User manual v 1.42

EMG-USB

electromyographic signal amplifier

⚠ **Read this manual carefully before using the EMG-USB amplifier.**

INDEX

1. GENERAL DESCRIPTION

The EMG-USB electromyograph is a multichannel amplifier for surface electromyography (sEMG). The EMG-USB electromyograph allows the acquisition and recording of the electric signals generated by muscles during voluntary or electrically elicited contractions and detected by surface electrode arrays applied on the skin. The signals acquired by the instrument are amplified, filtered and converted into digital form and then transferred to a PC, via an USB interface, for real-time visualization and storage.

The EMG-USB is a research instrument designed for clinical research carried out by qualified researchers. It is not available for general use by unqualified users.

The EMG-USB is a modular system. It can amplify from 16 to 128 channels of sEMG in modules of 8 channels per board installed. The number of amplifier boards installed in the system determines the total number of channels. Each amplifier board carries 8 sEMG channels. The total number of analog inputs can be customized on user request in modules of 8 channels up to 128 channels.

Several configurations of electrodes are possible by means of a number of cable adapters that allow splitting a block of 16 channels into groups of smaller number of channels.

Amplification boards other than sEMG amp-boards can be realized on user request to allow external synchronous acquisition of other biological and non-biological signals (ECG, EEG, MMG, force, etc.).

The EMG-USB instrument is completely safe for the patient. The safety is achieved by means of medical grade electrical insulation of all the circuitry connected to the patient.

This user manual refers to all hardware versions of the instrument.

2. EMG-USB KIT CONTENT

- 1 EMG-USB surface EMG amplifier with 16N channels (N = 1 to 8)
- 1 to 8 cable adapters with one 16 electrodes array for EMG signal detection (depending on the number of channels installed into the amplifier);
- 1 conductive gel package;
- 3 reference straps;
- Arrays and matrix of electrodes of different sizes, depending on the user request;
- 1 EMG-USB user manual.

3. END USER

EMG-USB surface EMG amplifier allows non-invasive recording of electromyographic signals (sEMG) generated during voluntary or electrically elicited muscular contractions and detected by surface electrode arrays or grids placed on the skin of the patient. The end user must be familiar with the technique and must have received proper training in multichannel EMG detection and interpretation.

Contraindications

EMG-USB has no particular contraindications when used jointly with neuromuscular stimulators or personal computers, provided that all the electrical devices connected to it and the power line comply with safety rules and standards concerning grounding and leakage currents.

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 electromyographic signal acquisitions.

4. SAFETY CAUTIONS AND OTHER WARNINGS

The use of the EMG-USB surface electromyograph 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.
- When other medical devices are used with the patient.
- By mentally impaired people.
- On patients not assisted by qualified staff (e.g. medical doctor or therapist).
- 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 distributor: EMG-USB is guaranteed to achieve tested performance only if used with electrodes supplied by the distributor.
- Contact the distributor immediately if extraneous materials permeate into the device (liquids, powders, etc.). In case of hard shocks suffered by the EMG-USB (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 distributor.
- The EMG-USB electromyograph 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 signal. 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.

- Before making any measurement, it is mandatory to check the quality of the grounding of the power line to which the EMG-USB is connected. **The use of electrical devices with grounding connections not compliant with safety standards represents a high risk for the patient and the operator**.
- The connection between EMG-USB and other electrical devices (e.g. a PC) must be done in compliance with the European standard EN 60601-1-1 on medical devices.
- Always use the EMG-USB with a PC manufactured in compliance with the European standards EN 60950 (safety standard for information technology devices), EN 55022 (EMC standard) and EN 55024 (immunity standard).
- Electrical motors and other electrical devices (relay, remote control switch, neon lights, etc.) near the EMG-USB electromyograph can be a source of electromagnetic interference that disturbs the amplifier. The presence of such electromagnetic fields is not dangerous for the patient, but can alter the electromyographic signals and cause unreliable measurements.
- The use of the EMG-USB electromyograph by unskilled personnel is not a danger for the patient, but it is discouraged. Only trained personnel with the proper clinical and physiological knowledge can correctly discriminate between a valid measurement and an incorrect one.
- 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.
- EMG-USB electromyograph is not designed to be portable equipment. Should it be necessary to move the EMG-USB electromyograph, it must be properly packaged to avoid typical vibrations and shocks arising from transportations. Vibrations could cause the release of metallic particles inside the appliance, such as screws, nuts and bolts, that could compromise the safety of the patient and the integrity of the appliance.

5. SYMBOLS USED ON EMG-USB AND IN THE USER MANUAL

Class BF for circuitry applied to patient.

Read carefully the instruction remarks before use.

Dangerous voltage level, power line voltage.

Multifunction keys to select the parameter to be modified.

Multifunction keys to modify the selected parameter value.

Input selection keys, indicated as Previous probe and Next probe. They can be used to select the group of channels related to an IN connector.

Multifunction key to enter the selected parameter value.

Signals input.

Signals output.

I O

Power on (I): switch on power line voltage supply.
Power off (O): switch off power line voltage supply.

6. TECHNICAL SPECIFICATIONS

The EMG-USB electromyograph is an optically and galvanically insulated device designed to guarantee a high safety level for the patient and the operator in all operating conditions. The optical and 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 and user interface.

The EMG-USB electromyograph is designed to measure surface EMG signals in monopolar and single differential mode during voluntary or electrically elicited contractions. An embedded circuitry, called Driven Right Leg (DRL) circuitry, is available to reduce common mode voltage noise arising from electrical interference from the power line. The DRL is particularly useful in monopolar acquisition mode.

Surface EMG signals can be recorded with different configurations of electrode arrays.

TAB. 1 shows an example of possible probe configuration with a 128 channel EMG electromyograph.

Number of electrodes in the array	**Number of probes simultaneously available**
128 electrodes	1 probe
64 electrodes	2 probes
16 electrodes	8 probes
8 electrodes	16 probes
4 electrodes	32 probes

TAB. 1: Examples of probe configurations with a 128-channel EMG-USB electromyograph. In version with a lower number of channels, the number of probes decreases accordingly.

As shown in the example, it is possible to simultaneously acquire signals with different electrode arrays. This is necessary when signals from different muscles need to be recorded at the same time.

Using the front panel keypad, it is possible to choose the number of probes and assign a gain value to each probe. When the signals are detected from different muscles (e.g. biceps brachii and upper trapezius) it can be necessary to set different gain levels for each probe to exploit the full range of the A/D converter and obtain the best possible recording of the signal. EMG-USB technical specifications are shown in TAB. 2.

EMG channels	
Maximum input range	50 mV_{PP}
Bandwidth	10 ÷ 750 Hz, 8th order Bessel band pass filter
Total noise (RTI)	< 0.8 μV_{RMS} (differential), < 1.3 μV_{RMS} (monopolar),
Selectable gain	OFF, 100, 200, 500, 1000, 2000, 5000, 10000 V/V
Input impedance	> 90 MΩ on the entire bandwidth
CMRR	> 96 dB (114 dB typical)
Cross talk between channels	<-50 dB (monopolar and differential)
Sample frequency	2048 Hz
A/D converter resolution	12 bit
A/D converter input dynamics	0 ÷ 5 V
Data transfer to PC	USB1.1 o USB2.0 interface
Insulation voltage	4.000 V_{DC}
Auxiliary channels (optional)	
Input range	± 5 V
Bandwidth	Channels are not filtered
Gain	0.5 V/V
Input impedance	200 kΩ
Sample frequency	2048 Hz
A/D converter resolution	12 bit
A/D converter input dynamics	0 ÷ 5 V

TAB. 2: EMG-USB technical specification

7. DETAILED DESCRIPTION

FRONT PANEL

FIG. 1 shows controls, indicators and connectors present on the front panel of the EMG-USB and described in the following sections.

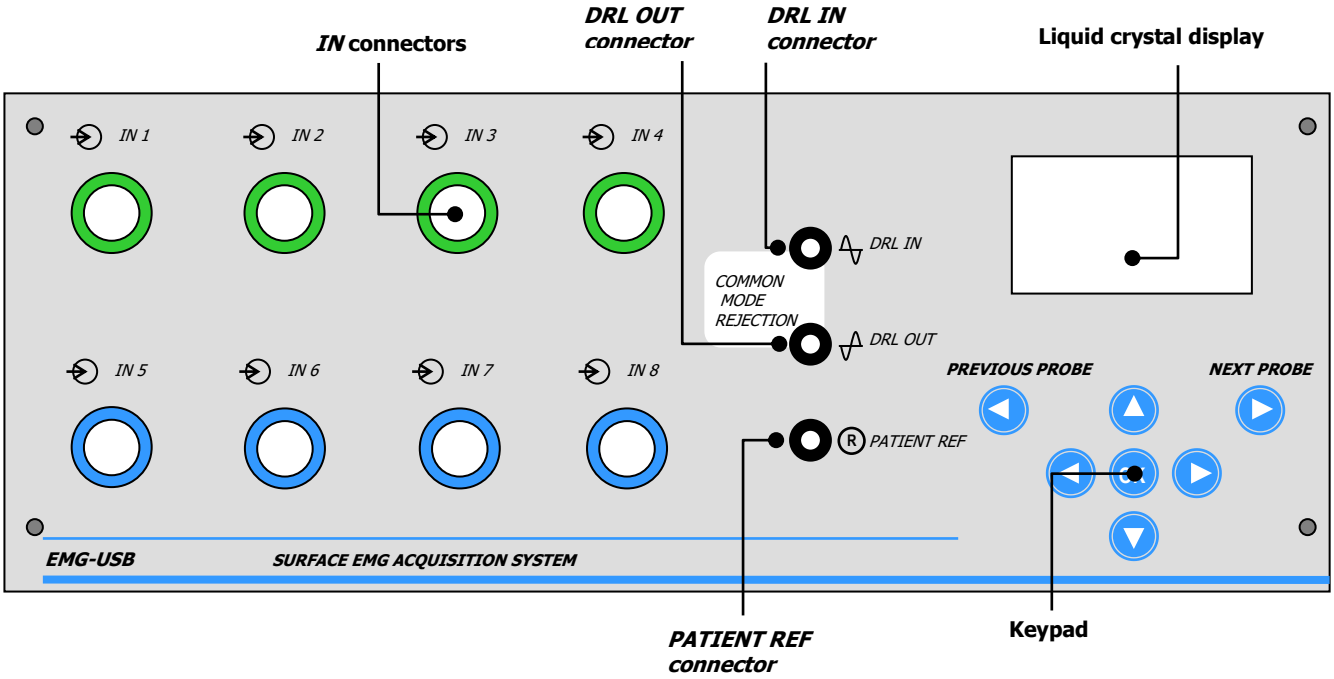


FIG. 1: EMG-USB front panel

IN connectors

Each of the **IN connectors** is used to connect a 16 electrodes array adapter (mode: **`Probes: 1x16CH`**), a double adapter for 8 electrodes arrays (mode: **`Probes: 2x8CH`**) or a quadruple adapter for 4 electrodes arrays (mode: **`Probes: 4x4CH`**).

