![OT Bioelettronica logo]

User Manual v 1.3

sessantaquattro

Portable bioelectrical signal amplifier

⚠ Read this manual carefully before using sessantaquattro

1   GENERAL DESCRIPTION

Sessantaquattro is a multichannel amplifier and datalogger for bioelectrical signals. It can detect surface electromyographic (sEMG) signals and electroencephalographic (EEG) signals. The sessantaquattro allows the detection and recording of the electric signals generated by human body. The signals acquired by the instrument are amplified, filtered, digitally converted and then transferred to a PC, through a WiFi connection, for real-time visualization and storage, or stored in a MicroSD card. A freeware software for real time display and storage, called OT BioLab, has been designed by OT Bioelettronica and is available for download on the website www.otbioelettronica.it, under the download page. The sessantaquattro is a research instrument designed for clinical research carried out by qualified researchers. It is completely safe for the patient. The safety is achieved by satisfying the design requirement for devices with an electronic part applied to the patient. Sessantaquattro has different adapters to connect different electrode configurations. Each of them makes also available two inputs for auxiliary signals.

2   SESSANTAQUATTRO KIT CONTENT

- 1 portable multichannel amplifier sessantaquattro;
- 1 adapter for the battery charging;
- cable adapters to connect electrodes to the amplifier, depending on the customer request;
- 1 conductive cream package;
- 1 reference straps for the wrist;
- 1 reference cables;
- 1 USB cable type A-C;
- Arrays and matrix of electrodes of different sizes, depending on the customer request;
- 1 sessantaquattro user manual.

3   END USER

Sessantaquattro multichannel amplifier allows non-invasive recording of biopotentials (sEMG, EEG) detected by superficial electrodes. The end user must be familiar with the technique and received a proper training in EMG or EEG detection and interpretation.

3.1   Contraindications

Sessantaquattro has no particular contraindications when used jointly with personal computers, provided that all the electrical devices connected to it comply with safety rules and standards concerning grounding and leakage currents.

3.2   Side effects

No significant side effects are known. The materials used for manufacturing all the parts in contact with the patient are biocompatible. Possible slight cutaneous allergic reactions (e.g. skin reddening) are reduced to a minimum during short duration of bioelectrical signal acquisitions.

4   SAFETY CAUTIONS AND OTHER WARNINGS

The use of the multichannel amplifier sessantaquattro is absolutely forbidden in the following conditions:

- While other monitoring devices are in use with the patient.
- While electro surgery equipment, short waves or microwaves therapy devices are used.
- By mentally impaired people.
- Whenever the equipment is damaged.
- In proximity of inflammable substances (especially inflammable liquids and gases) or in environments with high concentration of oxygen.
- On patients carrying life-supporting equipment that might be adversely affected by electromagnetic interferences, such as pacemakers, etc.

The following cautions should be observed:

- Only use electrodes supplied by the manufacturer: sessantaquattro is guaranteed to achieve tested performance only if used with electrodes supplied by the manufacturer.

- Contact the manufacturer immediately if extraneous materials permeate into the device (liquids, powders, etc.). In case of hard shocks suffered by the sessantaquattro (like a drop to the floor, etc.), verify that no crack or any other kind of damage of the box resulted from the shock. In case of doubt, please contact the manufacturer.
- The sessantaquattro is subject to electromagnetic interference that is not dangerous for the patient (such as electrostatic or electromagnetic interference generated by electrical motors and other sources). This interference may affect the measurements of the physiological variables derived from the EMG or EEG signals. These measurements are not meant to be used for diagnostic purposes, and thus these signal alterations cannot be dangerous for the patient, please always take into account the presence of noise in your signal processing tasks and evaluations.
- The connection between sessantaquattro and other electrical devices must be done in compliance with the European standard EN 60601-1-1 on medical devices.
- The use of the sessantaquattro is restricted to skilled personnel.
- Incorrect measurements can arise when unskilled personnel use the device in presence of strong sources electromagnetic interference (e.g. strong electromagnetic fields). The presence of interference in the signals is easily recognised by skilled personnel. Read carefully the instruction remarks before use.

5   SYMBOLS USED ON SESSANTAQUATTRO AND IN THE USER MANUAL

| SN | Serial number |

Device is double insulated, usually with an external cover. This could minimize the risk of electric shock

Class BF for circuitry applied to patient

Read carefully the instruction remarks before use

Manufacturer

Do not dispose of this product as non-differentiated waste. Prepare the re-use or separate collection of the product according to the provisions of Directive 2002/96 / EC of the European Parliament and of the Council of   the European Union on the disposal of electrical and electronic equipment

CE marking

Read the instruction

Signal input

6   TECHNICAL SPECIFICATIONS

Sessantaquattro is a battery powered device designed to guarantee a high safety level for the patient and the operator in all operating conditions. The insulation between sessantaquattro and the PC for real time data display and storage, is intrinsically achieved by the wireless data transfer and communication. The same connector is used for electrode interface and battery recharge avoiding the chance to supply the sessantaquattro from an external source when it is connected to the patient.

The connector for the auxiliary inputs is intended for the interface with other floating devices (goniometers, accelerometers or amplifiers for other biological signals). The connection must be done in compliance with the European standard EN 60601-1-1 on medical devices. Table 6.1 shows the list of available adapters and their connections.

