BioAmp DC Universal Biological Amplifier System

Ver.7 series

User Manual

SUPERTECH Instruments

General Description

BioAmp is a general purpose biological amplifier construction. It is perfect for nearly all of the electrophysiological applications. Most of the competitor amplifiers are not able to record DC potentials. **BioAmp has got DC recording capability.** In other words one of its high pass filter positions is 0 Hz. Furthermore there are precision offset voltage correction modules (analog and digital) as orderable options. BioAmp system can be configured 1 to many channels modularly.

DC BioAmp is the default equipment. Its modified version is the AC BioAmp. The most important difference between them is what their names say. There is another difference between the two versions. The gain range of the AC BioAmp is 10 times higher than the gain range of the DC BioAmp. Please look at the details in the Specifications / Technical Data section.

BioAmp's Main Fields of Applications

- Extracellular recording
- Microelectrode recording (Single-unit activity, Juxtacellular recording, Field Potential, Motor Units, etc.)
- Multi-channel DC recording in epilepsy research
- Evoked Potentials in the brain (EVP)
- Body-surface potentials (ECG, EMG, EEG, ERG, etc.)
- Heart micropotentials (HIS-bundle, Late Potential, etc.)
- Multi-channel applications (EEG Brain Mapping, Cortical Depth Mapping, etc.)

BioAmp is a programmable amplifier, but it has no sampling circuits in the signal path at all. In other words, it is controlled by a built-in microcontroller or a remote computer, but it has got only high-performance, low noise, low distortion analogue amplifier circuits. One can say, that it is old fashioned. We keep this traditional construction style, because it provides supreme accuracy and unsurpassable linearity. This full-analog feature is indispensable when you use averaging techniques for processing its output signal. The internal Amplifier Setup Controller and the optional digital port (which offers remote control facility from a PC) are optically isolated from the amplifier stages. This way we could connect all the advantages of high accuracy analogue amplifier circuits and easy usage of digital control.

Although BioAmp is programmable equipment, it does not need a separate computer to work. According to this fact, it can be used as a stand-alone amplifier (while possessing an optional serial port to communicate with a PC). This stand-alone feature is very comfortable, because the computer is always given, but it should be used to collect and to process the experimental data. Every Amplifier Setup Controller on the front panel has got a 3-button keypad and menu-driven internal firmware, so it is very friendly to use.

The internal structure of BioAmp is modular, so the number of the amplifier channels and the number of the Amplifier Setup Controllers built in the equipment can be decided independently. Only the aspects of the application field should be considered when we decide, how many amplifier channels and how many Amplifier Setup

Controllers will be placed in the equipment cage (for example it is comfortable to use only one Amplifier Setup Controller to program all the EEG channels together, but another Amplifier Setup Controller should be used if there is a single unit channel in the system, and a third Amplifier Setup Controller is necessary, if there are further channels for ECG). The front plate Amplifier Setup Controller drives an internal serial bus. On this bus the Amplifier Setup Controller is the master and the amplifier boards are the slaves. The slaves cannot be addressed on the bus. All slaves that are connected to the bus receive the commands from the master at the same time. An Amplifier Setup Controller can drive any number of amplifier boards. The slaves are wired on the bus on a fixed way. This is the reason, why usually more than one Controller is located on the front plate. Examples: a 16-channel equipment can be designed with three Amplifier Setup Controllers on the front: Arrangement (1): channels 1 to 8 are connected to the 1st Controller, channels 9 to 12 are connected to the 2nd Controller and channels 13 to 16 are connected to the 3rd Controller. Arrangement (2): channels 1 to 12 are connected to the 1st Controller, channels 13 to 15 are connected to the 2nd Controller and only channel 16 is connected to the 3rd Controller. Other convenient arrangements can be created, too.

BioAmp amplifier system offers a very reasonable price level in comparison to the number of channels.

Parts of the System

Every BioAmp amplifier is divided into two parts. They are the Main Amplifier and the Preamplifier. The Main Amplifier is table top or rack-mounted equipment. Preamplifiers are built into separated small cases.

