USER MANUAL

SennsLite user manual

Version 1.3

July 2025

Bitbrain

CONTENT

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 guides, operation modes (recording mode, data manager mode, settings) and a description of the exported data. Finally, annexes are included for specific information and guidelines for contacting Bitbrain technical support.

1.1 CONNECTIVITY

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

Note that Bluetooth connectivity does not guarantee that all the data packages are received. Due to this reason, our devices include an internal SD card to store the data.

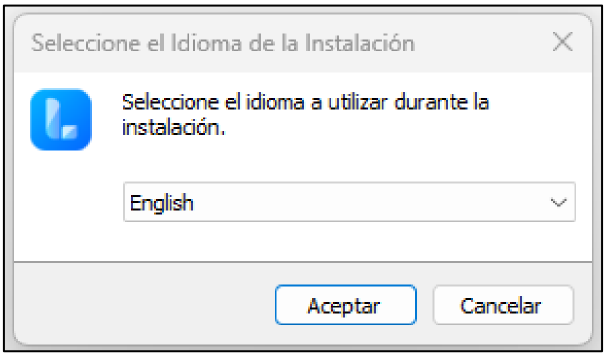
1.2 SOFTWARE VERSIONS

SennsLite is available for Windows OS and Ubuntu.

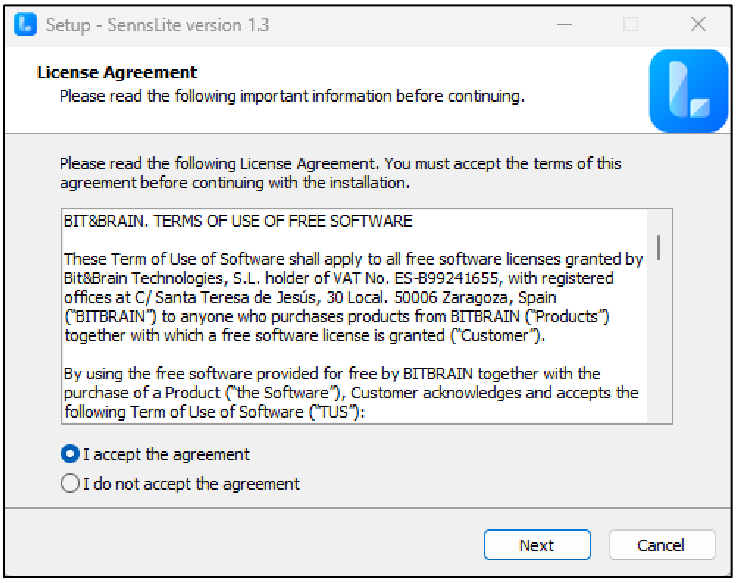
2. Windows installation

Use the installer provided by Bitbrain to setup the software in the selected computer. These are the steps to follow for a successful installation.

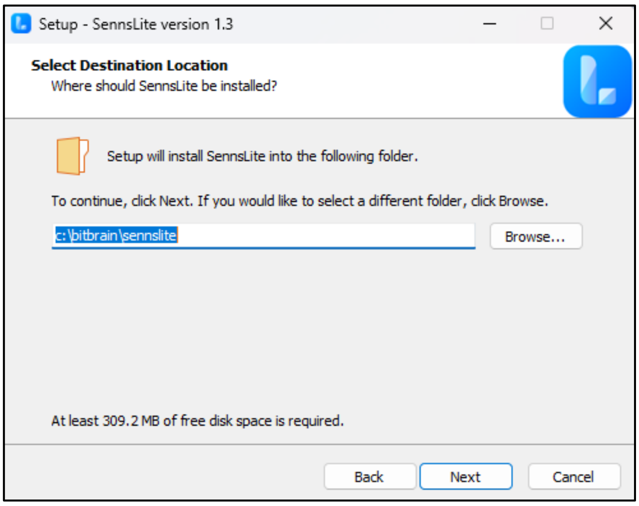
1. Select the language to use during the installation



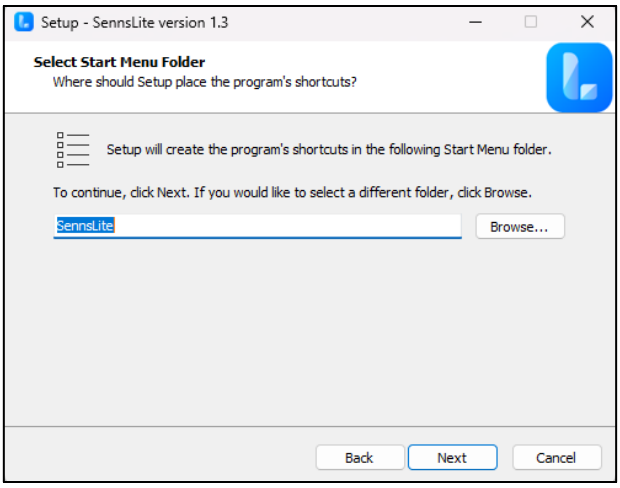
2. Accept the license agreement



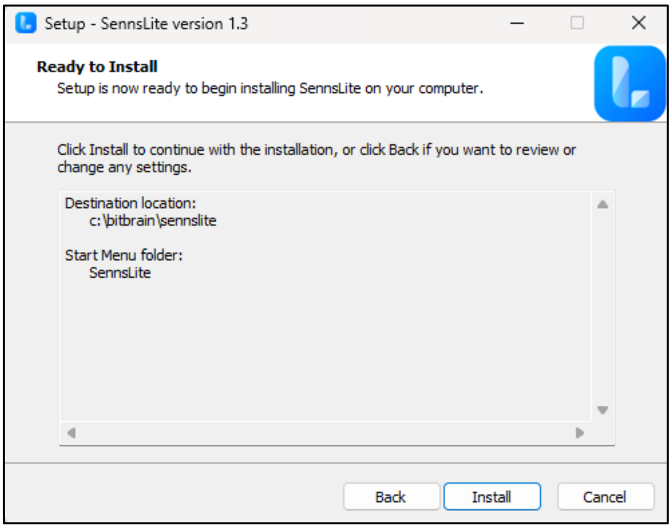
3. Select where to install SennsLite



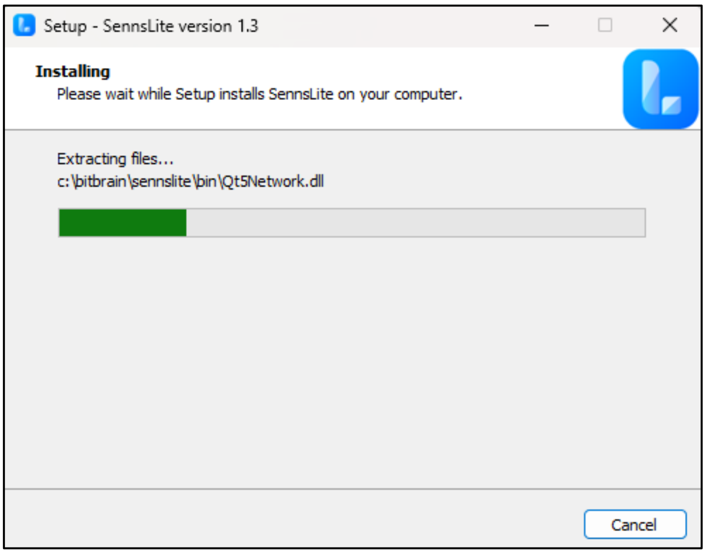
4. Select where to place the programs shortcuts.



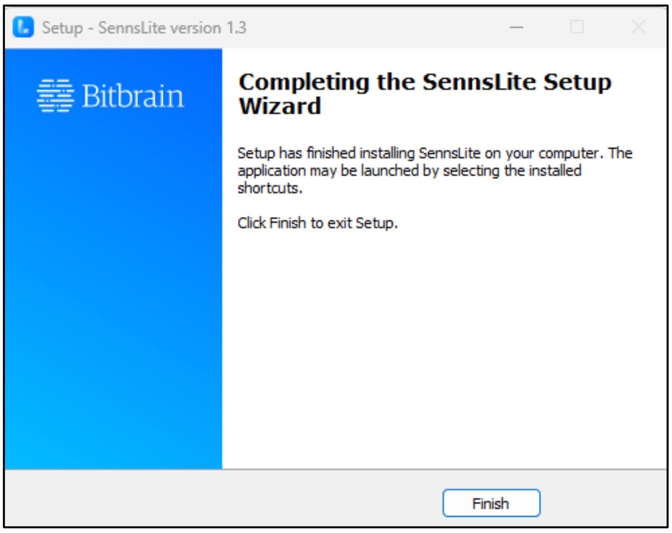
5. Confirm the previous settings to proceed with the installation of the software.



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



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

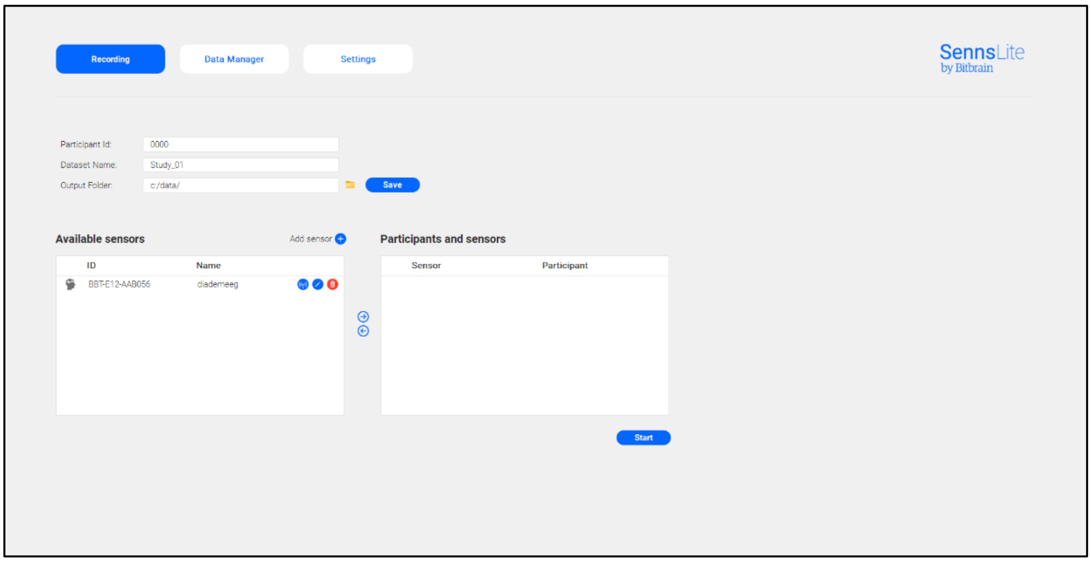


3. Software modes

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

- Recording: Biosignals data recording from Bitbrain devices.
- Data manager: Export recorded data seamlessly synchronized so that can be analyzed by the researchers. It is also possible to import the SD card data (if enabled) and visualize the data.
- Settings: Configuration of some settings (export settings, user marker)

In the initial screen there are three main buttons (top left corner) to switch between them.