To enable the array adapters of interest, choose the **`Probes`** mode with the keypad and select the menu value corresponding to the electrode arrays used. For detailed information on how to change the EMG-USB settings, refer to the *Liquid crystal display and keypad* section.

Each adapter can be connected either to:

- a standard array of silver bar electrodes (suitable to find the optimal position where to place the array on the muscle and to perform short time isometric measurements)
- an adhesive array (suitable for long duration signal acquisition and/or for acquisitions during dynamic contractions).

VERY IMPORTANT NOTICE:

For a correct signal recording it is necessary to connect the patient to the PATIENT_REF input of the EMG USB. The connection is established by attaching a wet strip to the patient's body at a point where there is NO MYOELECTRIC ACTIVITY (e.g. at the ankle or the wrist).

In monopolar acquisition mode (Mode: Monopolar) it is also necessary to connect another strip to the DRL_IN input of the EMG-USB. The DRL_IN strip actually becomes both the common electrode for the monopolar acquisition mode and the input to the DRL noise reduction circuitry. Also in this case, the DRL_IN strip MUST BE CONNECTED to a point on the patient where there is NO MYOELECTRIC ACTIVITY, usually close to the PATIENT_REF strip. It is mandatory to carefully AVOID that the two strips touch each other. If the two strips touch each other, the DRL_IN common electrode is shorted with the PATIENT_REF electrode and, in such a case, the whole measurement session becomes INVALID.

In case of high levels of electromagnetic interference, it may be necessary to activate the DRL noise reduction circuitry. To activate the DRL noise reduction circuitry a third strip MUST BE connected at a point on the patient far from the PATIENT_REF and the DRL_IN strip, usually on the other wrist or ankle. Be careful to place the DRL_OUT electrode in a way that the array of electrodes result to be placed between the DRL_IN and the DRL_OUT electrodes. The DRL_OUT electrode actually carries the cancellation signal. If the DRL_OUT electrode is not connected to the patient, the whole DRL noise reduction circuitry is INACTIVE.

For further specifications refer to DRL_IN and DRL_OUT sections.

PATIENT_REF input

The **PATIENT_REF** input connects the EMG-USB reference point of the amplifier to the patient. The reference point must be connected to a point on the patient's body without myoelectric activity (e.g. the ankle or the wrist) using the supplied ground strip. The strip must be wet with water to ensure a good electric contact with the patient.

⚠ **REMARK: failure in connecting this electrode prevents the correct acquisition of the EMG signal.**

DRL_IN input

The **DRL_IN** input connects the common input of the amplifiers to the patient's body while in monopolar acquisition mode, and is also used as the input to the DRL noise reduction circuitry. The **DRL_IN** input is always used for signal acquisition in monopolar mode (**Mode: Monopolar**) and for power line interference reduction as DRL input, if necessary, during differential acquisition mode (in this case also the **DRL_OUT** must be connected to the patient to reduce the interference). The electrode connected to this input is a conductive strip of the same type as the one used for referencing the patient to the amplifier circuitry. The strip must be wet with water to ensure a good electric contact with the patient and has to be attached to a point on the patient's body **without myoelectric activity** (e.g. the ankle or the wrist), usually alongside the strip used for the patient grounding. It is mandatory that the two strips **DO NOT TOUCH EACH OTHER**, otherwise the signal is completely disrupted and the acquisition becomes nonsense.

⚠ **REMARK: failure in connecting this electrode prevents the correct acquisition of the EMG signal in monopolar mode (`Mode: Monopolar`).**

DRL_OUT output

The **DRL_OUT** output connects the output of the DRL interference reduction circuitry to the patient's body. The **DRL_OUT** output should be used during acquisition in monopolar mode (`Mode: Monopolar`) in case of electromagnetic interference caused by electric engines, isokinetic machines or other electrical devices working near the EMG-USB. A wet strip to ensure a good electric contact with the patient must be connected at a point of patient's body in a way that the electrode array will be between the DRL output and the DRL input. Placing the DRL output at the opposite wrist or ankle with respect to the wrist or ankle bearing the DRL_IN strip usually satisfies this requirement. It is not strictly required to connect this strip at a point without myoelectric activity, whereas this is strictly required for the **DRL_IN** and **PATIENT_REF**.

⚠ **REMARK: failure in connecting this electrode prevents the correct acquisition of the EMG signal in case of high levels of electromagnetic interference.**

Liquid crystal display and keypad

The liquid crystal display is turned on when the EMG-USB amplifier is switched on. After an introducing screen-shot, the EMG-USB settings are presented as shown in FIG. 2.

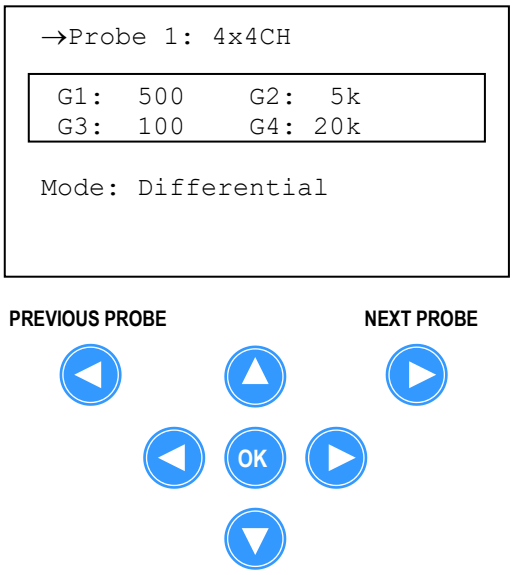


FIG. 2: Example of a screen-shot of the liquid crystal display

The embedded keypad allows the operator to change the settings of EMG-USB amplifier as explained in the following instructions:

- A group of 16 channels related to one of the IN connectors can be selected using the PREVIOUS PROBE ◀ and NEXT PROBE ▶ keys.
- Move the arrow (→) on the desired parameter using the ▲ and ▼ keys.
- Press OK to confirm the selection of the parameter. The arrow will be displayed in negative (→) to indicate that it is possible to change the value of the selected parameter.
- Scroll the available options and select the desired value using the ◀ and ▶ keys.
- Press OK to confirm the new value.

The selectable options for each programmable parameter of the EMG-USB amplifier are listed below in TAB. 3:

Parameter	Description	Available options
Probe	EMG input probe configuration: 16-electrode array probe, double 8-electrode array probe or quadruple 4-electrode array probe can be connected to each IN input. In differential acquisition mode, channels 16, 32, 48, … 128 show the difference between the signals detected from the 1ST and the 16TH electrode of the corresponding probe (that is: 16-1 for the first probe, 32-17 for the second probe, … 128-113 for the eighth probe) in all the **Probe** modalities, except for **Chain Mode**. When **Chain Mode** is selected the probes are chained. This means that, in differential acquisition mode, the difference between signals detected from electrodes: 16-17, 32-33, … 128-1 is performed. The selectable gain is the same for all channels in **Global Gain** and **Chain Mode** modality. The gain can be modified for group of 16 channels using **1x16CH** mode, group of 8 channels using **2x8CH** mode or group of 4 channels using **4x4CH** mode.	■ **Global Gain:** non-chained probes and unique gain for all channels ■ **Chain Mode:** chained probes and unique gain for all channels ■ **1x16CH:** 1 probe of 16 electrodes* ■ **2x8CH:** 2 probes of 8 electrodes each* ■ **4x4CH:** 4 probes of 4 electrodes each* * parameter referred to the selected IN input.
G1, G2, G3, G4	Probe gain: in mode **Global Gain** or **Chain Mode, G1** is the gain for all the probes connected; in mode **1x16CH**, **G1** is the gain of the 16 electrode array; in mode **2x8CH**, **G1** e **G2** are the gains of the two 8 electrode array and so on.	**OFF, 100, 200, 500, 1k, 2k, 5k, 10k** NOTE: 1k = 1000
Mode	Acquisition mode: monopolar or single differential	**Monopolar** **Differential**

TAB. 3: EMG-USB amplifier settings

REAR PANEL

FIG. 3 shows the connectors on the rear panel of EMG-USB described in the following sections.