Accessories

There are two orderable options for the BioAmp system. You can find their detailed description at our website.

Mains isolation transformers with symmetrical secondary coils can efficiently reduce the hum noise level of the amplifiers supplied from such transformers. In our product choice there is a 1 kVA toroidal isolation transformer.

Unit Spike Detector (Action Potential Level Discriminator) is very useful in such applications where the distribution of the action potential spikes should be processed.

Security Rules

The BioAmp system must not be used in human experiments, because it has no European permission for human applications.

Specifications / Technical Data

In the BioAmp system there are 8 positions of gain, 8 positions of high pass filter and 8 position of low pass filter in the menu to choose from. The actual values, what should be realized during the manufacturing process can be ordered with the default parameters, but they can be requested with special values, to meet any special requirements, as well. The default values for the filter and gain sections are listed below. Any combination of the parameters can be selected, even the invalid settings (for instance if the high pass filter is set to higher frequency, than the low pass filter). The invalid settings result no faults in the equipment, only the output voltage will be driven to zero.

High Pass Filter settings:

- DC (0 Hz)
- 0.16 Hz (1 s)
- 0.53 Hz (0.3 s)
- 1.6 Hz (0.1 s)
- 5.3 Hz (0.03 s)
- 10 Hz
- 30 Hz
- 100 Hz

Low Pass Filter settings:

- 15 Hz
- 30 Hz
- 70 Hz
- 150 Hz
- 500 Hz
- 2 kHz
- 5 kHz
- 10 kHz

Gain settings of DC BioAmp:

- 50
- 100
- 200
- 500
- 1,000
- 2,000
- 5,000
- 10,000

Gain settings of AC BioAmp:

500
1,000
2,000
5,000
10,000
20,000
50,000
100,000

There is a possibility to select the full amplifier chain of BioAmp as Inverting or Noninverting characteristics. This selection is also a menu point of the firmware running on the Amplifier Setup Controller.

Offset voltage arisen on the recording electrodes can be corrected on three different ways, depending on the actual amplifier model. All the below mentioned voltages are referring to the input of the preamplifier (in other words referring to the electrode).

- Analog Offset Voltage Correction in the Preamplifier:
  Offset voltage correction range: +/- 700 mV
  Control method: 10-turn helical potentiometers
  It can be built either into the Monopolar (single-ended) or into the Differential preamplifier.

- Digital Offset Voltage Correction in the Main Amplifier:
  Offset voltage correction range: +/- 200 mV
  Resolution: 100 microVolts
  Control method: Digital Offset Voltage Controller unit

- The above two methods combined together:
  Coarse offset voltage correction in the preamplifier
  Fine digital offset voltage correction in the Main Amplifier

Gain of the Preamplifier (abbreviated on the screen of the Amplifier Setup Controller as A(preamp)) can be selected, if you switch on the amplifier by F-button pressed. In DC BioAmp you must always choose A=100, even if the gain of the preamplifier is 10. DC BioAmp can operate correctly only with a preamplifier, which has a gain of 10. Why should we choose A(preamp) as 100 even in this case? Because the Digital Offset Voltage Correction circuit, or its zero-offset substitutive circuit if Digital Offset Voltage Correction is not installed, has a gain of 10. It multiplies 10 times the gain of the preamplifier, resulting a total preamplifier gain of 100.

BioAmp DC is an extremely versatile construction. Before ordering your amplifier, please consult with our development engineer to find the optimal and most comfortable offset correction method for your given signal recording paradigm.

Digital Offset Voltage Controller

This unit is an orderable part of the BioAmp DC amplifier models. It is a dedicated microcontroller with its own LCD display, built on the front plate of the Main Amplifier.