Main window of SennsLite software.
Main buttons in the initial screen to switch between the three modes.

4. Recording mode

In order to perform a recording, 3 steps must be performed:

1. Configuration: configure the participant-dataset ID, and output folder; the devices to record from, and settings of each device (i.e., serial number, signal types, ability to record in the SD card).

2. Data quality checking: check the data quality indexes before starting the actual recording so that the EEG device placement can be improved (if needed). Currently, data indexes are provided the EEG signals and for the ring device.

3. Actual recording: perform the actual recording to save the data to disk.

4.1 CONFIGURATION

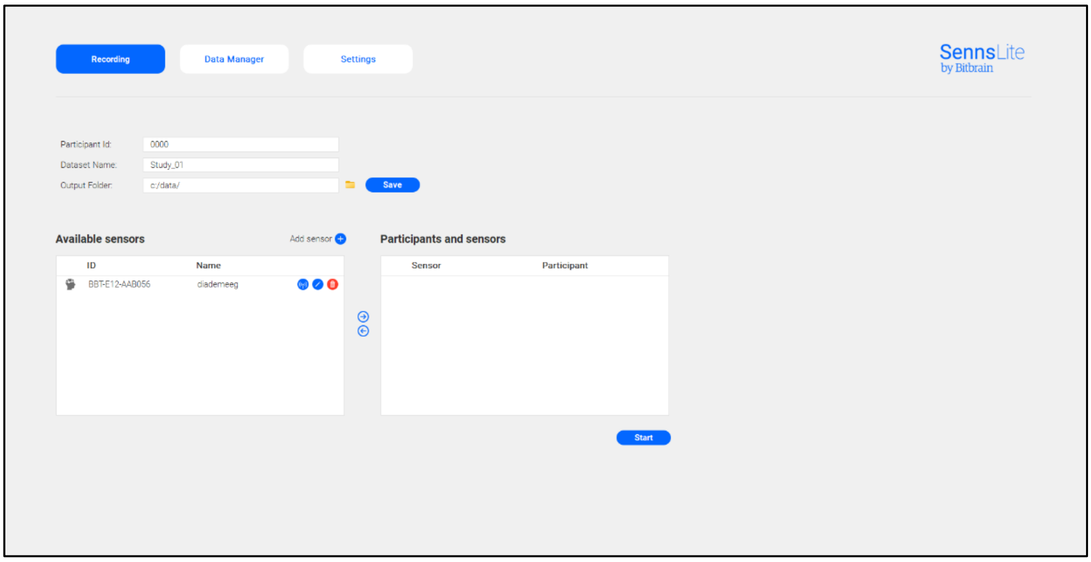
In the upper left part of the screen, there are three text boxes:

- Participant ID: Alpha-numerical ID.

- Dataset ID: Name of the dataset that will be recorded.

- Output folder: Path of the folder where to store the data.

Save button allows to persist “Participant ID”,”Dataset ID” and “Output folder” settings.



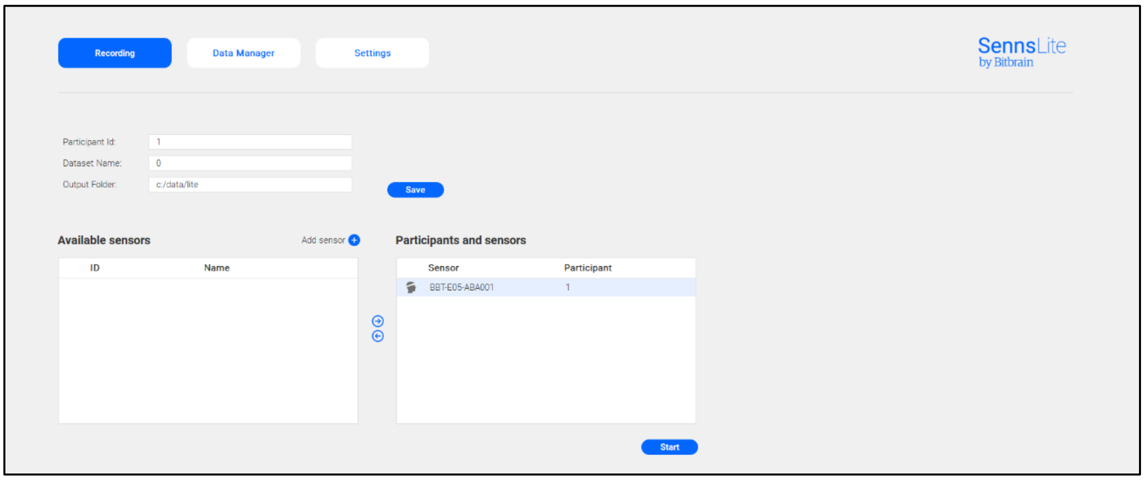
Recording mode.

These three configuration parameters are mandatory and determine the output folder where the data is stored (see Data manager - section 5).

After, select the device form the sensor list and transfer it to “Participants and sensors” list with the arrows buttons and click on “Start” button. The first time the software is used, or after acquiring a new device, it should be first added using the “Add sensor” button (4.1.1).

Using the buttons in the “Available sensors” list, the following actions can be done:

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

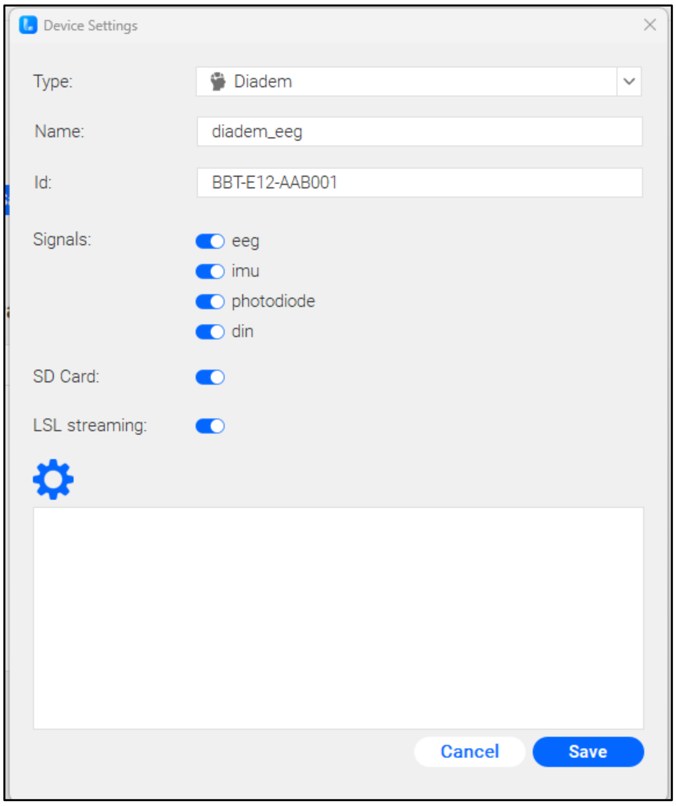


Device selected from the sensors list.

4.1.1 Adding a new device

By "Add sensor option", a connection display is open to guide the user in the connection configuration.

- Type: Select the type of the sensor from a dropdown menu.
- Name: Set a name to identify this device.
- Id: Type the serial number of the device.
- Signals: Select the signals to be recorded with the device.
  Selected signals are the only ones that would be recorded with the device and would not be possible to take back the non-selected signals when recording or exporting data.
- SD Card: Enable the recording in the SD card of the device.
- LSL streaming: Enable the streaming of data through LSL.
- Settings wheel: Shows the firmware version, and with Ikon devices shows the internal SD free capacity.

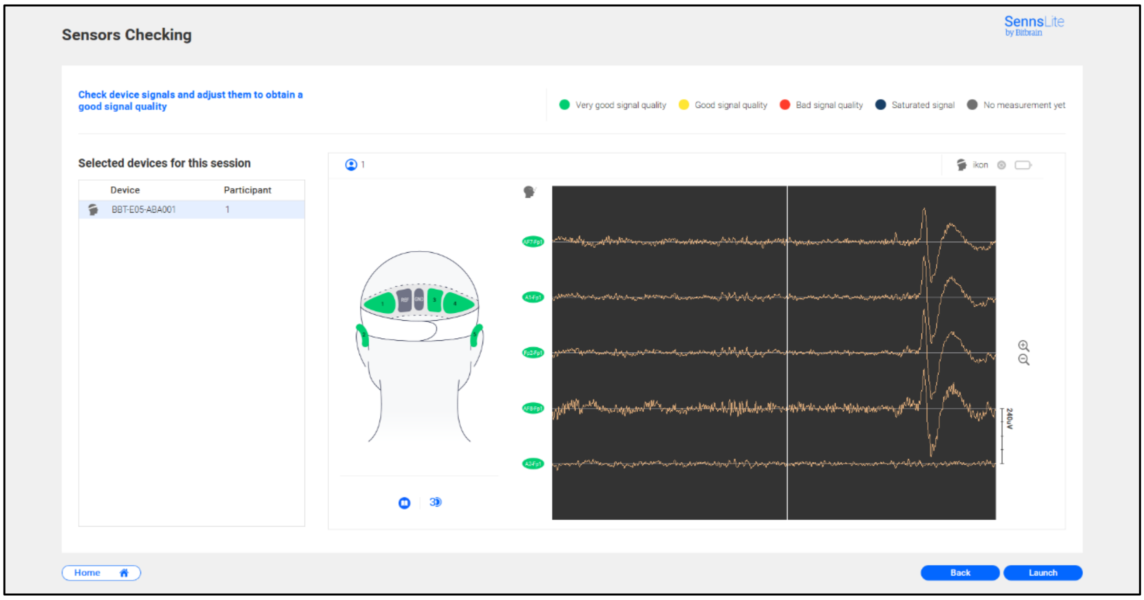


Sensor configuration tab.

