The blue buttons with inward and outward arrows control the vertical spacing between channels allowing a tighter or looser visualization of signals.

The left part of the window shows a list of devices. Selecting a device shows the corresponding streaming data in the signal viewer. Right-clicking on the signal viewer allows the configuration of filter settings (see Section 6.1.1 for more details).

In the screen shown in Figure 19, the signal quality indicators are displayed using a color legend (displayed in the upper part of the screen) for each sensor. These quality indicators are displayed over each position in the head illustration and in the left side of the signal viewer as well. Here, the name of each derivation is shown parallel to the number of the sensor. In Versatile EEG devices, they are shown as configured in the “Define custom layout” pop-up.

For EEG and Ring devices signals, the quality indicators can take the following levels:

- Light grey indicates that no measurement is available yet.
- Dark grey indicates that the signal is saturated.
- Red indicates poor signal quality.
- Yellow indicates good signal quality.
- Green indicates very good signal quality.

These quality indicators have a circle around it, which denotes how close the current level is from an adjacent one (i.e., transitions between green-yellow, and yellow-red states). This way the progress in the signal quality can be tracked.

Once the signal is checked and an optimal status is achieved, click on the “Launch” button to start the data acquisition.

6.1.1 Filter Settings

Besides the zoom and the spacing buttons on the right side of the viewer, there are more visualization options available by right clicking on the plot, including channel selection, x-y rescale and signal filtering.

These parameters **do not change the recording process, only visualization**. All the signals are registered unfiltered.

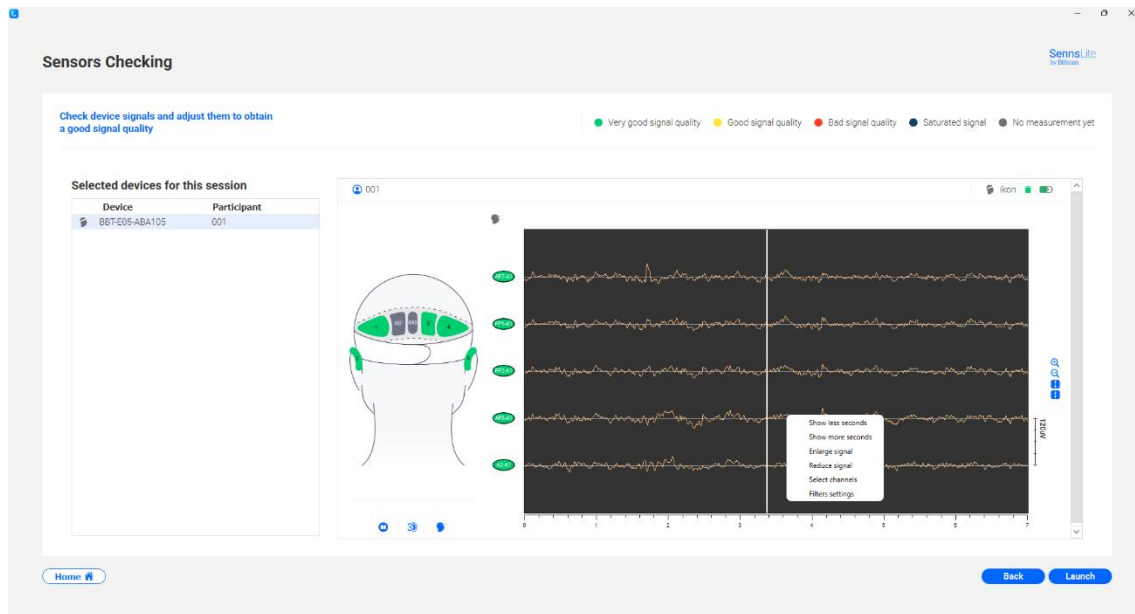


Figure 20. Visualization settings

The filter settings allow the user to apply visualization filters to the signal:

- Notch filter: Attenuates the electrical mains interference at 50 Hz or 60 Hz, depending on the power-line frequency configured for the region, helping to reduce power-line noise while preserving the rest of the EEG signal. Please refer to the section 8 Settings Module in order to change the power-line configuration.
- Pass filter: Highpass, lowpass, or bandpass filter
- Re-referencing (**just for the Ikon EEG device**): The Ikon has the reference in the forefront (FP1 position, see Section 11 for further information). With this option, the re-referencing can be disabled, or set to A1 or A2 sensors. **By default, the re-referencing for the EEG signal in the Ikon device is set to A1** (note again this does not change the recording process, only the visualization).

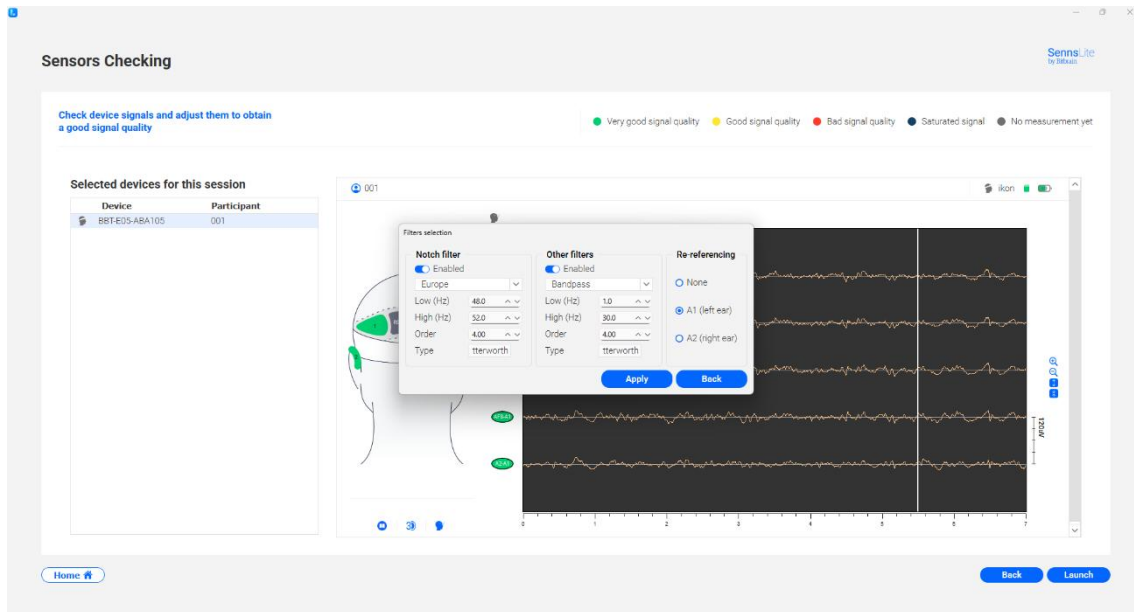


Figure 21. Recommended filter settings tab

The default visualization settings for each signal type are defined in Section 9.5

6.2 TASK RECORDING

Once the user clicks on the “Launch” button, the “Study in process” window will come up (as shown in Figure 22), where the data acquisition will take place. The recordings will be saved in the path previously established in the “Recording” module (Section 5.1).

Important: Before starting a recording, ensure that the computer used for data acquisition is configured to prevent sleep mode and that system updates are paused during the session. This is recommended to help avoid interruptions to the Bluetooth connection and prevent data loss. These settings can be adjusted in the operating system’s power management settings.

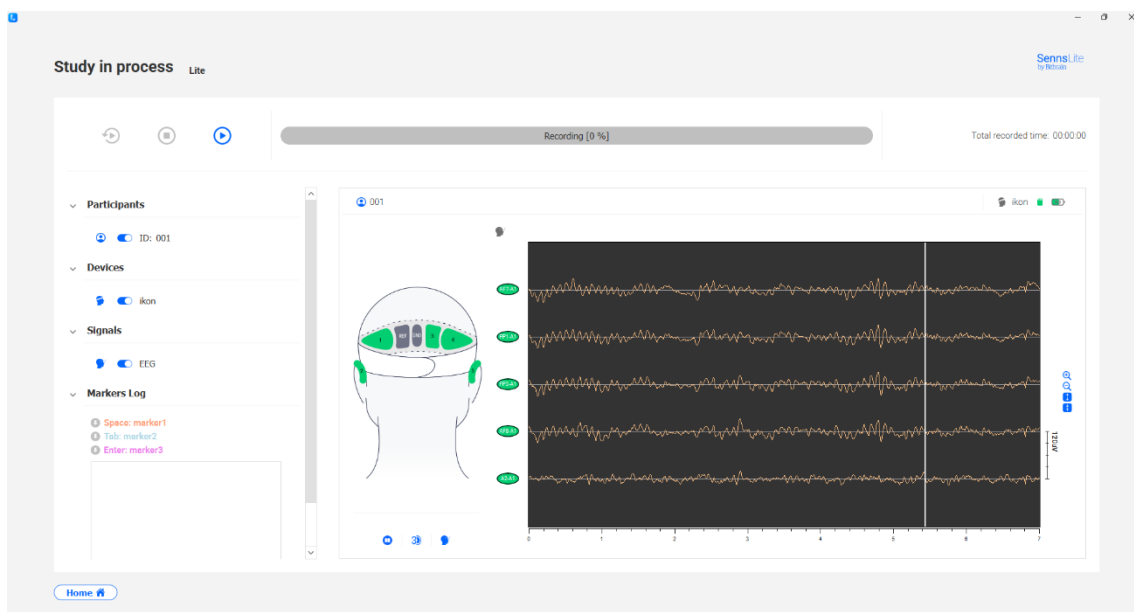


Figure 22. Recording window for Ikon EEG device

In the upper left corner of the window shown in Figure 22, “Start”, “Stop” and “Re-start” buttons are displayed and can be used to control the recording:

- To start the data acquisition process, click on “Start” button and carry out all the tasks defined on the experimental design.
- Click on “Stop” button to stop the recording process.
- To continue recording, click on the “Re-start” button. This will create a new recording within the same session. Once every task has been finished, click on “Home” button to get back to the main screen.
- After this, remove the devices from the participant and switch them off.

Below there is a description of the remaining options in the interface.

6.2.1 Registering Events

The user can register events during the recording by pressing different predefined keys. These keys must be configured in the Settings module before starting the session (see Section 8). When an event is triggered, it is marked in the online signal viewer as a vertical line and is also registered in the “Markers log”. These events are recorded across all the devices and signal types included in the session.

6.2.2 Graphical Elements Description

In the upper part of the “Study in process” window (see Figure 22) there are the following elements:

- In the upper central part of the window there is a bar that indicates when a task is being recorded.
- In the upper right corner, there is a timer that shows the total time recorded.

The left side of the window in Figure 22 shows a list of selectors that allow the user to customize how participants, devices and signals are **visualized** in this window. These options only affect what is shown on this screen and do not impact the recording process. If any item is deselected, it will simply stop being displayed, but the data will continue to be recorded as usual. The following options can be selected:

- Participant’s ID
- Devices being recorded
- Signals being recorded
- Markers log: User makers will be logged in the “markers log” window and will be a relative and absolute counter for the markers (for more information, see Section 8).

The right side displays the signal viewer together with the following information (see Section 6 for more details on the possible icon statuses):

- Device name

- SD card & connection feedback
- Battery status
- Buttons that control the vertical spacing between channels allowing a tighter or looser visualization of signals.

In Figure 22, below each of the illustrations representing the sensors' layout and the real-time contact-quality feedback, there are four blue buttons that can perform the following actions, from left to right:

- Access to the Bitbrain Download Center, where the Hardware's User Guides and Software's documentation can be found and downloaded.
- Display of the 3D brain layout (just for EEG devices).
- Display of the sensor numbers or locations (not available for Ikon and Ikon Sleep devices).
- Open a full screen graph to check all the EEG channels from a single device at once.

The bar in the signal viewer moves from left to right and represents the current time instant in every signal from every device.

7. Data Manager Module

This module allows you to manage recorded data: recordings can be managed either at the dataset level or at the session level. Figure 23 illustrates the Data Manager Interface. In the image below, the left-hand side of the window displays a file explorer that allows users to navigate through the dataset and session folder structure stored in the selected output location.

The information shown on the right-hand side depends on the folder selected in the file explorer. When a dataset folder is selected, the upper-right panel displays all sessions contained within that dataset. When a session folder is selected, the upper-right panel displays all recordings belonging to the selected session.

The action buttons available in the upper-right panel allow users to perform operations such as data visualization, SD card import, and data export. Depending on the selected folder, these actions can be applied at the dataset level, session level, or recording level.

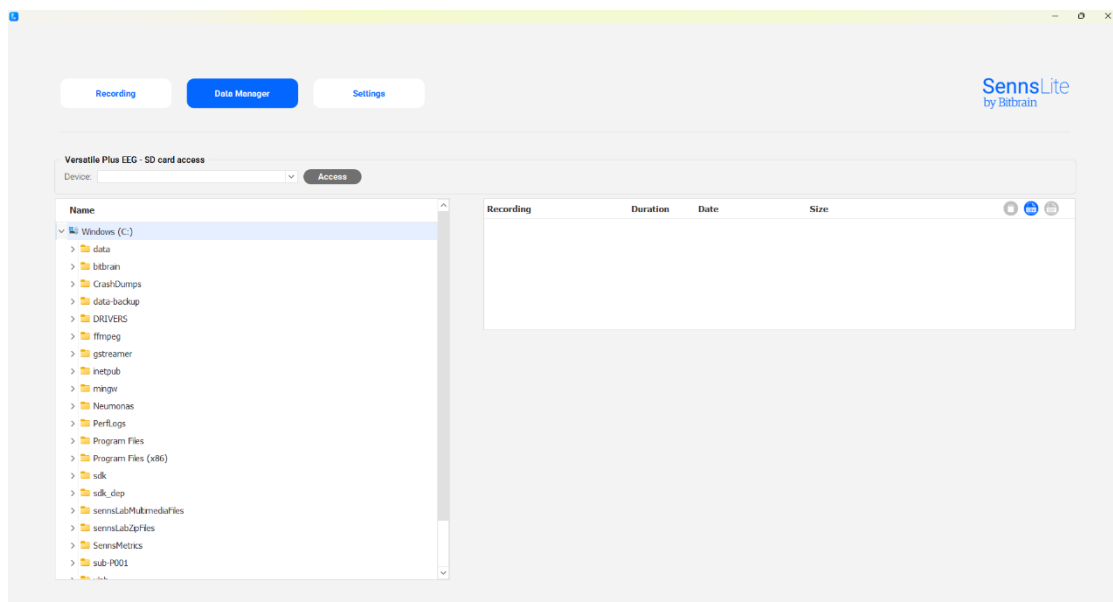


Figure 23. Data Manager Module Interface

Data recorded with SennsLite follows a logical folder structure:

- The output folder defined by the user (e.g., C:/data/lite) is the path in which the dataset folder is saved.

Note: If unexpected issues occur during data import or export, verify that the dataset folder is stored on a **local drive**. Datasets located in cloud-synchronized directories (e.g., OneDrive or similar services) may interfere with file access during data management operations. If such issues are encountered, Bitbrain recommends moving the dataset to a local storage location and repeating the operation.

- Folder with the dataset ID (e.g., DATASET_XXX)
- Folder with the participant ID (e.g., 1)

- Folder with the session number (e.g., Session01) contains the recording or recordings performed.

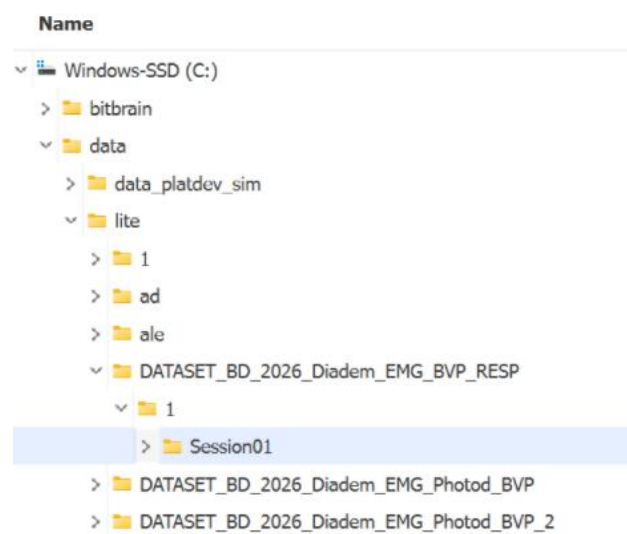


Figure 24. Logical Folder Structure in the Data Manager Module

Note that the session number is not defined by the user but is automatically managed by SennsLite. A new session is created every time a study is launched using the same combination of the selected dataset storage location, Dataset name and Participant ID. Session numbering starts at 01 and is automatically incremented by one for each new session created within the same study configuration.

Each recording is identified using the naming convention:

RecordingS[Session Number]R[Recording Number]

For example:

- **RecordingS01R000** corresponds to the first recording of Session 01.
- **RecordingS01R001** corresponds to the second recording within Session 01.
- **RecordingS02R000** corresponds to the first recording of Session 02.

The corresponding data is stored in a *.bbx* file. This is an internal format that must be exported to CSV/EDF. Note that only the signals from EEG devices data can be exported to EDF.

Note that the recording number is assigned automatically by SennsLite and cannot be modified by the user. Recording numbering starts at 000 and is incremented each time the Replay button is used to start a new recording within the same session from the Study in Process window.

The left-hand panel displays the folder structure of the selected output directory. **By selecting a dataset folder, the upper-right panel will display all sessions contained within that dataset.**

The upper-right panel provides the available actions for each displayed item through the corresponding action buttons, including data visualization, SD card import, and data export.