Adapter	Available connections
CUSB01SE	USB type C, for battery recharge
AD8x1SE	Eight four poles 3.5 mm jacks for connection of two bipolar electrode pairs (16 electrodes pairs in total). An additional four poles 3.5 mm jack for two auxiliary signals. 2 mm female banana for the patient reference connection.
AD1x16SE	16 pin connector for linear electrode arrays. An additional four poles 3.5 mm jack for two auxiliary signals. 2 mm female banana for the patient reference connection.
AD2x32SE	Two 32 pin connectors for 32 electrode matrixes. An additional four poles 3.5 mm jack for two auxiliary signals. 2 mm female banana for the patient reference connection.
AD1x64SE	70 pin connectors for 64 electrode matrixes or 64 electrode EEG caps. An additional four poles 3.5 mm jack for two auxiliary signals. 2 mm female banana for the patient reference connection.

TAB. 6.1: list of sessantaquattro available adapters

Additional adapter can be realized under user request to interface other type of electrodes or sensors. Sessantaquattro technical specifications are shown in Table 6.2.

EMG/EEG channels	
Number of channels	64
Gain	1 V/V
Low pass filter	$\sim F_{SAMP}/4$
High pass filter	DC coupled or 10 Hz digital
Noise level referred to input	< 1.2 μV_{RMS} (in standard mode)
Input resistance	500 MΩ
Input range	0 – 3.3 V
Auxiliary channels	
Number of channels	2
Gain	0.5 V/V
Low pass filter	$\sim F_{SAMP}/4$
High pass filter	DC coupled
Noise level referred to input	< 6.1 μV_{RMS}
Input resistance	500 MΩ
Input range	± 3.3 V
Data conversion and communication	
A/D converter resolution	16, 24 bits
A/D converter input dynamics	± 2.4 V
Selectable sample frequency	500, 1000, 2000, 4000 Hz
Data transfer to PC	WiFi through TCP socket
Data storage	MicroSD
Battery	
Battery life – Charging time	8 hours (full charge) – 2 hours

TAB. 6.2: *sessantaquattro technical specification*

7   DETAILED DESCRIPTION

Sessantaquattro is a battery portable equipment for acquisition of surface EMG and EEG. Signals can be transferred to a PC for real time display and recording or directly stored on a MicroSD card by the device. The device can act as a WiFi acces point or connect to an existing network provided by an external access point. In both cases, sessantaquattro has an IP address where a web page can be reached using any browser, for configuration, control and firmware update. Data transfer to a PC is obtained through a TCP socket opened by the PC. A configuration string sent to sessantaquattro can set all the acquisition parameters and start the data transfer. The communication protocol is available for custom development together with demonstration Matlab code.

7.1   Controls, indicators and connector

Sessantaquattro can be fully configured by means of its internal web page, while the LEDs and button just provide a quick access to basic functions.
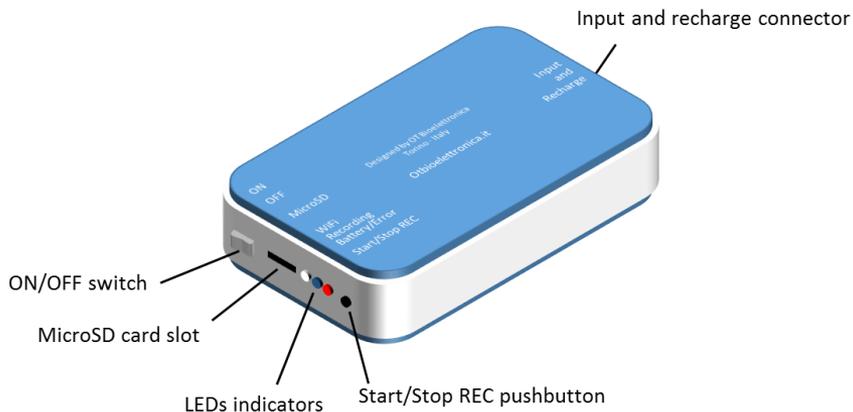

FIG. 7.1: Sessantaquattro controls, connectors and indicators

7.1.1   Input and recharge connector

The 80 pins connector is the interface between sessantaquattro and its adapters. The different adapters allow to connect the device with different type of electrodes and sensors or to recharge the battery. The pinout of the connector is available on request for custom developments. Refer to section 8.3 for additional details about the available adapters.

7.1.2   ON/OFF switch

This switch turns on and off the sessantaquattro by completely remove the battery supply from all its parts. Always move the switch in the OFF position when the device is not used to avoid battery discharge.

7.1.3   MicroSD card slot

This socket accepts MicroSD card formatted as FAT16 or FAT32 to use the sessantaquattro as a datalogger. The acquisition can be started with the Start/Stop REC pushbutton if enabled or through commands on the WiFi. Refer to section 8.5 for additional details about the data recording on the MicroSD card.

7.1.4   LEDs indicators

Three LEDs are used to identify the state of sessantaquattro. Each of them reflect the state of a different device activity: 1) the white LED is related to the wireless data transfer, 2) the blue LED report the state of the data logging, 3) the red LED highlight errors or problems. The three LEDs are independent and the information provided from each one is displayed cyclically by a given number of blink. In Table 7.1 the different states and related number of LEDs blinks are highlighted.

N. of blinks	1	2	3	4
White LED	WiFi active	Connected to a network	Connected to a TCP socket	Transferring data
Blue LED	Waiting for a trigger	Recording data on SD	-	-
Red LED	Data lost during wifi transfer	MicroSD card error	Low battery	-

TAB. 7.1: *Relation between the number of blinks of each LED and sessantaquattro states*

White LED. This LED indicates the state of the WiFi and data transfer through a TCP socket. Slightly different information are provided depending on the role of sessantaquattro. When acting as an access point: a) one blink of the white LED indicates that the network has been generated and is available for a connection by another device; b) two blinks indicate that a device is connected to the network generated by sessantaquattro. When configured to connect to an external WiFi network: a) one blink indicates that sessantaquattro is active and is searching for one network; b) two blinks indicate that sessantaquattro has successfully connected to an external network. Regardless of the sessantaquattro role, three blinks indicate that sessantaquattro is connected as a client to a TCP socked generated by a server device (usually the PC used for real time data display and recording); four blinks indicate that sessantaquattro is transferring data through the TCP sokect to a server. Using OT BioLab software the three blinks condition is never visible because the TCP socket is opened when pressing the button of data transfer and, as soon as sessantaquattro is connected to the socket, the data transfer begins. The three blinks condition can be useful for custom development in the debugging phase to understand when the TCP socket is correctly created and sessantaquattro is connected to it.