Once the sensor has been set click on "Save" button to continue.

4.2 DATA QUALITY CHECKING

After pressing the “start” button in the configuration interface, the quality of the registered signal must be verified through the indicators for each type of sensor.



Data quality checking window.

The left part of the window shows a list of devices. By selecting each one, the signal viewer displays the streaming data. Right-button click over the signal viewer allows to configure the filter settings (4.2.1).

In this screen, the signal quality indicators are displayed using a colour legend (displayed in the upper part of the screen) for each sensor. These quality indicators are displayed over its position and in the left side of the signal viewer as well.

In case of the EEG or Ring signal, the quality indicators take the following levels:

- Dark grey level means that is not recording yet
- Orange is a saturated signal.
- Red level is bad signal quality.
- Yellow is for fair quality level.
- Green is for optimal status.

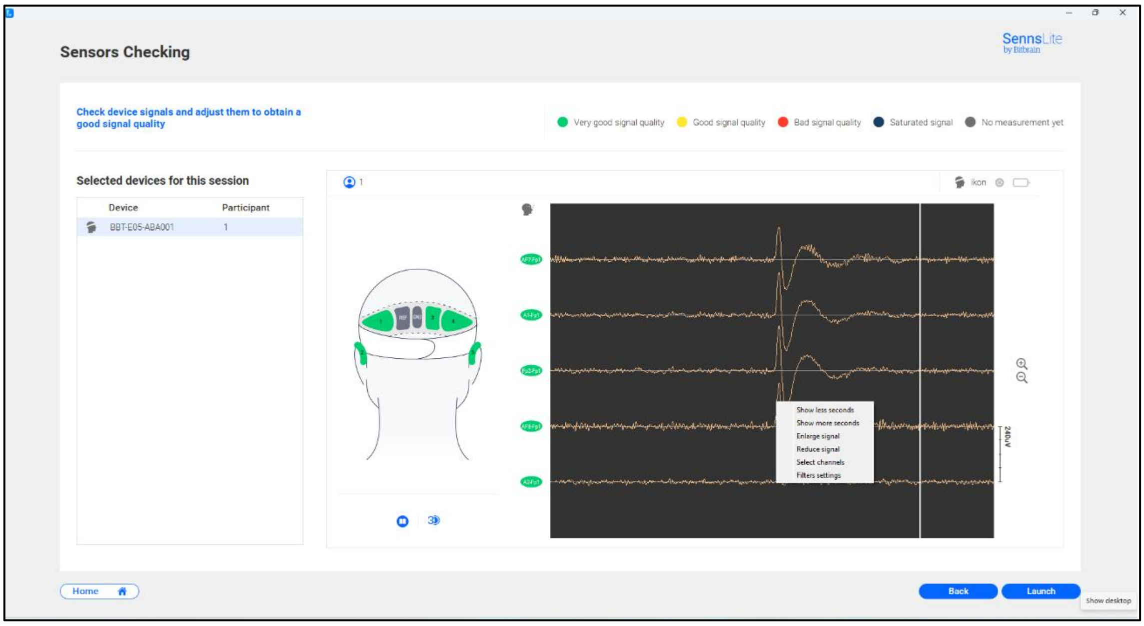
These quality indicators have a circle around it, which denotes how close the current level is from an adjacent one (i.e., transitions between green-yellow, and yellow-red states). This way the progress in the signal quality can be tracked.

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

4.2.1 Filter settings

Besides the zoom buttons on the right, 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 the visualization. All the signals are registered unfiltered.**

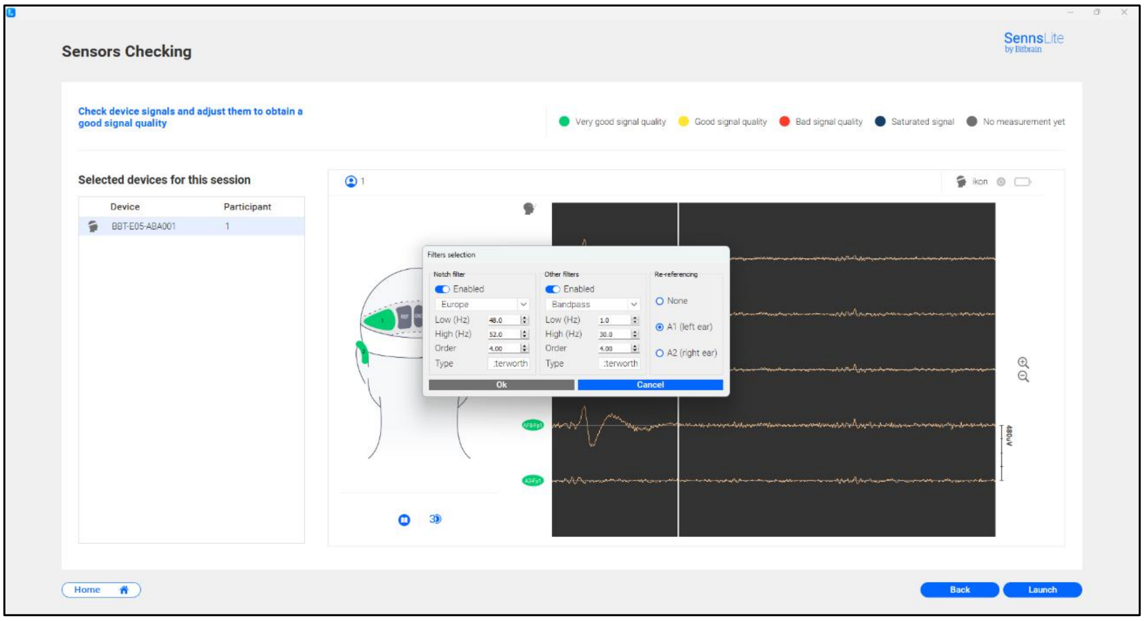


Visualization settings.

With the filter settings the user can add some visualization filter to the signal.

- Notch filter
- Pass filter: Highpass, lowpass, or bandpass filter
- Re-referencing **(just for the Ikon device)**: The Ikon device has the reference in the forefront (FP1 position, see Annex 8 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).

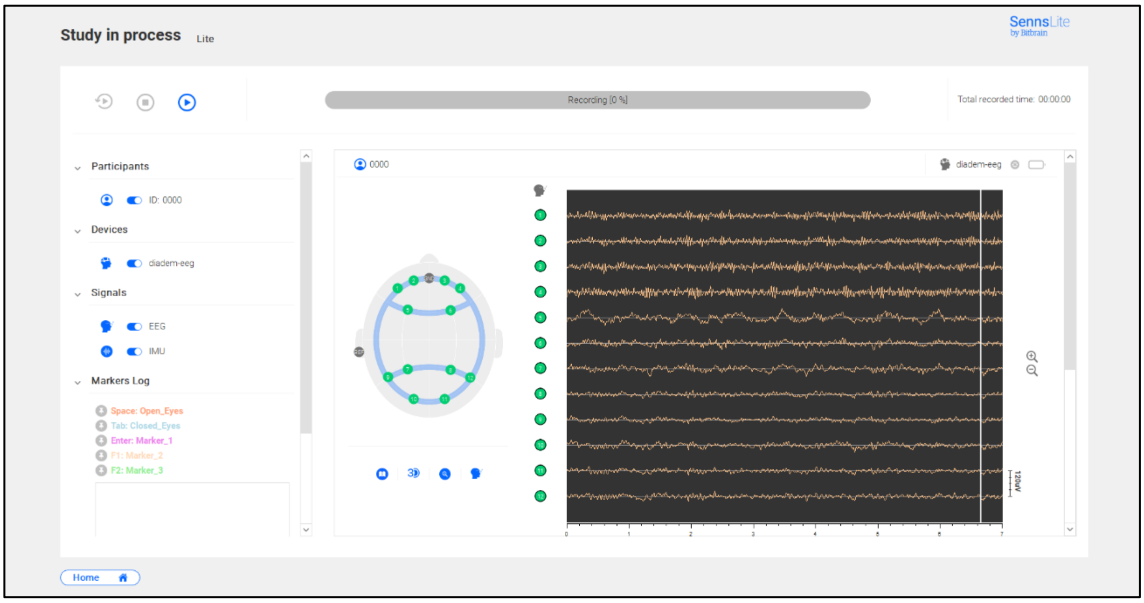


Recommended filter settings tab.

The default visualization settings for each signal type are defined in Section 0.

4.3 ACTUAL RECORDING

Once the user clicks on "Launch" button, the data acquisition window comes up.

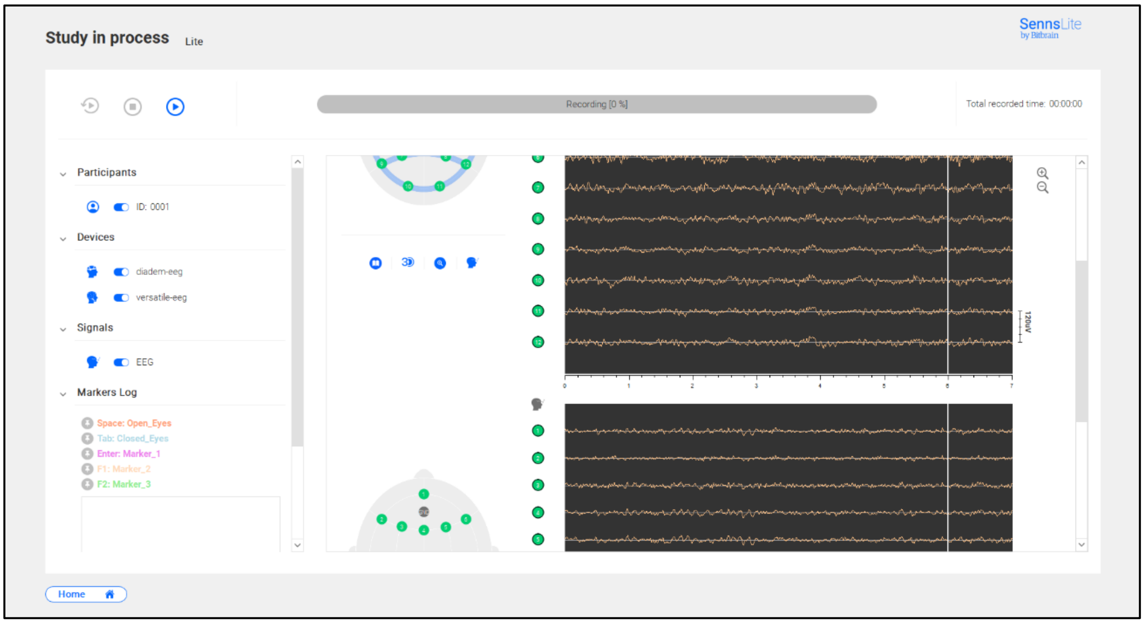


Recording window for Ikon device recording session.