Depending on the selected folder, these actions can be applied either to an entire dataset (Figure 25) or to a specific session (Figure 26):

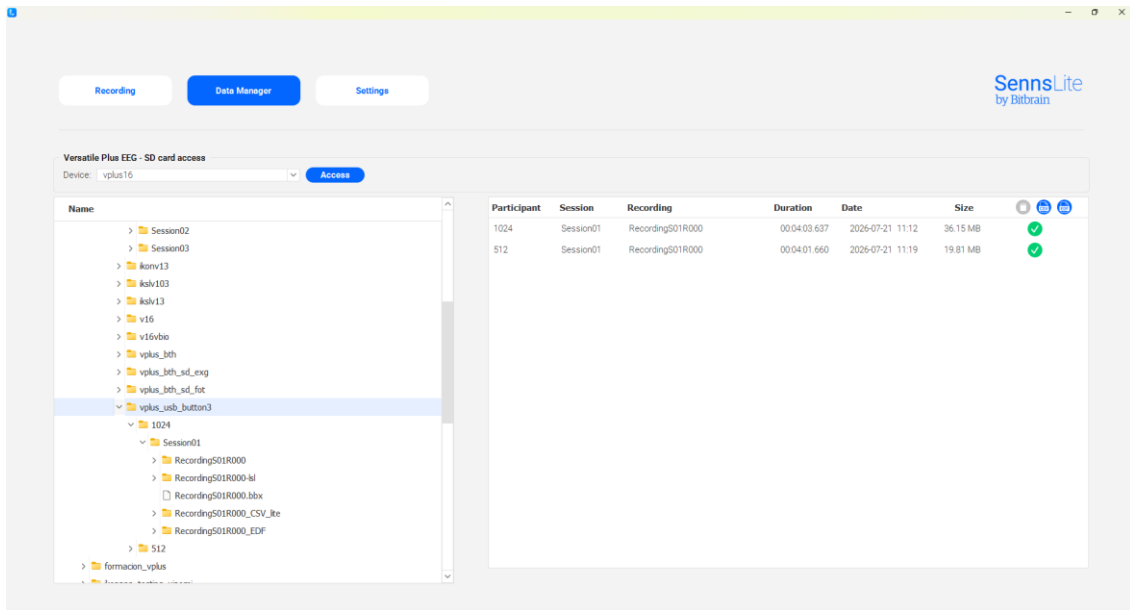


Figure 25. Dataset-Level Operations in the Data Manager

Alternatively, by selecting an individual session folder, the upper-right panel will display all recordings belonging to the selected session (Figure 26). The buttons displayed at the “Recording” row can be used for data import and export at entire Recordings of a session level. Each Recording displayed in the Recording List can be managed individually (for data visualization and export, but not for data import) using the action buttons available on its corresponding row. In addition, the lower-right panel shows the list of devices used during the acquisition, including the device type, name, serial number, and SD card import status when applicable:

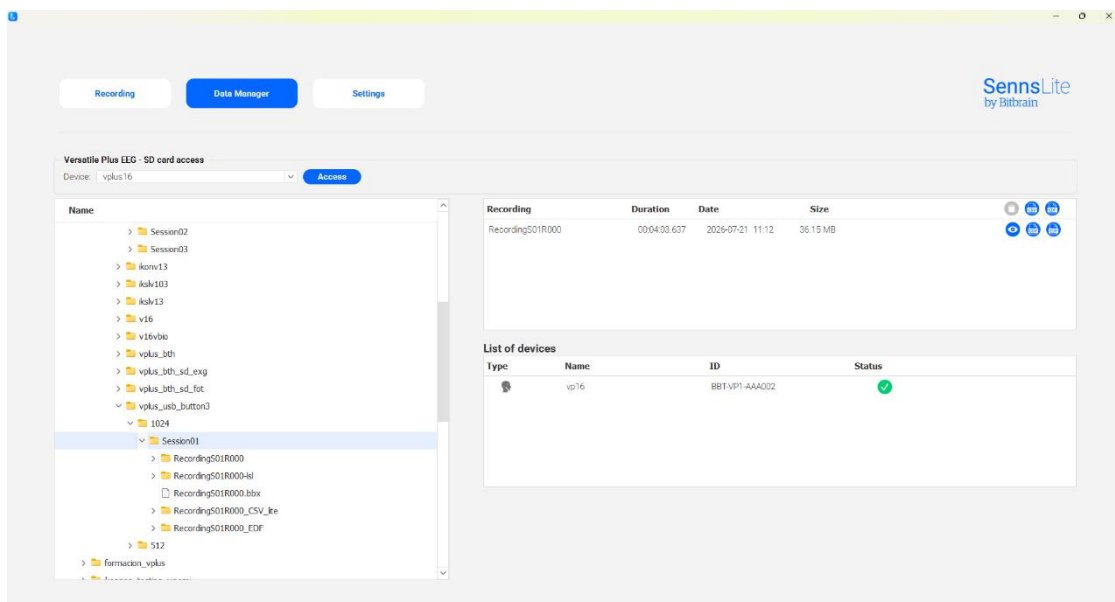


Figure 26. Session-Level Operations and Device Information Panel

In the “List of devices” menu, the **Status** icon can indicate one of the following states:

- A **red SD card icon** indicates that data was recorded correctly from the device, but the SD card content has not yet been imported. Figure 29 illustrates this state, specifically for the EEG signal recorded in that session.

- After the SD card data is imported, by clicking on the “Import sdcard file” button, the icon will change to a **green SD card icon** (Figure 30), confirming that the signals from the corresponding device have been recorded correctly and the SD card has also been imported successfully.
- If the SD card recording was not enabled during the session, these icons will show a **green checkmark**, indicating that the device was recorded correctly but without the SD card backup. Figure 25 and Figure 26 depict this status.

From left to right, the buttons showed at the upper-right panel in Figure 25 and Figure 26 allow the user (from dataset or session level) to import the SD card content, export the recording in CSV format (for all Bitbrain devices), and export the recordings in EDF format (only available for EEG devices).

The View Data button (blue eye icon) allows users to visualize the data recorded in a specific recording belonging to the selected session (only at session level, where the recordings are displayed; Figure 26).

The correct import and export procedures using these buttons will be explained individually in the following subsections.

7.1 VISUALIZATION WINDOW

The visualization window allows users to see the recorded signals in a specific Recording of a Session folder, within the software. Filter settings configuration is the same as the one described in Section 6.1.1. The window shown in Figure 27 can be accessed by clicking on the eye button that appears next to the specific Recording of a Session folder, as shown in Figure 26.

- On the upper left side of the screen, the timer shows the current time and the total duration of the recording.
- In the central part of the window, a time bar represents the total duration of the recording and can be used to navigate through different segments of the recording. The icons located to the left of this bar also facilitate navigation.
- On the upper right side, the “Scale” buttons allow the user to see the whole recording.
- On the left part of the screen, a list shows the sensors used in the recording, the signals recorded from each sensor, and the events logged during the session.

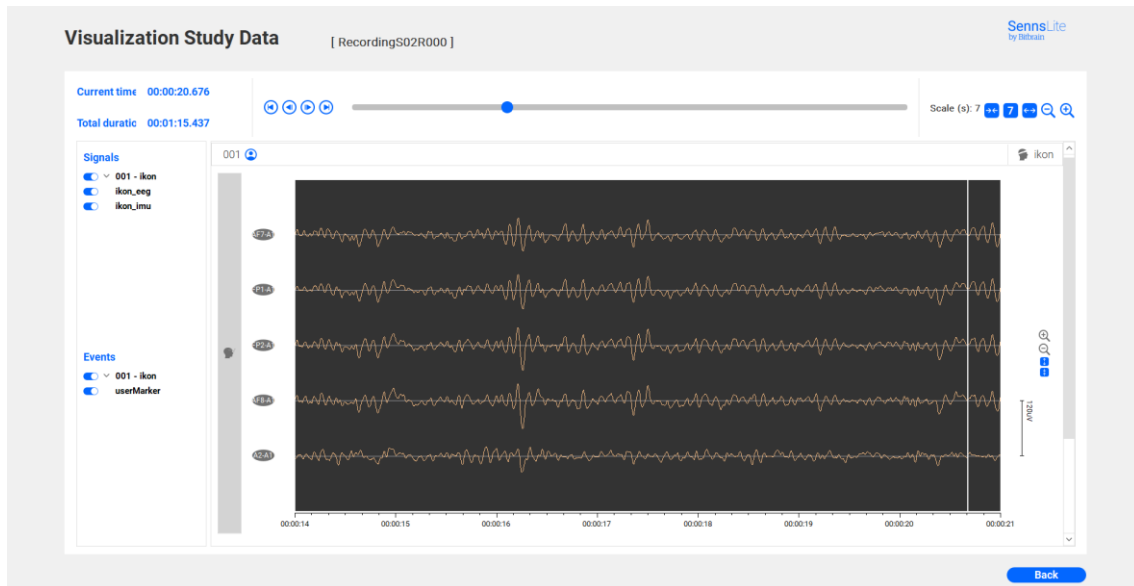


Figure 27. Window for offline visualization of recordings

Please note the following shortcuts for easier navigation:

- CTRL+Left/Right: Move forward or backward in the displayed data window.

7.2 IMPORTING SD CARD FILES

During the import process, SennsLite retrieves the data stored on the SD card and automatically fills any gaps that may have occurred in Bluetooth recordings due to temporary communication interruptions.

The first step required to access SD card recordings depends on the type of device being used and on whether the SD card is removable or integrated into the device. For this reason, device-specific instructions are provided in the following subsections.

Important: If the SD card data are not imported before exporting the recording, the exported files will only contain the data received through the Bluetooth connection. Any data stored exclusively on the internal SD card will not be included in the export.

1) Connecting the SD Card to the computer

Refer to the section that matches the device you are using before continuing with the import process:

- Section 7.2.1: Devices with Removable SD Cards
- Section 7.2.2: Importing SD Card Files in Ikon Devices
- Section 7.2.3: Importing SD Card Files in Versatile Plus EEG Devices

Once the SD card contents have been made available to SennsLite, the import procedure is common across all supported devices and is described below.

2) Importing Recordings

SD card recordings, as commented previously, can be imported either at the **dataset level** or at the **session level** (by selecting the corresponding folder), depending on the desired workflow:

To perform a dataset-level import, select the corresponding dataset folder and click the blue SD Card Import button available at the head of the right panel (Figure 28). All sessions and recordings contained within the selected dataset will be imported:

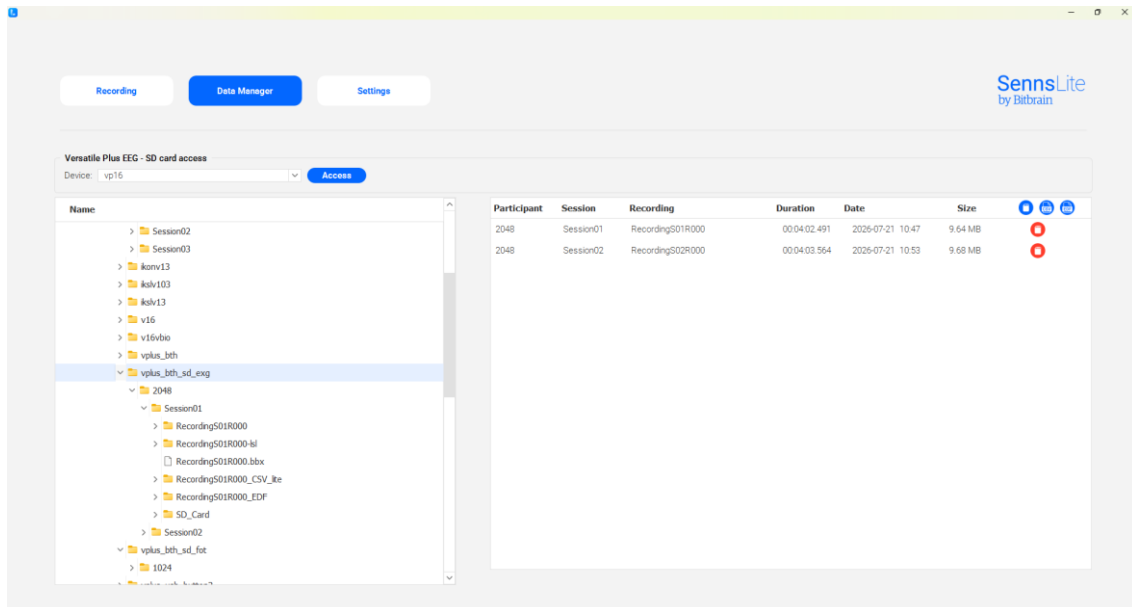


Figure 28. Dataset-Level SD Card Import: Importing All Sessions and Recordings Contained in the Selected Dataset

To perform a session-level import (Figure 29), select the corresponding session folder and click the blue SD Card Import button available in the upper-right panel. All recordings contained within the selected session will be imported.

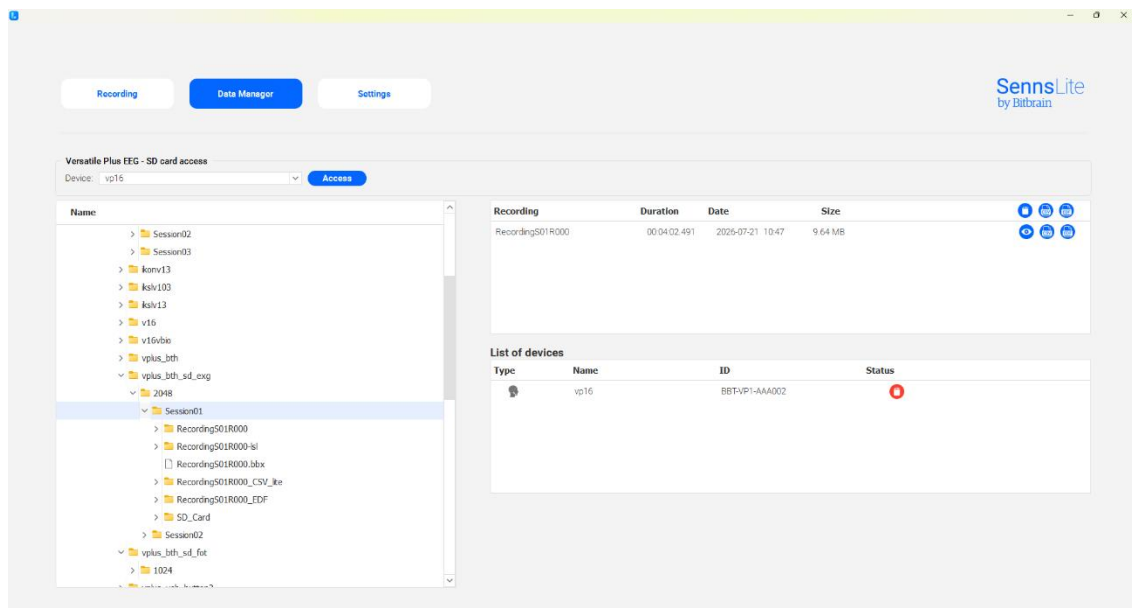


Figure 29. Session-Level SD Card Import: Importing All Recordings Contained in the Selected Session

Once a recording has been successfully imported:

- The SD card status indicator will change from **red** to **green**, as described in Section 7.
- The **Import** button associated with the imported session or dataset will become disabled (displayed in **grey** instead of **blue**), to prevent duplicate imports, as seen in Figure 30 and Figure 31.
- Once the data has been imported, the content from the internal SD card will be deleted automatically.

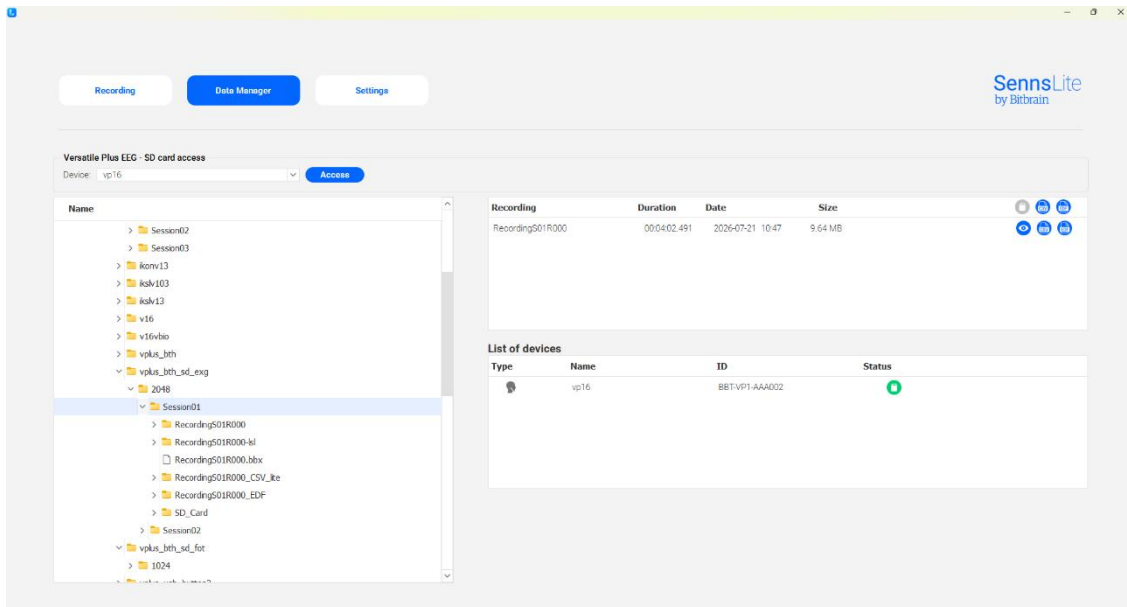


Figure 30. Session-Level Data Import Complete

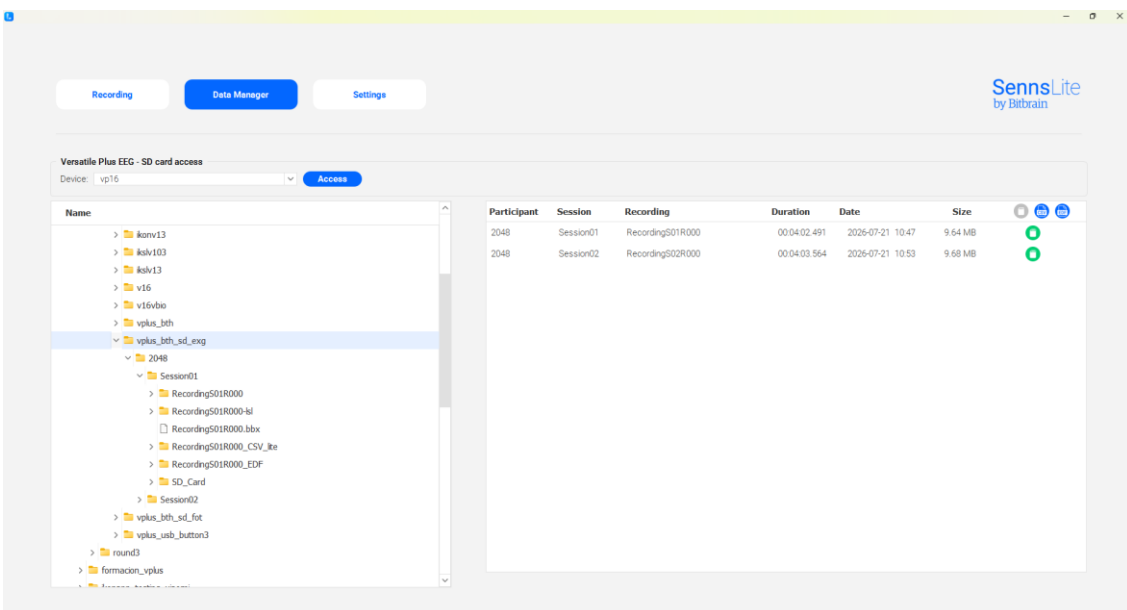


Figure 31. Dataset-Level Data Import Complete

Note: If the data needs to be imported on a different computer from the one used during the recording, the destination computer must also have SennsLite installed. In this case, first copy the dataset folder generated during the recording to the new computer. Then, open SennsLite, navigate to the copied folder path from the Data Manager module, locate the dataset or corresponding session folder, and follow the same SD card import procedure described above.