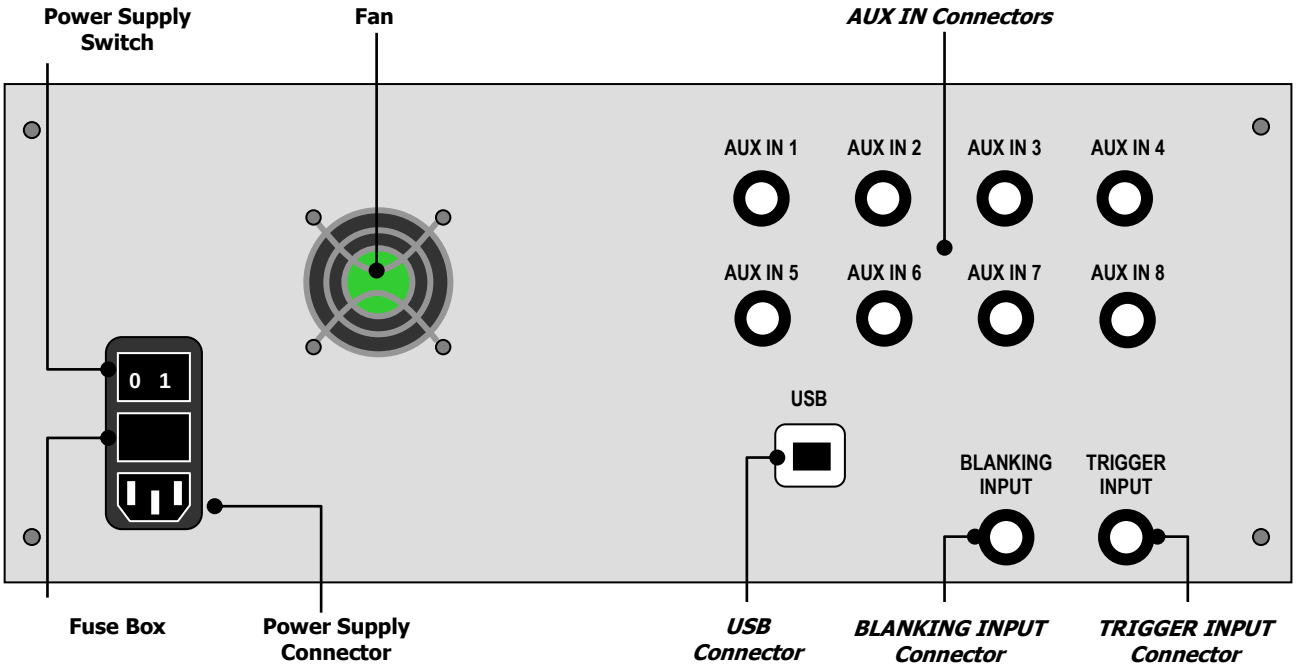


FIG. 3: EMG-USB rear panel view

Power Supply Connector

The EMG-USB must be connected to the power line socket only with the supplied cable. Ensure that the wall socket is properly grounded.

DANGER: the use of extension cords, multiple sockets or adapters can impair the performance of the EMG USB. Connection to sockets without proper grounding (e.g. lacking the "earth" conductor) or with bad quality grounding can impair the performance of the EMG USB and cause a potential risk for the patient and the operator.

Power Supply Switch

The **Power Supply Switch** turns on/off the EMG-USB. The switch position **I** turns the EMG-USB electromyograph on; the switch position **O** turns it off.

The **Power Supply Switch** breaks both the power line wires to improve the safety. When the EMG-USB amplifier is not in use, turn it off by this switch.

Fuse Box

In the same block of the power supply switch and the power supply connector there is a sliding box with one fuse for each power line wire. For proper operation both fuses must conduct electricity. A cover opening fuse breakdown indicates excessive current absorption and usually is a symptom of something seriously burnt. Have the EMG-USB properly checked by qualified personnel before replacing the fuses. Replacing the broken fuses may not restore the EMG-USB to its original integrity without a careful diagnosis of the causes that made the fuses burn out. The anomaly may have rendered the device no longer compliant with the safety standards. Should it be necessary, in any case replace the fuses with others of the same type. Fuse type is indicated on the rear ID label.

⚠ **DANGER: Replacing the fuses with other fuse types can be very dangerous for the patient and the operator.**

Fan

The fan on the rear panel cools the internal circuitry of the electromyograph. The airflow to avoid amplifier overheating enters the EMG-USB from the slits on the bottom panel and exits through the fan. The following cautions must be observed:

- Ensure to leave at least 8cm of clear space behind the EMG-USB to ensure a suitable airflow.
- Do not obstruct the slits on the bottom panel.
- Do not stop the fan.
- Do not obstruct the grid on the rear panel (FIG. 4).

⚠ **REMARK: blocking the airflow can cause overheating and device breakdown. Ensure that the fan can rotate freely and that nothing obstructs or blocks it.**

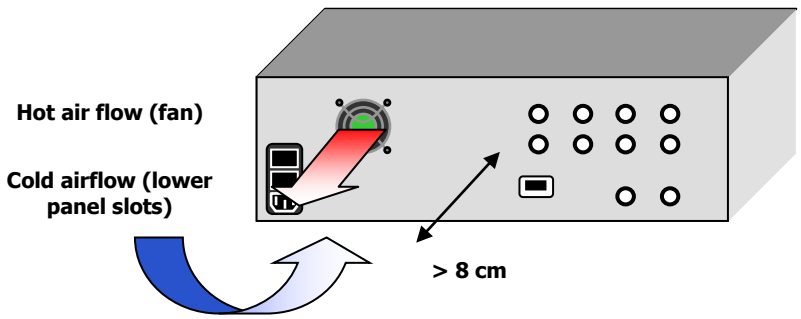


FIG. 4 Airflow and minimum required space behind the device

USB connector

Connect the PC by means of a standard A-B USB cable to this connector.

AUX IN connectors

These BNC type connectors can be used to acquire external amplified signals, in the range ± 5 V, together with the EMG signals. The eight auxiliary inputs work also without any EMG input and the EMG-USB can be used as an eight channels USB acquisition board with sampling frequency of 2048 Hz.

The signals at the AUX IN inputs can be assigned to any channel of the 128 available. To set the position of the AUX IN input and acquire the signals, refer to the *Acquisition Software* user manual version 1.80 or greater, in the "Setup Editor" chapter.

BLANKING INPUT connector

This BNC type connector is used to connect the electromyograph with a compatible neuromuscular stimulator, to allow EMG signal acquisition during electrically elicited contractions.

This input works with digital TTL compatible signals (0÷5V), coming from the stimulator that drives the internal blanking circuitry. When the BLANKING signal is active (5V), the amplifier stages are inhibited to prevent saturation caused by the stimulation pulse.

TRIGGER INPUT connector

The function provided from this BNC type connector depends on the version of the software used to acquire data.

If a version of *Acquisition Software* earlier than version 1.92 is used the TRIGGER INPUT can be used to connect the electromyograph with a compatible neuromuscular stimulator, to allow signal acquisition during electrically elicited contractions. This input works with digital TTL compatible signals (0÷5V), generated by the stimulator, that is sent to the internal acquisition board to reset the sampling process. An high level at this input reset the sampling process and the signals acquired can be perfectly aligned with the stimulation pulse removing the jitter effect.

When using an *Acquisition Software* version equal to or greater than 1.92 the TRIGGER INPUT behave as a data transfer enable between the EMG-USB and the PC. When the signal is a logic 0 the data transfer is disabled. This feature can be used to synchronize the acquisition start with an external event. If the input is leaved unconnected the data transfer is always enabled.

8. USE OF THE ELECTROMYOGRAPH

ELECTROMYOGRAPH SETUP

Before performing any measure it is necessary to set up all the instrumentation; this operation has to be done keeping the equipment turned off. Be careful to connect all the cables properly to the respective plugs and sockets.

To set up correctly the electromyograph follow the instructions hereinafter (FIG. 5):

- Make sure that the PC used with the electromyograph is turned off.
- Make sure that the EMG-USB power on switch is set in "**O**" position.
- Connect the USB port, placed on the EMG-USB rear panel, to one of the PC USB port by means of an A-B USB cable.
- Connect the EMG-USB power supply connector, placed on the rear panel, to a 90÷260 V_{AC}, 50÷60 Hz power line supply voltage using the provided cable.

⚠ **DANGER: the use of extension lead, multiple sockets or adapters can deteriorate the device performances. Connection to sockets lacking in the ground conductor ("earth" conductor) or with a bad quality of this connection can deteriorate the device performances and cause a potential risk for patient and operator.**

- Turn on the PC (desktop computer or notebook).
- Install the acquisition software following the instructions reported on the respective user manual.

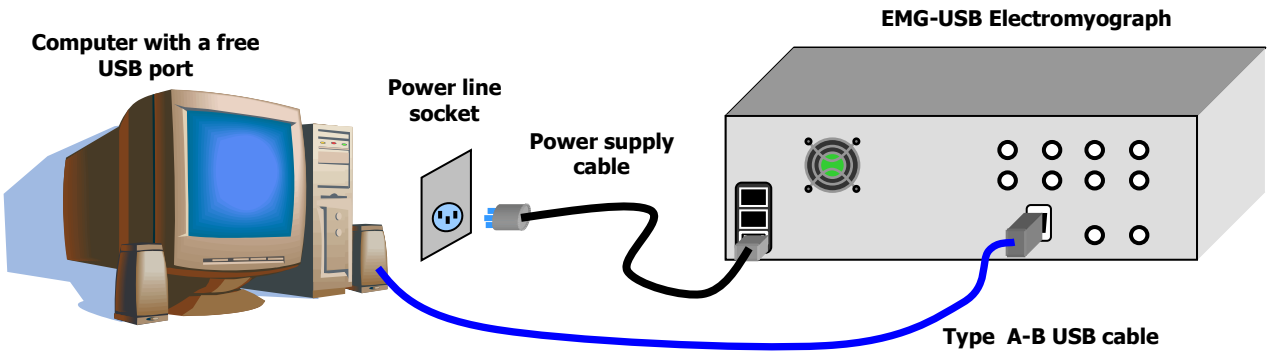


FIG. 5: Standard set up of the electromyograph

CONNECTION OF THE ACCESSORIES

It is possible to interface EMG-USB with external devices such as neuromuscular stimulators or biomechanical measurements instrumentation to detect, for example, the EMG signal during electrically elicited contractions or to measure the joint force/torque during a voluntary contraction. Subsections hereinafter show how to use the electromyograph in these conditions and how to connect EMG-USB to external devices.

