



User Manual v 1.4

Quattro

Portable EMG signal amplifier



Read this manual carefully before using Quattro

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1 GENERAL DESCRIPTION

The Quattro is a four-channel amplifier for surface electromyographic signals (EMG) detected from skeletal muscles with surface electrodes.

The Quattro 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 USB connection for real-time visualization and storage. 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 Quattro 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.

Quattro has different adapters for the connection to different electrode types.

2 QUATTRO KIT CONTENT

- 1 portable four-channel amplifier Quattro;
- cable adapters to connect electrodes to the amplifier, depending on the customer request;
- 1 reference straps for the wrist;
- 1 USB cable type A-MiniB;
- Electrodes of different sizes, depending on the customer request;
- 1 Quattro user manual.

3 END USER

Quattro allows non-invasive EMG recording detected by superficial electrodes. The end user must be familiar with the technique and received a proper training in EMG detection and interpretation.

3.1 Contraindications

Quattro 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 Quattro 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: Quattro 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 Quattro (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 Quattro 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 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 Quattro and other electrical devices must be done in compliance with the European standard EN 60601-1-1 on medical devices.

- The use of the Quattro 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.

5 SYMBOLS USED ON QUATTRO AND IN THE USER MANUAL



Class BF for circuitry applied to patient.



Read carefully the instruction remarks before use.






Signals input.

6 TECHNICAL SPECIFICATIONS

Quattro is a battery powered and galvanically insulated device designed to guarantee a high safety level for the patient and the operator in all operating conditions. The galvanic insulation separates the circuitry connected to the patient from the circuitry connected to external non-medical devices, such as the PC used for data acquisition.

The connection with external devices 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. Each of them allows the connection with different type of electrodes. One of the four possible adapter, provided in the Quattro kit, differs from the others because of an additional connection for the patient reference. All of them are active differential adapters with a gain of 5V/V and no filters, making directly the difference between the signals detected from the electrode pair inside the adapter.

Adapter	Description	Electrode example
ADx5JB	Active differential adapter with 1.5 mm banana connectors	
ADx5JC	Active differential adapter with concentric connectors	
ADx5JS	Active differential adapter with snap-on connectors	

TAB. 6.1: list of Quattro available adapters

Quattro technical specifications are shown in Table 6.2.

EMG channels	
Number of channels	4
Gain	150 V/V
Low pass filter	500 Hz
High pass filter	10 Hz
Noise level referred to input	$< 2 \mu\text{V}_{\text{RMS}}$
Input resistance	$> 10^9 \Omega$
Input range	$\pm 11 \text{ mV}$
Analog Outputs	
Number of outputs	4
Output dynamics	0 – 5 V
Data conversion and communication	
A/D converter resolution	16 bits
A/D converter input dynamics	$\pm 2.5 \text{ V}$
Sample frequency	1024 Hz
Data transfer to PC	USB cable

TAB. 6.2: *Quattro technical specification*

7 DETAILED DESCRIPTION

Quattro is a battery portable equipment for acquisition of surface EMG. Signals can be transferred to a PC for real time display and recording or for generation of real-time feedbacks to the patient.

Data transfer to a PC or other devices is obtained through a USB connection. A configuration string sent to Quattro 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 connectors

Controls, indicators and connectors are highlighted in figure 7.1 and described in the subsequent sections.



FIG. 7.1: *Quattro controls, connectors and indicators*

7.1.1 Input connectors

The four 4-pole 2.5 mm jack connectors are the interface between Quattro and the active adapters. These connectors provide power supply to the preamplifier and get back the differential signals amplified with a gain of 5 V/V.

The different adapters allow to connect the device with different type of electrodes. The connectors pinout is available on request for custom developments. Refer to section 8.3 for additional details about the available adapters.

A good procedure is to connect the adapters to the input jacks of Quattro when the device is off. No risk for the patient or for the device are known when connecting and removing the adapter and the Quattro is on, but big artefact are associated to the connection and disconnection of the adapters on all four channels.

One of the four adapter differs from the others because of an additional wire terminated with a snap-on connector. This connection is the Patient reference that is used to fix the common patient common mode to the mid-point of the Quattro power supply. Refer to section 8.4 for details about the patient connection.