7.2.1 Devices with Removable SD Cards

For proceeding with the data import if you have recorded data with one of these devices, first do the following:

- Remove the SD card from the device and plug it into the computer on which SennsLite is installed. Use a USB adapter if necessary.
- Wait a few seconds until the operating system recognizes the SD card (a beep sound in Windows will be played).
- When the external SD card has been detected, you can proceed with data import in SennsLite following the steps mentioned in Section 7.2.

After import, the exported dataset combines the data streamed via Bluetooth with the data stored on the external SD card, providing the most complete recording available.

7.2.2 Importing SD Card Files in Ikon Devices

The process of importing SD card content from Ikon and Ikon Sleep devices is slightly different as they have an internal SD card that can be accessed by connecting the device to the computer using a USB-C cable. To import files from the SD card, follow the steps below:

- **Connect the turned off amplifier through cable to the computer.**
- Click once the amplifier “On” button so that the computer will detect the internal SD card. A green or yellow light (depending on the battery level) will be seen on the amplifier.
- Once it is detected by the computer (a beep sound in Windows will be played), follow the detailed instructions for importing the data explained in Section 7.2.

Note: Once the data has been imported, please safely eject the disk using your operating system's eject option before turning off or disconnecting the device. Also, after import, the exported dataset combines the data streamed via Bluetooth with the data stored on the internal SD card, providing the most complete recording available.

7.2.3 Importing SD Card Files in Versatile Plus EEG Devices

When recording in Bluetooth + Internal SD Card mode, a complete copy of the acquisition is stored on the amplifier's internal SD card. To access and export these data, the SD card recording must first be imported into SennsLite. For importing internal SD card data from Versatile Plus EEG devices, please carefully follow the instructions below:

1) Connecting the Device

To import SD card recordings, the amplifier must be connected to the computer using the **USB cable and the Isolator³ accessory**.

³ **Important:** When using a Versatile Plus EEG device connected via USB (data acquisition, data transfer, or battery charging), always use the supplied Isolator accessory. The Isolator provides electrical isolation between the amplifier and the computer, helping protect the device from

1. Ensure that the amplifier is **powered off**.
2. Connect the amplifier to the computer **using the USB cable and the Isolator**.
3. **Once connected, press the amplifier power button**. A status LED will turn on.
4. Wait a few seconds until the operating system detects the device (a beep sound in Windows will be played).

Note: The amplifier must be recognized by the computer as an external storage device before the SD card contents can be imported within SennsLite. For that, the following step must be completed in the SennsLite Data Manager Module:

2) Accessing the SD Card

Once the amplifier has been detected as an external drive:

1. Go to **SennsLite** and navigate to the **Data Manager** window.
2. Locate the **Versatile Plus SD Card** section in the upper-left corner.
3. In the **Device** drop-down menu, select the Versatile Plus EEG device from which the recordings will be imported.
4. Click **Access**. An information dialogue box will appear to confirm that the data has been correctly accessed (Figure 32). At this point, the device will be recognized by the OS as an external storage device and consequently data can then be imported through SennsLite following the steps of Section 7.2.

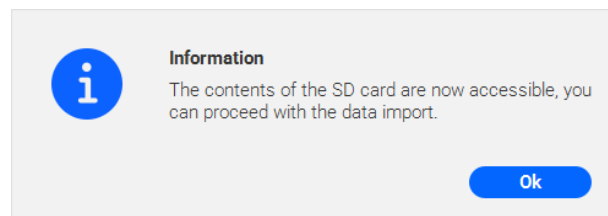


Figure 32. Data access complete for the internal SD card data recorded in Versatile Plus EEG

5. If the amplifier cannot be reached over USB, the warning shown in Figure 33 will be displayed instead. If this occurs, verify that the USB cable is correctly connected at both ends (computer and amplifier) and that the amplifier is powered on. Then click Access again.

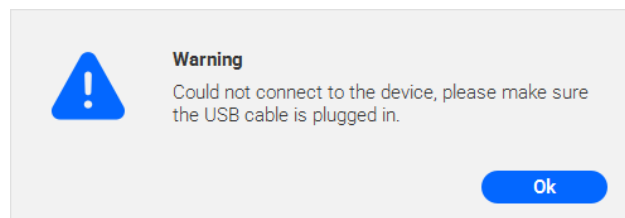


Figure 33. Connection warning shown when USB connection to the Versatile Plus cannot be established.

electrical noise and power surges. For detailed information about the Isolator and its correct use, please refer to the Versatile Plus EEG User Manual.

6. If the connection is established but the SD card contents cannot be accessed, the following message will be displayed. If this occurs, click Access again to retry.

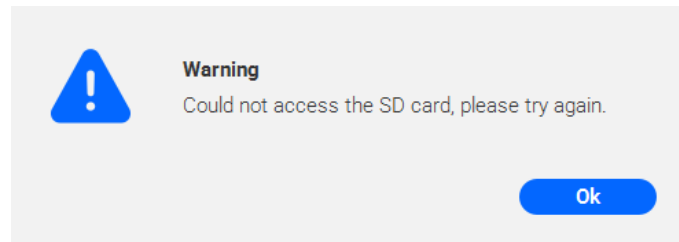


Figure 34. Warning message displayed when the internal SD card data cannot be accessed.

Note: Once the data has been imported, please safely eject the disk using your operating system's eject option before turning off or disconnecting the device. Also, after import, the exported dataset combines the data streamed via Bluetooth with the data stored on the internal SD card, providing the most complete recording available.

7.3 DATA EXPORT

Data can be exported from the Data Manager module either at the dataset level or at the session level, depending on the folder selected in the left-hand navigation panel.

The following export formats are available:

- EDF (European Data Format) is a [standardized file format](#) designed for storing biological signals. One file is generated for every recording device. Currently, this format is supported for Bitbrain devices that record EEG signals. Biosignals acquired with the Ring device or the Versatile Bio cannot be exported to EDF.
- CSV (Comma-Separated Values) is an interoperable file format for storing tabular data in plain text. One file is generated for every device signal. Signals recorded from all Bitbrain devices can be exported to this format. We provide two output formats with varying levels of detail. Depending on the selected mode in the "Settings" window (Lite or Full), the corresponding folder will be created with the name of the recording followed by "_CSV_full" or "_CSV_lite". If the user wishes to export both, they won't overwrite.

Dataset-Level Export

To export data at the dataset level, select the corresponding dataset folder in the left-hand panel. The export buttons identified by the CSV and EDF icons are available in the header of the right panel.

When a dataset-level export is performed, SennsLite exports all recordings contained in all sessions belonging to the selected dataset.

Session-Level Export

To export data at the session level, select the corresponding session folder within the desired dataset.

In this view, data can be exported in two different ways:

- **Session-level export:** Use the CSV or EDF buttons located in the header of the upper-right panel. All recordings contained within the selected session will be exported.

- **Recording-level export:** Use the CSV or EDF buttons displayed next to an individual recording. Only the selected recording will be exported.

Section 9 provides detailed information of the exported data format and its main differences.

Once the export process is completed successfully, a message will appear indicating the output folder where the exported files have been saved.

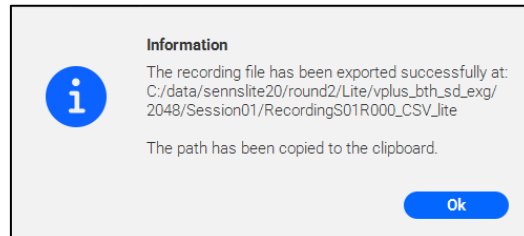


Figure 35. Message for the correct exportation of the recording files

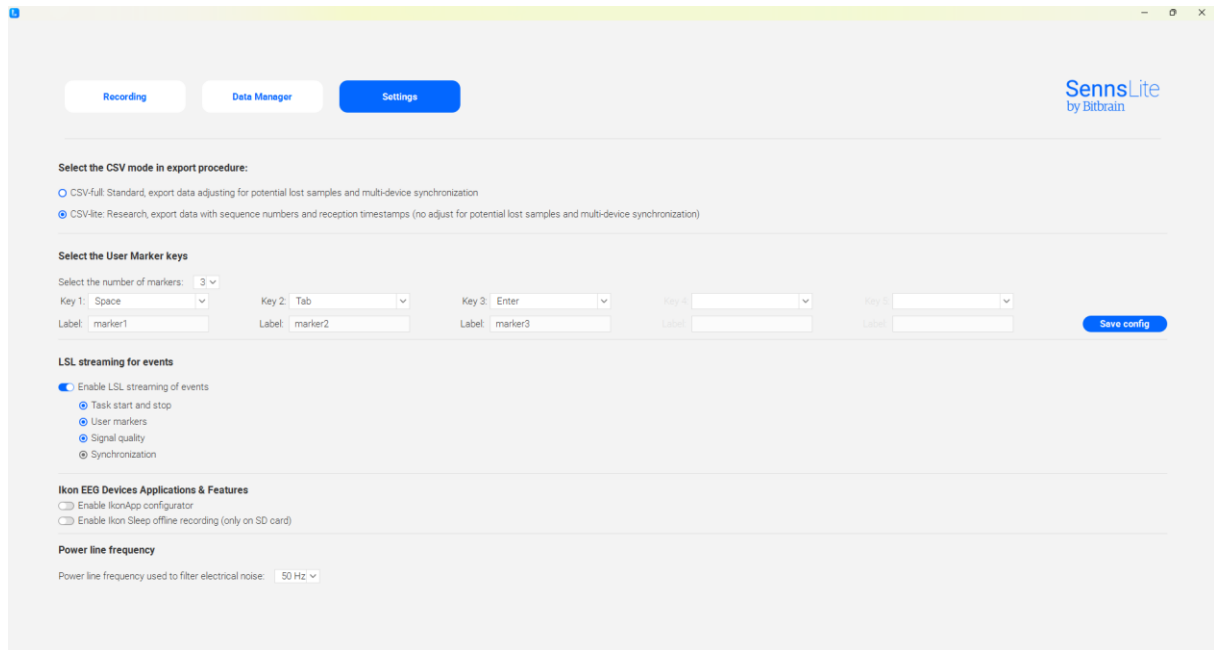
Before proceeding with the data export, SD card recordings (if enabled) should be imported. **If not, the exported data will only contain the data received during online operation with possible missing values due to the Bluetooth connectivity.** This can be checked in the *info.json* file, which stores metadata for each recording. If the fields *sd_sync_read* and *sd_data_read* are set to "true", it confirms that the SD card content was included in the exported data (see Section 9.4).

8. Settings Module

This module allows the user to configure various settings, as shown in Figure 36:

- **Exporting data method:** The CSV export format (CSV-Lite, CSV-Full) can be selected in this module. Check Section 9 for detailed information of the exported data.
- **User Marker keys:** Up to five markers can be set.
 - Select the number of markers from the dropdown menu from 0 to 5.
 - Key: Keys from the keyboard are set by default but can be changed from F1 - F12, Space, Tab and Enter. Please note that each key can only be assigned once. Using the same key for multiple events will cause an error when saving the configuration.
 - Label: be defined to identify the marker.
 - After setting the markers, save the configuration by clicking on the “Save config” button.
- **LSL streaming for events:**
 - Task start and stop: Event sent at the beginning and the end of the recording.
 - User markers: markers included by user.
 - Signal quality.
 - Synchronization: An event sent periodically to maintain synchronization.
- **Ikon & Ikon Sleep specific applications and features:**
 - Offline Recording (only for Ikon Sleep Devices with SD enabled during recording): This functionality has been specifically developed for **Ikon Sleep EEG devices** to better support sleep studies, where it is often more convenient to acquire data without having the acquisition computer powered on and located next to the participant throughout the night. To use Offline Recording, it is **mandatory to enable the internal SD card** in the device settings previously configured within the **Recording** window. Please refer to Annex 4: Apps & Features for Ikon and Ikon Sleep devices, Section 13.1 Offline Recording (Ikon Sleep + SD card) for more details regarding operation with this feature.
 - IkonApp Configurator: Participant self-recording module configurator only for Ikon and Ikon Sleep devices. Please refer to Section 13 for more details regarding the configurator and recorder.
- **Powerline Frequency Selector:**
 - This setting allows users to configure the powerline frequency used by the software (50 Hz or 60 Hz), matching the electrical network frequency of the region where the system is being used. Correctly configuring this parameter

helps ensure optimal signal quality and appropriate filtering of powerline interference with the Notch filter in signal visualization. Note that the powerline frequency is initially selected during the first software setup. However, this option can be modified at any time from the Settings menu using this functionality if the user moves the system to a different region with a different electrical network frequency or if the wrong value was selected during the initial installation.



The screenshot displays the SennsLite Settings Module interface. At the top, there are three tabs: 'Recording', 'Data Manager', and 'Settings', with 'Settings' being the active tab. The Bitbrain SennsLite logo is in the top right corner. The main content area is divided into several sections:

- Select the CSV mode in export procedure:** Two radio button options are present. The first is 'CSV-full: Standard, export data adjusting for potential lost samples and multi-device synchronization'. The second, which is selected, is 'CSV-lite: Research, export data with sequence numbers and reception timestamps (no adjust for potential lost samples and multi-device synchronization)'.
- Select the User Marker keys:** This section allows for the configuration of user markers. It starts with a dropdown to 'Select the number of markers' set to '3'. Below this, there are five key selection dropdowns (Key 1 to Key 5) and corresponding text input fields for labels. Key 1 is set to 'Space' with label 'marker1'. Key 2 is set to 'Tab' with label 'marker2'. Key 3 is set to 'Enter' with label 'marker3'. Keys 4 and 5 are currently empty. A 'Save config' button is located to the right of the labels.
- LSL streaming for events:** A toggle switch for 'Enable LSL streaming of events' is turned on. Below it, four radio button options are listed: 'Task start and stop', 'User markers' (which is selected), 'Signal quality', and 'Synchronization'.
- Ikon EEG Devices Applications & Features:** Two checkboxes are shown: 'Enable IkonApp configurator' and 'Enable Ikon Sleep offline recording (only on SD card)', both of which are currently unchecked.
- Power line frequency:** A label 'Power line frequency used to filter electrical noise:' is followed by a dropdown menu currently set to '50 Hz'.

Figure 36. SennsLite Settings Module

9. Description of Exported Data Format

SennsLite allows exporting the data in two formats:

- EDF is a standardized file format file designed for storing biological signals. One file is generated for every device. Supported only for Bitbrain devices that record EEG signals. For simplicity, this software and document refer to it as “EDF”; however, the files are specifically provided in the EDF+ format.
- CSV is an interoperable file format for storing tabular data in plain text. One file is generated for every device signal. Signals recorded from all Bitbrain devices can be exported to this format. We provide two output formats with varying levels of detail (Lite and Full).

These three output data formats (EDF, CSV-Lite, CSV-Full) differ in the following properties:

- Resolution and filtering: EDF represents the signal values in 2 bytes (16 bits), which does not allow to store the EEG and PPG signals as the full range of the amplifier ADC is 24 bits. Thus, EEG and PPG signals are high pass filtered (0.1 Hz, 2nd order Butterworth filter) when exported to EDF format. CSV formats (CSV-Lite, CSV-Full) export the full-band signals.
- Lost samples adjust: Some signal samples might be lost due to the wireless nature of communication. In EDF and CSV-Full, the exported signals are expanded with *NaN* values in case of lost samples. In CSV-Lite, additional information such as a sequence number (counter) is provided to detect these missing samples.
- Multi-device adjustment: In simultaneous multi-device recordings, the devices might start the recording with a slight difference (even when they are commanded at the same time). In EDF and CSV-Full, all signals share a common initial time (t_0), and they are padded with initial *NaN* values, so that the first sample corresponds to the same time point across devices. In CSV-Lite, each device’s signal includes its own initial timestamp (t_0), which may differ between devices.

The following table summarizes this information:

	<i>EDF</i>	<i>CSV-Full</i>	<i>CSV-Lite</i>
<i>Supported devices</i>	EEG devices (Ring and Versatile Bio not supported)	All	All
<i>Full-band</i>	No, EEG and PPG are high prefiltered (0.1 Hz)	Yes	Yes
<i>Lost samples adjust</i>	Yes	Yes	No
<i>Multi-device adjust</i>	Yes	Yes	No

In the next subsections we describe:

- EDF format
- CSV format
- Events
- Metadata (JSON files)
- Signal properties for every sensor modality, and the events properties.
- Information on how Bitbrain devices handle data transfer and timestamps.

9.1 EDF FORMAT

We provide an EDF file for every recorded device, thus containing all its signals that operate at different sampling rates.

The EDF file is composed of a set of channels:

Example:

```
eeg_AF7, eeg_A1, eeg_Fp2, eeg_AF8, eeg_A2, mask_eeg, imu_1, imu_2, imu_3, imu_4, imu_5, imu_6, imu_7,
imu_8, imu_9, mask_imu, spo_1, spo_2, spo_3, mask_spo
```

Channel	Description
<signal_id><i>i</i>	Values of signal <signal_id> and channel i (from 1 to N).
* In case of EEG signals, we provide the position: <signal_id>_<loc>	EEG and PPG signals are high pass filtered (0.1 Hz, 2nd order Butterworth filter) and clipped to (-3000, 3000) uV.
mask_<signal_id>	Mask of boolean values (0 or 1) for each signal that indicates whether samples were lost and should be interpreted as missing values (NaN). A sample j was lost in signal <i>eeg</i> when $mask_eeg[j]$ is 1. Note we include a mask channel because NaN values cannot be represented in EDF format.

Header of the EDF file

The header of the EDF file fills the following fields:

- Start date and start time (note these fields provide a resolution of seconds; for a higher time resolution access the UTC timestamps provided in the JSON file – metadata).
- Patient code
- Equipment (device type)

9.2 CSV FORMAT

We provide a CSV file for every recorded signal.

The first line contains a header with the name of the columns.

