

# **TDT Biological Amplifier User's Guide**

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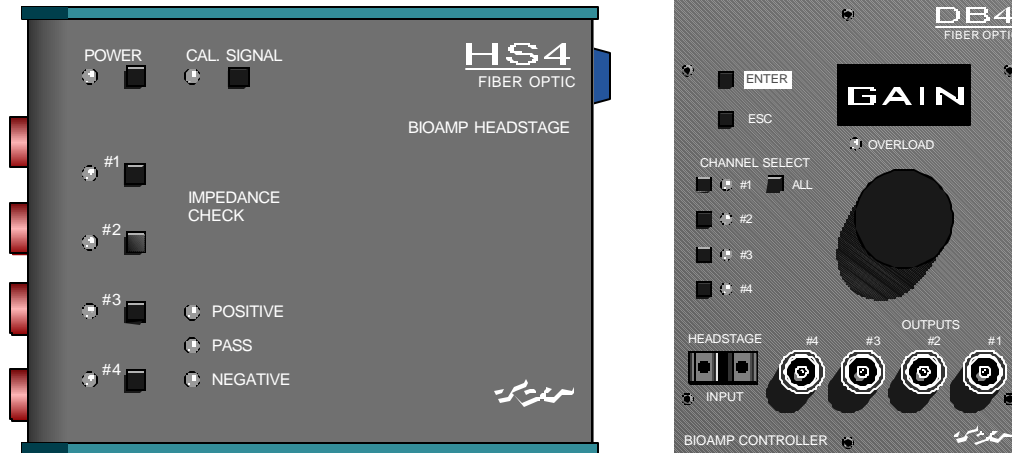
? 1999-2001 TDT



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## Overview

This user's guide covers the basic operation of the TDT BioAmp. Information on programming the BioAmp can be found in the DB4 BioAmp section of the XBUS manual.

The TDT BioAmp consists of a headstage (HS4) that is located at the site of amplification and a controller module (DB4) in a TDT device caddy. The headstage amplifies and digitizes the signal before sending it over the fiber optic cables to the controller where filtering and additional gain are added. The controller can be operated either through the front panel controls, or through programming from a computer and it is used to set gain, filters, and to monitor impedance. The maximum output of the amplifier is  $\pm 10V$ .

The HS4 is configured in one of two ways at the factory for different applications:

1. a low-impedance amplifier for surface electrode applications such as ABRs
2. high-impedance amplifier for extracellular neurophysiology with a special impedance matching probe cable

The DB4 will auto-detect which headstage configuration you are using. Some features, like impedance checking and test signal output, are only found on the low-impedance configuration. These differences will be noted throughout this manual.

# Connections

## **XBUS Device Caddy Installation**

If your BioAmp controller (DB4) is shipped as a separate module, install it in an empty slot in a TDT rack. Otherwise, it will come shipped in a rack and ready to go.

## **Fiber Optic Cables**

Connect the fiber optic cables between the headstage (HS4) and the controller. The duplex fiber optic cables supplied are keyed and can only be installed in one orientation.

## **Electrodes**

### **Low-impedance Headstage**

Connect your recording electrodes to the HS4 headstage. The red connector is (+), the green connector is Ground, and the black connector is (-).

TDT BioAmps are compatible with Grass SafeLead™, Biologic Touchproof™, or other DIN 1.5mm insulated female safety connector style electrodes. REM electrodes are available from TDT.

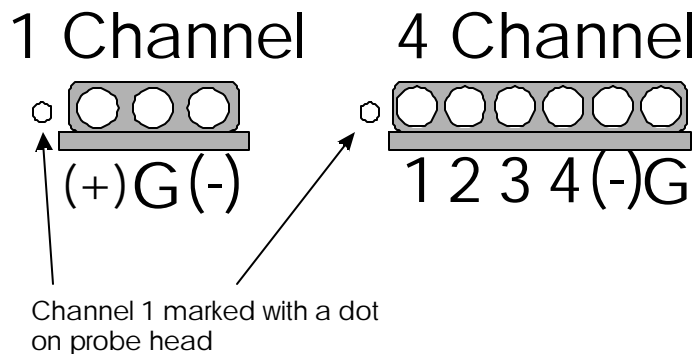
### **High-Impedance Headstage**

A headstage probe cable and connector is supplied with your amplifier. The 9-pin connector connects to the HS4. The electrode connector accepts 1 mm diameter male pins (such as 220-PO2 connectors supplied by FHC).