Number of channels: 16 (it can be used in amplifier models of 1 to 16 channels)

Offset voltage correction range (referring to the electrode): +/- 200 mV

Resolution: 100 microVolts

Noise

The noise level of BioAmp was measured under the following conditions. A monopolar (single-ended) headstage was used. The input signal of the headstage was generated by a battery-powered square wave generator. The output impedance of this generator was 470 Ohms. The measured noise voltages were referring to the input of the headstage (in other words, they were measured at the output, but they were calculated to the input, divided by the actual gain). The actual settings of the BioAmp Main Amplifier, except the low pass filter, have negligible effect for the total noise characteristics. The noise level depends mainly on the type of the preamplifier and the low pass filter setting. The results of the noise measurement are:

If the bandwidth is 10 kHz (the low pass filter is opened to the widest range), the input noise RMS voltage is less than 12 microVolts (50 microVolts peak-to-peak).

If the bandwidth is limited to 2 kHz with the low pass filter, the input noise RMS voltage is less than 5 microVolts (20 microVolts peak-to-peak).

If the bandwidth is limited to 500 Hz with the low pass filter, the input noise RMS voltage is less than 2.5 microVolts (10 microVolts peak-to-peak).

The difference between amplifier models mostly depends on the quality of the design. Such features as hum noise, square wave transient response, phase response, frequency domain characteristics, ability of parasite oscillations, thermal stability, reliability, etc. are responsibility of the designer. But there is no real difference in the signal to noise ratios of biological amplifiers manufactured by different firms. The signal to noise ratio depends on the internal design of the amplifier integrated circuits. The race of the smaller electronic noise is a race of the semiconductor manufacturers. The designer can choose the best amplifier ICs of the leader semiconductor factories.

Ground topology

There is a general design method in the high gain amplifiers, what is applied in BioAmp, as well. Usually in the biological amplifiers, as in our amplifiers, too (if optical isolators are not used) the Input GND and Output GND points are connected together internally. The resistance between them is less than 0.05 Ohms. However they are signed as different points, because in the interior of the amplifier the ground network forms a linear topology, not a single-point GND (as it is advised in the text-books). The suppression of the hum noise is better if the ground line follows the signal line linearly according to the increasing signal amplitudes from the input to the output. To establish a single-point shielding ground is a good solution at the output end of the signal ground line. Unfortunately the security ground wires are also connected to the metal enclosures of the equipments. The security ground wires are usually hum noise sources for the biological amplifiers (because they usually drive some mains-frequency fault currents from other equipments, from other rooms), but they must not be disconnected, they are compulsory to be used. If you use a mains isolation transformer with symmetrical secondary coil, you can eliminate the disadvantage of the security ground (if in your lab it is allowed to use, please check the local rules). The vibration isolation table, the manipulators, the Faraday-cage, metal parts in the Faraday-cage, the oscilloscope, the PC, the Output GND of the amplifier and the real, separated signal ground line (coming from the earth directly, if it is available) should be connected to this single-point shielding ground. But the ground point of the biological target (the slice chamber or the body of the animal) should be isolated from the shielding ground point (special care should be taken with the metal parts close to the target in the Faraday-cage). The Input GND point of the amplifier is used to provide a low impedance ground to the biological object only. The Input GND point to the biological object is the GND pin at the input of the headstage.

First Time Installation and Setup

In switched off state of the Main Amplifier please connect all the cables: the power cord, the output cables to the PC-based data acquisition system, the Output GND cable to the central ground point of the setup and the optional Input GND cable. Please connect the Main Amplifier and the preamplifier together with the appropriate cable (standard accessory). Please connect the wires from the recording electrodes to the input of the preamplifier. Switch on the Main Amplifier and the system is ready to use.

Front Panel Controls

Since the BioAmp system is modular, custom configurable construction, there is a variety of the front panel controls. In general, the following basic components can be found on the front plate of every BioAmp Main Amplifier. In custom designed amplifiers there can be special, unique controls established, too.

Amplifier Setup Controller: It deals with the parameter setup of the amplifier boards. At least one piece must be in every Main Amplifier. The actual number of the Amplifier Setup Controllers depends on the channel number and the assignment of the channels. For the details see the General Description section.

Digital Offset Voltage Controller: It deals with the digital offset voltage correction of the electrode in the Main Amplifier. It is installed only in the BioAmp DC models. Up to 16 channels one Digital Offset Voltage Controller can complete the task.