Examples:

CSV-Full: ch1-AF7, ch2-A1, ch3-Fp2, ch4-AF8, ch5-A2

CSV-Lite: ch1-AF7, ch2-A1, ch3-Fp2, ch4-AF8, ch5-A2, sequenceNumber, timestampReception, timestamp

The CSV file contains the following columns:

Column	Full/Lite	Description
ch<i> * In case of EEG signals, the position is added: ch<i>-<loc>	Full/Lite	Values of channel i (from 1 to N).
sequenceNumber	Lite	Sequence number (counter) is incremented by 1 every block.
timestampReception	Lite	Reception timestamp (high res., us) per block, might be <i>null</i> if lost online.
timestamp	Lite	Corrected timestamp (high res., us), using the t0 computation

9.3 EVENTS

The events registered with SennsLite during the recording are exported to CSV files.

We provide a CSV file for every event type.

The first line contains a header with the name of the columns.

Examples:

timestamp, value1

The CSV file contains the following columns:

Column	Description
timestamp	Timestamp (high res., us) when the event occurred.
value<i>	Value(s) of the event. Note that one event might have several values. For instance, one event type "quality" is provided for every device that provides the signal quality of every channel.

9.4 METADATA (JSON FILES)

The metadata is provided in a file with a JSON data format with the following fields.

system

- version: version of the data exporter
- adjust: full, lite

status:

- ok: bool, indicates whether the data export was successful
- t0: float, initial ts (high res., us) of the recording (full export only)
- tn: float, final ts (high res., us) of the recording (full export only)
- utc: object with fields:
 - enabled: bool, indicates whether UTC timestamp could be measured
 - stable: bool, indicates whether the UTC timestamps were stable
 - t0: float, initial ts (us) in UTC units (when stable = true)
 - tn: float, final ts (us) in UTC units (when stable = true)

signals: array object of:

- id: string, id
- num_channels: int, number of channels
- num_elements: int, samples per block
- sampling rate: int, nominal sampling rate
- other information:
 - signal loc: string list, list of EEG positions (only available for EEG)
 - subject name: id of the participant
 - device name: id of the device
 - device type: (Ikon, Ikon Sleep, Diadem, Hero, Air, Versatile Plus EEG, Versatile EEG, Versatile Kids EEG, Versatile Bio, Ring)
 - signal type: signal type, see Section 9.5
 - connection type: string (ble, bluetooth, usb)
 - dio mode: int (1 = input, 2 = output)
- status: status of the export procedure on this signal, object with fields:
 - enabled: bool, indicates whether the signal could be exported
 - error_flag: int, indicates the error (when enabled = false)
 - error_message: string, indicates the error (when enabled = false)
 - sd_sync_read: bool, indicates whether the SD card (sync file) was read
 - sd_data_read: bool, indicates whether the SD card (data file) was read
- internal: advanced metadata information, object with fields:
 - pad_ini: int, number of padding samples added to the beginning (full export only)
 - pad_end: int, number of padding samples added to the end (full export only)
 - t0: float, initial ts (us)
 - tn: float, final ts (us)
 - utc: object (idem as utc object in status)

event: array object of:

- id: string, id
- num_channels: int, number of channels
- other information: device name, config

9.5 UNDERSTANDING DATA TRANSFER AND SYNCHRONIZATION

Bitbrain EEG devices iteratively register a “block of data” and transfer it to the recording software SennsLite. The frequency at which these blocks are transmitted, referred to as the transfer rate, depends on the device and acquisition mode. For example, most Bitbrain EEG devices transfer data at 32 Hz via Bluetooth (i.e., every 31.25 ms a “block of data” is recorded and transferred to the recording computer), while the Versatile Plus EEG transfer data at 128 Hz via USB.

Once we know this transfer rate is fixed by design of our devices, we know the samples that are transferred in each block (samples per block) using the following relationship:

$$\text{Samples per Block} = \frac{\text{Sampling Rate (Hz)}}{\text{Transfer Rate (Hz)}}$$

In addition to the samples, each block contains a sequence number that acts as a counter to detect missing packages (e.g., due to problems with Bluetooth connectivity or being out of range). Upon reception in the recording software, a “reception timestamp” is captured.

Based on all this information (sequence number, reception timestamps, and the fact that we impose a data transfer at a fixed rate), SennsLite applies a series of algorithms to correct the jitter from the timestamps, estimate the initial time point of each signal (referred as to “ t_0 ” in this section), and synchronize the signals from multiple devices. The synchronized data is exported in CSV or EDF format along with metadata.

9.5.1 Timestamps

We capture two types of timestamps:

- High resolution timestamps (using QueryPerformanceCounter in Windows OS). These timestamps have a high resolution (<1 us) and can be used for time-interval measurements.
- Coordinated Universal Time (UTC) timestamps (using GetSystemTimePreciseAsFileTime in Windows OS). UTC is the primary time standard globally used to regulate clocks and time. These timestamps measure absolute time units and can be used to synchronize to external events.

Both types of timestamps are captured in microsecond units.

All the timestamps contained in the exported files (either signals or events) are high resolution timestamps. The metadata contains the initial time point estimates in both timestamps formats, so that a correspondence between them can be computed.

9.6 SIGNAL AND EVENTS PROPERTIES

This section contains a description of the signal and event properties. The signal properties are grouped into devices sharing sensor modalities:

- Versatile EEG Devices (Water-based EEG)
- Versatile Plus EEG Devices (Water-based EEG)
- Dry EEG Devices (Air, Diadem, Hero)
- Textile EEG Devices (Ikon & Ikon Sleep)
- Versatile Bio Device
- Ring device

Note that all signals are recorded without any filtering. In the case of EEG signals, [1-30] Hz bandpass filter and a notch filter are applied for visualization purposes only.

9.6.1 Signals of Versatile EEG Devices

All the signals are sampled at 256 Hz (8 samples per block) except for the IMU (32 Hz, 1 sample per block).

Note: In Versatile 8 ch and 16 ch EEG devices, the Photodiode Input and Digital Input share the same physical connector and are therefore mutually exclusive.

SIGNAL TYPE	DESCRIPTION	SAMPLING RATE	SAMPLES PER BLOCK	UNIT
eeg	EEG signal Number of channels depends on the device type: (n = 8 / 16 / 32 / 64)	256 Hz	8	uV
imu	Inertial measurement unit (IMU) Number of channels: 9 - ch 1: accelerometer, x-axis - ch 2: accelerometer, y-axis - ch 3: accelerometer, z-axis - ch 4: gyroscope, x-axis - ch 5: gyroscope, y-axis - ch 6: gyroscope, z-axis - ch 7: magnetometer, x-axis - ch 8: magnetometer, y-axis - ch 9: magnetometer, z-axis	32 Hz	1	ch 1–3 (g) ch 4 – 6 (deg/s) ch 7 –9 (uTeslas)
photodiode	Photodiode input Number of channels: 1	256 Hz	8	uV
din	Digital input Number of channels: 1, except for the Versatile 32 (n=3)	256 Hz	8	bit
exg	Input for bipolar signals (ECG, EMG, etc.) Number of channels: 2 *Available only for Versatile 32.	256 Hz	8	uV

9.6.2 Signals of Versatile Plus EEG Devices

Versatile Plus EEG devices define a configurable sampling rate:

- In USB, the available sampling rates are 256, 512 and 1024 Hz (SD card backup is not available).
- In Bluetooth, the streaming rate is fixed to 256 Hz; and the storage into the SD card can be configurable (256, 512, 1024, 2048 Hz).

These configurable sampling rates apply to EEG, EXG, DIO, and photodiode. IMU sampling rate is fixed and depends on the configured operation mode.

Note: Versatile Plus EEG devices provide a single physical auxiliary input that can be configured either as a Photodiode Input or as a Digital Input/Output (DIO). Because both functionalities share the same connector, they are mutually exclusive and cannot be used simultaneously.

SIGNAL TYPE	DESCRIPTION	SAMPLING RATE	SAMPLES PER BLOCK	UNIT
eeg	EEG signal Number of channels: depends on the device type: (n = 16 / 32)	*Configurable	*Depending on Sampling Rate	uV
exg	Input for bipolar signals (ECG, EMG, etc.) Number of channels: 2	*Configurable	*Depending on Sampling Rate	uV
photodiode	Photodiode input Number of channels: 1	*Configurable	*Depending on Sampling Rate	uV
dio	Digital Input / Digital Output Number of channels: 1	*Configurable	*Depending on Sampling Rate	bit
imu	Inertial measurement unit (IMU) Number of channels: 6 - ch 1: accelerometer, x-axis - ch 2: accelerometer, y-axis - ch 3: accelerometer, z-axis - ch 4: gyroscope, x-axis - ch 5: gyroscope, y-axis - ch 6: gyroscope, z-axis	*Depends on the connection mode	*Depending on Sampling Rate	ch 1 – 3 (g) ch 4 – 6 (deg/s)

Sampling rates and samples per block in EEG, ExG, Photodiode and DIO

In USB connection, the amplifier transfers data to the computer at a fixed frequency of 128 Hz. The samples per block can be computed as the signal sampling rate divided by 128.

CONNECTION	SAMPLING RATE (Hz)	SAMPLES PER BLOCK
USB	256	2
USB	512	4
USB	1024	8

In Bluetooth connection, the data is streamed in real time to the computer at a fixed frequency of 256 Hz (thus having 8 samples per block). When recording with higher sampling rates (thanks to the backup in the internal SD card), the samples per block can be computed as the signal sampling rate divided by 32.

CONNECTION	SAMPLING RATE (Hz)	SAMPLES PER BLOCK
Bluetooth / Bluetooth + SD	256	8
Bluetooth + SD	512	16
Bluetooth + SD	1024	32
Bluetooth + SD	2048	64

Sampling rates and samples per block in IMU

The IMU samples at 32 Hz, so 32 Hz is the effective sampling rate. In Bluetooth streaming the sensor is read at that same rate, so the output sampling rate is 32 Hz. In USB streaming and in Bluetooth transfer after SD recovery, the sensor is polled at 128 Hz. Since it cannot sample faster than 32 Hz, each sample is returned four times. The output sampling rate in these cases is 128 Hz in terms of samples received, while the IMU effective sampling rate is still 32 Hz.

CONNECTION	SAMPLING RATE (Hz)	SAMPLES PER BLOCK
USB	128	1
Bluetooth only	32	1
Bluetooth + SD	128	4

9.6.3 Signals of Dry EEG Devices (Air, Diadem and Hero EEG)

All the signals are sampled at 256 Hz (8 samples per block) except for the IMU (32 Hz, 1 sample per block).

SIGNAL TYPE	DESCRIPTION	SAMPLING RATE	SAMPLES PER BLOCK	UNIT
eeg	EEG signal Number of channels: depends on the device type: Air (n = 8) Hero (n = 10) Diadem (n = 12)	256 Hz	8	µV
imu	Inertial measurement unit (IMU) Number of channels: 9 - ch 1: accelerometer, x-axis - ch 2: accelerometer, y-axis - ch 3: accelerometer, z-axis - ch 4: gyroscope, x-axis - ch 5: gyroscope, y-axis - ch 6: gyroscope, z-axis - ch 7: magnetometer, x-axis - ch 8: magnetometer, y-axis - ch 9: magnetometer, z-axis	32 Hz	1	ch 1 – 3 (g) ch 4 – 6 (deg/s) ch 7 – 9 (uTeslas)

photodiode	Photodiode input Number of channels: 1 (Not available in Hero EEG)	256 Hz	8	uV
din	Digital input Number of channels: 1 (Not available in Hero EEG)	256 Hz	8	bit

Note: In Air EEG and Diadem EEG devices, the Photodiode Input and Digital Input share the same physical connector and are therefore mutually exclusive. Only one of these signals can be recorded at a time. Hero EEG devices do not provide a Photodiode/Digital Input connector, and therefore neither of these signals is available.

9.6.4 Signals of Ikon & Ikon Sleep EEG Devices

All the signals are sampled at 256 Hz (8 samples per block) except for the IMU and PPG (32 Hz, 1 sample per block).

Note: PPG signal is available only for Ikon Sleep EEG devices.

SIGNAL TYPE	DESCRIPTION	SAMPLING RATE	SAMPLES PER BLOCK	UNIT
eeg	EEG signal Number of channels: depends on the device type: Ikon (n = 5) Ikon Sleep (n = 2)	256 Hz	8	uV
imu	Inertial measurement unit (IMU) Number of channels: 9 - ch 1: accelerometer, x-axis - ch 2: accelerometer, y-axis - ch 3: accelerometer, z-axis - ch 4: gyroscope, x-axis - ch 5: gyroscope, y-axis - ch 6: gyroscope, z-axis - ch 7: magnetometer, x-axis - ch 8: magnetometer, y-axis - ch 9: magnetometer, z-axis	32 Hz	1	ch 1 – ch3 (g) ch 4 – ch 6 (deg/s) ch 7 – ch 9 (uTeslas)
ppg	PPG signal* Number of channels: 3 - ch 1: red light intensity - ch 2: infrared light intensity - ch 3: green light intensity *Available only for Ikon Sleep EEG devices.	32 Hz	1	nA

9.6.5 Signals of Versatile Bio Device

All the signals are sampled at 256 Hz (8 samples per block) except for the IMU (32 Hz, 1 sample per block).

<i>SIGNAL TYPE</i>	<i>DESCRIPTION</i>	<i>SAMPLING RATE</i>	<i>SAMPLES PER BLOCK</i>	<i>UNIT</i>
analog	Input to record analogic signals such as GSR, respiration, temperature, photodiode, etc. Number of channels: n = 7.	256 Hz	8	uV
imu	Inertial measurement unit (IMU) Number of channels: 9 - ch 1: accelerometer, x-axis - ch 2: accelerometer, y-axis - ch 3: accelerometer, z-axis - ch 4: gyroscope, x-axis - ch 5: gyroscope, y-axis - ch 6: gyroscope, z-axis - ch 7: magnetometer, x-axis - ch 8: magnetometer, y-axis - ch 9: magnetometer, z-axis	32 Hz	1	ch 1 – 3 (g) ch 4 – 6 (deg/s) ch 7 – 9 (uTeslas)
din	Digital input Number of channels: n = 3	256 Hz	8	bit
exg	Input to record bipolar signals such as ECG, EMG, etc. Number of channels: n = 9	256 Hz	8	uV
dout	Digital output Number of channels: n = 1 This signal type generates TTL pulses that, when received in the DIN of another device, can be used to synchronize them at sample level.	256 Hz	8	bit

9.6.6 Signals of the Ring Device

The signals are sampled at 32 Hz (2 samples per block). [0.5-2] Hz and [0.5-4] Hz bandpass filters are applied to the GSR and BVP signals, respectively, for visualization purposes only.

<i>SIGNAL TYPE</i>	<i>DESCRIPTION</i>	<i>SAMPLING RATE</i>	<i>SAMPLES PER BLOCK</i>	<i>UNIT</i>
gsr_bvp_acc	Number of channels: 5 - ch 1: galvanic skin response (GSR) - ch 2: blood volume pulse (BVP) - ch 3: accelerometer (ACC), x-axis - ch 4: accelerometer (ACC), y-axis - ch 5: accelerometer (ACC), z-axis	32 Hz	2	ch 1 (S) ch 2 (uV) ch 3 – 5 (g)

We describe below the signal quality provided for the Ring device (as an event).

<i>SIGNAL QUALITY</i>	<i>DESCRIPTION</i>
ring_quality	Signal quality values for the Ring device. A signal quality value is provided for every channel; thus, the number of channels matches the number of channels in the original data (please refer to the table above). - ch 1: GSR quality - ch 2: BVP quality - ch 3: ACC quality The signal quality values are: - value = 1, optimal quality - value = 2, fair quality - value = 3, bad quality - value = 4, saturated signal Accelerometer quality is computed from the three accelerometer axes (x, y, z) by analyzing signal variability over short time windows. Large variations are interpreted as motion and may reduce the quality classification. To simplify interpretation, an aggregated quality value is reported: if any axis has bad quality, the overall ACC quality is bad; otherwise, if any axis has fair quality, the overall ACC quality is fair; if all axes have optimal quality, the overall ACC quality is optimal. This accelerometer quality is provided because excessive movement can affect the interpretation of the Ring physiological signals (GSR and BVP). Therefore, movement information is summarized through an accelerometer quality metric. Accelerometer channels do not support the saturation state, therefore quality value 4 is never reported for ACC signals.

9.6.7 Events

The table shows all possible events logged by SennsLite along with a description.

<i>EVENT</i>	<i>DESCRIPTION</i>
userMarker	Denotes the time instants in which the user pressed a key. Each marker presents three values: - ch1: marker index as defined in Settings: - value = 0 (Key 1) - value = 1 (Key 2) - value = 2 (Key 3) - value = 3 (Key 4) - value = 4 (Key 5) - ch2: number of occurrences of this marker type - ch3: number of occurrences of any marker type
{EEGdeviceId}_quality	Signal quality values for EEG devices. Note that signal quality metrics are not available for Versatile Bio devices. A signal quality value is provided for every channel; thus, the number of channels matches the number of channels in the original data. - ch1: signal quality of channel 1 - ... - chN: signal quality of channel N The signal quality values are: - value = 1, optimal quality - value = 2, fair quality - value = 3, bad quality - value = 4, saturated signal

10. Annex 1: Multi-device and Multi-participant Recording Configuration

SennsLite allows the simultaneous and synchronized recording of multiple Bitbrain devices across different participants within the same session. To enable this functionality, each participant must be configured with a unique participant ID and associated with a specific device.

Participants and devices must be added sequentially, ensuring that each participant-device pair is saved and assigned before configuring the next one.

To configure the first participant, these steps must be followed:

1. In the Recording module, define the participant ID in the study parameters and click “Save”, as described in Section 5.1.
2. Add and configure the device that will be used by this participant in the Device Settings window, following the instructions in Section 5.2.
3. Assign the device to the participant by moving the configured device from the “Available sensors” list to the “Participants and sensors” list. At this point the association between the Participant ID and the device serial number can be verified in the “Participants and sensors” list.

It is very important that before configuring the second participant, the previous participant-device pair has already been added to the “Participants and sensors” list. Otherwise, previously defined parameters will be overwritten.