In the upper left corner of the window "Start", "Stop" and "Re-start" buttons are displayed and can be used to control the start and end of 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.
- 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.

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



SennsLite used with two EEG devices.

4.3.1 Registering events

The operator can press different keys (see Settings, section 6) to register events that will be stored for its latter interpretation. The events that are triggered are displayed in the online signal viewer as a vertical line; and registered in the "Markers log".

4.3.2 Graphical elements description

In the upper part there are the following options:

- In the upper centre part of the window there is a bar used to indicate that the task is being recorded.
- In the upper right corner, there is a timer that shows the total time recorded.

The left side provides a list with the following information.

- Participant´s ID
- Devices being recorded
- Selected 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 Settings, section 6)

The right side displays the signal viewer together with the following information:

- Device name
- SD card connection feedback
    - Recording in SD. The signal is being received and is being recorded to the microSD card correctly

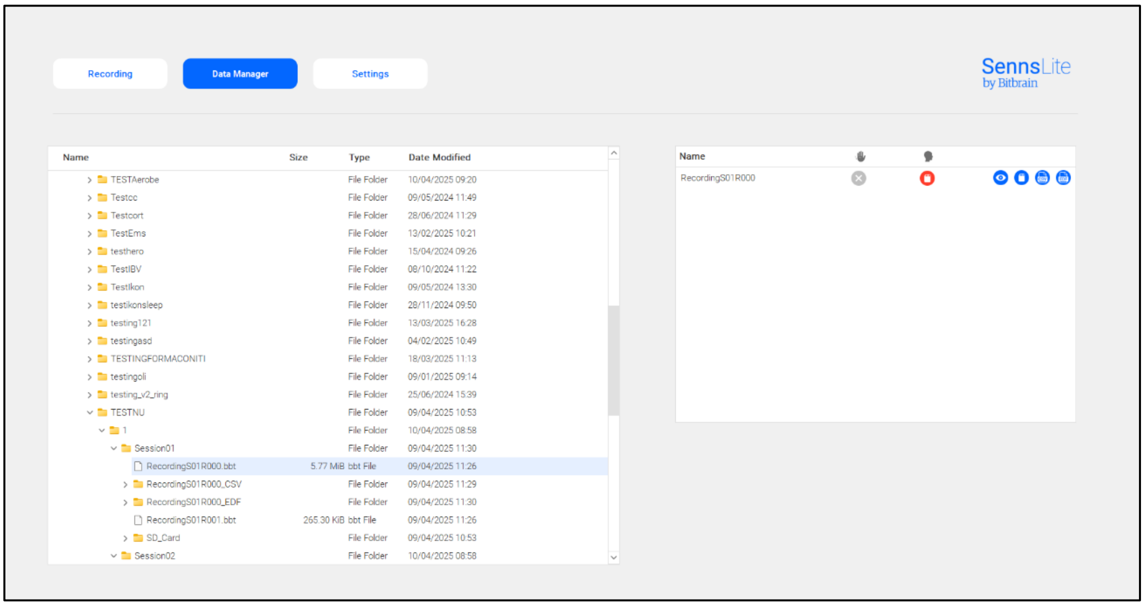
  - Communication interrupted. The recording has started on the microSD card, but no signal is currently being received.
  - Writing error. An error has occurred, and data is not being written to the microSD card.
- Battery status: The icon shows 5 battery ranges depending on the charge level sent by the device:
  - 0-20%
  - 20-40%
  - 40-60%
  - 60-80%
  - 80-100%
- Sensors layout for EEG and Ring devices
- Hardware’s user guide
- 3D brain layout (just for EEG devices)
- Sensor numbers or locations. Note that in case of the Ikon device, as it supports a re-referencing, the sensor locations in the EEG also represent the reference (e.g., FP1-A1).
- 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.

5. Data manager mode

In this mode, you can manage the recorded data:

- Import the data of the SD card (if enabled in the recording).
- Visualize the data.
- Export the data to EDF or CSV..

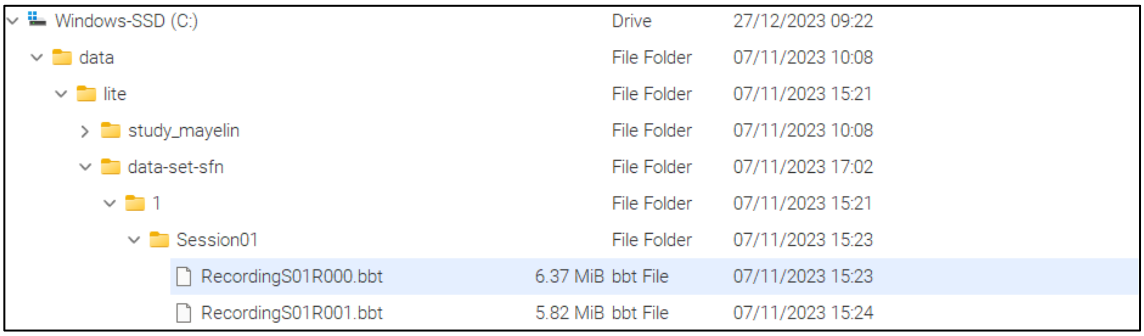


Data manager window.

In the left of the window, a file explorer tab is shown.

The recorded data with SennsLite follows a logical organization:

- The output folder defined by the user (e.g., C:/data/lite).
- Folder with the dataset ID (e.g., data-set-sfn)
- Folder with the participant ID (e.g., 1)
- Folder with the session number (e.g., Session01)



Folder logical organization for a recording.

Note that the session number is not defined by the user but is an internal number that is automatically increased every time a recording is started using the same configuration of the three parameters (output folder, participant, dataset).

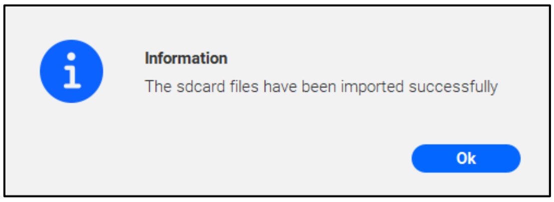
After selecting a recording session, the right side of the window displays the kind of sensor used in the recording (EEG, Biosignals), and options to visualize the signal, Import the SD card, and export the data in .csv and .edf files.

5.1 IMPORTING SD CARD FILES

For recordings performed in the SD card of the devices, those files can be imported into the computer.

Get the SD card from the device and plug it in the computer where SennsLite is installed. Once it is recognized by the computer, click on the button to import the SD card files. This process will take the data from the SD card.

If the import of the files is correctly done, a message like this will pop up.



Pop up message for the SD card importation.

5.1.1 Importing in Ikon device

For Ikon devices, the process is slightly different. To import SD card files the following steps should be followed:

- Connect the turned off amplifier through cable to the computer.
- Click on “On” button therefore the computer will detect the internal SD card.
- Once it is detected, click on import SD card button from SennsLite to import files.

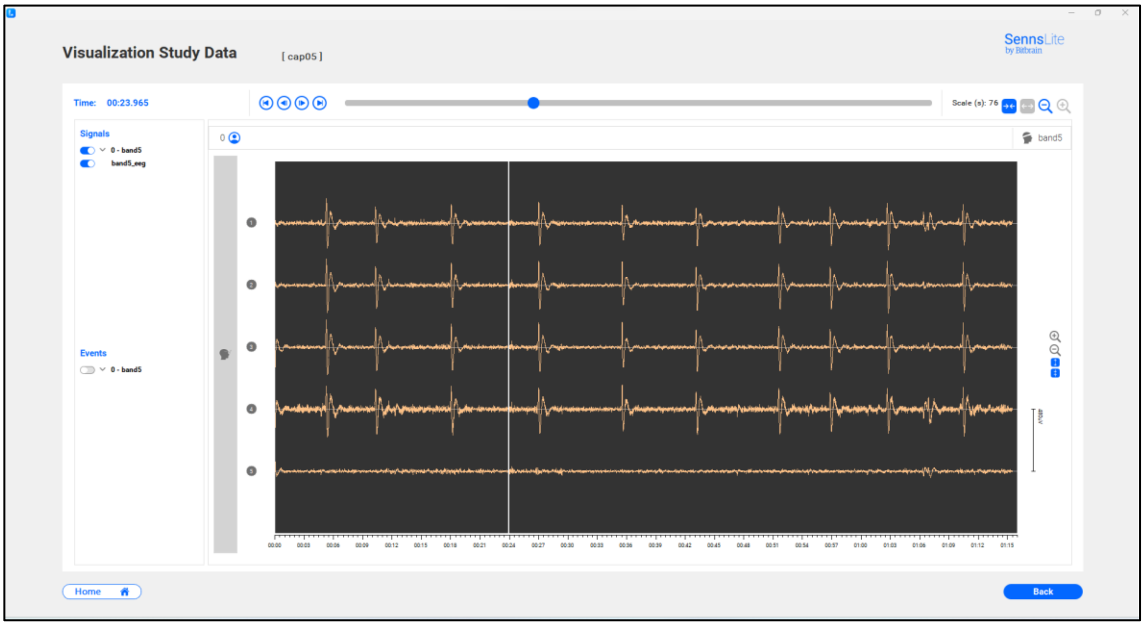
Once data has been imported, the data from the internal SD card will be deleted automatically.