Mains switch

Connectors and Controls on the Back Side

Like the front panel controls, the back side controls and connectors of the BioAmp Main Amplifier can also be unique or special. The necessary default connectors are listed below.

Analogue Outputs: BNC connectors and/or IDC sockets to the PC-based data acquisition system.

The pin assignment of the 20-pin, 2.54 mm output wire connector of each 8-channel output sections of the BioAmp amplifier is shown in the end of this booklet.

Dedicated input socket to connect the preamplifier

The pin assignment of the 20-pin wire connectors, what are used to connect the 4-channel or 8-channel preamplifier to the BioAmp are not published. The user must not connect any other equipment into these connectors, only the appropriate products manufactured by Supertech Instruments should be connected. However, if you are interested to know them, please call or email us.

Output GND banana jack

Input GND banana jack

Mains socket

Preamplifiers (in other words Headstages)

Preamplifiers are built into separated small cases, because they should be located close to the biological target in the shielded environment. The enclosures of the preamplifiers are always made of metal to provide a good shielding of the sensitive input circuitry.

The actual choice of the preamplifiers and headstages (very small preamplifiers) manufactured by Supertech Instruments is quite big. All of them can be built with monopolar (single-ended) inputs or differential (instrumentational) inputs. The available possibilities are:

- Monopolar (single-ended) preamp choice: 1 - 16 channels
- Differential ((instrumentational) preamp choice: 1 - 16 channels
- EEG cable-end version preamp choice: 2 - 24 channels

Until now we have developed many different preamplifier versions for the BioAmp system, including special preamplifiers for user demands. If you cannot find the appropriate model for your special task in our actual choice, we will develop a preamplifier especially for you. Our method is, how we improve the features of our BioAmp system, that we collect all the notices, feedbacks and ideas of our customers and we implement their (may be your) knowledge into the features of BioAmp.

The crucial features of the amplifier ICs, what are continuously developed by the semiconductor manufacturers are: noise (signal to noise ratio), offset voltage, offset drift (thermal stability), input bias current, transient response, bandwidth (slew rate). The topologies of the electronic amplifier circuits are similar at the different amplifier manufacturers. The quality of an amplifier is mostly defined by the quality of the first stages. There are no big tricks in the circuitry. The differences of the amplifiers are basically coming from the parameters of the different IC models used in the preamplifiers. Our engineers make huge efforts to study, measure and compare the newest ICs of different semiconductor manufacturers. Supertech Instruments changes the IC models used in the preamplifiers if a better IC model appears on the market. This way we can keep our electronic circuits the best and up-to-date, because always the most sophisticated ICs are implemented in our constructions.

BioAmp Main Amplifiers have got universal, multi-purpose connectors for external preamplifiers. This method gives an opportunity to support all the future preamplifier development projects.

Calibration

Every BioAmp amplifier is calibrated by the factory. You can check its calibration easily by involving a high precision function generator and a calibrated digital storage oscilloscope.

Warranty

Supertech Instruments gives you 5 years of full warranty for electronic products and 3 years of full warranty for mechanical products by default. Longer warranty periods can also be defined and agreed (the actual conditions should be discussed before placing the order).

Supertech Instruments gives you full warranty for its products against defects in materials or workmanship as long as the equipment has been subjected to normal and proper use. During the warranty period, faulty products will be repaired or replaced free of charge provided they are returned to our workshop. Postage of the warranty repair actions is paid by the Customer. The exceptions are the Vibration Isolation Tables. There are special conditions introduced for repairing of Vibration Isolation Tables (see the appropriate User Manual).

Supertech Instruments will undertake the servicing and calibration after the expiration of the warranty period for a nominal fee.

The warranty does not cover the faults made by the user.

The measuring equipments manufactured by Supertech Instruments are for experimental and/or lab animal purposes only and are not intended for human use.

Electrical safety measurements of proper operation of the 115 / 230 V AC mains electric system (from the equipments have been supplied) is the sole responsibility of the user.

You can find the general commercial and warranty conditions in the beginning of the Price List page of our website.

Further Information Sources

As the first step for further technical information please visit our website (www.superte.ch). On the website of Supertech Instruments you can find related products and further information.