Repeat the steps above for each additional participant making sure that each participant ID is associated with a different device; and each device is assigned to a single participant, as seen in

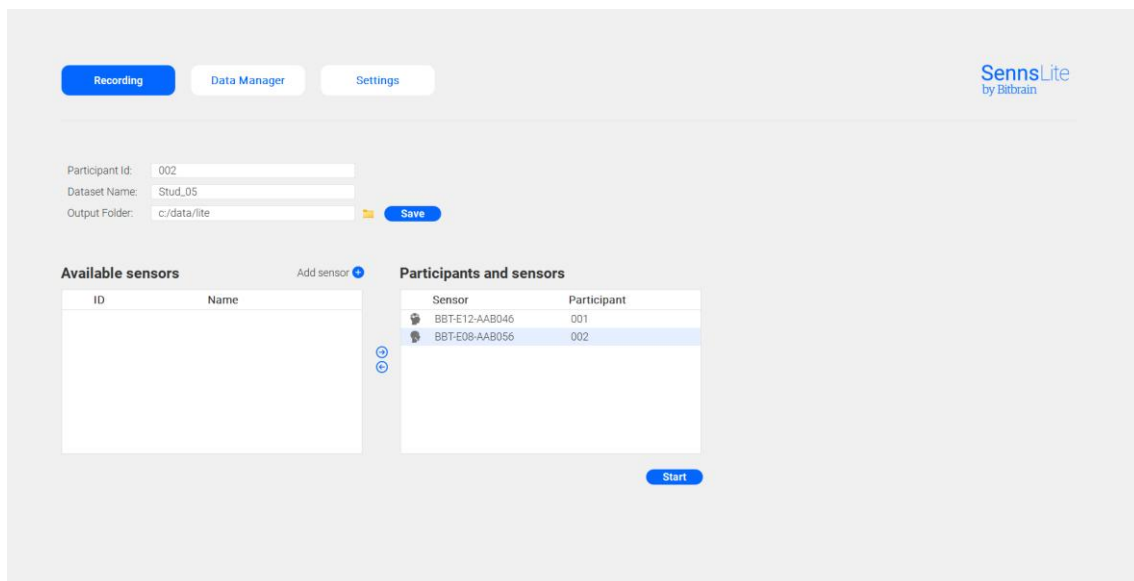


Figure 37. Multi-participant and multi-device Recording module

Once all participant-device pairs have been correctly configured, the “Participants and sensors” list will display them as the final confirmation before moving onto the next windows. Click on “Start” to begin the Sensors checking process and the actual recording. Signals from all the participants and devices will be displayed simultaneously in the subsequent screens.

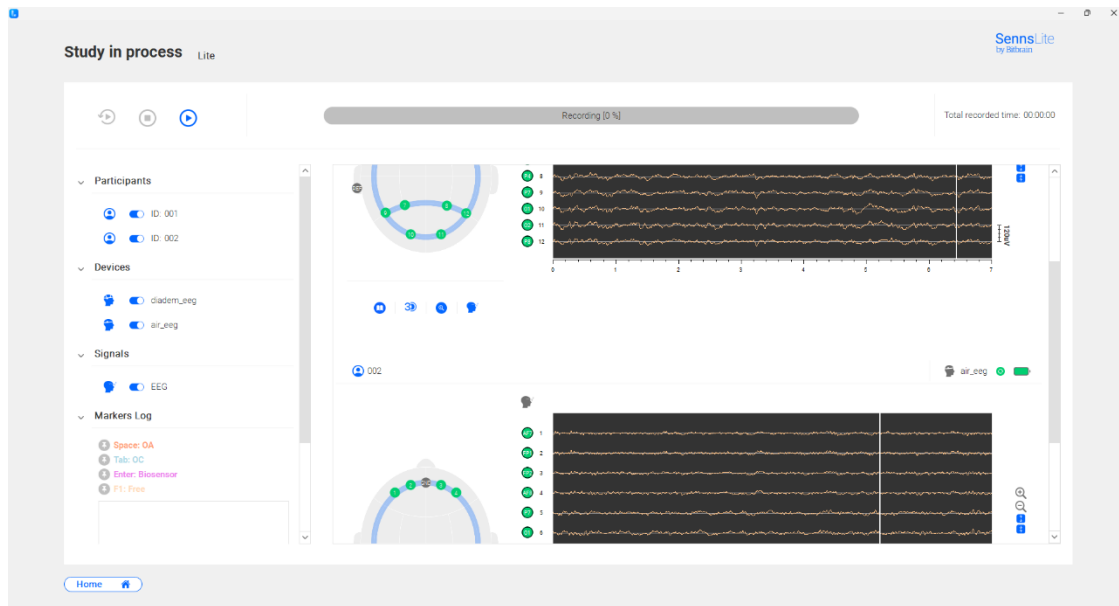


Figure 38. Recording module with two EEG devices

11. Annex 2: Device-specific Information

11.1 IKON EEG REFERENCE

The Ikon device has sensors in the forehead (Af7, Fp1, Fp2, Af8) and in the upper part of the ears (A1, A2). The ground electrode is in Fpz, and the amplifier reference is in Fp1.

The design decision to have the amplifier reference in Fp1 allows to:

- Provide signal quality indexes in the ear sensors. This is interesting as the ear sensors are likely to be more difficult to place correctly than forefront sensors, thus helping in the correct placement of the device by non-experts.
- Set the reference to A1 or A2 in offline analysis depending on the researcher's needs, or switch between them if the contact is lost in any of them. In summary, this potentially makes the technology more robust for real-word recordings. This point also applies to online processing scenarios, in which the reference can be dynamically switched.
- Have a linked-ears reference.

Important: while the EEG signal is re-referenced in the signal viewer in SennsLite for usability, it is stored unfiltered and with the amplifier reference (Fp1). Thus, researchers that load the exported data will commonly need to re-reference the signal to either A1 or A2 for its interpretation.

11.1.1 Re-referencing

Recorded data can be expressed in the form:

(Af7-Fp1, A1-Fp1, Fp2-Fp1, Af8-Fp1, A2-Fp1)

Re-referencing implies performing a mathematical operation to transform this to:

(Af7-A1, Fp1-A1, Fp2-A1, Af8-A1, A2-A1)

This Python code performs such an operation:

```
def _rereference_array(data: np.ndarray) -> np.ndarray:
    """
    Perform re-referencing of EEG data to A1 (ch index = 1).

    Parameters:
    - eeg_data: numpy array of shape (num_channels, num_samples)
    - locations: (Af7-Fp1, A1-Fp1, Fp2-Fp1, Af8-Fp1, A2-Fp1)

    Returns:
    - eeg_data_referenced: numpy array of shape (num_channels, num_samples)
    - locations: (Af7-A1, Fp1-A1, Fp2-A1, Af8-A1, A2-A1)
    """
    reference_ch = 1
    ch_ref = np.copy(data[reference_ch, :])
    for ch in range(data.shape[0]):
        if ch != reference_ch:
            data[ch, :] = data[ch, :] - ch_ref
        else:
            data[ch, :] = -data[ch, :]
```

return data

11.2 VERSATILE 64CH EEG CONFIGURATION

The Versatile EEG 64 consists of two 32-channel EEG amplifiers connected to each other through a synchronizer. For this system, **both amplifiers** must be manually paired via Bluetooth with the computer before configuring the device in SennsLite. In the SennsLite interface, when configuring the device, you will be asked to enter the Main and Secondary amplifier IDs.

The Main ID corresponds to Amplifier 1 serial number, and the Secondary ID corresponds to Amplifier 2 serial number, as described in the Versatile 64ch EEG user guide. When viewing the participant from behind, the Main amplifier is positioned on the left side of the base and the Secondary amplifier on the right side.

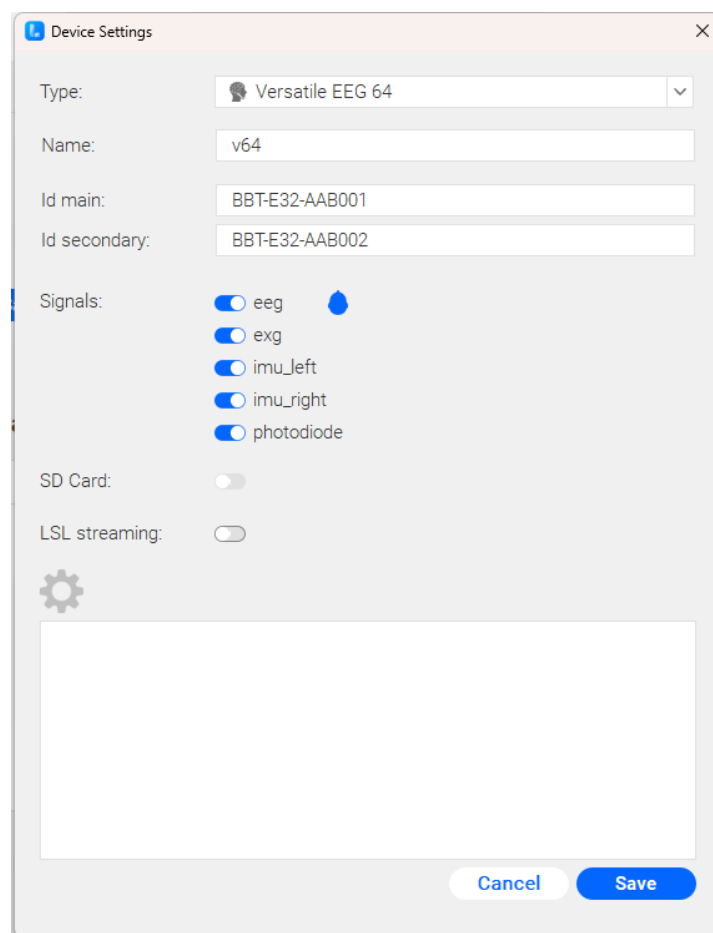


Figure 39. Device Settings dialog box for Versatile EEG 64

11.2.1 Versatile 64ch EEG Layout

In the “Device Settings” dialog box shown in Figure 39, when clicking on the head illustration next to the “EEG” signal selector, another window will appear to define the custom layout, as mentioned in Section 5.3. In this device, the section to choose the channel visualization order is particularly interesting due to the quantity of available channels. The “Anatomical order” option is recommended as the signals will be organized by brain region making the analysis easier. This allows channels affected by eye movements and blinks to be displayed in a logical order in the frontal region, while alpha waves are more prominent in the occipital channels and gradually decreases towards the prefrontal ones. This facilitates the interpretation of spatial patterns across the scalp.

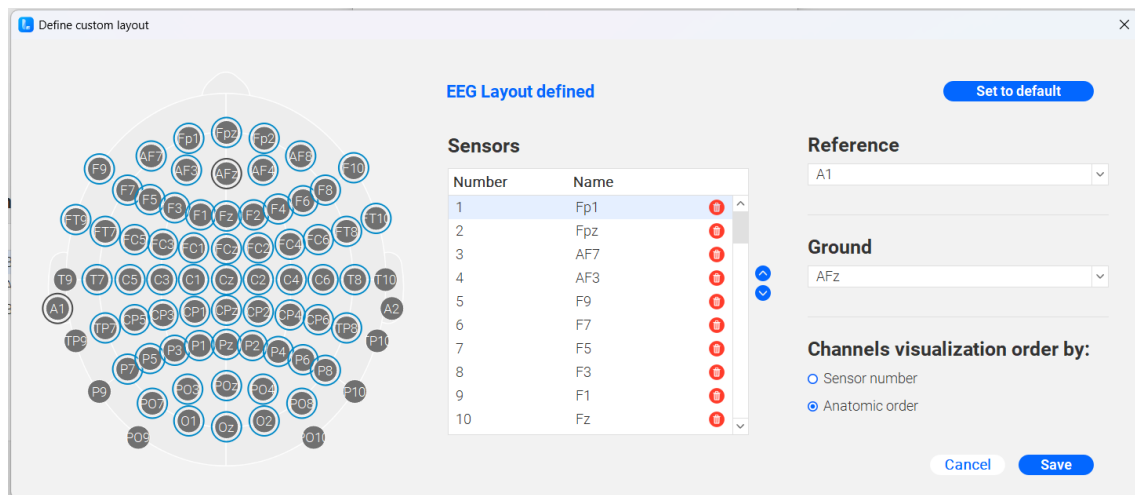


Figure 40. Define custom layout for Versatile 64ch EEG

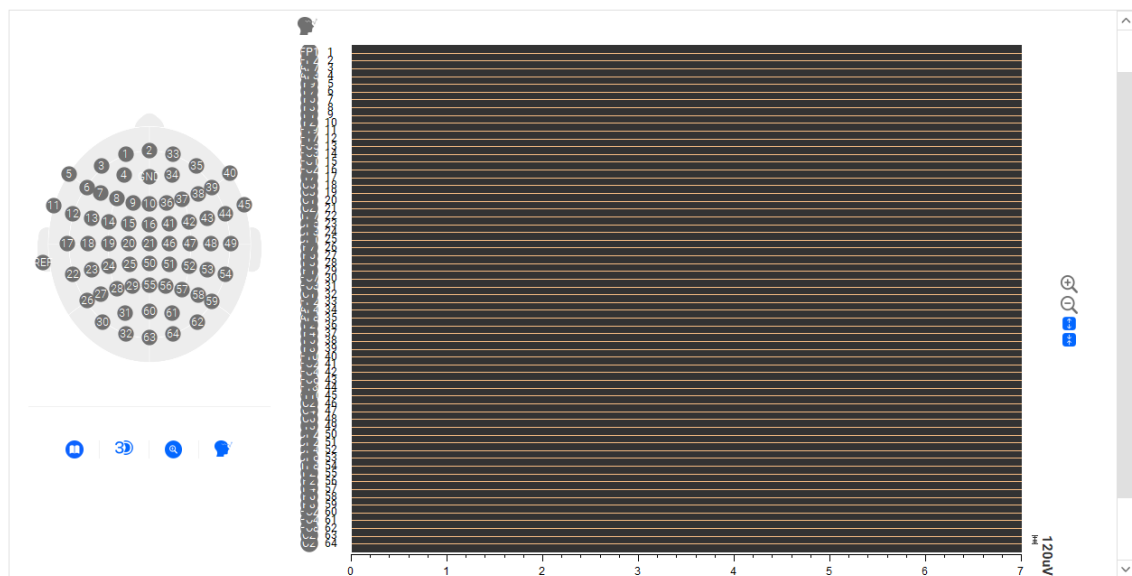


Figure 41. Visualization of channels ordered by sensors number

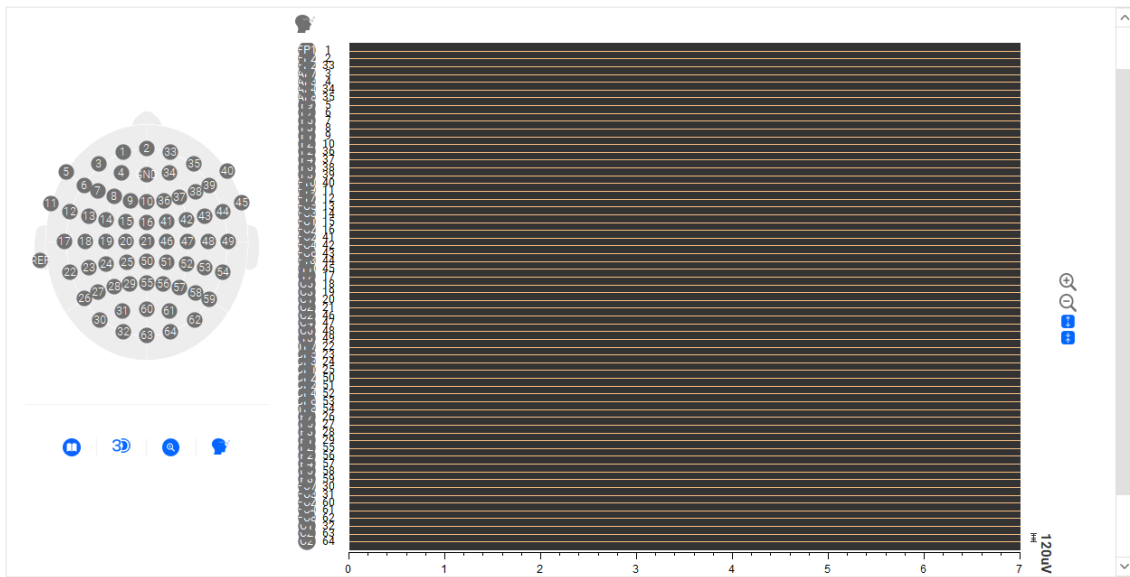


Figure 42. Visualization of channels ordered by anatomic order

12. Annex 3: LSL Connectivity

This software allows no further interaction with the data while acquiring but visualization (filtering only affects visualization). For those users that want to access the data while being acquired, we provide the LSL server option.

If this feature is enabled (Section 5.2), an LSL server will be created when the acquisition starts. This server will publish one data stream per signal being acquired. Other applications in the same computer or over the network can connect to the server to subscribe to any of the stream and receive the data online to do any kind of external processing using this standard protocol.

To record properly with LSL protocol, some third-party applications should be needed to perform this recording. The LabRecorder is the default recording program that comes with LSL. It allows the recording of all streams on the lab network (or a subset) into a single file. The LabRecorder application is shown in the following example.