Blue LED. The blue LED reflects the state of the data logging on the MicroSD card. All the settings for the data logging can be provided to sessantaquattro using the internal web page, including how to control the start and stop recording. One blink of the LED indicates that the recording on MicroSD card has armed and sessantaquattro is waiting for the triggering event to start the recording. The typical trigger event to start a recording is pressing the button, but more option are available using the configuration string sent to sessantaquattro through the TCP socket. When starting an acquisition directly from the internal web page or with the configuration string, the 1 blink state does not occur and the recording start directly. Two blinks of the blue LED reflect that data storing on the MicroSD card is in progress.

Red LED. The red LED is used to alert the user of an error or a critical condition. One blink indicate that samples has been lost in the wireless data transfer. This happen when the sessantaquattro internal data buffers are full and the transmission of data packet is not possible. The acquisition of the next signal sample will create a reset of the internal data buffer with the loss of an

amount of data equal to the data buffers size (refer to section 8.2 for additional details). If this condition is temporary (e.g. sessantaquattro for a limited time is too far from the PC for the acquisition), and then the data transfer restart properly the red LED will stop to blink. The data loss in recorded data can in any case be verified offline by checking one of the accessory channel (see section 8.2 for additional details). Two blinks of the red LED indicate an error in the process of the MicroSD data recording. Typical condition that generate this error are: MicroSD not inserted, MicroSD not formatted as FAT16 or FAT32, maximum file size larger than the maximum contiguous space on the MicroSD. This error condition persist until another data recording on MicroSD card starts successfully or until another type of error occur. Three blinks of the red LED correspond to a battery level lower than the 20%. Please note that there is no priority in the error reporting and always the last error detected generates the number of blinks of the red LED. For example, if a data recording on the MicroSD produce an error and then an error on data transfer happen, the LED will indicate the error related to the data transfer until it persists (because it happens later). As soon as the wireless communication restart properly, the LED will indicate no error. In general, the low battery level will prevail on the other error conditions, simply because the battery level is monitored quite frequently and continuously.

7.1.5   Start/Stop REC pushbutton

The sessantaquattro pushbutton has the main function to start and stop the data recording on the MicroSD. It can be activated/deactivated from the internal web page or by means of the commands sent through the TCP socket. The option to deactivate the pushbutton has been introduced to avoid the possibility to accidentally press the button during a long-time data recording and stop involuntarily the data logging. A second function of the pushbutton is obtained if it is pressed for about 5 seconds at the device power on. In this condition, all the three LEDs start flashing simultaneously for four times and the sessantaquattro role is forced to be "access point". This feature can be really helpful if sessantaquattro has been configured as a station connecting to an external WiFi network, but no one of the networks in the sessantaquattro list is available. In this particular condition, the device cannot be reached for any type of communication and the only way to access it again is the use of this secondary function of the pushbutton.

8 USE OF SESSANTAQUATTRO

The sessantaquattro can be interfaced to any computer with a network interface and running any kind of operative system. This manual refers to the use of sessantaquattro together with PC with Windows and the freeware software OT BioLab. In case a different type of operative system is used, or if the user interface needs to be customized the configuration and communication protocol of sessantaquattro is available as Matlab examples. Please contact OT Bioelettronica to receive the additional manual and examples.

8.1 Sessantaquattro WiFi interface

The WiFi interface available for sessantaquattro is similar to the interface available for other devices like printers, routers or access points. As any other device connected to a network, sessantaquattro has its own IP address. When sessantaquattro is connected to a network (with the same IP range of the PC) it is accessible for data transfer, ping or configuration through its web configuration page. It can act as an access point or can connect to a WiFi network generated from other access points. In the default factory settings, sessantaquattro generate a WiFi network open (with no password) with name "sessantaquattro" and act as a DHCP server providing the settings to the devices that are connected to the network. The sessantaquattro default IP address, when it acts as access point, is 192.168.1.1, with subnet mask 255.255.255.0. When successfully connected to the network generated by sessantaquattro, typing the IP address on any browser the internal configuration page will be displayed (refer to section 8.6). The configuration page allows to check the device current settings and to change all the parameters.

A list of networks, and relative password to access them, can be saved in the internal flash memory of sessantaquattro (refer to section 8.6). When the sessantaquattro is configured to connect to an external WiFi network, at start-up, it tries to connect to one of the network in its list and, when successfully connected, it starts to blink the white led twice. In this condition, a service called mDNS running on sessantaquattro can be used to find its IP address. OT BioLab software makes available a button in the configuration window to directly open the sessantaquattro web page. Another option is to use a free software called *Bonjour* that will receive the mDNS message displaying the sessantaquattro IP address.

8.2   Signals

The natively resolution of sessantaquattro is 24 bits obtained by sampling the signals with a sigma-delta A/D converter. The signals are acquired DC coupled and the only hardware filtering is a simple antialiasing filter at 154 kHz. The low pass filter is imposed by the sampling frequency and is about ¼ of the sampling frequency. The acquisition with all the 24 bits is intended for EEG signals DC coupled to a maximum sampling frequency of 1 kHz. For the EMG data collection, a firmware high pass filter is implemented (only on the bioelectrical signals, not on the auxiliary) removing the DC component and moving the signals baseline to the middle scale of the dynamic. This condition makes possible the acquisition of the EMG signals with a reduced 16 bits resolution. The data format in both cases, 24 bits and 16 bits, is little endian.