Neuromuscular stimulator

EMG-USB surface EMG amplifier can be used to detect EMG signals during electrically elicited contractions. It is equipped with an internal circuitry, controlled by the **BLANKING INPUT** signal that provides stimulus artifact reduction by turning off the amplifier stages and thus avoiding saturation caused by the stimulation pulse present on the input. Another input signal (**TRIGGER IN**), allows the screen refreshing of the acquisition software after each stimulation pulse maintaining the EMG signal traces perfectly synchronized with the stimulation pulses. This inputs work with digital TTL compatible signals (0÷5V)

⚠ **REMARK: to guarantee good performances of the system it is necessary to use medical neuromuscular stimulator (built in compliance with the European standards EN 60601-1 and EN 60601-2-10) able to provide the special synchronization signals to be interfaced with the electromyograph.**

To use the electromyograph with a neuromuscular stimulator follow the instructions listed below:

- Verify the compatibility between the electromyograph and the neuromuscular stimulator contacting the Technical Support Service of OT Bioelettronica.
- With the electromyograph and the stimulator turned off, connect the *blanking* output of the stimulator with the **BLANKING INPUT** of the electromyograph using a BNC-BNC cable.
- Connect the *trigger* output of the stimulator with the **TRIGGER INPUT** of the electromyograph (FIG. 6) using a BNC-BNC cable.
- It is not possible to use the *blanking* signal of the stimulator also as *trigger* signal.
- Turn on the PC.
- Turn on the electromyograph.
- Turn on the neuromuscular stimulator.
- If it is necessary and allowed by the stimulator, it is possible to adjust the duration of the *blanking* signal provided by the stimulator to prolong or shorten the time of intervention of the circuitry that provides stimulus artifact cancellation, to obtain good quality EMG signals

avoiding excessive signal windowing and loss of information. For further details refer to the subsection *MEASUREMENT EXECUTION.*

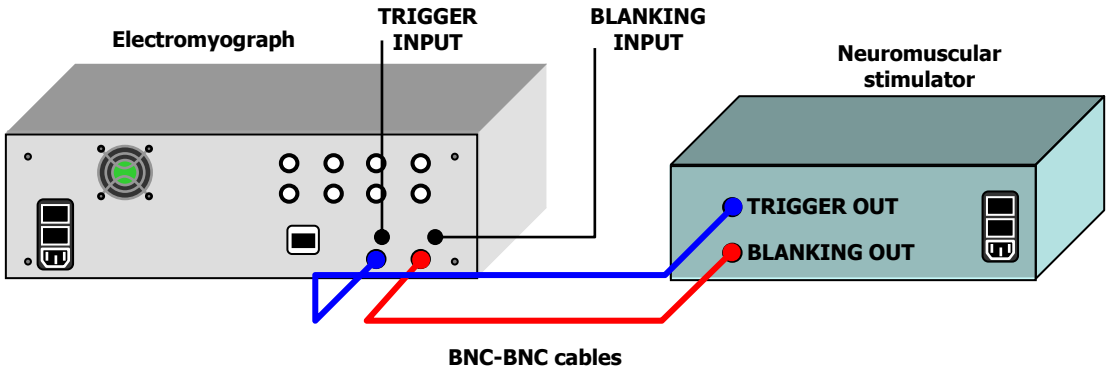


FIG. 6: Connection of the electromyograph to a neuromuscular stimulator equipped with the *blanking* and *trigger* outputs (USB cable and power supply connections are omitted for simplicity)

PATIENT CONNECTION

After the correct installation of the electromyograph and after verifying that it works properly, it is possible to connect the sensors to patient in order to perform an electromyographic test. Follow the instructions listed below:

- For each input, select the adapters more suitable for the measurement to perform (16-electrode array probe, double 8-electrode array probe or quadruple 4-electrode array probe) and plug it into the **IN** connectors.
- Connect the probes to the arrays selected. It is possible to connect to each adapter an array of silver bar electrodes (suitable to find the best position to place the array on the muscle and to perform short time isometric measurements) and an adhesive array (suitable for long term signal acquisition and/or during dynamic contractions). If it has been planned to use an adhesive array, however an array of silver bar electrodes has to be used first, to detect the optimal position for the adhesive array as described hereinafter. To use the 64-electrode adhesive grid (which carries 4 connectors), four standard adapters for 16-electrode array should be used.
- Connect a patient ground strip to **PATIENT REF** plug with the enclosed cable. The strip has to be wet with water to assure a good electric contact with the patient and has to be connected on a point without any myoelectric activity (e.g. the ankle or the wrist, FIG. 7).

⚠ **REMARK: the lack of this connection prevents the correct acquisition of the EMG signal.**

- If a monopolar mode of signal acquisition is planned (**`Mode: Monopolar`**), connect another strip to the **DRL IN** plug, using the enclosed cable. The strip has to be wet with water to ensure a good electric contact with the patient and has to be applied to a point without any myoelectric activity near the patient ground strip (e.g. the ankle or the wrist, FIG. 8). It is important to prevent the contact between the two strips to obtain a good signal.

⚠ **REMARK: the lack of this connection prevent the correct acquisition of the EMG signal in monopolar acquisition mode (`Mode: Monopolar`)**

- In case of high level interference during a monopolar mode signal acquisition (**`Mode: Monopolar`**), caused by the presence of electrical engines, isokinetic machines or other electrical devices working in proximity of the amplifier it is necessary to connect another ground strip to the **DRL OUT** plug with the enclosed cable, wetting it with water to ensure a good electric contact with the patient and fixing it on a point without myoelectric activity (e.g. the ankle or the wrist) next to the strips connected to **PATIENT REF** and **DRL IN** plugs. It is important to prevent the contact between the three strips to obtain a good signal.

After these operations it is possible to continue with the next subsection: *MEASUREMENT EXECUTION.*

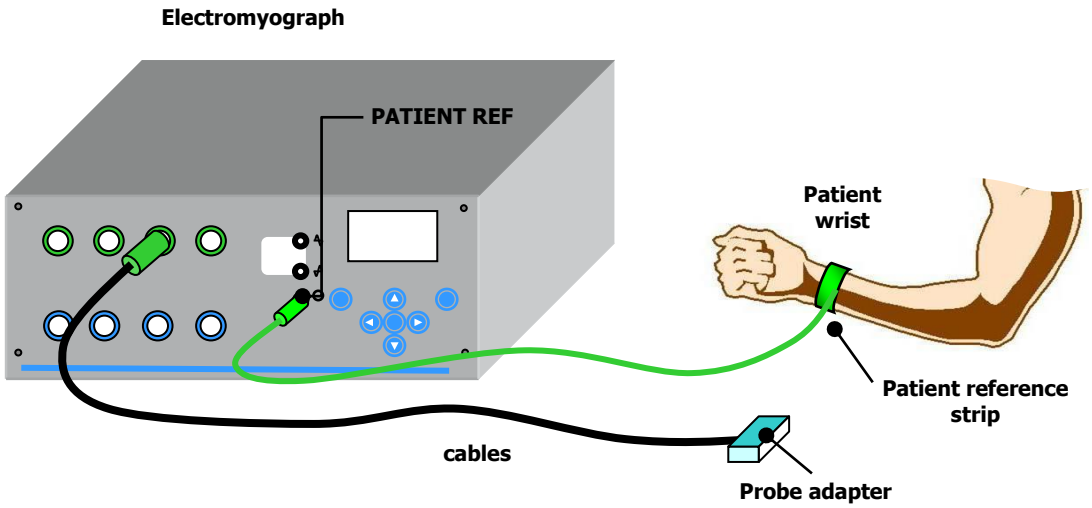


FIG. 7: Patient connection diagram for signal acquisition in single differential mode (`Mode: Differential`)

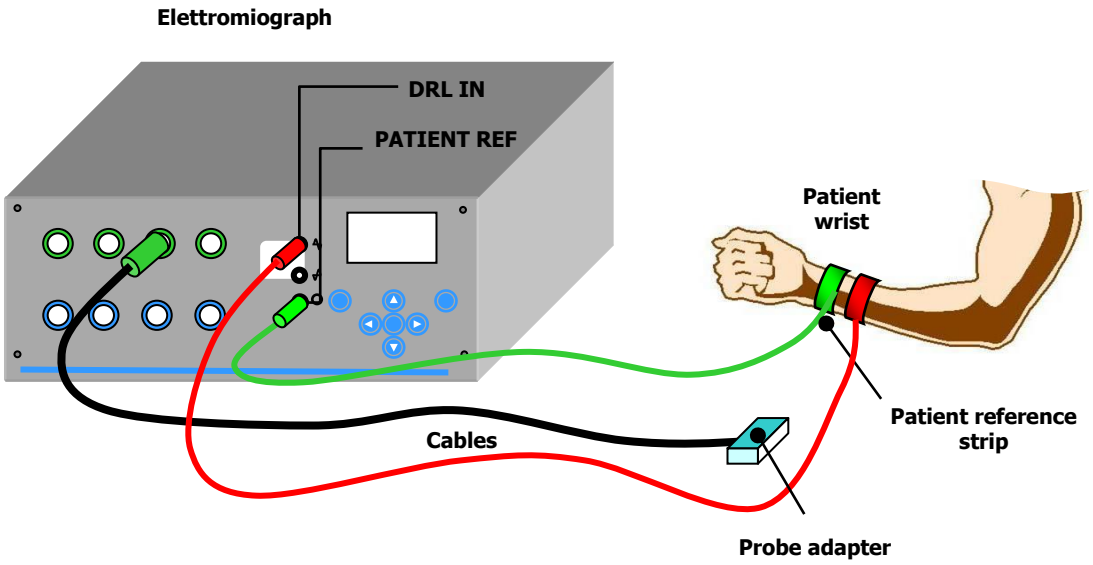


FIG. 8: Patient connection diagram for signal acquisitions in monopolar mode (`Mode: Monopolar`). Take care to avoid contact between strips