5.2 VISUALIZATION WINDOW

The visualization window allows users to see the signal recorded. Filter settings configuration is the same as the one described in section 4.1.2.

- Upper left side of the screen, the timer shows the exact time of the recording.
- Centre part, time bar that represents the total duration of the recording and can move through it to see different parts of the recording. This bar has also some icons on the left that also help the user to move through this bar.
- On the upper right side, Scale allows the user to see the whole recording.

In the left part of the screen a list of the sensors used, the signals recorded with that sensor and the events logged are shown there.



Visualization screen.

Please note the following shortcuts for an easier navigation:

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

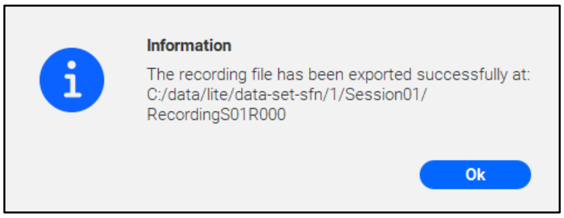
5.3 DATA EXPORT

In order to export the data, select the recording to export and click on the corresponding button to export in EDF or CSV format:

- EDF is a standardized file format designed for storing biological signals. One file is provided for every recording device. We currently support this format for Bitbrain devices containing EEG signals.
- CSV is an interoperable file format for storing tabular data in plain text. One file is provided for every device signal. All the Bitbrain devices are supported. We provide two output formats with varying levels of detail.

Section 7 provides a detailed information of the exported data.

Once the export process has been done successfully a pop-up message will come out displaying the output folder where the exported files were created.



Pop up message for the exportation of the recording files.

SD card importation

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.**

It can be checked in the metadata of the exported data whether the output data integrated the contents of the SD card, specifically checking the fields *sd_sync_read* and *sd_data_read* are true (see section 7).

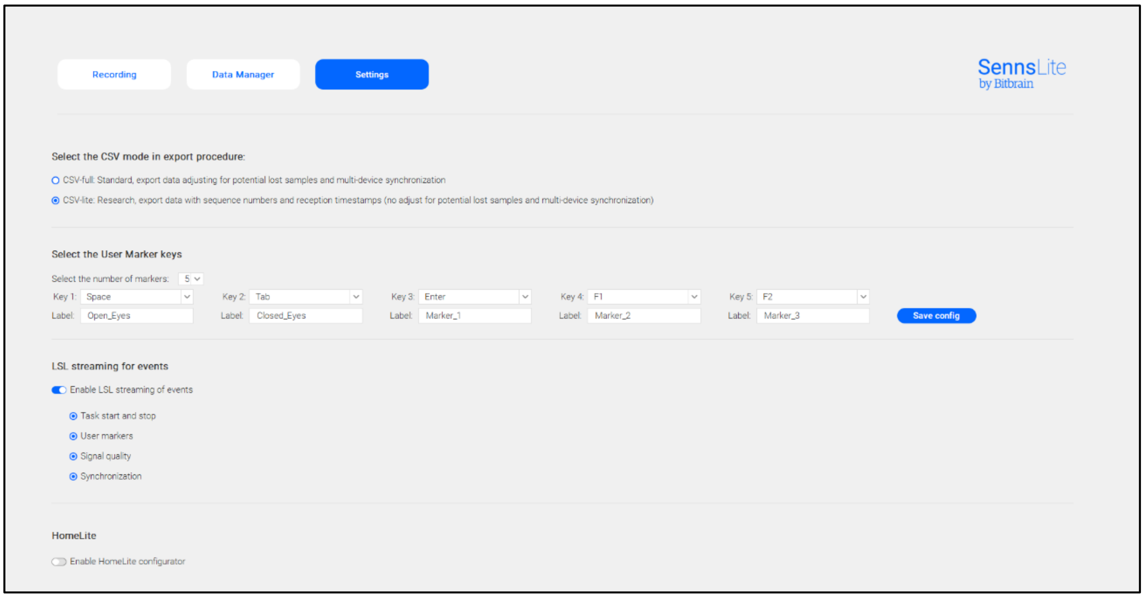
5.3.1 Export data per dataset

To export several recordings at once. It can be done by selecting the name of the dataset that will be exported and click on the export buttons, to export data in CSV or EDF. (To know more about the data exported check, section 7. Description of exported data format.).

6. Settings

In this window some settings can be selected:

- Exporting data method: To select the kind of data exportation for the CSV (CSV-Lite, CSV-Full). The user is directed to section 7 for detailed information of the exported data.
- Key User Marker: 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.
    - Label: can be defined to identify the marker.
    - After setting the markers, Save the configuration.
- 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
- HomeLite Configurator: Participant self-recording module configurator.



7. Description of exported data format

SennsLite allows exporting the data in two formats:

- EDF is a standardized file format designed for storing biological signals. One file is provided for every device. Supported for Bitbrain devices containing EEG signals. We refer to "EDF" through the software and this document for simplicity, note however that we specifically provide the EDF+ format.

- CSV is an interoperable file format for storing tabular data in plain text. One file is provided for every device signal. Supported for all Bitbrain devices. 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 the communication. In EDF and CSV-Full, the exported signals are expanded with nan values in case of lost samples. In CSV-Lite, additional information is provided such a sequence number (counter) to detect these cases.

- Multi-device adjust: 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, we provide a common t0 for all signals, and expand the signals with initial nan values so that the initial sample corresponds to the same time point. In CSV-Lite, we simply provide the initial timestamp (t0) for each device signals, which might be different.

The following table summarizes this information:

	EDF	CSV-Full	CSV-Lite
Supported devices	EEG devices (Ring or Versatile Bio not supported)	All	All
Full-band	No, EEG and PPG are high prefiltered (0.1 Hz)	Yes	Yes
Lost samples adjust	Yes	Yes	No
Multi-device adjust	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 the Bitbrain devices data transfer works and timestamps.

7.1 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> * In case of EEG signals, we provide the position: <signal_id>_<loc>	Values of signal <signal_id> and channel i (from 1 to N). 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 *eeg* 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)

7.2 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 null if lost online.
timestamp	Lite	Corrected timestamp (high res., us), using the t0 computation

7.3 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.

7.4 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 worked fine
- 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: device type (Ikon, Ikon Sleep, Diadem, Hero, Air, Versatile EEG, Versatile Kids EEG, Versatile Bio, Ring)
  - signal type: signal type, see section 7.5
- 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, initial 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

7.5 SIGNAL AND EVENTS PROPERTIES

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

- EEG systems and Versatile Bio
- Ring device

7.5.1 Signals of EEG systems and Versatile Bio

The signals are recorded without any filtering. All the signals are sampled at 256 Hz (8 samples per block) except for the IMU (32 Hz, 1 sample per block). In case of EEG, [1-30] Hz bandpass filter is applied to the EEG for visualization purposes only.

SIGNAL TYPE	DESCRIPTION	DEVICE TYPE
eeg	**EEG signal** Number of channels * Samples per block: 8 Sampling rate: 256 Hz Unit: uV Visualization filter: [1-30 Hz] *The number of channels [value n] depends on the device type.	Ikon (n=5) Ikon Sleep (n=2) Air (n=8) Diadem (n=12) Hero (n=10) Versatile EEG 8 (n=8) Versatile EEG 16 (n=16) Versatile EEG 32 (n=32)
imu	**Inertial measurement unit (IMU)** Number of channels: 9 - ch 1: accelerometer, x-axis (g) - ch 2: accelerometer, y-axis (g) - ch 3: accelerometer, z-axis (g) - ch 4: gyroscope, x-axis (deg/s) - ch 5: gyroscope, y-axis (deg/s) - ch 6: gyroscope, z-axis (deg/s) - ch 7: magnetometer, x-axis (uTeslas) - ch 8: magnetometer, y-axis (uTeslas) - ch 9: magnetometer, z-axis (uTeslas) Samples per block: 1 Sampling rate: 32 Hz	Ikon Ikon Sleep Air Diadem Hero Versatile EEG Versatile Bio
photodiode	**Photodiode input** Number of channels: 1 Samples per block: 8 Sampling rate: 256 Hz Unit: bit	Air Diadem Hero Versatile EEG Versatile Bio
din	**Digital input** Number of channels: 1* Samples per block: 8 Sampling rate: 256 Hz Unit: bit	Diadem Versatile EEG Versatile Bio

	*The number of channels is 1, except for the Versatile 32 (n=3)	
dout	Digital output Number of channels: 1 Samples per block: 8 Sampling rate: 256 Hz Unit: bit This signal type generates TTL pulses that, when received in the DIN of another device, can be used to synchronize them at sample level.	Versatile Bio
analog	Input to record analogic signals such as GSR, respiration, temperature, etc. The Versatile Bio has 7 analogic inputs. Samples per block: 8 Sampling rate: 256 Hz	Versatile Bio
exg	Input to record bipolar signals such as ECG, EMG, etc. The number of inputs depends on the device type [value n]. Samples per block: 8 Sampling rate: 256 Hz	Versatile EEG 32 (n=2) Versatile Bio (n=9)
ppg	PPG signal Number of channels: 3 - ch 1: red light intensity - ch 2: infrared light intensity - ch 3: green light intensity Samples per block: 1 Sampling rate: 32Hz Unit: nA	Ikon Sleep

7.5.2 Signals of the Ring device

The signals are recorded without any filtering. The signals are sampled at 32 Hz (1 sample 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.

SIGNAL TYPE	DESCRIPTION	DEVICE TYPE
gsr_bvp_acc	The Ring device provides the following signals: Number of channels: 5 - ch 1: galvanic skin response (GSR) (uS) - ch 2: blood volume pulse (BVP) (uV) - ch 3: accelerometer (ACC), x-axis (g) - ch 4: accelerometer (ACC), y-axis (g) - ch 5: accelerometer (ACC), z-axis (g) Samples per block: 2 Sampling rate: 32 Hz	Ring

7.5.3 Events

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

EVENT	DESCRIPTION
userMarker	Denotes the time instants in which the operator pressed a key. Each marker denotes the index of the markers as defined in Settings: - value = 0 (Key 1) - value = 1 (Key 2) - value = 2 (Key 3) - value = 3 (Key 4) - value = 4 (Key 5)
{deviceID}_quality	Signal quality values for a given device (specified by its ID), available for EEG devices and 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. - 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

7.6 UNDERSTANDING THE DATA TRANSFER AND SYNCHRONIZATION

Bitbrain devices iteratively register a “block of data” and transfer it to the recording software. This data transfer happens block by block at a fixed rate of 32 Hz (i.e., every 31.25 ms a “block of data” is recorded and transferred to the recording computer).