The probe is sensitive to electric shock. Always ground yourself before handling the probe.

### **High Impedance Probe Electrode Connections**

The electrode connections for the 1-channel and 4-channel probe heads are shown in the diagram below. For orientation, the probe head is marked with a dot next to channel 1. For situations where you do not want differential recording, tie the (-) and G (ground) together.



### High Impedance Probe Leads

The high impedance probes are also supplied with a connector with wire leads to make it easier to connect them to any electrode. Use of this cable is optional.

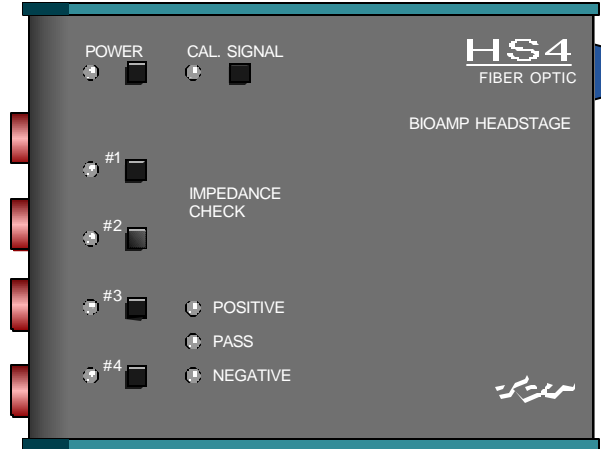
Channel	Wire Color
1 (dot)	Red
2	Orange
3	Yellow
4	Blue
(-)	Black
G	Green

## DB4 Controller Output

Connect the output BNCs of the DB4 controller to your data acquisition system. The output of the DB4 is maximally +/- 10V.



# HS4 Headstage



## Operation

The HS4 headstage is powered by batteries and sends the amplified signal to the DB4 controller through a pair of fiber optic cables. One pair of fiber optic cables is used for all channels on the headstage. The headstage can be used to amplify electrode voltages up to 10 mV.

- Power ON* To turn the headstage on press and briefly hold the Power button.
- Power OFF* To turn the headstage off, press and hold the Power button until the headstage turns off.
- Cal Signal* Calibration signal: The test signal is programmed from the DB4 controller. Press the button once to turn the test signal on, and once to turn it off. This signal also goes on when electrode impedance is measured. This feature is not available on the high-impedance HS4.
- Impedance Check* See the section on impedance measurement for instructions on how to measure electrode impedance from the headstage. The channel buttons (labeled #1, #2, #3, and #4) are used to check impedance. This feature is not available on the high-impedance HS4.

## Analog Clipping

Analog clipping occurs when the amplified signal at the headstage exceeds the maximum signal that can be digitized by the A/D converter. Clipping will cause loss of accuracy in signal amplification.

The red channel LEDs on the headstage illuminate when there is analog clipping on that channel (labeled #1, #2, #3, and #4). If this occurs, decrease the gain through the DB4 controller.

## Battery Power

The low-impedance headstage is powered by 4 AA batteries. For the low-impedance HS4 either alkaline or rechargeable NiCad batteries may be used, but do not mix battery types. Batteries should last for about 35 hours under normal operation. A battery saver mode that turns off the headstage automatically after 2 hours of inactivity is described under the DB4 Controller section.

The high-impedance HS4 is shipped with a Ni Metal Hydride rechargeable battery pack and a charger. Use only the charger that is shipped with your system.

## **Low Battery Power Indicator**

The red Power LED on the HS4 will flash when the battery power is low. The batteries should be replaced when this LED begins to flash.