7.1.2 ON/OFF switch

This switch turns on and off the Quattro 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 USB MiniB connector

This USB port has a double function for battery recharging and data transfer between Quattro and a PC. When connected to a PC this port is seen as a Virtual COM. When Quattro is used in combination with OT BioLab+ there is no need to install drivers or configuring anything. For custom development, drivers are available for all major operative systems (Windows, Windows CE, Linux, Mac OS) on the web page www.ftdichip.com/Drivers/VCP.htm.

Please contact OT Bioelettronica to get all the necessary information about drivers and communication protocol to communicate with Quattro in a custom scenario. Matlab codes are also available as guideline for direct communication with Quattro.

The supply for battery charging can be provided with any USB A-MiniB 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 *Recharge* red LED beside the USB port indicates, when it is on, that the battery recharge is in progress and, when it turns off, that the recharge is completed.

The circuit that controls the battery recharge 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 210 mA. A complete charge can require several hours, since the internal battery has a capacity of 1600 mAh. The recharge can occur even when the patient is connected to Quattro thanks to an internal insulation circuit that guarantee an insulation of 4000 V between the part applied to the patient and the recharge source.

7.1.4 LEDs indicators

The three LEDs are used to identify the state of Quattro. Each of them reflect the state of a different activity of the device:

- The *Recharge* red LED indicates that the Quattro is charging the internal battery. Refer to section 7.1.3 for details about battery charging.
- The *Battery/Error* red LED highlights low battery level or data transfer error. In particular, it is turned on when the battery level goes under the threshold of 20% and, during the communication, is turned on if the internal buffer of Quattro is full. This can happen when data cannot be send out though USB.

7.1.5 Analog Out connector

The four EMG signals amplified and filtered from Quattro are also available on this output connector. The signals are internally sampled for the data transfer to USB, the digitalized data cross the insulation barrier and is then converted back to analog signals by means of an internal D/A converter. The internal sampling frequency is set to 10 kHz, when data transfer on USB is not active, and is 1024 Hz (the same used for data acquisition) when the one of the two communication is active.

The voltage range at this connector is 0 to 5V, with the mid-point used as reference for the analog signals that can swing between $\pm 2.5\text{V}$ with respect to the reference. The default gain factor is 150V/V but an internal multiplication factor of 2, 4 or 8 can be added by sending specific commands to Quattro.

The connector used for the Analog output is a female 5-pin connector produced by Binder with part number 09 9792 30 05, the pinout is reported in table 7.1. Accessory cable that split this output to 4 BNC connector is available.

Pin n.	Signal
1	Ch1 Out
2	Ch2 Out
3	Ch3 Out
4	Ch4 Out
5	GND

TAB. 7.1: pinout of the analog output connector

8 USE OF QUATTRO

The Quattro can be interfaced to any device with a USB port and running any kind of operative system. This manual refers to the use of Quattro 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 Quattro is available, as Matlab examples. Please contact OT Bioelettronica to receive the additional manual and examples.

8.1 Quattro digital interface

Quattro can transfer data to OT BioLab+ for real-time data display and storage through the USB port. Only one interface is available at a time.

USB Interface

USB drivers for Quattro are pre-installed during the installation of OT BioLab+. On the first connection between the PC and Quattro the installation will be completed automatically and a Virtual COM number will be associated to the Quattro. OT BioLab+ will be able to automatically recognize the right COM port and start the communication with Quattro without the need to set any particular parameter. Refer to OT BioLab+ manual for details about the real-time data display and recording.

8.2 Signals

The resolution of Quattro is 16 bits obtained by sampling the signals with a SAR A/D converter. The amplification chain has the first stage in the adapter, few cm apart the electrodes, allowing the reduction of interferences to the minimum. The other stages into the Quattro allow to amplify and filter the EMG signals with a fixed gain of 150 V/V and bandwidth between 10 Hz and 500 Hz (filters respectively of the second and fifth order). An additional circuit on the first stages of the amplification chain has been designed for the reduction of artefact during electrically elicited contractions.