On the Download page of our website you can find many more useful documents, technical descriptions and application leaflets to support our products. Please check the list of the available documents.

Technical hotline via email (all of them work):

office@supertechinstruments.co.uk (Supertech Instruments UK Ltd.)
office@superte.ch (Development Department of the Factory)
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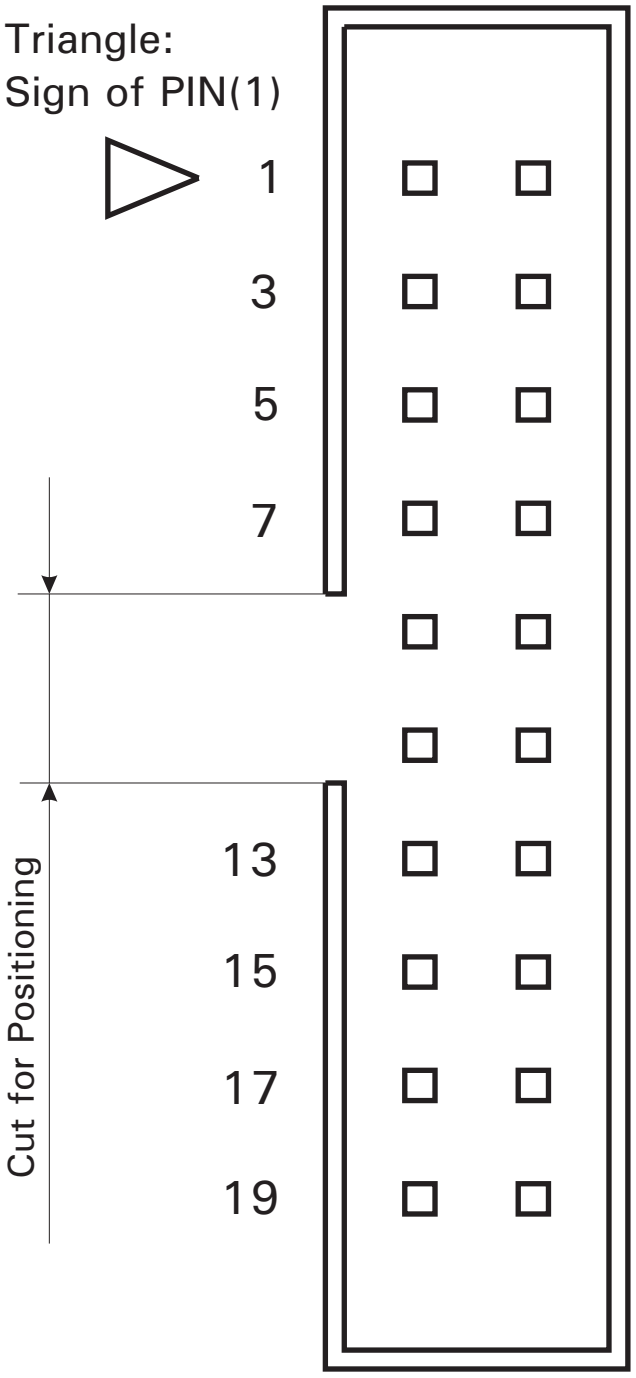
International technical hotline on the phone: +36 20 9234 386

In the past Supertech Instruments used several websites with similar contents for the different affiliates. For the sake of stability and continuity we keep working all the previously used domain names forever, but now they are automatically redirected to this one website presenting our measuring equipments:

www.superte.ch

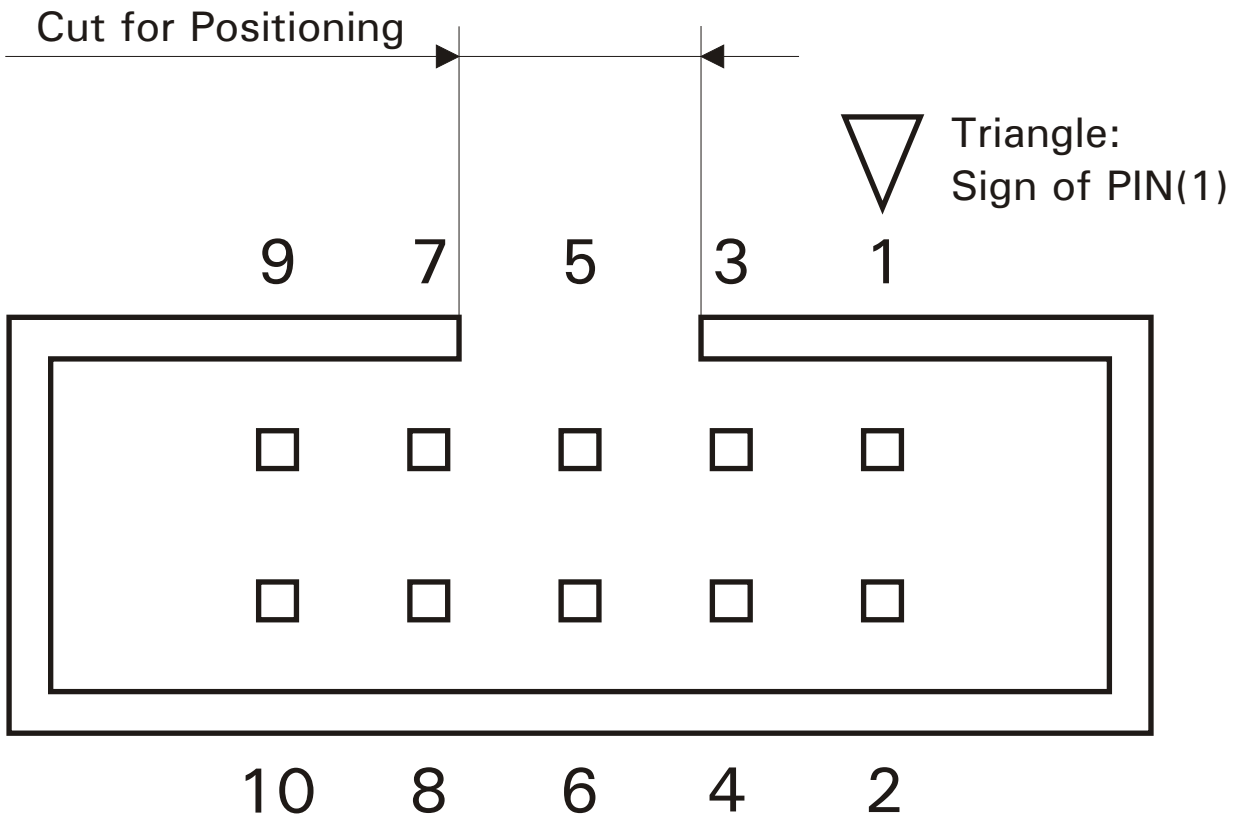


PIN(1): Out GND
PIN(2): Output 1, or 9
PIN(3): Out GND
PIN(4): Output 2, or 10
PIN(5): Out GND
PIN(6): Output 3, or 11
PIN(7): Out GND
PIN(8): Output 4, or 12
PIN(9): Out GND
PIN(10): Output 5, or 13
PIN(11): Out GND
PIN(12): Output 6, or 14
PIN(13): Out GND
PIN(14): Output 7, or 15
PIN(15): Out GND
PIN(16): Output 8, or 16
PIN(17): Out GND
PIN(18): Out GND
PIN(19): Out GND
PIN(20): Out GND

The appropriate 20-pin, 2.54 mm female plug compatible with this output connector is IDS-020-S100-01/P manufactured by E-tec Corp.

Output Connector of each 8-channel sections of BioAmp, V.1

PIN(1): +IN1
PIN(2): - IN1
PIN(3): +IN2
PIN(4): - IN2
PIN(5): +IN3
PIN(6): - IN3
PIN(7): +IN4
PIN(8): - IN4
PIN(9): Input GND
PIN(10): Input GND



Input Connector of the
4-channel Differential Preamplifier
of the DC BioAmp V7.2