## **Replacing Batteries**

Batteries should be replaced whenever the red Power LED on the HS4 Headstage begins to flash.

To replace the batteries remove the battery cover from the HS4 headstage, and install new batteries.

## **Recharging the High Impedance HS4**

The high-impedance HS4 is shipped with a rechargeable battery pack and a charger. Fully charged batteries will last approximately 20 hours. The HS4 may be operated while that batteries are charging, however an elevation in low frequency noise may be a problem.

It is a good idea to charge batteries after each use, even if they were used only for a few hours (recharging memory is not a problem with these batteries). It takes 24 hours to fully charge the batteries. If the amplifier will not be used for an extended period of time (more than one week), disconnect the HS4 from the charger to prolong the life of the batteries.

Additional battery packs may be purchased from TDT.

# DB4 Controller



The DB4 Controller runs in one of three modes. The DB4 is actively filtering and amplifying signals in Configuration Mode and Monitor Mode. No signal is output when in Impedance Measurement Mode.

~~☞~~ **Configuration Mode** is used to change gain, filter and other settings.

~~☞~~ **Monitor Mode** is used to monitor signal level on all channels simultaneously.

~~☞~~ **Impedance Measurement Mode** is used to measure electrode impedance. This mode is only available for the low-impedance HS4.

When initially turned on the DB4 will start in Configuration Mode and display 'Gain'. After about 1 minute of inactivity (no settings being changed), the DB4 will switch to Monitor Mode and the green LEDs will cycle through the active channels.

## ***DB4 Configuration Mode***

All of the parameters for the amplifier can be set through the DB4 front panel controls and can be set for an individual channel or for all channels simultaneously. Different channels may have different settings. All settings are maintained in non-volatile memory, and will be retained when the power is off.

### **Changing a setting**

1. Make sure you are not in Monitor Mode or Impedance Measurement Mode. To exit either of these modes and return to Configuration Mode press ENTER or ESC or turn the dial. 'Gain' (or another of the menu choices shown below) will be displayed when you are in Configuration Mode.
2. Select a channel by pressing the channel button (labeled #1, #2, #3, or #4) on the DB4 or press ALL to select all channels.
3. Select a menu item by turning the knob.
4. When you reach a menu item you wish to change, press ENTER. The current value will be shown (if ALL channels are selected, the current value for channel 1 will be shown).
5. Dial in the new value. The new value will be enabled as the dial is turned.
6. Press ENTER to keep it or ESC to discard the change. The display will return to the main menu and display 'Gain'.

**Table of DB4 Configuration Settings**

<b>DB4 Display</b>	<b>Configuration Setting</b>	<b>Range/Function</b>
<b>Gain</b>	Gain	Low impedance HS4 $\times 10^2$ - $\times 10^6$ High impedance HS4 $\times 10^2$ - $\times 10^5$
<b>/HP</b>	High-Pass Filter	5-10 Hz 1 Hz steps 10-100 Hz 10 Hz steps 100-1000Hz 100 Hz steps 1000-5000 Hz 1000 Hz steps
<b>LP \</b>	Low-Pass Filter	5-10 Hz 1 Hz steps 10-100Hz 10 Hz steps 100-1000Hz 100 Hz steps 1000-15000Hz 1000 Hz steps
<b>\NT/</b>	Notch Filter	50, 60, 100, 120, 150, 180 Hz
<b>ImpT*</b>	Impedance Threshold	1-99 k?
<b>Opts</b>	Options SubMenu (Press Enter to enter submenu. Turn dial to select submenu choices)	

**Options SubMenu**

<b>DB4 Display</b>	<b>Configuration Setting</b>	<b>Range/Function</b>
<b>Vcal*</b>	Calibration Signal Voltage	0.1, 1, 10, 100 mV
<b>Fcal*</b>	Calibration Signal Frequency	10, 30, 50, 100, 300, 500, 1000, 3000, 5000 Hz
<b>1/2-Ch</b>	1 or 2-Channel Mode	Low impedance HS4: Places DB4 in 2-Channel Mode High impedance HS4: Places DB4 in 1-Channel Mode
<b>4-Ch</b>	4-Channel Mode	Places DB4 in 4-Channel Mode
<b>BS ↻*</b>	Battery Saver On	HS4 will shut off after 2 hours of no command input to DB4 or HS4
<b>BS ↻*</b>	Battery Save Off	HS4 will only shut off manually