The filter is obtained by subtracting to the signals the exponential moving average, obtained by:

$$Average\_ChX[t] = (1-\alpha) \, Average\_ChX[t-1] + \alpha \, ChX[t]$$

Where α is equal to $1/2^5$. This result in a high pass filter with a cut-off frequency of 10.5 Hz, when sampling the signals at 2000 Hz. More in general the High-pass cut-off frequency is Fsamp/190.

The A/D converters have differential inputs that allow the positive and negative inputs to swing theoretically between ± 2.4 V. In the case of sessantaquattro, the limit is imposed by the voltage supply that is 3.3V. The positive input is feeded with the signals from the electrodes, the negative signals are connected to the patient reference (midpoint of the power supply). The least significant bit (LSB) of the signals is obtained by:

$$LSB = ADC_{RANGE}/2^{24} = 286.1 \text{ nV}$$

On the standard adapters, that have the jack connector for the collection of the two auxiliary signals, a simple circuit allows to extend the input range to ± 3.3 V by increasing the LSB value to 572.2 nV. An additional extension factor on the bioelectrical analog signals can be added (only in custom development, not using OT BioLab) to increase the input range when the 16 bits resolution is used, with values of 2, 4, 8. When the 16 bits resolution is set, only the 16 less significant bits are transferred for the bioelectrical signals and only the 16 most significant bits are transferred for the AUX signals. This introduce a limitation in the

signal range for the bioelectrical signals to 18,75 mV$_{PP}$ and a limitation in the resolution for the auxiliary signals with an LSB of 146,48 µV.

Table 8.1 summarize the different input ranges, LSB values, RMS and peak to peak noise with the different acquisition settings for bioelectrical and auxiliary signals.

Condition	Input Range	LSB	Noise RMS R.T.I.	Noise P-P R.T.I.
16 bits, BioSig	18,75 mV	286.1 nV	0.6 – 1.2 µV	3.6 – 7.8 µV
16 bits, Ext = 2, BioSig	37.5 mV	572.2 nV	0.9 – 1.8 µV	5.7 – 12.1 µV
16 bits, Ext = 4, BioSig	75 mV	1.144 µV	1.6 – 3.2 µV	9.8 – 22.2 µV
16 bits, Ext = 8, BioSig	150 mV	2.289 µV	3 – 6.1 µV	17.9 – 41.8 µV
24 bits, BioSig	3,3 V	286.1 nV	0.6 – 1.2 µV	3.6 – 7.8 µV
16 bits, AuxSig	6,6 V	146,48 mV	3 – 6.1 µV	17.9 – 41.8 µV
24 bits, AuxSig	6,6 V	572.2 nV	3 – 6.1 µV	17.9 – 41.8 µV

TAB. 8.1. *Characteristics of acquired signals with different settings. The noise range is related to different sampling frequencies.*

Additionally to the biological and auxiliary signals, two accessory channels are added to the signals set, both, when data is transferred through the WiFi and when the signals are recorded on the MicroSD card.

The first channel provides information about the internal buffer usage and the trigger state. The buffer usage is represented on the 15 less significant bits and indicates how many bytes (the value has to be multiplied by 4) are currently in the internal buffer waiting to be written on the MicroSD card or sent through the WiFi. The remaining bit is used to represent the binary state of the trigger. This information can be used to start an acquisition or simply as an additional binary channel. The internal buffer size is 90 kBytes, thus, values around 45000 on the buffer usage, indicate that the internal buffer is full.

The second channel is a sample counter. The sample counter is incremented every sample and can be used to check if some sample has been lost. It ranges from -32768 to 32767 and then restart from -32768.

8.3   Electrode and recharge adapters

The different adapters essentially provide access to the 80 pins input connector. Each adapter is intended for the connection to a particular electrodes type or for the battery recharge. A predefined detection mode is associated to each adapter. Detailed description of each adapter is highlighted in the following section.

CUSB01SE

It is the adapter for the sessantaquattro battery recharge. The supply can be provided with a USB type C cable connected to a PC or to a wall DC adapter, like the ones used for any smartphone. When connected to a PC, please check the PC power supply setting to ensure that it won't enter the standby mode during the recharge and interrupting it. The red LED on the top of the CUSB01SE indicates, when it is on, that the battery recharge is in progress and, when it turns off, that the recharge is completed.

Charge status LED

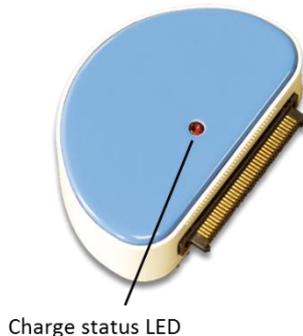**FIG. 8.1:** *The CUSB01SE adapter*

The integrated circuit that controls the battery recharge is in the adapter itself and implement different recharge technique depending on the battery level: battery conditioning, constant current and constant voltage. The constant current phase is the one that last longer and produce a more efficient battery recharge. The recharge current is internally set to about 300 mA.

Providing the recharge voltage through the adapter avoid the patient connection while the device is also connected to an external power supply source.