The data blocks contain multiple signals (for instance EEG, SPO, IMU) and a sequence number. This sequence number is a counter to detect missing blocks due to the wireless nature of the communication (either using standard Bluetooth or Bluetooth Low Energy in Ikon). At reception, the software captures a “reception timestamp”.

Based on all this information (sequence number, reception timestamps, and the fact that we impose a data transfer at a fixed rate), we can apply a series of algorithms to correct the jitter from the timestamps, estimate the initial time point of each signal (referred as to “t0” in this section), and synchronize the signals from multiple devices. The synchronized data is exported in CSV format along with metadata.

Finally, it is important to understand that data blocks contain, for each signal, a pre-defined number of samples. For instance, since the sampling rate of the EEG is 256 Hz, we capture 8 samples of EEG per block (and channel). In case of SPO and IMU signals they have a sampling rate of 32 Hz, thus 1 sample of data is transferred per block.

7.6.1 Timestamps

We capture two types of timestamps:

- High resolution timestamps (using QueryPerformanceCounter in Windows OS). These timestamps have a high resolution (<1us) and can be used for time-interval measurements.
- UTC timestamps (using GetSystemTimePreciseAsFileTime in Windows OS). 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.

8. Annex 1: Ikon reference

The Ikon device has sensors in the forefront (Af7, Fp1, Fp2, Af8) and in 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's sensors. This is interesting as the ear's 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 needs, or switch between them if the contact is loss 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.

8.1 RE-REFERENCING

Recorded data can be expressed in the form:

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

Re-referencing implies to perform 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
```

9. Annex 2: HomeLite

9.1 INTRODUCTION

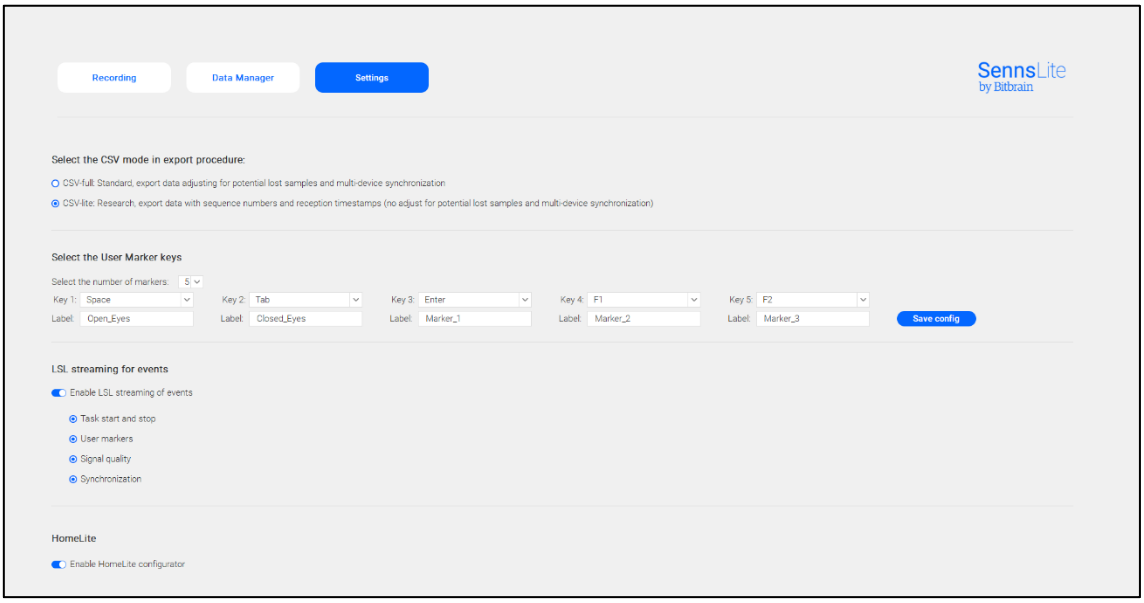
HomeLite is a recording module for participants to record data by themselves even if they are not experts and have no previous experience.

HomeLite is only available for Windows OS.

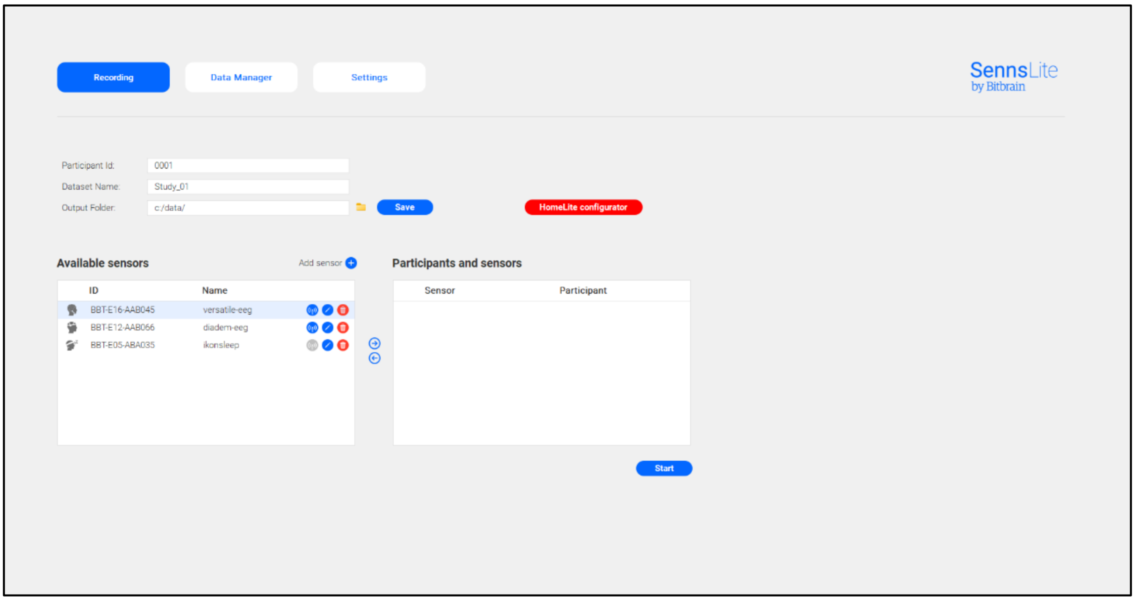
9.2 HOW TO SET HOMELITE CONFIGURATOR

HomeLite must be set with SennsLite as well as the Ikon devices that would be used for the recording.

1. In SennsLite settings, enable HomeLite Configurator.

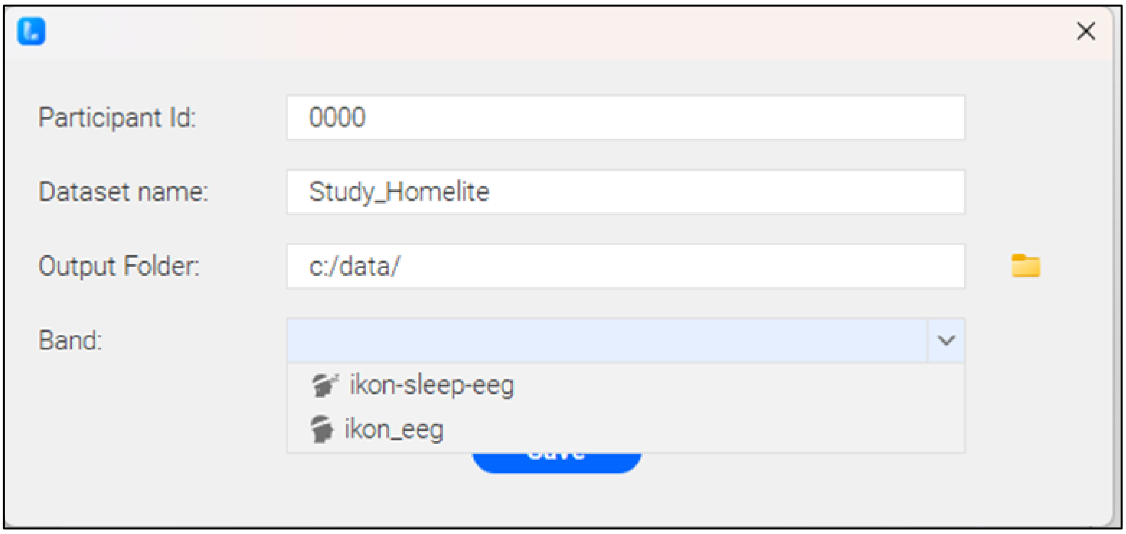


2. In SennsLite go to “Recording” and click on the red button HomeLite module to set it.



3. Include the device that will be used in the recordings. To set a device check "4.1.1 Adding a new device".

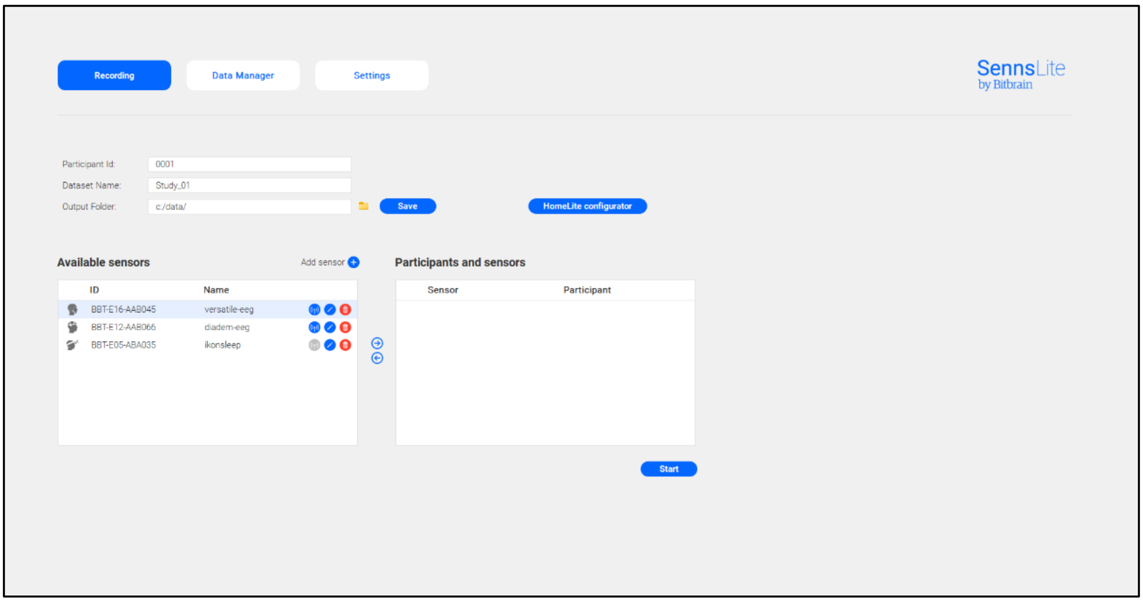
4. After clicking on the button, set the values at your convenience and select the pre-set device that will be used in the recording.



5. After setting all the parameters click on save.

6. If everything has been set correctly, HomeLite button should be shown in blue.

2



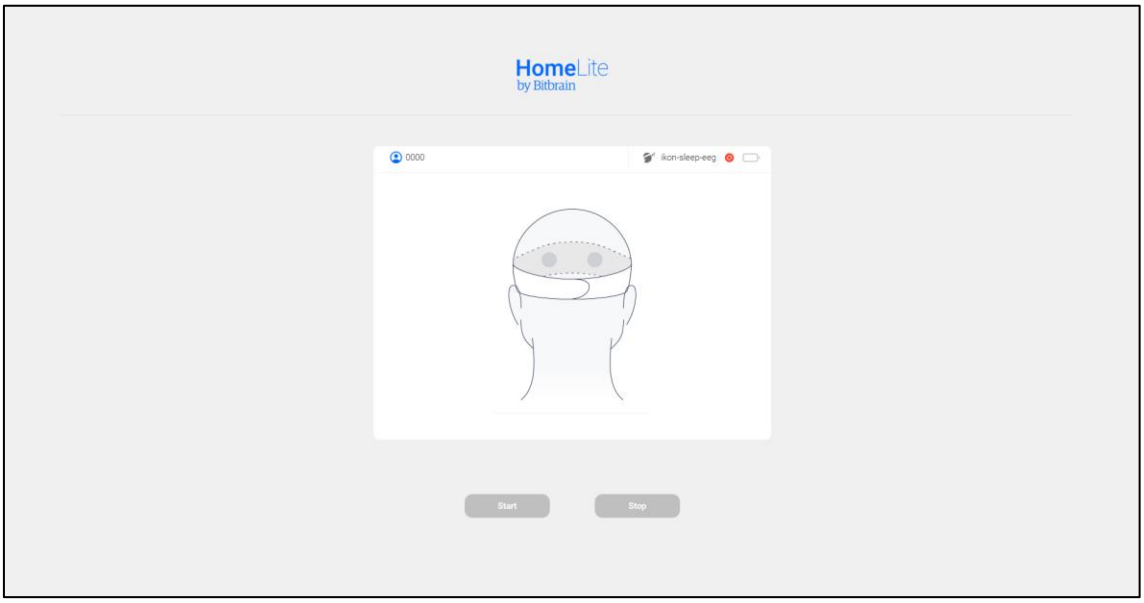
7. At this point SennsLite can be closed as this functionality is only for setting the HomeLite recorder.

9.3 HOW TO RUN HOMELITE

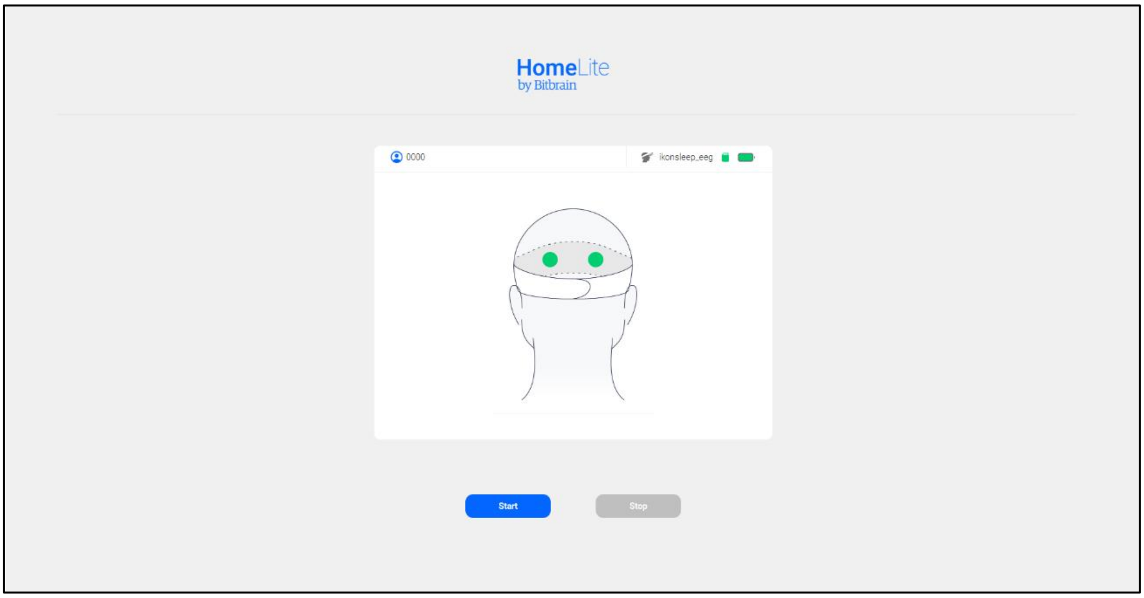
HomeLite can be used for non-experts to record data following these steps:

1. If SennsLite has been installed by default, go to "C:\bitbrain\sennslite\bin\homelite.exe"

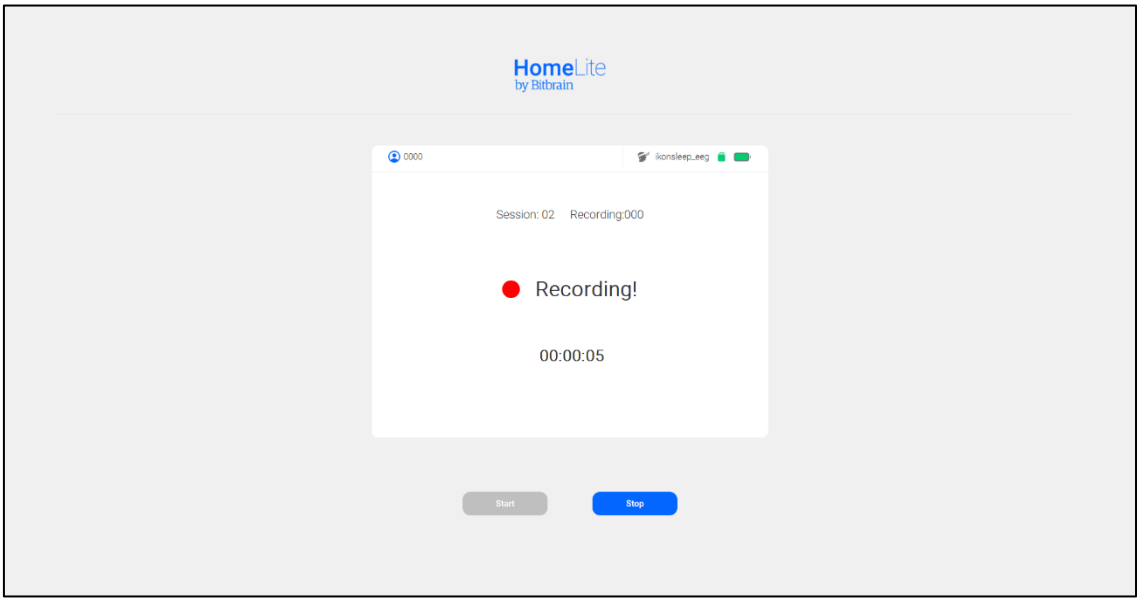
2. HomeLite will show the following window. Here the impedances for the device can be checked.



3. Adjust the device until all the impedances are in green.
The “Start” button would not be available until the impedances are in green.



4. Click on “Start” to start the recording.
5. Once the recording has begun the participant will see the following screen:
    a. Time: Timer that shows the total amount of time recorded.
    b. Session: Number of the session and the participant that is being recorded.
    c. Device: Id of the device set for the recording.



6. Click on “Stop” to stop the recording
7. Close HomeLite.

9.4 HOW TO EXPORT DATA RECORDED WITH HOMELITE

Export data recorded with HomeLite through SennsLite data manager. Check “5. Data manager module” for data export.

10. 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.

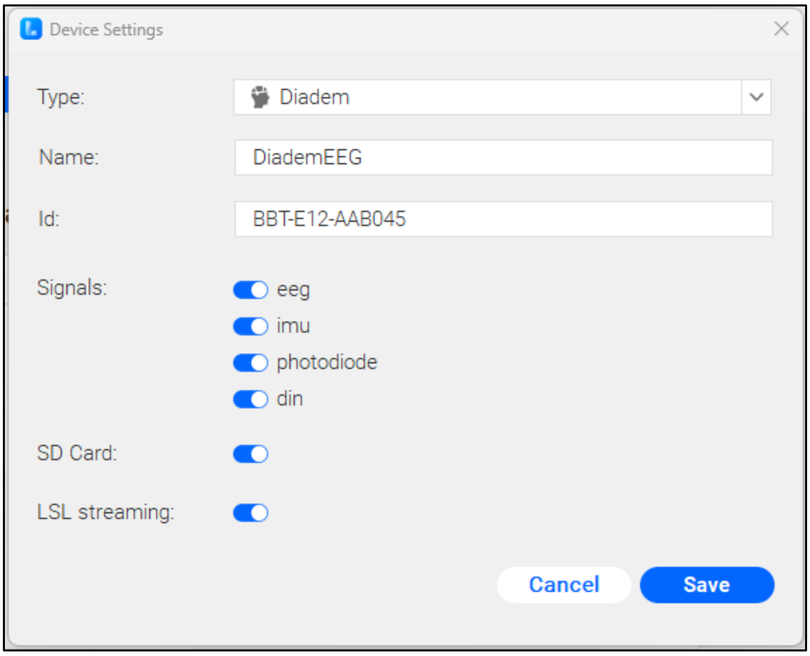
If this feature is enabled, an LSL server will be created when the acquisition starts. This server will publish one data stream per signal being acquired. Other applications in the same computer or over the network can connect to the server to subscribe to any of the stream and receive the data online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

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

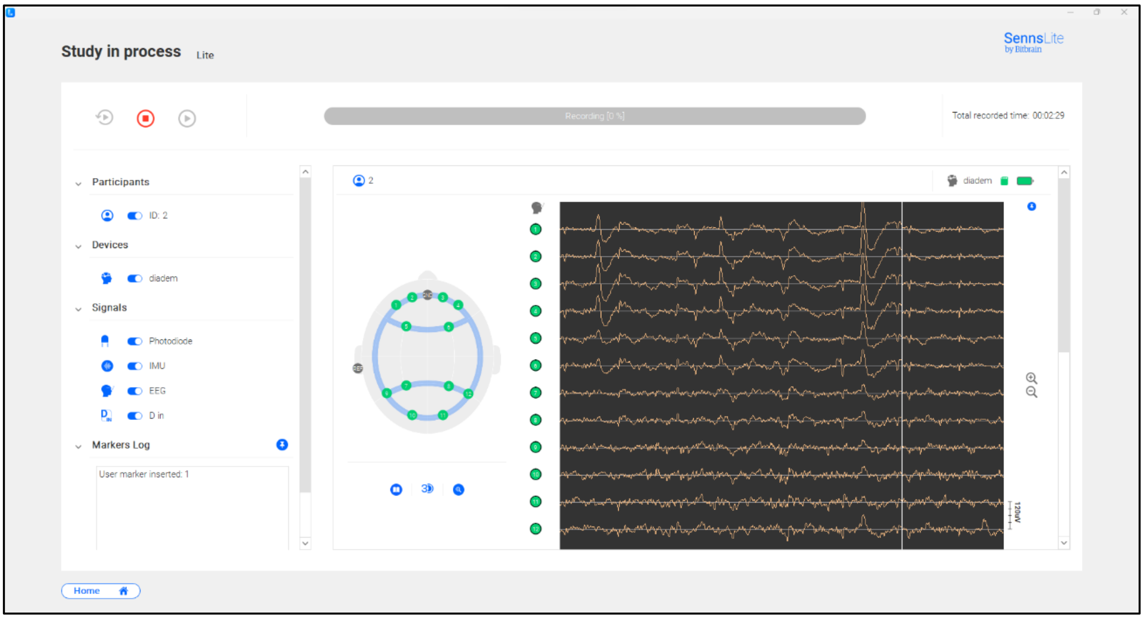
LabRecoder can be downloaded here: [GitHub - labstreaminglayer/App-LabRecorder: An application for streaming one or more LSL streams to disk in XDF file format.]

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

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

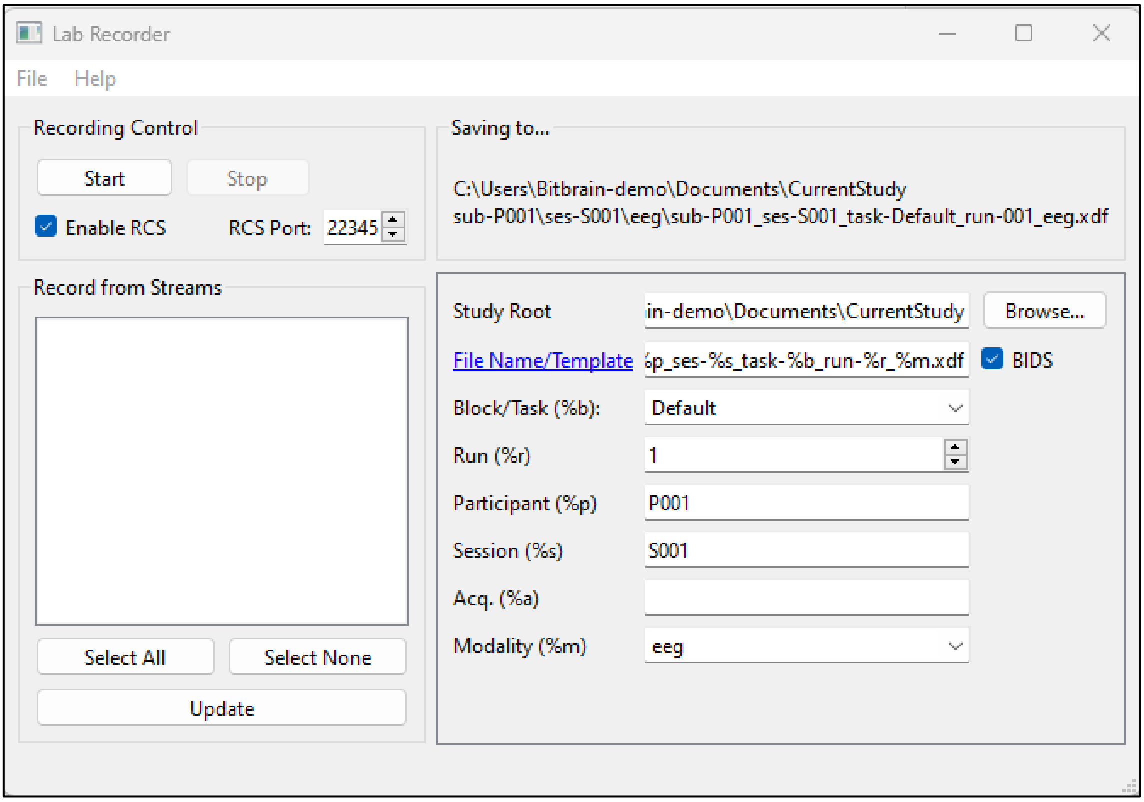


2. Go through the configuration steps and throughout the quality check process. And get to the recording screen.



3. Start SennsLite recording.

4. Launch LabRecorder.