**\* Not available on HS4 configured for high impedance electrodes.**

## Filters

The DB4 has three cascaded filter banks for each channel that implement 2-pole (12 dB/octave) Butterworth filters. There are pre-programmed filter coefficients for low-pass, high-pass, and notch filters that are assigned to specific filter banks. Each channel may have its own filter settings.

You may also download coefficients to any of these filter banks by programming through a computer interface (see the section on programming).

## Impedance Threshold

The impedance threshold is used by the quick impedance checking on the HS4 headstage and DB4 controller. The value can be set to 1-99 k $\Omega$ . Impedance checking is not available on the high-impedance HS4.

## Calibration Signal

The low-impedance HS4 headstage can output a calibration tone with a specified frequency and voltage. The calibration signal is not available on the high-impedance HS4. The calibration tone is turned on and off by pressing the Cal. Tone button on the HS4 headstage. The signal is output through two connectors on the side of the HS4 below the optical fiber plugs.

## 1/2-Ch or 4-Ch Mode

The low-impedance headstage may have either 2 or 4 channels. The high-impedance headstage may have either 1 or 4 channels (note, if you have a 4-channel high-impedance headstage, setting it to two channels will leave 2 channels active). The DB4 controller that is connected to the headstage should be configured to the same number of channels or fewer. The DB4 is shipped with the default set to 1/2-Ch or to the number of channels in the headstage if a headstage is shipped with it. You may wish to run a 4 channel headstage in 2-Channel mode if you want a higher sampling rate. Of course, you will not be able to use channels 3 and 4 of the HS4. See the section on sample rate for more information.

If the headstage has one or two channels:

1. Dial to 'Opts'.
2. Press Enter.
3. Dial to '2-Ch'.
4. Press Enter.


If the headstage has four channels:

1. Dial to 'Opts'.
2. Press Enter.
3. Dial to '4-Ch'.
4. Press Enter.


## Battery Saver

The battery saver is only available for the HS4 configured for low-impedance electrodes. The battery saver mode is either on or off. If it is turned on, the HS4 will be automatically powered down after 2 hours of inactivity on the DB4 and HS4 (i.e. no commands being sent or buttons pressed). The battery saver *does not* check whether there is a signal on the electrodes before shutting down.

To turn on the Battery Saver:

1. Dial to 'Opts'.
2. Press Enter.
3. Dial to '**BS** .
4. Press Enter.

To turn off the Battery Saver:

1. Dial to 'Opts'.
2. Press Enter.
3. Dial to '**BS** .
4. Press Enter.

## DB4 Monitor Mode

### Entering Monitor Mode

Monitor mode is used to monitor whether the signal is being clipped and to check impedances from the controller. The controller will enter monitor mode by default after about 1 minute of no command input to the controller. You can also enter monitor mode by pressing ESC from the main menu. The green channel LEDs will flash in succession when in monitor mode.

### Monitor Mode Display

When in monitor mode the display will indicate whether your signal is being clipped. Each position in the display window corresponds to a different channel. Also, the red LED below the display will illuminate for either analog or digital clipping.

DB4 Display	Meaning
_	more than 10dB from clipping
-	within 10 dB of clipping
^	within 3 dB of clipping
A	Analog clipping
D	Digital clipping

### Example:

_ _ A ^
---------

 Channels 1 and 2 are more than 10 dB from clipping, channel 3 has analog clipping, and channel 4 is within 3 dB of clipping.

### Exiting Monitor Mode

To exit Monitor Mode and return to Configuration Mode, press Enter or ESC or turn the dial on the DB4.