A single A/D converter with multiplexed inputs is used for all 4 channels. This introduces a small delay in the order of 20 μ s between the sampling of one channel and the next one. This error is negligible for any kind of processing applied on the EMG signals. The A/D converter input dynamic is 0 ÷ 5 V, considering the amplification gain this reflects a resolution referred to the input equal to:

$$\text{LSB}_{\text{RTI}} = \text{ADC}_{\text{RANGE}}/\text{Gain}/216 = 508.6 \text{ nV}$$

That is absolutely lower than the intrinsic noise generated by the electrode-skin contact, allowing the detection of the smallest possible EMG activity.

The unused channels, if the adapter is not connected, have the inputs connected to the reference that forces the signals to be flat and equal to zero, avoiding any disturbance on the active channels.

8.3 Electrode adapters

Each adapter is intended for the connection to a particular electrode type. All of them are active and have a differential stage in the small box close to the electrode with a gain of 5 V/V. No filters are implemented in the adapters. It is recommended to connect the adapter to the Quattro when the Quattro is off, avoiding artefacts on all channels during the connector insertion or removal. In the set of adapters provided, one of them has an additional connection for the patient reference. This adapter must always be used when acquiring EMG signals and the patient reference connection applied to the patient body.

ADx5JB

This adapter allows the connection of electrode with 1.5 touchproof banana connectors. Figure 8.1 shows the adapter.



FIG. 8.1: *The ADx5JB adapter*

ADx5JC

This adapter allows the connection of electrode concentric connectors. Figure 8.2 shows the adapter.

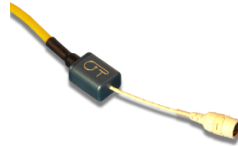


FIG. 8.2: The ADx5JC adapter

ADx5JS

This adapter allows the connection of electrode with snap-on connectors. Figure 8.3 shows the adapter.



FIG. 8.3: The ADx5JS adapter

8.4 Patient connection

Regardless of the adapter used, in every Quattro kit, one adapter has an additional connection terminated with a snap-on connector. This connection is used to fix the common mode body potential of the patient to the midpoint of Quattro power supply. The skin-electrode impedance of this connection must be as low as possible, for this reason a large electrode is suggested (a wetted reference strap is often a good choice) and have to be placed in a point without EMG activity. Typically, wrist, ankle or over a bone. If this connection is missing, or the impedance too high, interferences can occur in all the EMG channels and the signals can be strongly compromised.

Each channel is differential and amplifies the difference between two electrodes. The electrode choice depends on many factors like the investigated muscles, the motor task, the need to avoid crosstalk from adjacent muscles, etc... Many books are available to define the optimal condition for EMG recording, and different studies has been carried out demonstrating the repeatability of particular variables extracted from bipolar EMG signals. Refer to the available scientific literature for further details about EMG recording and interpretation.

There is no risk for the patient if the device has the USB connected to a power source and the battery are charging during the measurements. The internal insulation between the part applied to the patient and other devices guarantee the patient safety in every condition

9 TROUBLESHOOTING

This section describes the most common problems that may be found by Quattro 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 Quattro does not turn on	The battery level is too low	Let the device in charge for at least one hour
The device is not recognized by Windows	A problem occurs during driver installation	Install manually the drivers. They can be found in the OT BioLab+ installation folder, under "driver"

TAB. 9.1: Troubleshooting of the general problem that can occur using the Quattro

10 QUATTRO MAINTENANCE AND STORAGE

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

Quattro 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 Quattro 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:	Quattro
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 plexiglass case.
Power supply:	Internal Rechargeable Li-Po battery 3.7 V
Consumption:	0.2 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:	4 independents
Input range:	± 11 mV
Bandwidth:	10 ÷ 500 Hz
Total noise (RTI):	< 2 μ VRMS
Signal gain:	150 V/V
Resolution:	16 bits
Input resistance:	$10^9 \Omega$
Dimensions:	96 x 60 x 20 mm
Weight:	110 g

12 WARRANTY

Quattro 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.

Designed and produced by:

OT Bioelettronica s.r.l.

**C.so Unione Sovietica 312
10135 – Torino (TO) - ITALY**

Tel: +39.011.6198498

Fax: +39.011.6198498

www.otbioelettronica.it

mail@otbioelettronica.it