AD8x1SE

This adapter allows the connection of up to 8 electrode pairs through four four-poles 3.5 mm jacks. The signal detected from the 16 electrodes feed the positive inputs of the first 16 channels. The patient reference, available on the adapter as a 2 mm female banana connector, has to be placed using a reference strap or a large electrode to the patient body on a place without bioelectrical activity. At the same time, this electrode fixes the common mode patient body potential to the midpoint of the power supply of sessantaquattro and feed the negative inputs of all the channels.
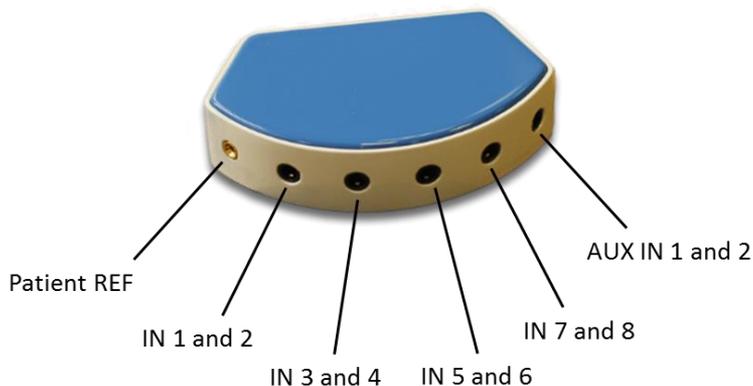

FIG. 8.2: The AD8x1SE adapter

This adapter is intended for the detection of 8 bipolar signals obtained as a difference between each electrode pair. The differences are estimated from the microcontroller by subtracting, sample by sample, the A/D conversions generated from the channels

corresponding to each electrodes pair. Figure 8.3 shows the 3.5 mm jack pinout to interface the two electrode pairs to the sessantaquattro.
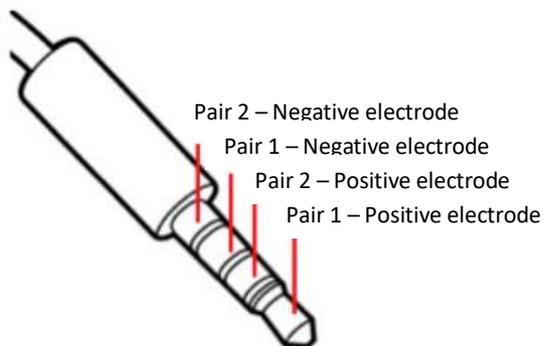

Pair 2 – Negative electrode
Pair 1 – Negative electrode
Pair 2 – Positive electrode
Pair 1 – Positive electrode

FIG. 8.3: *Four poles 3.5 mm jack connector pinout for the connection of two electrode pairs to the AD8x1SE adapter*

GND
AUX IN1
AUX IN2
3.3 V
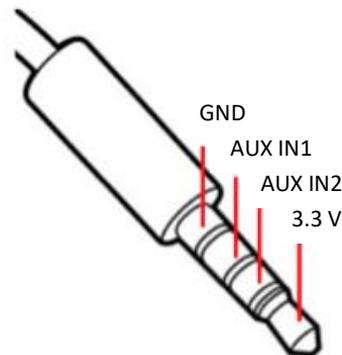
FIG. 8.4: *Four poles 3.5 mm jack connector pinout for the connection of two auxiliary signals to the AD8x1SE adapter*

Additionally to the EMG signals, the AD8x1SE allows the connection of two auxiliary signals through a fifth jack connector. This connector can also provide a 3.3 V output voltage to eventually supply external circuits.

There is no a particular limit for the current supplied by this output voltage, but it is intended for small loads, in the order of few tens of milliamps. This voltage is also the voltage used for the internal analog circuits supply, thus, unregulated absorption can generate noise on the biopotential signals. Figure 8.4 shows the pinout of the auxiliary input connector.

The input swing for the AUX IN signals is ± 3.3 V. Refer to section 8.2 for further details about the AUX IN signals conversion.

AD1x16SE

This adapter can be used to acquire signals from a 16 electrode linear array. The connector makes available the standard interface for any linear array produced from OT Bioelettronica: dry and adhesive arrays with different interelectrodic distances (refer to our website for a complete list).

FIG. 8.5: *The AD1x16SE adapter*

Like for the other electrodes adapters, the AD1x16SE make available on a 2 mm female banana connector the patient reference. It has to be placed using a reference strap or a large electrode to the patient body on a place without bioelectrical activity. At the same time, this electrode fix the common mode patient body potential to the midpoint of the power supply of sessantaquattro and feed the negative inputs of all the channels. The acquisition of the 16 signals is natively monopolar with respect to the patient reference, but online or offline differences between signals detected from adjacent electrode can be estimated generating the differential signals.

A four pole 3.5 mm jack connector allows the simultaneously recording of two auxiliary channels together with the EMG signals. Refer to figure 8.4 for the pinout of the connection and to the description of the AD8x1SE for additional details about the auxiliary channels.

AD2x32SE

The AD2x32SE make available two connections towards 32 electrode matrixes. A single model of 4 rows and 8 columns is available as standard electrode grid, but additional shapes and sizes can be designed on request. The two adapter branches are labelled with 1 and 2 indicating witch matrix will be connected to the first 32 channels and witch to channels 33 to 64.

FIG. 8.6: *The AD2x32SE adapter*

The patient reference connection is available on a 2 mm banana connector as well as two additional auxiliary inputs. Refer to previous described adapters for further details about patient reference connection and auxiliary inputs.

AD1x64SE

The AD1x64SE make available a connection for 64 electrode matrixes. Different electrode matrixes types, sizes and shapes are available, refer to our website for a complete list.

The patient reference connection is available on a 2 mm banana connector and as well as two additional auxiliary inputs. Refer to previous described adapters for further details about patient reference connection and auxiliary inputs.