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.

10.1 OUTPUT STREAMS

SIGNAL TYPE/OUTLET ID	LSL METADATA	DEVICE TYPE
eeg <device_name>_eeg	EEG signal Number of channels * Samples per block: 8 Sampling rate: 256Hz Unit: uV *The number of channels [value n] depends on the device type.	Ikon (n=5) Ikon Sleep (n=2) Air (n=8) Diadem (n=12) Hero (n=10) Versatile EEG 8 (n=8) Versatile EEG 16 (n=16) Versatile EEG 32 (n=32)
imu <device_name>_imu	IMU signal Number of channels: 9 - ch 1: accelerometer, x-axis (g) - ch 2: accelerometer, y-axis (g) - ch 3: accelerometer, z-axis (g) - ch 4: gyroscope, x-axis (deg/s) - ch 5: gyroscope, y-axis (deg/s) - ch 6: gyroscope, z-axis (deg/s) - ch 7: magnetometer, x-axis (uTeslas) - ch 8: magnetometer, y-axis (uTeslas) - ch 9: magnetometer, z-axis (uTeslas) Samples per block: 1 Sampling rate: 32 Hz	Ikon Ikon Sleep Air Diadem Hero Versatile EEG Versatile Bio
photodiode <device_name>_photodiode	Photodiode input Number of channels: 1 Samples per block: 8 Sampling rate: 256 Hz Unit: bit	Air Diadem Hero Versatile EEG Versatile Bio
din <device_name>_din	Digital input Number of channels: 1* Samples per block: 8 Sampling rate: 256 Hz Unit: bit *The number of channels is 1, except for the Versatile 32 (n=3)	Diadem Versatile EEG Versatile Bio
dout <device_name>_dout	Digital output Number of channels: 1 Samples per block: 8	Versatile Bio

	Sampling rate: 256 Hz Unit: bit	
analog <device_name>_analog	**Input to record analogic signals such as GSR, respiration, temperature, etc.** The Versatile Bio has 7 analogic inputs. Samples per block: 8 Sampling rate: 256 Hz	Versatile Bio
exg <device_name>_exg	**Input to record bipolar signals such as ECG, EMG, etc.** The number of inputs depends on the device type [value n]. Samples per block: 8 Sampling rate: 256 Hz Unit: uV	Versatile EG 32 (n=2) Versatile Bio (n=9)
ppg <device_name>_ppg	**ppg signal** Number of channels: 3 - ch 1: red light intensity - ch 2: infrared light intensity - ch 3: green light intensity Samples per block: 1 Sampling rate: 32Hz Unit: nA	Ikon Sleep
gsr_bvp_acc <device_name>_signal	**ring signal** The Ring device provides the following signals: Number of channels: 5 - ch 1: galvanic skin response (GSR) (uS) - ch 2: blood volume pulse (BVP) (uV) - ch 3: accelerometer (ACC), x-axis (g) - ch 4: accelerometer (ACC), y-axis (g) - ch 5: accelerometer (ACC), z-axis (g) Samples per block: 1 Sampling rate: 32 Hz	Ring
start/stop	Denotes the instant when the recording in SennsLite has started or stopped.	All
userMarker	Denotes the time instants in which the operator pressed a key. The marker is a string containing its label (as defined in Settings)	All
{deviceID}_quality	Signal quality values for a given device (specified by its ID), available for EEG devices and 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. - ch1: signal quality of channel 1 - ... - chN: signal quality of channel N	Ikon Ikon Sleep Air Diadem Hero Versatile EEG Ring

	The signal quality values are: - value = 1, optimal quality - value = 2, fair quality - value = 3, bad quality - value = 4, saturated signal	
lslSync	Pulse sent every 10 seconds. Each pulse is marked by a number starting in 0 that grows one by one	All

A timestamp is assigned to every sample of every signal. These timestamps values are stored 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.

11. Contact

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

www.bitbrain.com
info@bitbrain.com