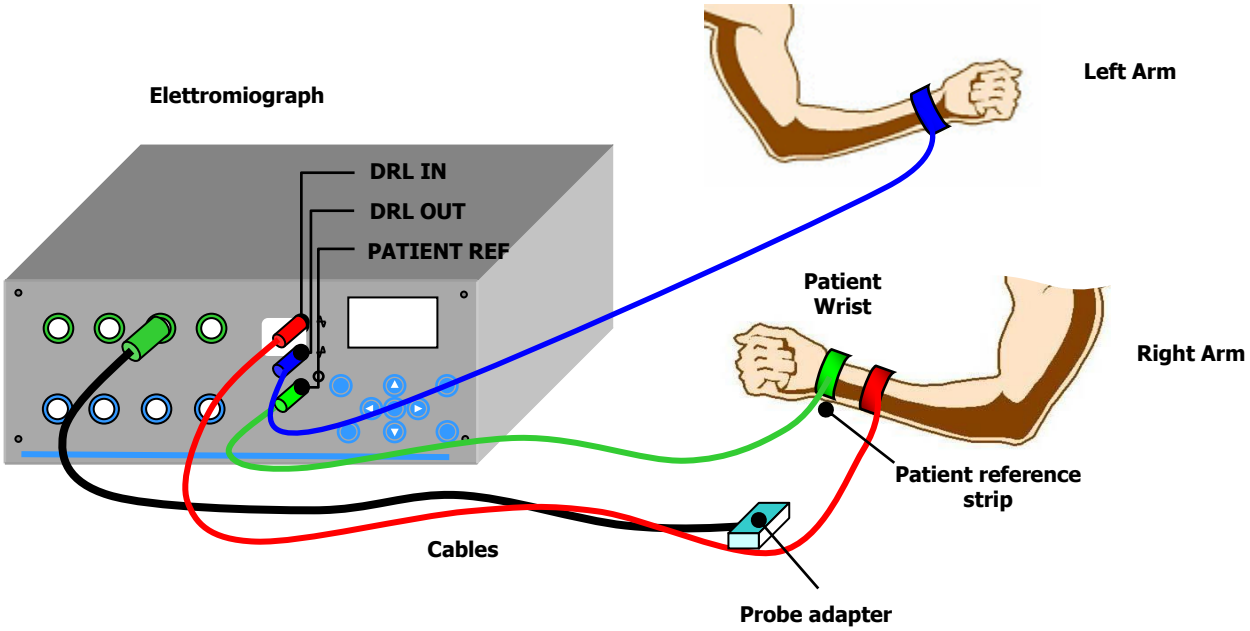


FIG. 9: Patient connection diagram for signal acquisitions in monopolar mode (`Mode: Monopolar`) in presence of high level interference (electric engines, isokinetic machines, etc.). Take care to avoid contact between strips

MEASUREMENT EXECUTION

If all the instructions listed above have been followed correctly, it is now possible to perform an EMG signal acquisition. In this section it is assumed that the patient reference strip, the electrode array adapter and the possible DRL strips are correctly connected. The following paragraphs show how to position an electrode array and how to configure the electromyograph to acquire good quality signals.

Differential acquisition mode

The single differential acquisition mode is the most used because it has low sensitivity to external electromagnetic interference. However, in this acquisition mode it is not possible to observe clearly the so-called "end of fiber effects" on the motor unit action potential (*MUAP*).

Each EMG signal trace represents, in single differential mode, the difference between the signals detected underneath two consecutive electrodes of the array. For example, channel 1 trace represents the difference between the signal detected by electrode 1 and 2, and so on. A single differential signal, thus, is obtained from two monopolar signals (FIG. 10). An N electrodes array allows the acquisition of N monopolar signals and N-1 single differential signals.

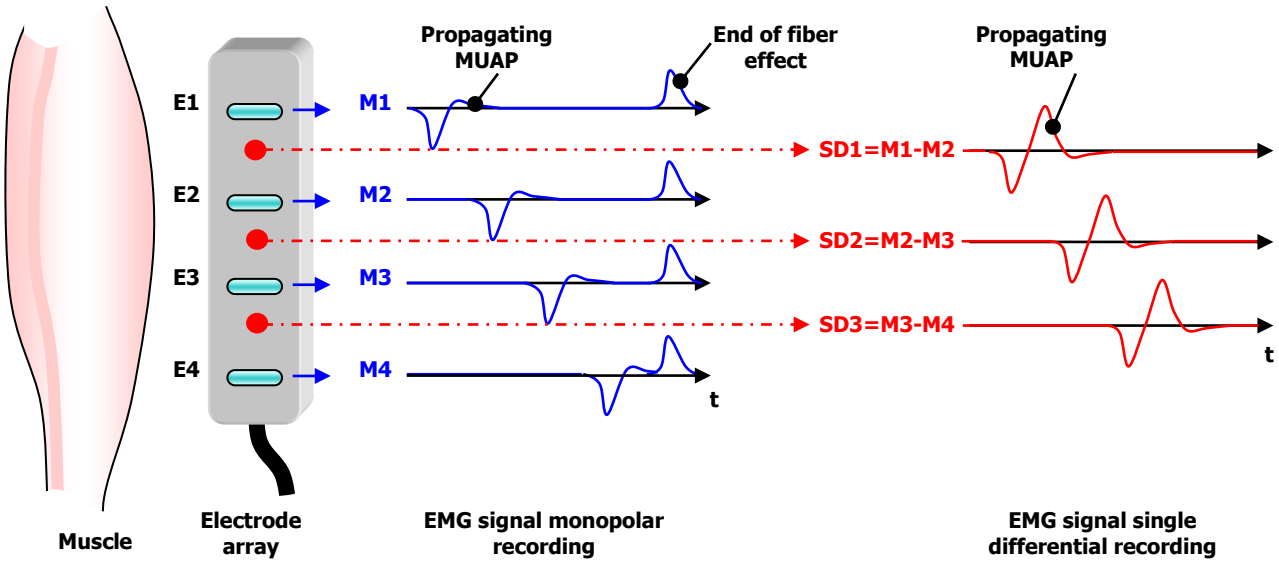
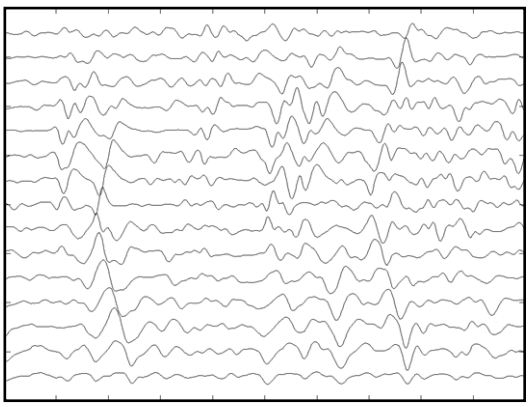


FIG. 10: Correspondence between the recording electrodes (E1-E4) and the acquired signals registered in monopolar mode (M1-M4) and single differential mode (SD1-SD3). Note that a monopolar signal is corresponding to the recording electrode whereas the single differential signal is corresponding to the mid point between the two electrodes from which it has been recorded. Note that the end fiber effect is strongly attenuated or absent in single differential signals.

To acquire a signal in differential mode follow the instruction listed below:

Defining the optimal array position

- Take care that the patient reference strip is wet, connected to the wrist or the ankle and connected to **PATIENT_REF** plug on the front panel of the electromyograph.
- Choose the more suitable silver bar electrode array with respect to muscle length, taking the one with the highest number of electrodes (better if 8 or 16), even if this array won't be used for signal recordings.
- Taking care that the electromyograph is turned off, connect the array to its own adapter (supplied) and plug it into the **ARRAY IN** connector on the front panel of the electromyograph.
- Turn on the electromyograph; then select differential mode (**`Mode: Differential`**) and the input configuration corresponding to the array selected (e.g. **`Probes: 1x16`**); then set a gain of 2000 or 5000 (e.g. **`G1: 2k`**) for the array selected.
- Turn on the PC and start the acquisition software tool in *display* mode (it allows to see in real time the row EMG signal detected by the array on the PC screen). Select a time base of about 50 - 100 ms/screen.
- Slightly wet the skin over the muscle and/or the array with water.
- Put the array on the muscle belly, taking care to align it with the fiber directions; keep it in place with a light pressure. If possible, ask the patient to hold the array on his muscle because the contact with the operator can introduce interference on the acquired signals.
- Ask the patient to relax the muscle, waiting some seconds to allow the electrode-skin contact to be stabilized; traces on the PC display should be flat and no interference signal (e.g. spikes, glitches, periodic signals) sholud be observed. In case of any problems, refer to the section *9. TROUBLESHOOTING.*
- Ask the patient to contract his muscle to about the 20%-50% of his maximum voluntary contraction level and look at the signal quality on the PC screen. With respect to the position of the array to the innervation zone(s) and to the level of the contraction, it should be possible to observe a signal like that in FIG. 11, in which are present several action potentials (*MUAP*) that are propagating along the muscle fibers.



Muscle: biceps brachii
Array: 16 ch / 10 mm
Gain: 2000
Mode: differential
Screen time base: 200 ms

← **INNERVATION ZONE**

FIG. 11: Example of a good quality EMG signal detected in single differential mode

- If the signal appears too low or too high in amplitude change proportionally the gain to obtain a good quality signal displayed with no clipping of the peaks.
- If the signal is too noisy try to wet again the array and the skin on the muscle; if necessary, slightly abrade the skin using abrasive paste.
- When a good quality signal is obtained, move the array along the muscle fiber direction to observe the innervation zone (*IZ*) around the middle of the array; it should be possible to detect clearly the action potentials inversion. Identify the position of the *IZ* as indicated in FIG. 12 and mark it on the skin with a biocompatible marker.
- Rotate the array around IZ until it is possible to observe a symmetric propagation (the slope of the imaginary line that connects the propagating MUAP has to be the same above and below the IZ). Mark the optimal direction found with a biocompatible marker. If it is clear, mark also the position of the tendons (where the signal stops to propagate and is weak).
- In case of non-isometric contractions, repeat the instructions above for the maximum and the minimum joint angle predicted and observe and record the location of the innervation zone.