LabRecorder can be downloaded here: [GitHub - labstreaminglayer/App-LabRecorder: An application for streaming one or more LSL streams to disk in XDF file format.](https://github.com/labstreaminglayer/App-LabRecorder)

To perform the recording properly the following steps should be performed:

1. Configure the device in SennsLite, activating the LSL streaming switch.

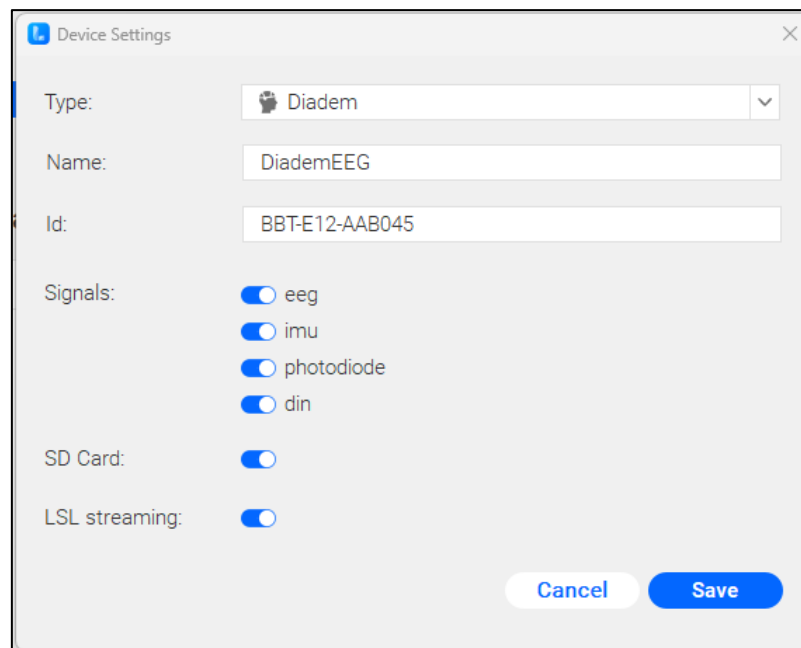


Figure 43. Device Settings window with LSL Streaming enabled

2. Go through the configuration steps and throughout the quality check process. And get to the recording screen.

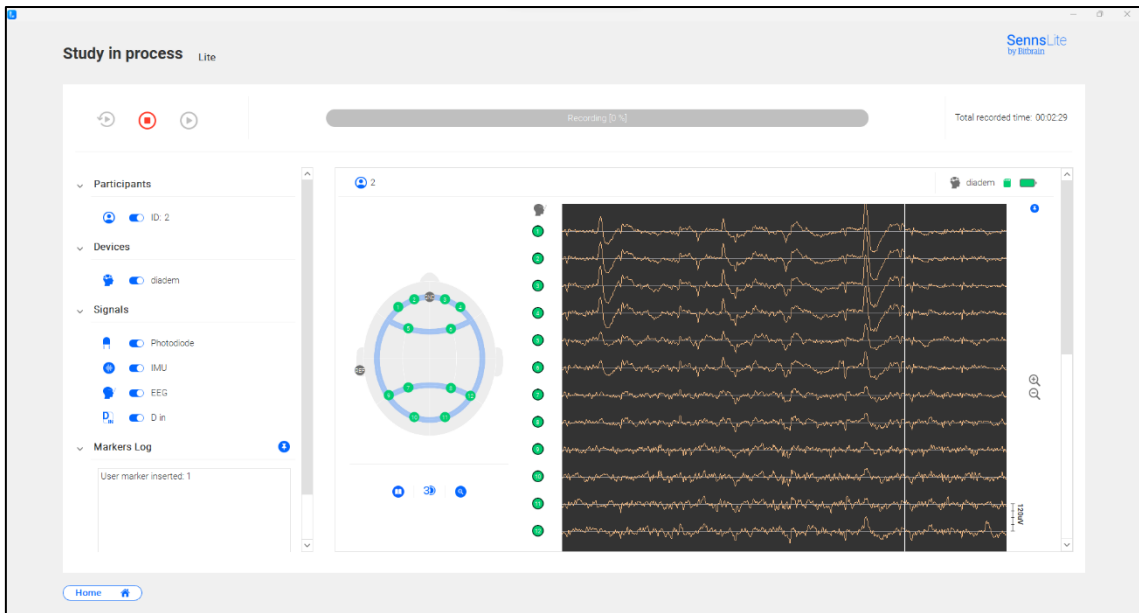


Figure 44. Study in process window

3. Start SennsLite recording.
4. Launch LabRecorder.

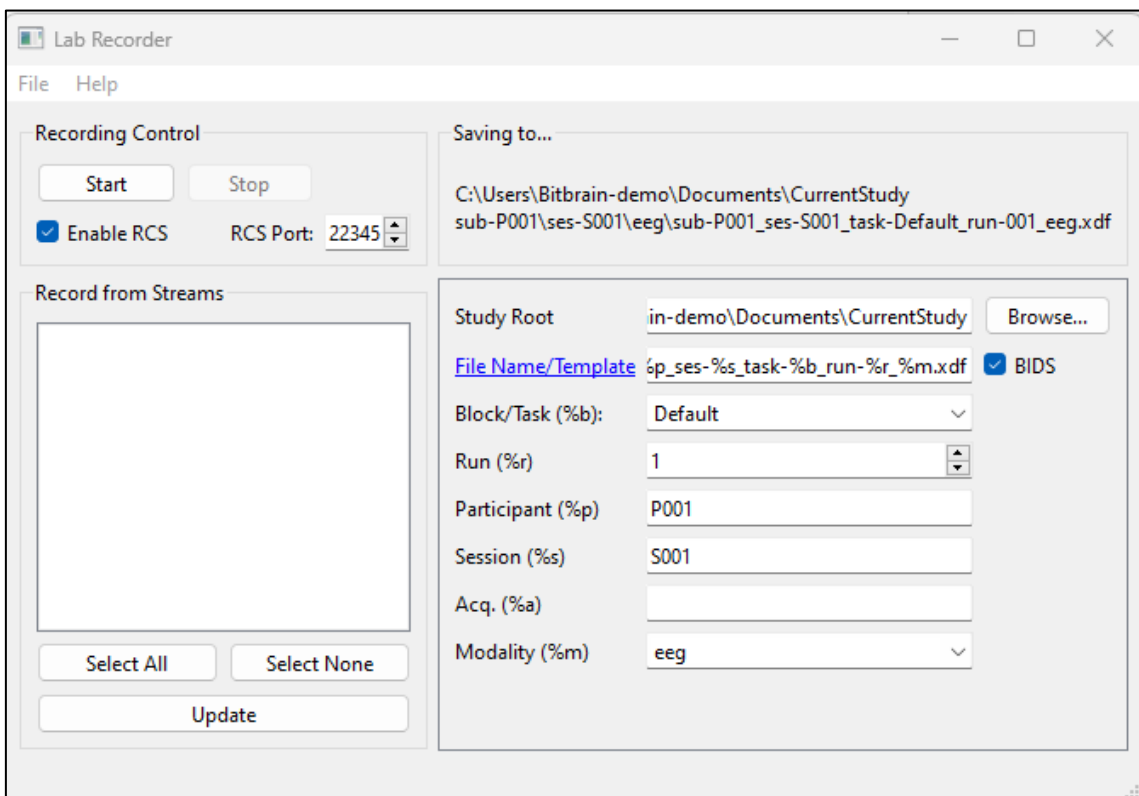


Figure 45. Lab Recorder Window

5. Update available signals and select the relevant ones for the data set.
6. Select the folder to record the data set.

7. Start LabRecorder recording.
8. Carry out the experimental design.
9. Stop LabRecorder recording.
10. Stop SennsLite recording.

After this recording process, a .xdf file should have been created in the previously selected directory.

12.1 SIGNAL STREAMS & MARKERS

The table below lists the signal streams provided. Note that in addition to signal values a sequence number is also provided for detecting potential lost packages: Channels ch 1 to ch n in each signal correspond to the number of channels for the specific device and/or signal type; and the next channel, ch n +1, contains the sequence number.

A timestamp is assigned to every sample of every signal. These timestamps values are in seconds with a precision up to milliseconds. A smooth algorithm is performed over the transmitted timestamps (LSL) to reduce the inherent jitter in the Bluetooth transmission.

The table below provides a description of the signal streams provided and the associated device types, and the markers provided. More details of the signals and markers are already provided in Section 9.6.

<i>SIGNAL TYPE</i>	<i>OUTLET ID</i>	<i>DEVICE TYPE</i>
<i>EEG signal</i>	<device_name>_eeg	All EEG devices
<i>IMU signal</i>	<device_name>_imu	All EEG devices Versatile Bio
<i>Photodiode</i>	<device_name>_photodiode	Air, Diadem Versatile EEG Versatile Plus EEG
<i>Digital input</i>	<device_name>_din	Air, Diadem Versatile EEG Versatile Bio
<i>Digital output</i>	<device_name>_dout	Versatile Bio
<i>Digital input/output</i>	<device_name>_dio	Versatile Plus EEG
<i>EXG signals (bipolar signals such as ECG, EMG, etc.)</i>	<device_name>_exg	Versatile EEG 32 Versatile Plus EEG Versatile Bio
<i>PPG signal</i>	<device_name>_ppg	Ikon Sleep
<i>Analogic signals such as GSR, respiration, temperature, photodiode, etc.</i>	<device_name>_analog	Versatile Bio

Ring signal (GSR, BVP, ACC)

<device_name>_signal

Ring

MARKER	OUTLET ID	DEVICE TYPE
Start/stop <i>Denotes the instant when the recording in SennsLite has started or stopped.</i>	Start_Stop	All
User marker <i>Denotes the time instants in which the user pressed a key. The marker is a string containing its label (as defined in Settings)</i>	Markers	All
Sync <i>Pulse sent every 10 seconds. Each pulse is marked by a number starting in 0 that grows one by one</i>	Sync	All
Signal quality <i>Signal quality values for a given device (specified by its ID), available for EEG devices and for the Ring device.</i>	{deviceId}_quality	All EEG devices Ring device

13. Annex 4: Apps & Features for Ikon and Ikon Sleep devices

13.1 OFFLINE RECORDING (IKON SLEEP + SD CARD)

SennsLite provides an Offline Recording feature for Ikon Sleep devices, allowing a recording to continue after the device has been disconnected from the software. This feature gives the user the possibility to start a recording with an Ikon Sleep, close the application, close the lid of the laptop or even turn off the PC while continuing recording data.

Once this functionality is activated, data acquisition continues autonomously on the device and is stored on its internal SD card until the recording is manually stopped by turning off the amplifier.

This functionality is currently available in Windows and Linux only for Ikon Sleep devices with SD card recording activated.

13.1.1 Requirements

- The recording is being performed with an Ikon Sleep device.
- The Offline Recording option has been enabled in the Settings module before starting the study.
- The device is configured to record to its internal SD card.
- When recording multiple devices simultaneously, at least one of them must be an Ikon Sleep device, and all devices participating in the session must be configured to record to their respective SD cards.

13.1.2 How to use Offline Recording functionality

1. Open the Settings module and enable the *Ikon Sleep Offline Recording (only on SD card)* option in section *Ikon EEG Devices Applications & Features*.

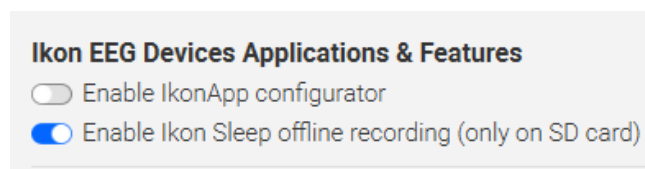


Figure 46. Enabling the Ikon Sleep Offline Recording Option in the Settings module.

2. Configure the device/device(s) making sure the **SD card option is selected** in the *Device Settings* window. Check Section 5.2.
3. Configure the study and start the session as usual. Refer to Section 6 for detailed instructions.
4. Once **the recording is running** in the *Study in process* window, click the *Stop online* button to switch from online streaming to Offline Recording mode. The recording will continue

on the device's internal microSD card without requiring SennsLite to remain connected or running.

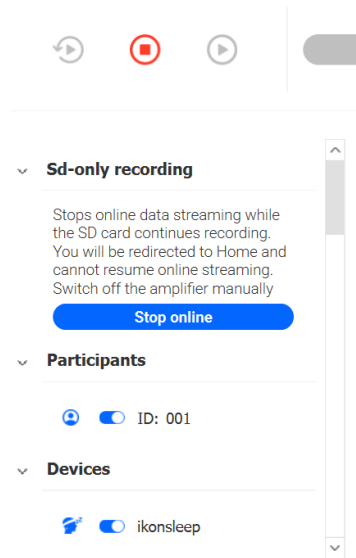


Figure 47. Clicking Stop online during an active recording to switch to Offline Recording mode.

5. A confirmation dialog will appear. Click Yes to stop online streaming and continue the recording in offline mode.

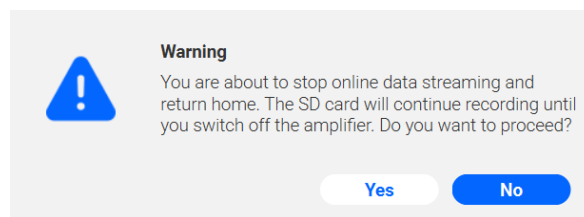


Figure 48. Confirmation dialog before stopping online streaming.

6. After confirming, an information message is displayed indicating that the Study in process interface will be closed automatically in a few seconds. The recording continues uninterrupted on the device's internal microSD card and SennsLite will return to the Recording module in a few seconds.

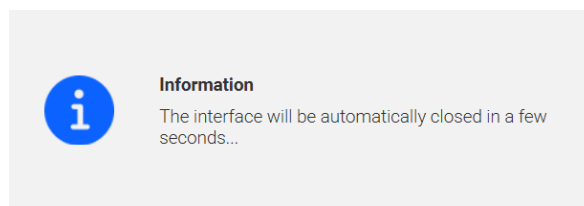


Figure 49. Study in process interface will close automatically while the recording continues on the device.

7. Once the Study in process window has been closed, SennsLite returns to the **Recording** module. An information message confirms that the device is currently recording to the microSD card only. From this point onwards, the recording continues independently of SennsLite, and no additional data is transferred to the computer. SennsLite can be safely closed if desired. To stop the recording, **turn off the Ikon Sleep amplifier** by pressing its power button.

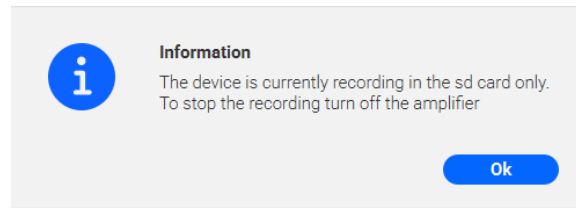


Figure 50. Confirming that the recording is continuing exclusively on the device's internal microSD card.

Once the recording has been stopped, the recorded data will remain stored in the device's microSD card and can be later imported into SennsLite as defined in Section 7.2.1, for Ikon Sleep devices, and in Section 7.2, for Bitbrain devices with external microSD card.

13.1.3 Detection and warning of ongoing offline recordings

To prevent accidental interruption of ongoing offline recordings and to remind the user of forgotten SD card-only recordings, SennsLite keeps track of devices that had initiated a recording on their microSD card and provides a reminder before starting a new session with those ones. An example of this question dialog is shown below:

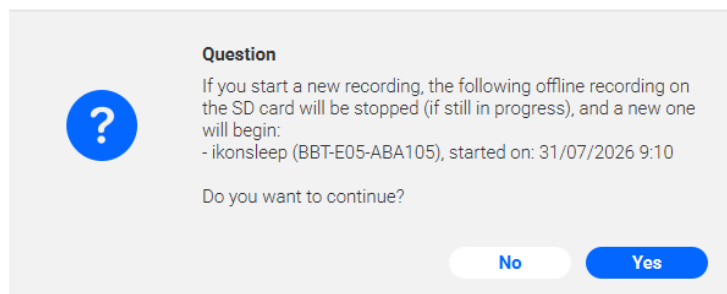


Figure 51. Dialog displayed when starting a new recording with a device that initiated an offline recording previously.

When a new recording is about to start, SennsLite checks whether any of the selected devices were previously involved in an offline recording. If a match is found, **starting a new recording with that device will stop the previous offline recording (if it is still in progress) and begin a new one.**

The user can then decide whether to continue with the new recording or cancel the operation.

If the user chooses to continue, only the recordings from the selected devices that are about to start a new recording are affected. Any other devices that may still have an ongoing offline recording but are not participating in the new session remain unchanged. An example of this question dialog is shown below:

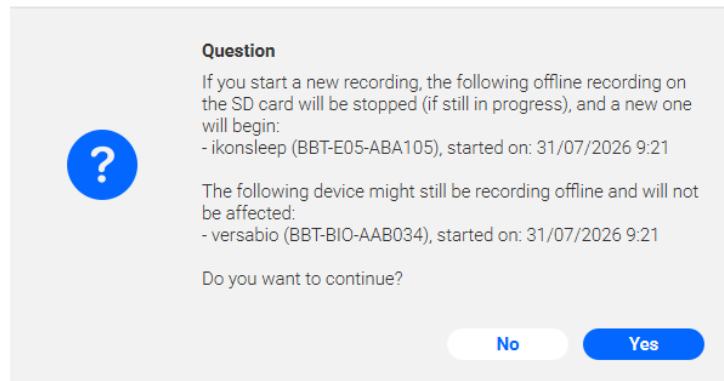


Figure 52. Only the selected device(s) will start a new recording, while offline recordings on non-selected devices remain unaffected.

IMPORTANT: This mechanism is intended as a user reminder, not as a method to determine whether a device is currently recording. Since the amplifier is no longer connected to SennsLite after an offline recording has been activated, the software cannot determine whether the amplifier is still powered on, or whether the offline recording has already ended.

The intended workflow when using the offline recording feature is to stop the recording by turning off the device when the acquisition is finished. This ensures that the recording is properly completed and avoids unintentionally interrupting an ongoing offline recording when starting a subsequent session.

The reminder dialog should be regarded as an additional safeguard to help prevent accidental interruptions. However, the correct management of offline recordings ultimately relies on following the recommended workflow.

NOTE: If a device is removed from the hardware list in SennsLite, any stored information about a previous offline recording for that device is discarded.

13.2 IKON APP FOR WINDOWS

Ikon App in Windows is a software module that allows the recording of EEG signals in a home-based environment from a Windows device. ***Ikon App is only compatible with Ikon and Ikon Sleep devices.***

Ikon App in Windows comprises a configurator, called Ikon App Configurator; and a recorder, which is the Ikon App itself. The Ikon App Configurator is integrated into SennsLite, while the recorder (Ikon App) can be accessed from the same computer but, outside of SennsLite. It is included by default when downloading and installing SennsLite.

The idea is to download the Ikon App into a Windows laptop that the participant can take home. For that, the researcher will have to first complete the participant parameters through the Ikon App Configurator and leave the Ikon App shortcut in a visible spot on the desktop of the computer. This way it can be easily accessed by the participants at their home.

Ikon App consists of a simple recorder that enables participants to start and stop sessions by themselves.

13.2.1 How to Set Ikon App Configurator

Ikon App must be configured through the specific SennsLite module, as well as the Ikon EEG devices that will be used for the recording. The workflow is defined by the following steps:

1. At the bottom of SennsLite Settings module (Figure 53), enable Ikon App Configurator.

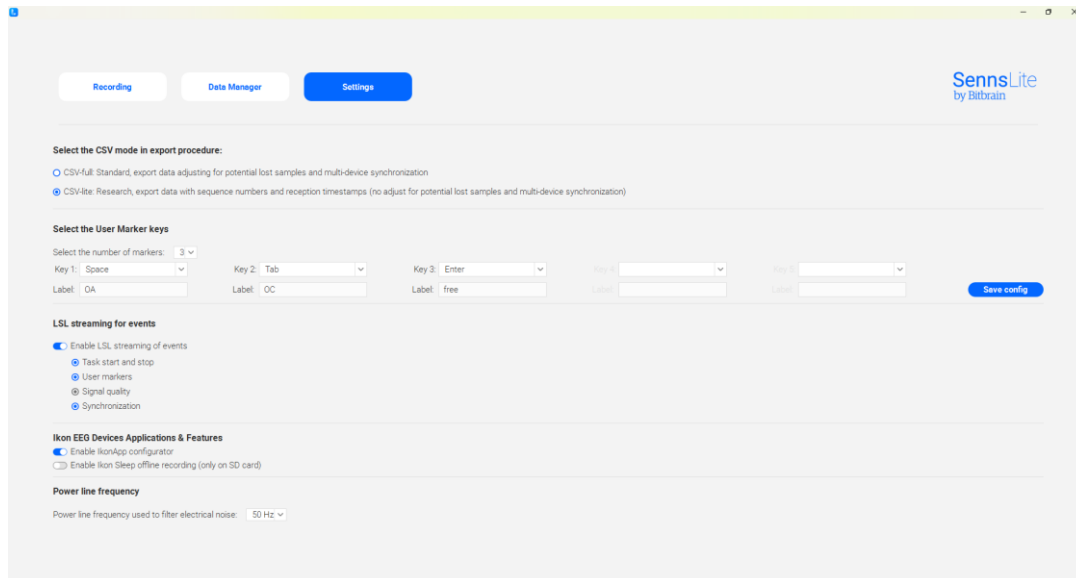


Figure 53. Settings Module to enable Ikon App Configurator

2. In the SennsLite Recording module, add the device that will be used for the recordings to the "Available sensors" list. Refer to Section 5.2. to add a new device.
3. Click on the red "Ikon App Configurator" button to set the desired parameters for the study (Figure 54).