# Impedance Measurement

Impedance measurement is only available on the HS4 configured for low-impedance electrodes. It is not available on the high-impedance HS4.

## ***From the DB4 controller (Impedance Measurement Mode)***

To enter Impedance Measurement Mode, first enter the Monitor Mode by pressing ESC on the DB4. Note that the DB4 will enter Monitor Mode from the Configuration Mode automatically after 1 minute of inactivity.

### **Monitoring Individual Channel Impedance**

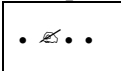
In Monitor Mode, press the channel (#1, #2, #3, or #4) of the channel for which you want to measure the impedance. The impedance for each pair of electrodes for that channel will be alternately displayed with + and - signs for each electrode.

### **Checking Impedance of All Channels Simultaneously**

In Monitor Mode, press and hold the ALL channels button on the DB4. The display will show whether a channel is lower than the impedance threshold. Each position in the display window corresponds to a different channel.

<b>DB4 Display</b>	<b>Meaning</b>
.	less than impedance threshold
⚡	greater than impedance threshold

#### **Example:**

 Channels 1, 2, and 4 are less than the impedance threshold, and channel 3 is greater than the impedance threshold.

### **Exiting Impedance Measurement Mode**

Press the ENTER or ESC or turn the DB4 dial to exit from Impedance Measurement Mode and return to Configuration Mode.

## ***From the HS4 Headstage***

A quick-check impedance measurement is available from the headstage that can be used to check the impedance of single channels or all channels.

### **Check Impedance on Single Channels**

Press the button next to the channel for which you want to measure the impedance. The Calibration Signal will be activated, and its yellow LED will go on.

#### **Impedance Check LEDs**

If the center green OK LED is illuminated, both 'left' and 'right' electrode impedances are less than the impedance threshold set on the controller.

The outer yellow LEDs illuminate when the corresponding channel's impedance is greater than the impedance threshold for the POS and/or NEG electrodes.

#### **Exit from impedance check**

To exit from impedance checking, press the channel button again.

### **Check Impedance on all Channels**

1. Press the Cal. Signal button on the HS4 to turn on the Calibration Signal.
2. Press channel #2 on the HS4 to test channels 1 and 2, or press channel #3 on the HS4 to test channels 1-3, or press channel #4 to test channels 1-4.

### **Impedance Check LEDs**

If the center green OK LED is illuminated, all electrode impedances are less than the impedance threshold set on the controller.

If both outer yellow LEDs (POS and NEG) illuminate, the impedance of one or more channels is greater than the impedance threshold. The red LED next to the channel's with impedance's greater than the impedance threshold will illuminate.

### **Exit from Impedance Check**

To exit from impedance checking all channels, press any channel button.

# Signal Clipping

Signal clipping can occur if the input signal is too large or if there is too much gain on the amplifier. Adjusting the gain setting on the DB4 controller changes the amount of gain on the HS4 headstage (analog gain) as well as gain on the DB4 controller (digital gain). Clipping can usually be eliminated by decreasing the gain.

If you have no analog clipping, but have digital clipping (see discussion under Monitor Mode), you may be able to eliminate the digital clipping by filtering your signal (if it is contaminated by unwanted noise).

# Sample Rate and Group Delay

The one or two channel headstage samples the electrode signal at 48 kHz per channel with a 1.0 ms group delay.

The four channel headstage samples the electrode signal at 24 kHz per channel with a 2.0 ms group delay. The four channel headstage may be run in one or two channel mode for a 48 kHz sample rate and 1.0 ms group delay.

# Other DB4 Display Messages

The DB4 controller will display some other messages while it is booting and initializing, or if there is a communication problem with the headstage.

DB4 Display Message	Meaning
Boot	The DB4 controller is booting.
Lock	The controller is trying to phase lock to the signal from the headstage. If this message stays on the controller, either the headstage is not on, or the fiber optics are not connected correctly.
ACE!	Amplifier communication error.
INIT	Initializing system. After Initializing the DB4 will enter the Configuration Mode and show Gain on the display.