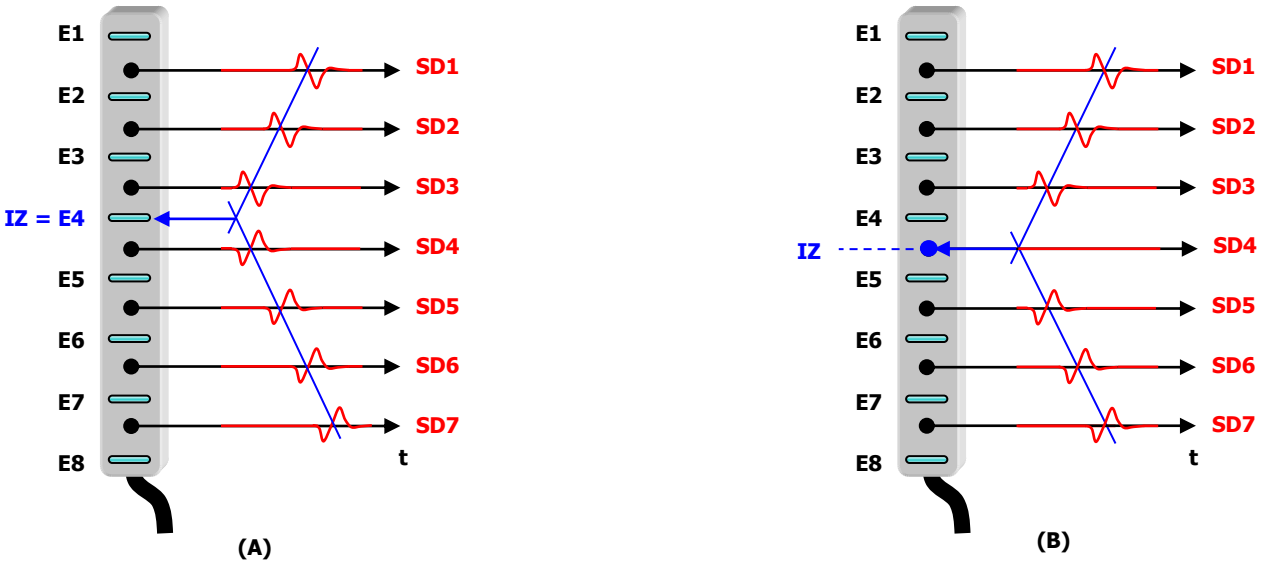


FIG. 12: Example of identification of the innervation zone (IZ). Remembering FIG. 10, to each differential signal (SD) corresponds to the mid point between two consecutive electrodes. The position of IZ, therefore, is:

(A) The trace SD4 in reversed with respect to SD3; IZ is in the middle between the two signals detection points, under the electrode E4;

(B) The trace SD4 is flat; IZ is in the middle between electrode E4 and E5;

Positioning of the recording array (silver bar electrode array)

⚠ **REMARK: indications below refer to silver bar electrode array use, suitable for short-term signal acquisitions and during isometric contractions.**

- Select the more suitable array, with respect to the number of electrodes for each muscle and to the experimental issues (see TAB. 2), and put it on the skin in the position marked before.
- Taking care the electromyograph is turned off, connect the array(s) to the adapter and plug it into the **ARRAY IN** connector.
- Turn on the electromyograph, select the differential mode (`Mode: Differential`) and the input configuration corresponding to the selected probe type (e.g. `Probes: 1x16`); set a gain for each probe of 2000 or 5000 (e.g. `G1: 2k`).
- Turn on the PC and start the acquisition software tool in *display* mode (it allows to see in real time the row EMG signal detected by the array on the PC screen). Select a time base of about 50 - 100 ms/screen.

- Slightly abrade the skin over the muscle using abrasive past, than reuse and wet with water the array and the skin.
- Align the array along muscle fiber direction as marked before (FIG. 13).
- If the estimate of conduction velocity is desired, it is recommended to have the maximum number of channels in the same propagation direction to reduce estimation variance; with respect to the markers set before, put the array with the maximum number of electrodes number between IZ and one tendon, in stead of symmetrically on IZ.
- Fix the array with a strip, a biocompatible adhesive tape or, in case of a very short-term acquisition, ask the patient to keep the array in the selected position exerting a light pressure on it.
- Ask the patient to perform a contraction to test the quality of the signals displayed on the PC screen. If necessary, change the gain settings to ensure good signal quality.
- Follow the instructions above for all the arrays used.
- Acquire the EMG signal during muscular contraction using the acquisition software. For further details refer to software user guide.

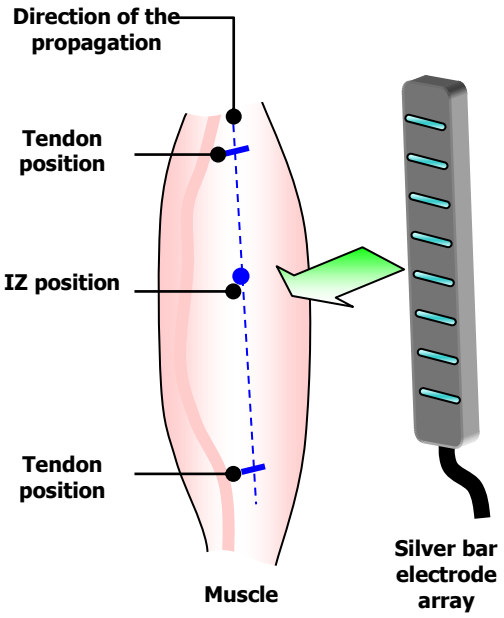


FIG. 13: Silver bar electrode array placement diagram: the array should be placed along the muscle fiber direction marked as described previously. If conduction velocity estimation is desired, it is recommended to have the maximum number of channels in the same propagation direction to reduce estimation variance; with respect to the markers set before, put the array with the maximum number of electrodes between IZ and one tendon, on the area in which there is the best propagation (the subcutaneous layer is thinner and/or we are far from other muscle tendons)

Positioning of the recording array (adhesive electrode array)

⚠ **REMARK: indications below are referred to adhesive electrode array use, suitable for long term signal acquisitions and/or during dynamic contractions.**

- Select the most suitable array, with respect to the number of electrodes for each muscle and to the experimental issues (see TAB. 2).
- If necessary, shave the area where the array will be placed. Slightly abrade the skin using abrasive paste, and then carefully dry the skin.
- Peel off the tape from one side of the adhesive foam and apply it on the array, taking care to cover neither the electrodes (black rectangular shaped) nor the holes.
- Peel off the other side of the adhesive foam and stick the array on the skin (FIG. 14), with respect to the position marked before when the silver bar electrode array was used. Take care that the array has been correctly stuck on the skin to avoid conductive gel leakage that can cause short circuits between consecutive electrodes. Press the array on the skin

⚠ **REMARK: in case of wrong positioning, is not possible to peel off the array to replace it, but its necessary to remove the array, carefully change the foam with a new one, repeating the procedures explained above.**

- If large movements are planned, fix the semi-reusable the array on the skin next to the probe connector using biocompatible adhesive tape.

⚠ **REMARK: some adhesive tapes are too sticky and can damage the semi-reusable part of the array. Test the tape compatibility before use.**

- Take care that the electromyograph is turned off, connect the array(s) to the adapter and plug it into the **ARRAY IN** connector.
- Turn on the electromyograph, select the differential mode (**`Mode: Differential`**) and the input configuration corresponding to the selected probe type (e.g. **`Probes: 1x16`**); set a gain for each probe of 2000 or 5000 (e.g. **`G1: 2k`**).
- Turn on the PC and start the acquisition software tool in *display* mode (it allows to see in real time the row EMG signal detected by the array on the PC screen). Select a time base of about 50 - 100 ms/screen.
- Fill the array holes with EMG conductive gel with a dispenser. It is recommended to use 20 μl of gel for each hole. After the insertion of the gel the recorded signal traces must be flat.
- Remove the gel excess using a paper napkin, taking care to not cause gel connections between adjacent holes (wipe in the transversal direction).

- Ask the patient to perform a contraction to test the quality of the signals displayed on the PC screen. If necessary, change the gain settings to ensure good signal quality.

⚠ **REMARK: if one or more channels appear weaker (or absent) with respect to others, it is possible some gel leakage between consecutive electrodes. Remove the array, wipe the skin, change the adhesive foam and replace the adhesive array as described above.**

- Follow the instructions above for all the arrays used.
- Acquire the EMG signal during muscular contraction using the acquisition software. For further details refer to software user guide.

⚠ **REMARK: after the use of the adhesive array, remove carefully the foam trying to avoid damaging the array and clean the semi-reusable part to remove gel to ensure future use. Wipe the array with a soft wet cloth. If the array has been cleaned properly after every use, it can be applied up to 8-10 times without affecting the signal quality.**