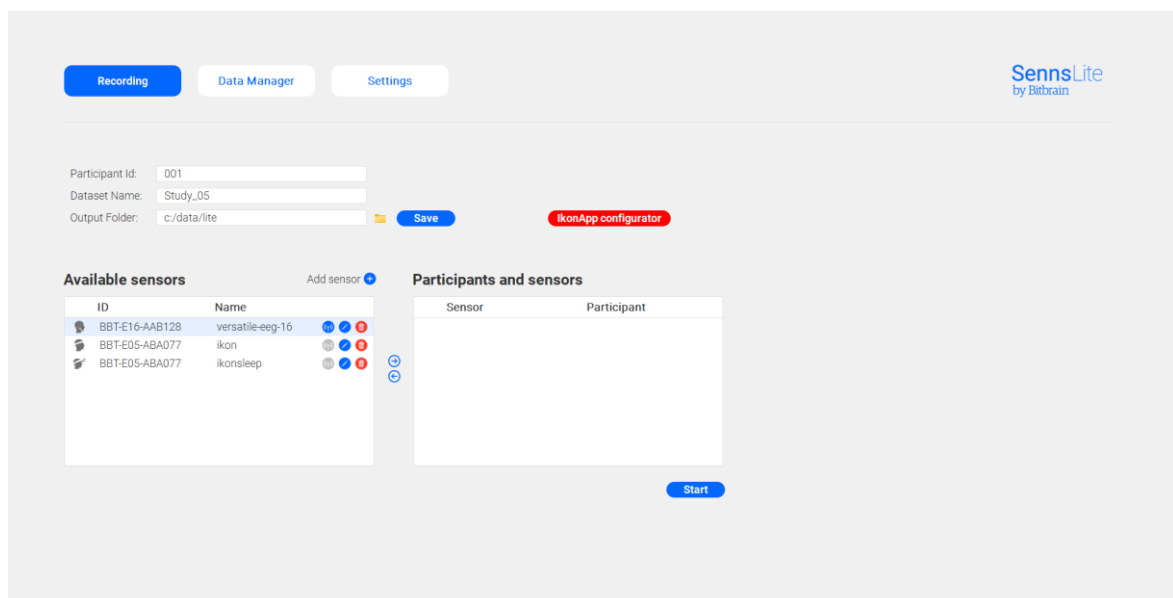


Figure 54. Ikon App Configurator button appears red until the parameters are set

- Complete the required information regarding participant ID, dataset name, and output folder, as shown in Figure 55. Then, select the device that was previously configured for use in the recording and click on “Save” to keep the defined parameters.

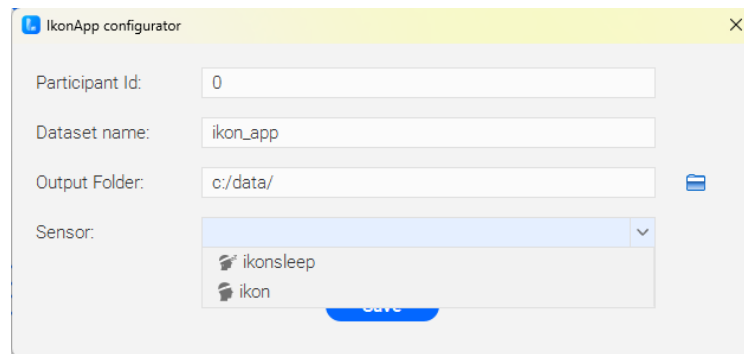


Figure 55. Ikon App Configurator dialog box

- Once everything has been set correctly, the Ikon App button in the Recording module will be shown in blue, as seen in Figure 56.

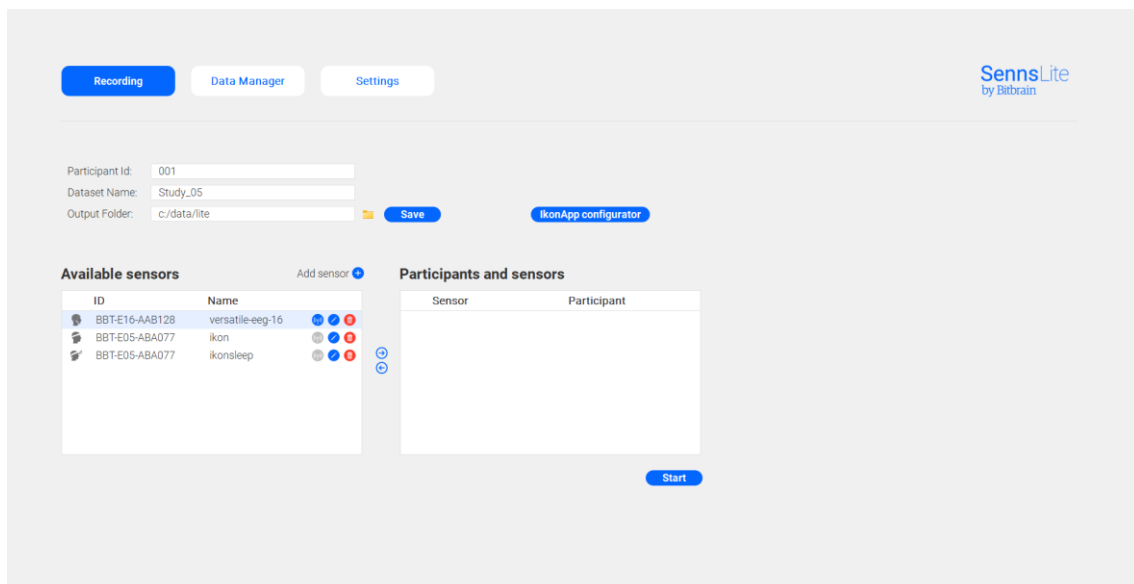


Figure 56. Ikon App Configurator button appears blue after the parameters are set

- At this point, SennsLite can be closed as it only serves to configure the Ikon App recorder.

13.2.2 How to Run Ikon App

Ikon App can be used by participants with no technical expertise to record EEG data by themselves, following these steps:

- If SennsLite was installed using the default settings, the Ikon App can be launched by running "C:\bitbrain\sennslite\bin\ikonapp.exe". Alternatively, the Ikon App may be opened by searching for it in the Windows taskbar.
- Ikon App will open displaying the main window shown in Figure 57. Here, the online impedances read from the sensors of the device can be checked. This window also allows the user to identify the participant and device being used for the current session.

They should correspond with what was established in the Ikon App Configurator. The correct connection status is represented through the green SD card icon in the top right corner, next to the battery status icon. This means the recording in the SD card was enabled in the Device Settings window, and the signal is being received and recorded to the SD card correctly. The following information is displayed on that screen:

- a. Participant ID
- b. Type of sensor being used in the recording (Ikon / Ikon Sleep)
- c. Device connectivity and battery status. Please refer to Section 6 (SD card & connection feedback) for a complete overview of all connectivity icon indicators, including their possible statuses and corresponding meanings.
- d. Sensors' layout diagram in the corresponding type of band
- e. Start/ Stop buttons for recording

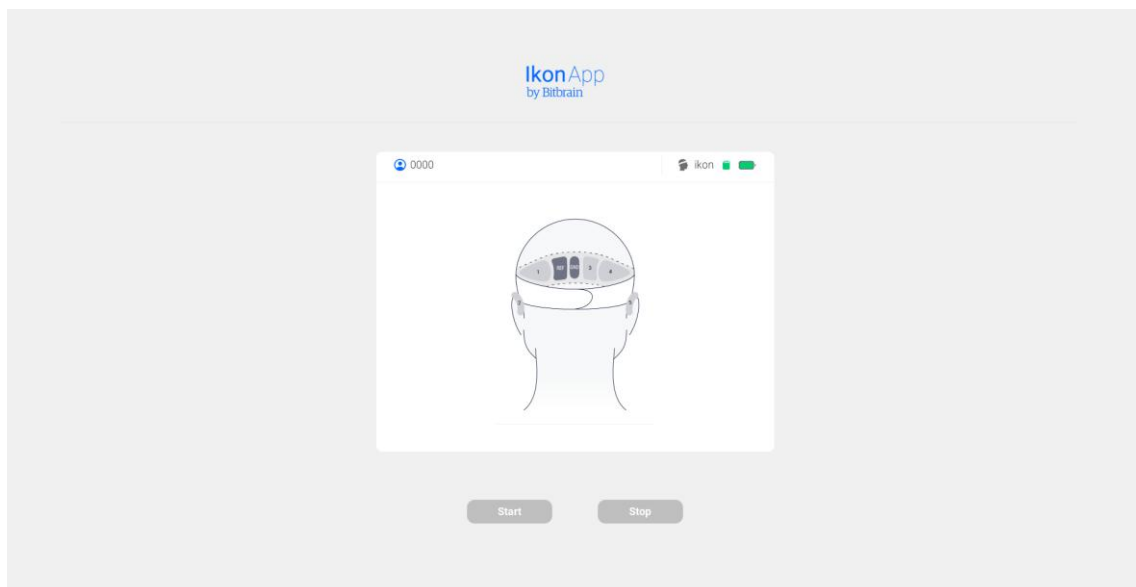


Figure 57. Ikon App Main Window

3. Before starting the recording, it is recommended to adjust the device to the participant's head until all the impedances appear in green, to ensure optimal sensor placement and obtain the highest possible EEG data quality. However, the recording can still be initiated even if not all impedances reach optimal levels.

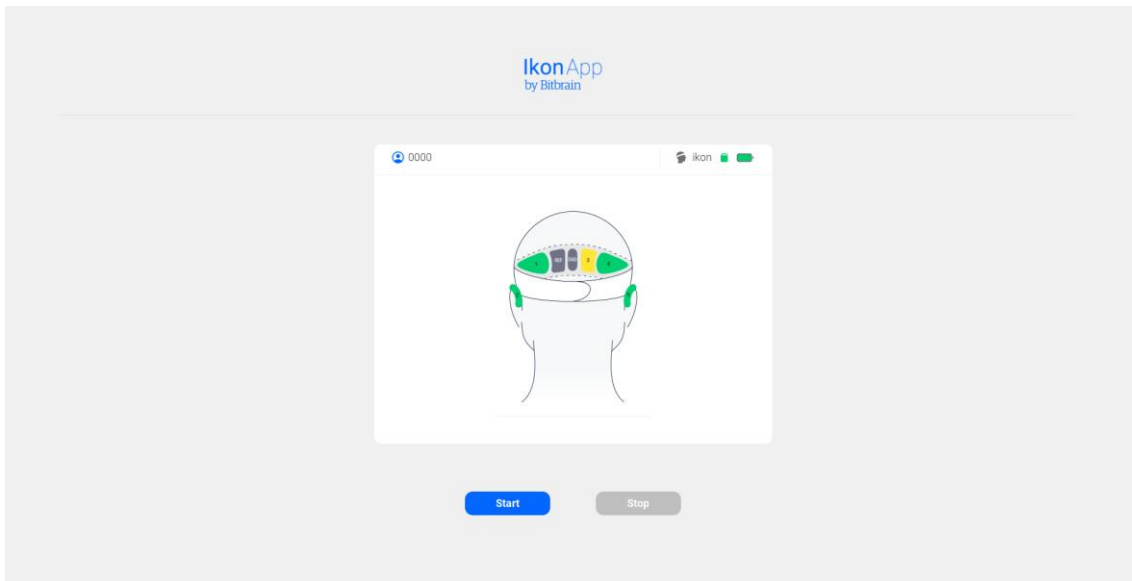


Figure 58. Signal quality check in Ikon App

4. It is important that the amplifier is powered on and properly connected to the corresponding band. If these conditions are not met, a message with a “Retry” button will appear (see Figure 59), allowing the user to re-check the connectivity of the device with the band.

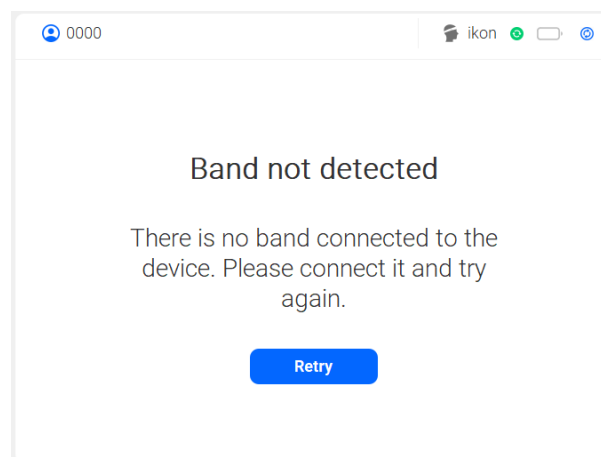


Figure 59. Dialog box to retry the connection of the device in Ikon App

5. Click on “Start” to start the recording.
6. Once the recording has begun the participant will have access to the same information as above (the participant ID, the type of device, the device connectivity and battery status), as well as the following:
 - a. Session and recording identification numbers
 - b. Timer showing the total recording duration.

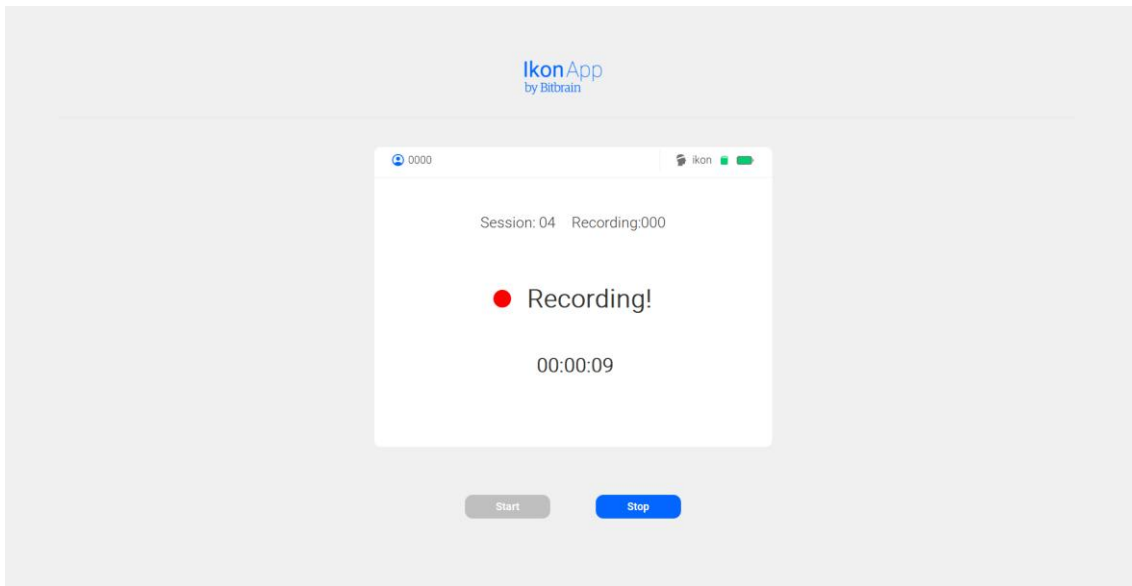


Figure 60. Recording Window in Ikon App

7. Click on “Stop” to stop the recording
8. Close Ikon App.

13.2.3 How to Export Data Recorded with Ikon App

Export data recorded with Ikon App through SennsLite Data Manager. Check Section 7 for detailed information regarding data export.

13.3 IKON APP FOR ANDROID

Ikon App in Android is a mobile recording solution that allows the recording of EEG signals in a home-based environment from an Android smartphone. *Ikon App is only compatible with Ikon and Ikon Sleep devices.*

Ikon App for Android comprises a configurator called Ikon App Configurator; and a recorder, which is the Ikon App itself. Both the Ikon App Configurator and the Ikon App can be installed through an APK that can be downloaded in [our Download Center](#), and can be used directly from the smartphone. However, SennsLite will be needed later for the import of the SD card content and export of the recordings in CSV and/or EDF formats.

Before starting data collection, researchers must first configure the study parameters through the Ikon App Configurator. The Ikon App provides a simple interface that allows participants to start and stop recording sessions. Once recordings are completed, SennsLite on a Windows or Linux computer is required to import the SD card content and export the data in CSV and/or EDF formats.

13.3.1 Download and Installation

Ikon App for Android can be downloaded from the appropriate link in our [Download Center](#), where you will find an Android Package Kit (APK) file to install the two mobile apps (Configurator and Recorder). Since the application is distributed as an APK file, the smartphone must allow the installation of third-party applications. During the installation process, the Android operating system will prompt the user to grant the required permission, if it is not already enabled.

You can directly download the APK into your mobile phone or download it to a computer and transfer it to the smartphone using a cable. Using the phone's file browser, navigate through the internal storage to locate the .apk file and tap on it to run the installer. This process is shown in Figure 61. Once installed, the applications will be available in the application menu, as shown in Figure 62.