FIG. 8.7: *The AD1x64SE adapter*

8.4   Wireless data transfer

Signals acquired with sessantaquattro can be read with a WiFi interface using a TCP connection. A TCP socket have to be opened by the computer (or tablet, smartphone) running OT BioLab or other custom application. The default port is 45454 but can be changed in custom application by the user. When sessantaquattro is connected to a WiFi network, it continuously searches for a TCP socket opened on the IP address provided through the internal web page and connect as a client to the socket as soon as it is found.

When the connection through the socked is established, the communication can be started by sending a configuration command that sets the number of channels, the sampling frequency, the detection mode etc…

The server-client role has been chosen to allow the connection of more sessantaquattro to the same PC. Options for the synchronization are available for future implementations.

The signals acquired are internally double buffered from the first microcontroller that manage the signals sampling and from the second who manage the WiFi and data tranfer. The space available on the first microcontroller is 90 kBytes while on the second microcontroller it is about 74 kBytes. Data is transferred between the two microcontrollers in blocks of about 0.5 kBytes (depending on channels settings) and firstly placed in the buffer of the second microcontroller. When this buffer is full, due to impossibility to transfer data to the PC, the data is accumulated also in the first microcontroller buffer. The accessory channel that report the buffer usage only report the buffer usage of the first microcontroller.

8.5   MicroSD data logging

Sessantaquattro can work as datalogger by recording the data on a MicroSD card. The MicroSD card have to be formatted as FAT16 or FAT32. Acquisition parameters: sampling frequency, number of channels to be acquired, resolution, high pass filter and detection mode, can be set through the embedded webpage (refer to section 8.6), with OT BioLab software or with custom software using the communication protocol available on request.

The Start/Stop REC button can be used to manually start and stop an acquisition with data storing on the MicroSD card, when the button is enabled. The button can be disabled by the web page or with OT BioLab, to avoid undesired clicks on it.

Due to the large amount of data flow to be written on the MicroSD card, sessantaquattro needs to optimize the writing process and for this reason it needs to know a maximum file size (from the web page or OT BioLab) when starting a new recording. This information will be used by the device for searching an available contiguous space on the MicroSD card and lock that space for data writing. At any time, it will be possible to stop the data recording and the sessantaquattro will free the unused space. If no stop commands are issued before to reach the maximum data acquisition time, sessantaquattro will automatically stop the acquisition and close the file. The time limit for data acquisition is 4 hours and 30 minutes, the file size associated to this maximum acquisition time depends on the sampling frequency, number of channels and resolution.

A prefix code of 5 characters can be set for the filenames, additional 3 numbers will be added from sessantaquattro to sequentially enumerate the files related to each acquisition. At any start of an acquisition, the device will search for available filenames starting from the provided prefix followed by "000" and then incrementing the 3 digits until an unused filename will be found.

Since the ON/OFF switch completely disconnect the battery from the circuit, the internal real time clock lose time and date. The correct time and date can be easily passed to sessantaquattro from a computer automatically when opening the sessantaquattro embedded web page or connecting to it with OT BioLab. In case, after turning on the device, one of this two actions is performed, the file created on the MicroSD will have the proper time and date. If instead, the start/stop REC button is active and it is pressed after turning on the sessantaquattro, a file with the last settings will be created and the time and date will be calculated starting from 23:00 of December 31ST, 2012.

Especially when working with all 64 channels and 2000 Hz of sampling frequency, the MicroSD have to be chosen with care. More than the MicroSD class, that represent how fast is the data writing on the card, it is important how long the card takes to provide the address of a new sector or cluster. The buffer usage can provide a feedback of the goodness of a particular MicroSD card.

8.6   Webpage setup

Sessantaquattro has an internal web page that allows to see the current configuration and to change it. To reach this page it is necessary to be connected to the same network of sessantaquattro, it could be the network generated by the device itself or the

network generated from another access point. The IP address and the subnet mask must be in the same range. Refer to section 8.1 for additional details about the sessantaquattro IP address.

The internal web page can be opened typing the IP address of sessantaquattro with any browser, but Mozilla or Chrome are suggested due to few features that other browsers does not have. Alternatively, in OT BioLab, the button *WebPage* is available under Tools->Option when sessantaquattro is set as Device.

Two different views are available depending on the network role of sessantaquattro. Few options are common between the two views and other are specifically related to the network role. Figures 9.1 and 9.2 show an example of the two views.

When loading the web page automatically the time and date of the device used to access the page are transferred to the sessantaquattro to update its internal real-time clock. The page has different sections, each section has an *info* area on the right bottom corner. Moving the mouse cursor over this area will pop-up an explanation of that section. Few settings need the restart of sessantaquattro to take effect. A description of each section of the web page follows.

General Information

This section only provide information that cannot be changed: serial number, MAC address, firmware version and the battery level. To update the battery level it is necessary to refresh the web page.

Data Logger

The parameters in this section reflect the current configuration of sessantaquattro and can be changed to set an acquisition on the MicroSD card. Refer to section 8.5 for details about the parameters. The recording can be started directly when pressing the *Apply* button of this section if the option *Start/Stop Recording* is set to *When submitting the settings*.

sessantaquattro

General Informations

Serial Number: SE004

MAC address: F4:B8:5E:05:5C:0F

Firmware Version: 2.43

Battery Level: 36%

info

Data Logger

Channels to acquire: 64 EMG + 2 AUX

Sampling Frequency: 2000 Hz

Detection Mode: Monopolar

High Pass Filer: 10 Hz

Resolution: 16 bits

Time Limit: 00:42:40 *hh:mm:ss before auto stop acquisition*

Start/Stop Rcording: Using the sessantaquattro pushbutton

File Name Prefix: SNQTR

Apply *info*

Wireless

Network role: sessantaquattro is the access point

Apply

Changes will take effect after Reset *info*

Firmware Update

Check for firmware upgrades

info

Access Point

Channel: 6 *Range: 1..13*

SSID: sessantaquattro

Security Type: ● Open ○ WEP ○ WPA

Password:

Apply

Changes will take effect after Reset *info*

IP Settings

sessantaquattro IP Address: 192.168.1.1

DHCP Server Start Address: 192.168.1.2

DHCP Server Last Address: 192.168.1.254

DHCP Server Lease Time: 86400

Apply

Changes will take effect after Reset *info*

FIG. 9.1: *Embedded web page of sessantaquattro when it acts as access point*

sessantaquattro

General Informations

Serial Number: SE004

MAC address: F4:B8:5E:05:5C:0F

Firmware Version: 2.43

Battery Level: 36% *info*

Data Logger

Channels to acquire: [64 EMG + 2 AUX ˅]

Sampling Frequency: [2000 Hz ˅]

Detection Mode: [Monopolar ˅]

High Pass Filer [10 Hz ˅]

Resolution [16 bits ˅]

Time Limit: [00:42:40] *hh:mm:ss before auto stop acquisition*

Start/Stop Rcording: [Using the sessantaquattro pushbutton ˅]

File Name Prefix: [SNQTR]

[Apply] *info*

Wireless

Network role: [use an external access point ˅]

[Apply]

Changes will take effect after Reset *info*

Firmware Update

[Check for firmware upgrades]

info

IP Settings

DHCP Client: ◯ Disabled ◉ Enabled

IP Address: [0.0.0.0]

Subnet Mask: [0.0.0.0]

Default Gateway: [0.0.0.0]

DNS Server: [0.0.0.0]

Server IP address: [10.40.30.100]

[Apply] *info*

Add Network

SSID: [_____]

Security Type: ◉ Open ◯ WEP ◯ WPA1 ◯ WPA2

Security Key: [_____]

Network Priority: [_____] *Enter a value 0-7 (0 = highest)*

[Add Network] *info*

Network List

	SSID	Security	Priority
☐ Network 1:	-	-	-
☐ Network 2:	-	-	-
☐ Network 3:	-	-	-
☐ Network 4:	-	-	-
☐ Network 5:	-	-	-
☐ Network 6:	-	-	-
☐ Network 7:	-	-	-

[Remove Selected Networks] *info*

FIG. 9.2: *Embedded web page of sessantaquattro when an external access point is used*

Wireless

The network role of sessantaquattro can be selected between:

1) sessantaquattro is the access point
2) use an external access point

Changing the selection in the drop-down list will change the view in the web page, in particular, the right column. Until the *Apply* button is not pressed the new settings are not sent to sessantaquattro. After the settings are changed by pressing the *Apply* button, it is in any case necessary to turn off and on the sessantaquattro to let it restart in the new configuration mode.

Firmware Update

The upgrade of sessantaquattro happens through a folder on dropbox. Thus, it is necessary that the sessantaquattro is connected to an external access point providing an internet access. When pressing the *Check for firmware upgrade button*, in fact, the sessantaquattro search for the upgrade files on a specific folder in the OT Bioelettronica dropbox account and, if a new file is found, it automatically download the file and updates itself. The firmware upgrade will open a new page and display the progress in the process. In particular, the firmware of two microcontrollers have to be updated. The main processor is updated simply by replacing a file into the internal flash memory, the secondary microcontroller, by entering the boot mode and transferring the new firmware from main processor.

It is important that the battery level of the device is not too low and can gone during the firmware upgrade. This can put the device in an unknown state that will need to open it and reprogram using a specific hardware interface.

Access Point

This section is available when the sessantaquattro act as access point. It is possible to set the WiFi channel, the serving set identifier (SSID, the name of the network) and assign a protection with a password. In case the password is applied and then lost, by pressing the push button of sessantaquattro while turning on the device and the keeping the button pressed for five seconds, it will be possible to force the default settings with no password.

IP Settings (Access Point mode)

When sessantaquattro is the access point, it can also provide the IP settings to the devices connected to its network. The parameters of this section let the user set the IP address of sessantaquattro and the range of available addresses for providing the IP to other connected devices.

IP Settings (Using external Access Point)

When an external access point is used, the IP settings of sessantaquattro can be assigned from the access point (if the DHCP option is enabled) or fixed by the user. The field *Server IP Address* is automatically filled and transferred to the sessantaquattro when the web page is loaded. It is the IP address of the PC that is displaying the web page and it is expected that will also communicate with sessantaquattro for the data transfer. The sessantaquattro will use this particular address for searching the TCP socket for data transfer. The automatic detection of the IP address of the PC connected to the web page is only available when using Mozilla and Chrome browsers.

Add Network

Up to seven networks with associated passwords and priorities can be stored in the internal flash memory of sessantaquattro. This section allows to add networks to the existing list. At start-up sessantaquattro will try to connect the network in its list starting from the one with lower number in the priority field.

Networks List

In this section, the list of networks previously added can be checked and deleted, if necessary. The sequential order of the network is not relevant, is the priority that fix the order used from sessantaquattro when trying to connect to them.

8.7   Patient connection

Regardless of the adapter used and the detection mode, sessantaquattro need to be connected to the patient with a reference strap or electrode. This is necessary to fix the common mode body potential of the patient to the midpoint of the sessantaquattro power supply. All the adapters provide a 2 mm female banana connector for this purpose.

All the signals are recorded from sessantaquattro as monopolar signal with respect to the patient reference. For this reason, it is important that the patient reference strap or electrode is placed on a point without activity and possibly close to the electrode for the detection on the biopotential signals. The bipolar or differential modes are obtained by subtracting the samples, digitalized by the A/D converter, in the microcontroller firmware.