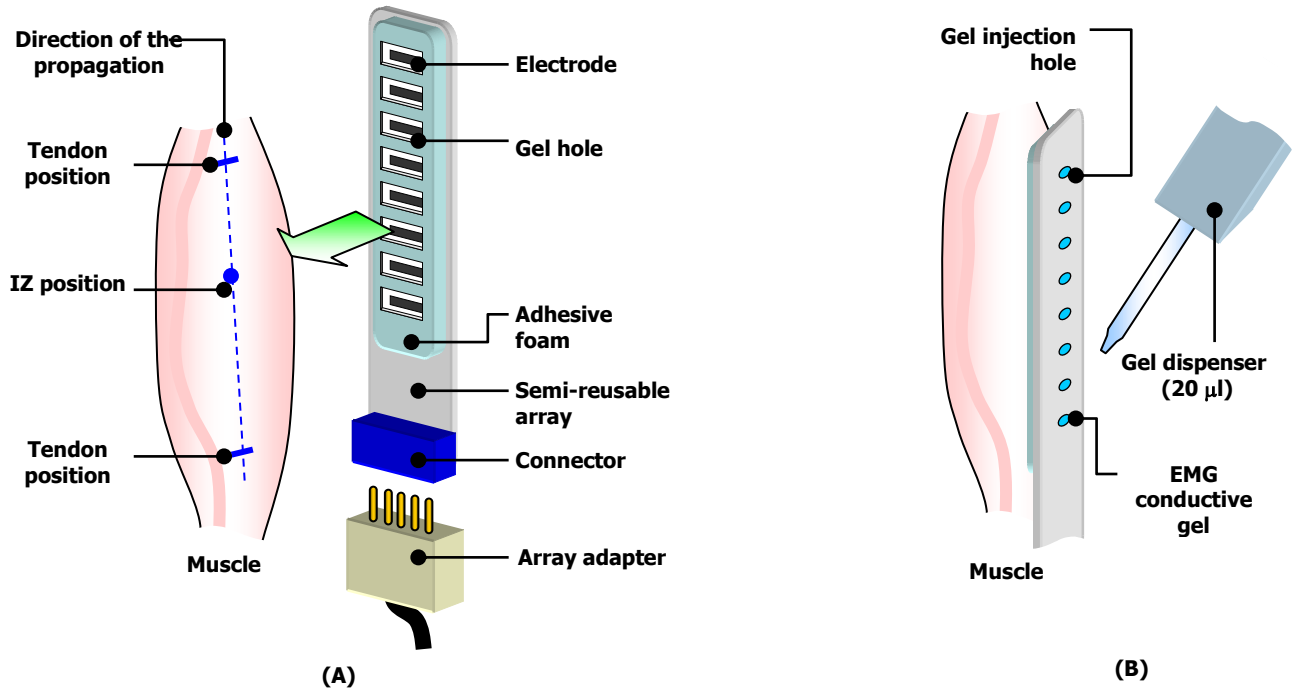


FIG. 14: Adhesive array positioning diagram: after positioning the adhesive foam on the semi-reusable array, it is applied on the skin (A) in the optimal position found before using a silver bar electrode array. A conductive gel is injected into the provided holes with a dispenser (B)

Monopolar acquisition mode

Each signal trace, when EMG signal is acquired in monopolar mode, corresponds to an electrode of the array. The monopolar signal presents, with respect to the single differential signal, some typical EMG non propagating signal components, the so-called "end of fiber effect", generated by the potential extinction on tendons.

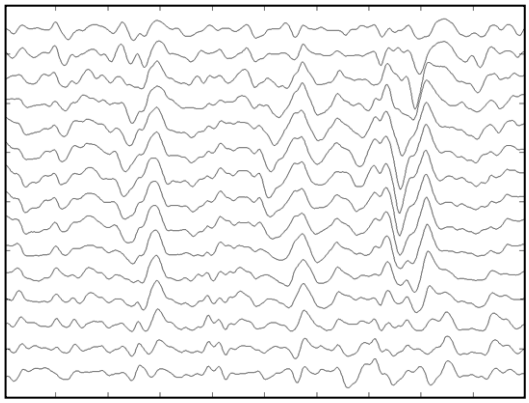
The steps to follow to record a signal in monopolar mode are similar to those for the single differential acquisition, except for the following ones:

Defining the optimal array position

- The optimal array position should be found as described above, using the differential acquisition mode, more suitable in the recognition of the anatomic characteristics, because the non-translating components are attenuated (even the end fiber effect).

Positioning of the recording array (silver bar electrode array)

- Follow the same instructions listed above for the differential mode.
- After verifying the good signal quality in differential mode, configure the electromyograph to work in monopolar mode (**`Mode: Monopolar`**) and, if not already done, connect the DRL IN reference strip (FIG. 8).
- Ask the patient to contract the muscle to test the signal quality. A monopolar signal correctly acquired appears as the signal shown in FIG. 15. In case of high-level interference try to use the DRL OUT strip (FIG. 9) or refer to section *9. TROUBLESHOOTING.*
- After verifying the signal quality, start the acquisition as described above.



Muscle: biceps brachii
Array: 16 ch / 10 mm
Gain: 2000
Mode: monopolar
Screen time base: 200 ms

FIG. 15: Example of a good quality EMG monopolar signal

Positioning of the recording array (adhesive electrode array)

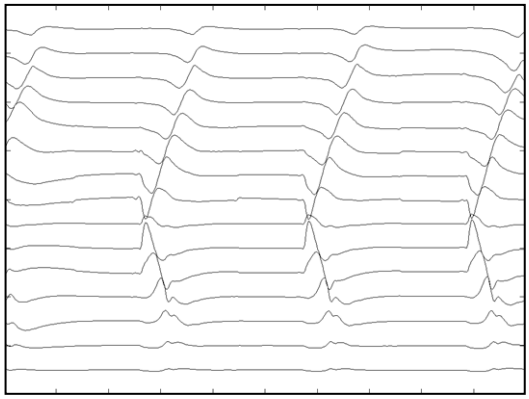
- Follow the same instructions listed above for the positioning of the adhesive arrays.

Acquisition during electrically elicited contractions

- Follow the same instructions listed above for the differential mode
- After verifying the good signal quality in differential mode, connect the stimulation electrodes to patient and turn on the neuromuscular stimulator. If necessary, search for the optimal position (*motor point*) before array placement using a pen electrode to stimulate the muscle, searching for the point where the mechanical response is the maximum with the minimum of stimulation current intensity. For further details read carefully the neuromuscular stimulator user manual.

⚠ **REMARK: typically (but not always) the motor point is situated near to the innervation zone, localized as described above when talking about array placement. A monopolar simulation configuration is recommended (one small electrode on the motor point and a large electrode on the opposite side of the limb).**

- Configure the acquisition software tool in electrically elicited contraction mode. For further details refer to the software user guide.
- Start to stimulate with a frequency of 2÷4 Hz and change the stimulation intensity until a muscular contraction is visible and synchronized with the stimulation pulses.
- Look at the EMG signals detected (*M-wave*): after each stimulus, the acquisition software should display an EMG trace similar to a single MUAP shape, but higher in amplitude. If necessary change the gain settings to allow good quality signal assessment on the PC screen (usually during electrically elicited contractions is used a gain from 100 to 1000).



Muscle: biceps brachii
Array: 16 ch / 10 mm
Gain: 1000
Mode: differential, electrically elicited (2 Hz)
Screen time base: 200 ms

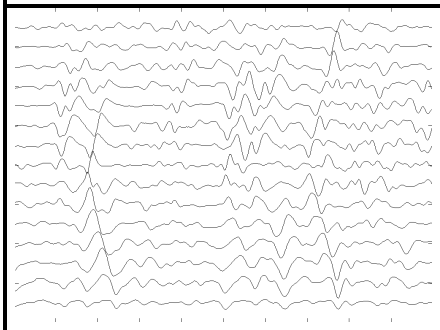
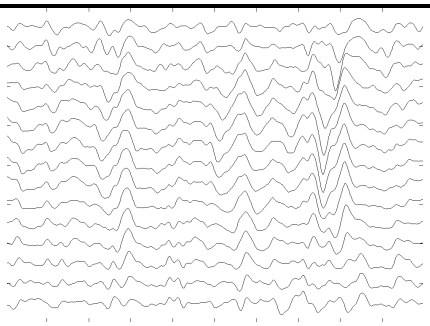
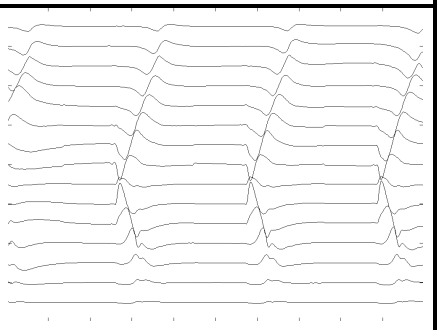
FIG. 16: Example of a good quality EMG signal acquired in differential mode during electrically elicited contractions.

- Some stimulators compatible with the use of an electromyograph are equipped with a *blanking* command used to control a stimulus artifact cancellation circuitry implemented in the amplifier. If it is possible, change the *blanking* command settings on the stimulator to remove the entire artifact without cutting the M-wave (blanking time too long) to avoid loss of information.
- For further details refer to section *9. TROUBLESHOOTING.*
- After verifying the signal quality, start the acquisition as described above.

9. TROUBLESHOOTING

This section describes the most common problems that may be found by EMG-USB users, with some suggestions to solve them. In case of problems that could have different causes, these are listed in a decreasing order of importance. If the problem is referred to the acquisition of the EMG signal, an example signal screen of a duration of 200 ms is reported. TAB. 4 shows some example of signals properly acquired in the three modes: differential, monopolar and during electrically elicited contractions.

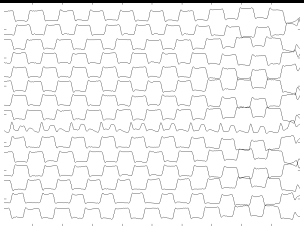
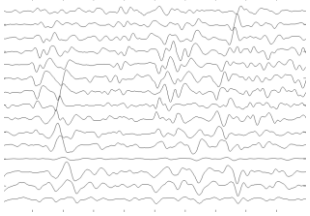
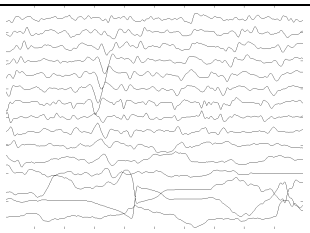
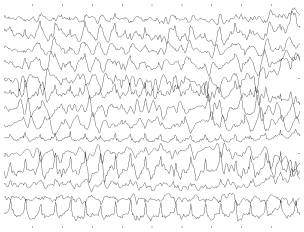
For problems not described in this section contact the Technical Support Service of OT Bioelettronica.