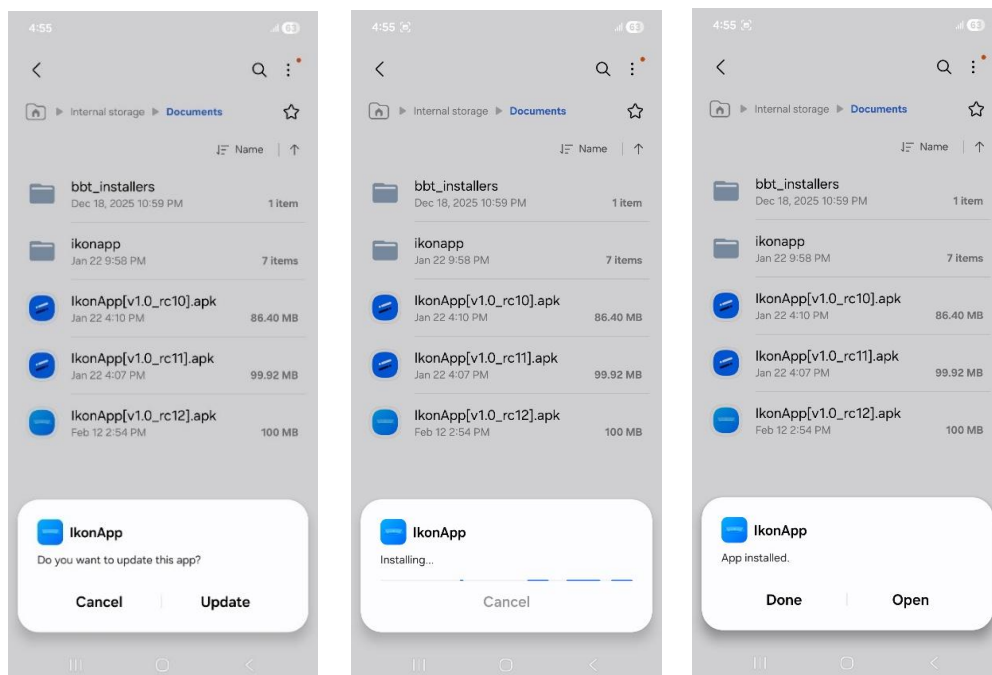


Figure 61. Ikon App installation process

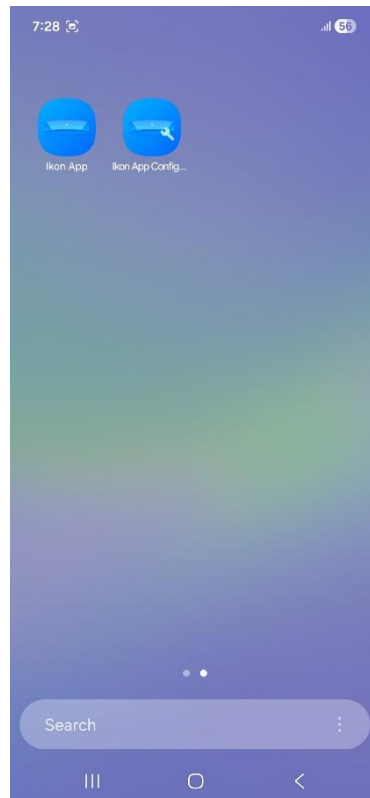


Figure 62. Ikon App and Ikon App Configurator installed in the application menu

13.3.2 How to Set Ikon App Configurator

Before starting the session, the first step will be to open the Ikon App Configurator and complete the recording parameters shown in Figure 63:

- Participant ID: Alpha-numerical identification for the participant.
- Dataset Name: Name of the folder where the dataset of recordings will be saved.
- Sensor ID: Amplifier Serial Number.
- Sensor Type: Selector for the type of device that will be used in the recording (Ikon or Ikon Sleep)

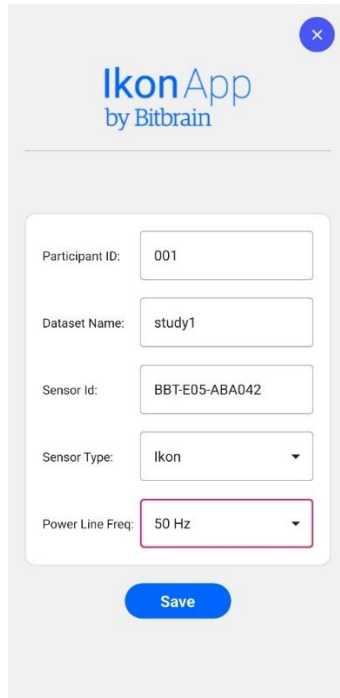


Figure 63. Ikon App Configurator main window

Once the parameters are set, click on the “Save” button and a confirmation message will appear stating that the configuration was updated successfully.

These parameters will define the recording that will be performed in the Ikon App.

At this point the amplifier can be turned on and connected to the type of band selected in “Sensor type”.

13.3.3 How to Run Ikon App

Ikon App is the application from which the sessions will be recorded.

After setting the parameters in the Ikon App Configurator, turning on the amplifier and connecting it to the corresponding band, the Ikon App can be directly opened to begin with the recording.

Figure 64 shows the window that opens when the Ikon App is first launched, given a certain set of parameters established in the Ikon App Configurator. At this point, the Ikon App is trying to find the device in the Bluetooth network and connect to it. The serial number will be the unique identifier of the amplifier, and no manual Bluetooth connection is needed as the Ikon and Ikon Sleep devices feature BLE connectivity that allows the automatic connection between the device and the Ikon App.

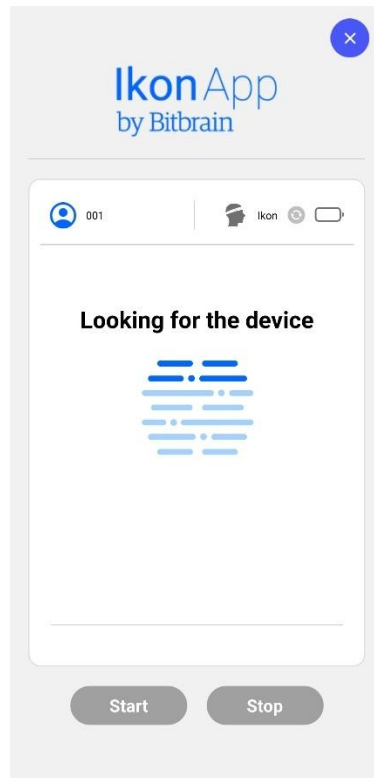


Figure 64. Ikon App process of finding the device in the Bluetooth network

Please refer to Section 13.3.4 for more details regarding connectivity checks and troubleshooting after device setup.

Once the amplifier-band pair is correctly detected, the participant can proceed with the placement of the device. The correct connection status is represented through the green circle with arrows in the top right corner, next to the battery status icon, as seen in Figure 65. Additional information is displayed on that same screen (from top to bottom and from left to right):

- Participant ID
- Type of sensor being used in the recording (Ikon/ Ikon Sleep)
- Device connectivity and battery level status. Please refer to Section 6 (SD card & connection feedback) for a complete overview of all connectivity icon indicators, including their possible statuses and corresponding meanings.
- Sensor's layout diagram in the corresponding type of band
- Start/Stop buttons for recording

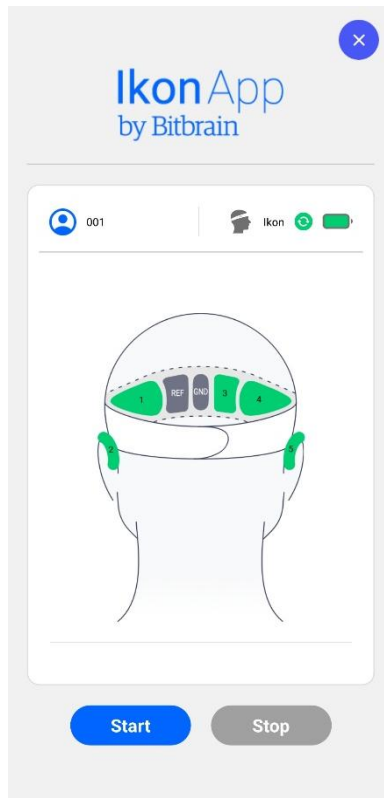


Figure 65. Signal quality check in Ikon App

This window allows the user to check the online impedances read from the device's sensors. This window also enables the user to identify the participant and device being used for this session, in alignment with the parameters established in the Ikon App Configurator.

Before starting the recording, it is recommended to adjust the device to the participant's head until all the impedances appear in green, in order to ensure optimal sensor placement and obtain the highest possible EEG data quality. However, the recording can still be initiated even if not all the impedances reach optimal levels.

To start the recording, click on "Start" and the screen shown in Figure 66 will appear.

The user will have access to the same information (the participant ID, the device connectivity and battery status), as well as:

- Session and recording identification numbers
- Timer showing the total recording duration

Once a recording has been started, data acquisition will continue uninterrupted even if the user temporarily leaves the Ikon App (for example, by switching to another application or returning to the home screen). The recording runs safely in the background and remains active until the user explicitly stops it from within the Ikon App or exits the application using the on-screen close button.

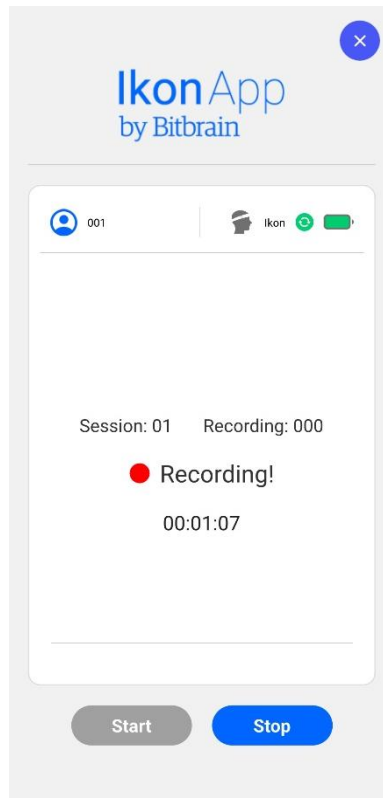


Figure 66. Recording window in Ikon App

To stop the recording click on the “Stop” button and the session will finish. If you wish to perform another task, you can click on “Start” again and a new recording will be created inside that session. The dataset will be stored in the internal storage of the device > Documents > ikonapp. The rest of the folders in this path are created according to the configuration of the Ikon App Configurator (Dataset name > Participant ID > Session > Recording).

To exit the application, click the cross button in the top-right corner of the screen and a confirmation message will appear, as shown in Figure 67. This is the recommended and safest way to close the application, as it ensures that any ongoing recordings are properly terminated and that the connection with the amplifier is correctly stopped.

Alternatively, but less safe for successfully disconnecting, you can exit the application by closing it and removing it from the device’s background tasks, ensuring that it disconnects from the amplifier. This can be verified by checking the white LED lights on the amplifier: if they are blinking, it indicates that the device is correctly disconnected.

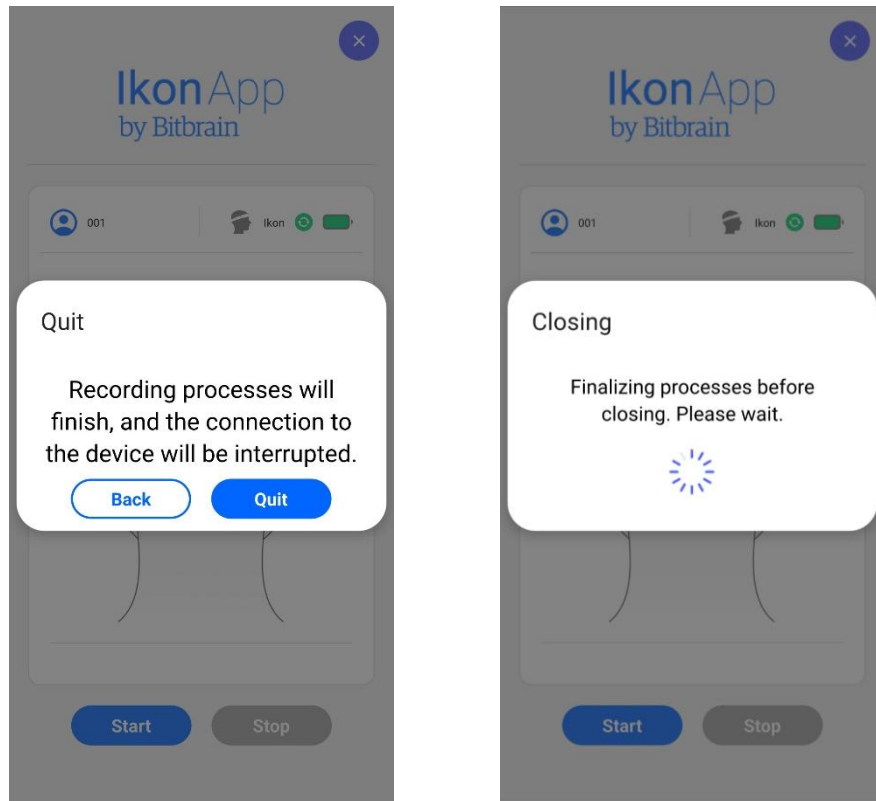


Figure 67. Confirmation message to exit Ikon App

13.3.4 Connectivity Support

When Ikon App is launched, the connectivity and status of the device are automatically checked to ensure it is ready for recording. This step verifies that the system is properly set up and that the amplifier and band are correctly connected. If any of these conditions are not met, a message with a "Retry" button will appear, allowing the user to re-check the device and band connectivity before starting the recording. The most common cases and their solutions are described below:

- "Couldn't find the device" message appears when the amplifier is turned off at the time of the check. To resolve this, turn on the amplifier and click Retry.
- "Band not detected" message appears when the amplifier is on but not connected to a band. To solve this, connect the amplifier to the correct band and click Retry.
- "Wrong band" message appears when the amplifier is connected to a band type that does not match the one configured in the Ikon App Configurator. To solve this, connect the amplifier to the correct band type and click Retry.
- "Reconnecting" message appears when the amplifier goes out of Bluetooth range. To solve this, bring the amplifier back within range of the smartphone and the connection will be re-established automatically.

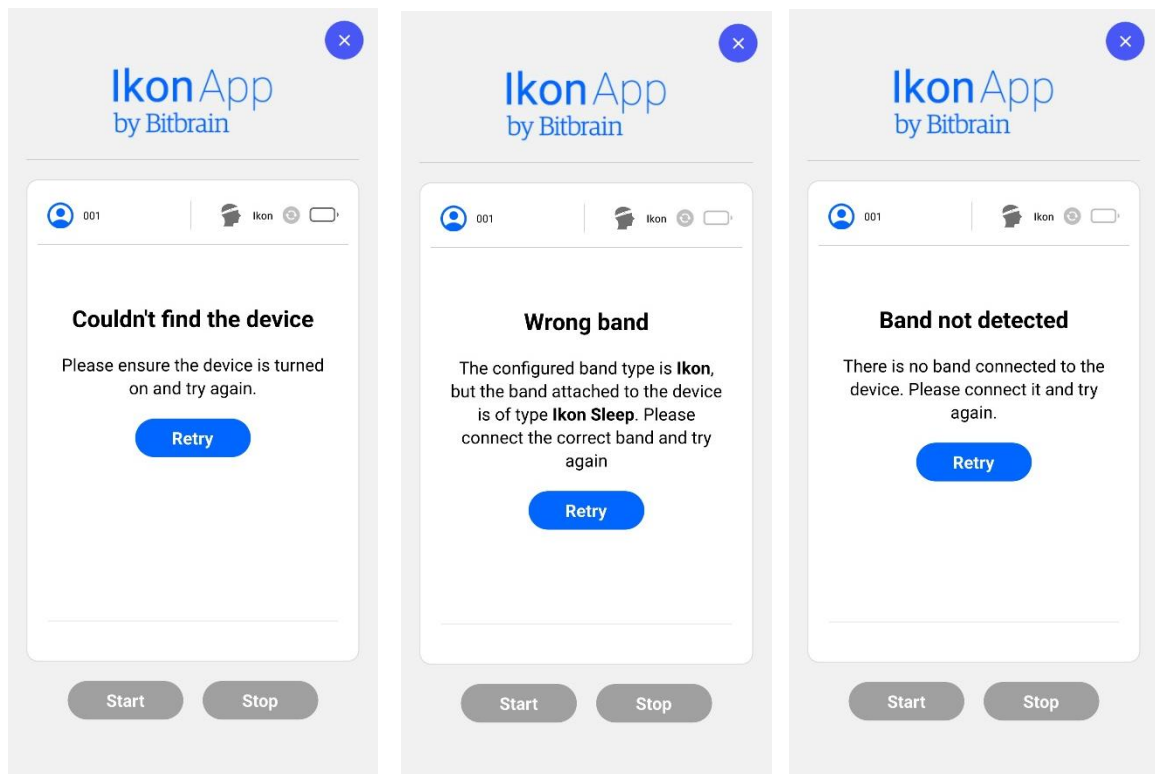


Figure 68. Connectivity feedback messages shown when device or band conditions are not correctly met.

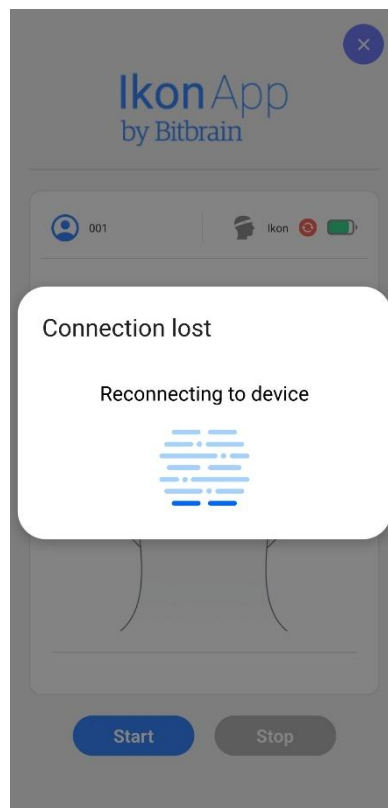


Figure 69. "Reconnecting" notification during temporary disconnection.

13.3.5 Data Import from Ikon App Recordings in Android

The import of recordings stored in the internal SD card of Ikon and Ikon Sleep devices must be carried out through SennsLite. To do so, please follow the steps below:

1. Connect the smartphone on which the Ikon App recordings were performed to a computer on which Sennslite is installed using a cable.
Note: Make sure to select the “Transferring files” option in the smartphone’s USB settings. This is necessary for the computer to correctly access the internal storage and retrieve the recorded files.
2. Copy the recorded files from the mobile device storage to a directory on the computer.
3. Disconnect the smartphone from the computer, then connect the device amplifier.
4. Follow the instructions in Section 7.2.1 to import files from the internal SD card of Ikon / Ikon Sleep devices.

13.3.6 How to Export Data Recorded with Ikon App in Android

Export data recorded with Ikon App through SennsLite Data Manager. Check Section 7 for detailed information regarding data export.

14. Contact

For any problem, question or comment please contact us at support@bitbrain.com

www.bitbrain.com
info@bitbrain.com