Sessantaquattro has been designed as a floating device. For this reason, the battery recharge occurs through the same connector of the electrodes, avoiding the simultaneous connection of the patient and an external power source.

The same concept has to be respected when connecting external signals to the auxiliary input, both, for the patient safety and to avoid interferences on the biological signals.

Impedance measurement

Sessantaquattro allows to measure the skin-electrode contact impedance, for each electrode connected, at a frequency equal to ¼ of the sampling frequency. This is obtained by pulling individually each electrode line to the positive and negative supply alternatively through a pull up and pull-down resistors, by generating an AC signal, witch amplitude is inversely proportional to the skin-electrode impedance. The signal acquired, when the impedance check is activated, is the summation of the biological signals from the electrodes and the AC signal. They can be separated by appropriate digital filters.

The value of the impedance can be obtained by considering that the patient common mode voltage is fixed through the patient reference to the middle supply. The power supply is 3.3 V and the pull up and pull-down resistors are a 100 kΩ

9   TROUBLESHOOTING

This section describes the most common problems that may be found by sessantaquattro users, with some suggestions to solve them. For problems not described in this section contact the technical support service of OT Bioelettronica.

GENERAL PROBLEMS		
Problem	Possible cause	Solution
The sessantaquattro does not turn on	The battery level is too low.	Let the device in charge for at least one hour.
	If a firmware upgrade has been just performed something wrong could be happened.	Contact OT Bioelettronica.
The embedded webpage is not displayed at the expected IP address	The PC is not connected on the same network of sessantaquattro or they are not in the same address range.	Check that connection is on the same network and verify the network adapter settings on the PC.
	The expected IP address could be wrong.	Use OT BioLab to reach the Web page or the software Bonjour to find the sessantaquattro IP Address.
Signals are not displayed on OT BioLab	Sessantaquattro can't find the TCP socket opened on the PC.	Open the sessantaquattro internal Web Page and check that the *Server IP Address* is the same of the computer.

The acquisition with microSD does not work	MicroSD format doesn't supported, e.g. model/constructor or dimension.	Try to replace the microSD card.
The red LED flashes during acquisition with microSD	The microSD may not be inserted correctly.	Try to remove and replace the microSD in the appropriate housing.
	The device can not communicate with the microSD.	Contact OT Bioelettronica.

TAB. 10.1: *Troubleshooting of the general problem that can occur using the sessantaquattro*

10   SESSANTAQUATTRO MAINTENANCE AND STORAGE

Sessantaquattro has to be used in the following ambient conditions:

Temperature: from 0°C to +40°C

Maximum relative humidity: 75%

Atmospheric pressure: from 700 hPa to 1060 hPa

It is recommended to turn off the sessantaquattro at the end of each measurement session, and to remove all the cables and connections. The sessantaquattro should be stored with all the enclosed accessories on a safe desk far from all the situations listed in the section *Warnings.*

Sessantaquattro should be stored in the following ambient conditions:

Temperature: from −20°C to +40°C

Maximum relative humidity: 75%

Atmospheric pressure: from 700 hPa to 1060 hPa

Cleaning: use only a dry cloth to clean the device.

It is recommended to plan a device check every 24 months with the manufacturer. The sessantaquattro should be repaired by the manufacturer only. Every repair executed by unauthorized personnel will be considered as a device violation voids the manufacturer's warranty.

Disposal

The device and the accessories should be disposed in compliance with the relative standards in special equipped areas or with special waste.

11   TECHNICAL CHARACTERISTICS

Model:	sessantaquattro
Risk class:	I in compliance with the standard 93/42/CEE.
Insulation class:	BF type applied part, in compliance with the European standard EN 60601-1.
Classification:	- class II, about the protection from indirect contact.
	- IP20, about the penetration of fluids and dust; device not protected.
Case:	painted plexiglas case.
Power supply:	Internal Rechargeable Li-Po battery 3.7 V
Consumption:	0.6 W
Limitations:	the device is not suitable for use in environments with high oxygen concentration and/or flammable fluids and/or gases; do not use with electro-surgery or short wave/microwave therapy equipment.
Working conditions:	device suitable for continuative work.
Input channels:	66 independents
Input range:	0 – 3.3 V for biopotential signals, ±3.3 V for auxiliary signals
Bandwidth:	DC ÷ 1000 Hz
Total noise (RTI):	< 1.2 µVRMS (in standard mode) for biopotential signals, < 6.1 µVRMS for auxiliary signals
Signal gain:	1 V/V for biopotential signals, 0.5 V/V for auxiliary signals
Resolution:	16/24 bits
Input resistance:	500 MΩ
Commands:	1 pushbutton
Dimensions:	96 x 60 x 20 mm
Weight:	110 g

12 WARRANTY

Sessantaquattro is covered by a 24 months warranty starting from the purchasing date of the electronic parts. Connection cables are covered by a 24 months warranty.

The warranty is void in case of device violation or in case of intervention from unauthorized staff.

Warranty conditions are reported hereinafter.

12.1 Warranty conditions

1. The warranty lasts 24 months on the electronic parts. Warranty is provided by the manufacturer.

2. The warranty covers only device damages that cause malfunctioning. The product must have the same serial number indicated on this certificate, or the warranty is released.

3. The warranty covers only the cost of repair or substitutions of defective components, including the costs of labour.

4. The warranty is void in case of damages caused by negligence, use not compliant with the instructions supplied, unauthorized repairs and accidental circumstances, especially for the external part.

5. The warranty is void with damages caused by incorrect power supply.

6. The warranty is not applied on all the parts subject to wear and tear.

7. The warranty does not include the shipment costs.

8. After 24 months, the warranty is released. All the substituted parts, the labour costs and the shipment costs will be charged to the purchaser according to the rates in force.

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