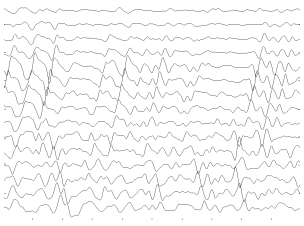
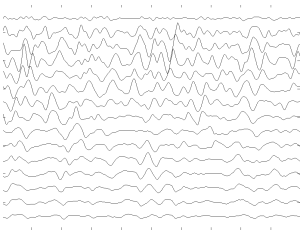
PROPERLY ACQUIRED EXAMPLE SIGNALS		
Differential mode	**Monopolar mode**	**During electrically elicited contractions**
		
16/10mm array on biceps brachii muscle, G=10.000, low level contraction; 200 ms/screen	16/10mm array on biceps brachii muscle, G=2.000, low level contraction; 200 ms/screen	16/10mm array on biceps brachii muscle, G=1.000,mid/low level stimulation intensity; 200 ms/screen

TAB. 4: example of signals properly acquired in the three modes: differential, monopolar and during electrically elicited contractions. All the screens lasts 200 ms and the amplifier gain is set to have the best signal quality. All these signals are acquired with a 16 electrode array / 10 mm inter-electrode distance on biceps brachii muscle.

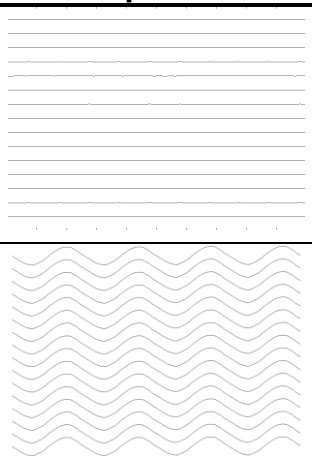
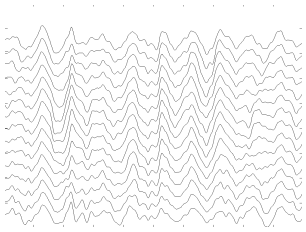
GENERAL PROBLEMS			
Problem	**Example screen**	**Possible cause**	**Solution**
The electromyograph does not turn on	-	Power supply switched off	Turn to "**I**" the power supply switch.
	-	Power supply cable is not inserted properly in the amplifier or into the wall socket	Check the power supply cable and the socket connection
	-	Breakdown of the fuses	Contact the Technical Support Service of OT Bioelettronica
The electromyograph turns on, but the characters are not shown properly on the display	-	Ambient temperature is too low	Wait that the electromyograph warms up

TAB. 5: Troubleshooting of the general problem that can occur using the electromyograph

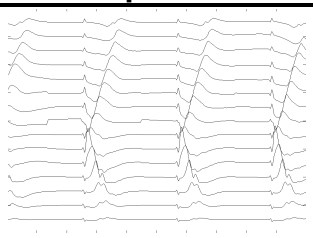
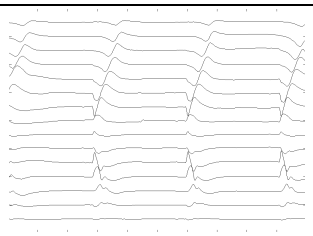
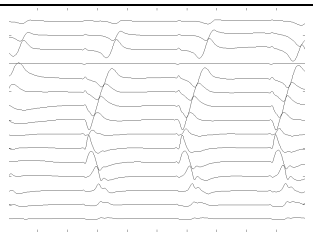
DIFFERENTIAL MODE SIGNAL ACQUISITIONS			
Problem	**Example screen**	**Possible cause**	**Solution**
Saturated signals on all the channels		Reference strip is not connected	Connect the reference strip to PATIENT REF plug (FIG. 7)
One channel (not corresponding to the innervation zone) is weak or zero		Two consecutive electrodes are short circuited	SILVER BAR ELECTRODE ARRAY: dry the skin and the array ADHESIVE ARRAY: remove the adhesive array, change the foam, clean the skin and reapply the array
Signals on some channels are floating with unsteadiness		Bad electrode-skin contact under those electrodes	SILVER BAR ELECTRODE ARRAY: slightly wet the skin and the array, press the array on the skin ADHESIVE ARRAY: add some gel (10 μl recommended) into the corresponding electrode holes
The signal is noisy and there are periodic or burst interferences superimposed to the signal		Neon lamps generating interference (100 Hz burst interference)	Turn off sequentially the lights till identify the lamp(s) that cause the interference.
		Computer monitor interference (in particular LCD displays) operating in proximity of the amplifier	Move the electromyograph away from the display
		Notebook or desktop PC power supply interference	Move the notebook (or desktop PC) power supply away; connect the electromyograph to a different wall socket; if using a notebook try to use battery power supply
			Use power line filters on PC power supply connections
		Electric engines interference (e.g. isokinetic machines) working in proximity of the amplifier	Connect the electromyograph to a wall socket far from the electric device, if it is possible using a different power line phase; check for a correct device ground connection
		Interference due to power active devices with a metallic case (e.g. systems for force/torque measurement) working in proximity of the amplifier	Check for a correct device ground connection

DIFFERENTIAL MODE SIGNAL ACQUISITIONS			
Problem	**Example screen**	**Possible cause**	**Solution**
Good electrode skin contact, but the signal is weak and the signal does not propagate on one or more electrodes at the extremity of the array		Electrodes placed on tendon	Move the array along muscle fiber direction toward the innervation zone; use an array with a smaller inter-electrode distance to have a great number of propagating signals
Good propagation only in one direction with respect to the innervation zone; on the other side signals are weak and does not propagate very much		The array is not aligned with muscle fibers	Rotate the array to observe a symmetric propagation in both directions (amplitude can be different depending on the thickness of the subcutaneous layers)
		The array is aligned with muscle fiber but there is a thicker subcutaneous layer or a tendon (even of another muscle) under those electrodes	Use an array with a shorter inter-electrode distance applied where there is the best signal propagation, to have a greater number of propagating signals; use only channels with good propagation properties for signal processing
Signal amplitude is too low	-	Amplifier gain is too low	Increase the amplifier gain
Signal amplitude i s too high and MUAP appear clipped	-	Amplifier gain is too high	Decrease the amplifier gain

TAB. 6: Troubleshooting of the problems that can occur using the electromyograph in differential mode acquisition. All the screens lasts 200 ms and the amplifier gain is set to have the best signal quality. All the example signals are acquired with a 16 electrode array / 10 mm inter-electrode distance on biceps brachii muscle.

MONOPOLAR MODE SIGNAL ACQUISITIONS			
Problem	**Example screen**	**Possible cause**	**Solution**
Signals are zero or there is only a high power line interference (50 Hz)		DRL IN and DRL OUT strips are not connected	Connect DRL IN and DRL OUT strips to the respective plugs (FIG. 8 and FIG. 9).
Monopolar EMG signal is clearly visible but it is superimposed with a power line interference		High level power line interference and DRL OUT not connected	Connect the DRL OUT strip to the relative plug (FIG. 9). After that, if the signal looses many of those synchronous components, keep on the DRL OUT strip.

TAB. 7: Troubleshooting of the problems that can occur using the electromyograph in monopolar mode acquisition. All the screens lasts 200 ms and the amplifier gain is set to have the best signal quality. All the example signals are acquired with a 16 electrode array / 10 mm inter-electrode distance on biceps brachii muscle.

SIGNAL ACQUISITION DURING ELECTRICALLY ELICITED CONTRACTIONS			
Problem	**Example screen**	**Possible cause**	**Solution**
Stimulus artifacts are visible before the M-waves		*Blanking* time is too short	If it is possible, increase the blanking time on the neuromuscular stimulator
Stimulus artifact is partially or totally superimposed with the M-wave that is no more recognizable	-	Neuromuscular stimulator output is not designed to work with an electromyograph	Is not possible to perform the measure; contact the Technical Support Service of OT Bioelettronica to select a compatible stimulator
There are no stimulus artifacts but the M-waves appear windowed, especially on the channels more proximal to the stimulation electrode		*Blanking* time is too long	If it is possible, decrease the blanking time on the neuromuscular stimulator
One channel (not corresponding to the innervation zone) is weak or zero		Two consecutive electrodes are short circuited	SILVER BAR ELECTRODE ARRAY: dry the skin and the array ADHESIVE ARRAY: remove the adhesive array, change the foam, clean the skin and reapply the array

TAB. 8: Troubleshooting of the problems that can occur using the electromyograph during electrically elicited contraction signal acquisition; all the screens lasts 200 ms and the amplifier gain is set to have the best signal quality. All the example signals are acquired with a 16 electrode array / 10 mm inter-electrode distance on biceps brachii muscle.

10. EMG-USB MAINTENANCE AND STORAGE

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

EMG-USB 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.

⚠ **WARNING: it is recommended to clean the probes with a disinfectant solution (alcohol or other) to avoid microbe infections among patients**

It is recommended to plan a device check every 24 months with the distributor. The EMG-USB should be repaired by the distributor only. Every repair executed by unauthorized personnel will be considered as a device violation voids the distributor'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

Risk class:	IIa 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 I, about the protection from indirect contact. - IP20, about the penetration of fluids and dust; device not protected.	
Case:	painted metallic case.	
Power supply:	voltage from 90Vac to 260Vac ± 10%, frequency from 47 to 400Hz.	
Consumption:	90 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.	
Protections:	2 x 1,5A fuses.	
Input channels:	up to 128 independent	
Amplifier:	Maximum input range:	50 mV_{PP} with gain = 100
	Bandwidth:	10 ÷ 750 Hz (for EMG channels)
	Total noise (RTI)	< 0.8 μV_{RMS} (differential)
		< 1.3 μV_{RMS} (monopolar)
	Selectable gain	100, 200, 500, 1000, 2000, 5000, 10000
	Input impedance	> 90 MΩ on the entire bandwidth
	CMRR	> 96 dB (103 dB typical)
	Cross talk between channels	<-50 dB (monopolar and differential)
	Insulation voltage	4000 V_{DC}
Visualization:	graphic LCD 128x64 pixel display.	
Commands:	7 keys protected by polycarbonate membrane.	
Dimensions:	350 x 271 x 120 mm	
Weight:	3 Kg.	

12. WARRANTY

EMG-USB is covered by a 24 months warranty starting from the purchasing date of the electronic parts.

Connection cables are covered by a 6 months warranty. Electrodes and all the parts subject to wear and tear are excluded from the warranty.

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

Warranty conditions are reported hereinafter.

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.

For further information:

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