OPERATING INSTRUCTIONS

BRAIN PRODUCTS
Solutions for neurophysiological research

BrainAmp series & BrainAmp MR series

BrainAmp Standard / DC

BrainAmp MR / MR plus

BrainAmp ExG / ExG MR

Operating and Reference Manual
for use in a laboratory and MR environment

Amplifier

Published by	**Brain Products GmbH**		
	Zeppelinstrasse 7	Phone:	+49 (0) 8105 733 84 - 0
	82205 Gilching	Fax:	+49 (0) 8105 733 84 - 505
	Germany	Web:	www.brainproducts.com
Published on*	31. August 2020	Document version	005

*Valid until publication of a new version of this document.

Contents

List of figures

About this manual

This manual describes how to use the BrainAmp MR, BrainAmp MR plus and BrainAmp ExG MR amplifiers and their accessories[1] under laboratory conditions and in an MR environment. Specifically, this manual contains information concerning:

- General installation instructions that you must perform irrespective of whether you want to use the amplifier system under laboratory conditions or in an MR environment.
- Instructions that apply only to the use of the system in the laboratory
- Essential conditions for the safe use of the BrainAmp MR system in the MR environment. These safety conditions are also available as a standalone printed document that you can keep with the equipment.
- Interfaces with the scanner that are necessary for simultaneous EEG-fMRI recordings

This manual forms an integral part of the amplifier system. It must be precisely adhered to in order to ensure that the amplifier system is used as intended, operated correctly and to guarantee the concomitant safety of test subjects, users and third parties. Make sure that this manual is always available to users.

The amplifiers are operated using BrainVision Recorder recording software. You will find a detailed description of the hardware functions that are fully software controlled (impedance measurement, DC offset correction, configuration of the digital ports, setting of the resolution and configuration of the filters) in the User Manual for the Recorder.

Who is the manual intended for?

The current manual is intended for physicians, medical experts and users working in the field of psychological and neurological research. (For details, see section "Intended use" on page 14).

Conventions used in the manual

The manual uses the following typographical conventions:

Italic — Italic text is used to identify menus, menu commands, dialog boxes, options, the names of files and folders and the labels on the products. Italic font is also used to highlight portions of running text.

1. The amplifiers and the accessories supplied by Brain Products are referred to as the "amplifier system" below.

Underscore — Underscored text indicates a cross-reference or a web address.

● — The blue dot indicates the end of a chapter.

The manual also uses the following symbols to help you find your way around:

 The *Personal injury* symbol indicates that incorrect use of the products may result in a health hazard to the test subject, the user and/or a third-party. Incorrect use means non-adherence to the stipulations set out in this manual.

 The *Damage to property* symbol indicates that the incorrect use of the products may bring about a risk of damage to property.

 The *Stop* symbol indicates that you should not carry out a particular action.

 A *note* draws your attention to important (technical) information.

 A *cross-reference* refers to another section or an external document that has a bearing on the running text at this point.

 A *tip* gives you advice, recommends a particular approach or draws your attention to an interesting aspect.

Revision history

Page	*Status*	*Change*
9	New	Manual has been edited throughout to provide clarity and up-to-date information.
57	modified	Perfektan replaces the previous recommended solution.
58	new	Using a disinfectant information added.

Reporting errors and support

We would ask you to report to us without delay any error you find in this manual, any fault in the products or any malfunction that you observe when operating the products and any event where a test subject, user or third party has been injured, however slightly, or could have been injured. To do so, contact your dealer who can also advise you about general questions relating to these products. For technical questions please contact our technical support team: techsup@brainproducts.com.

About the products

The BrainAmp and BrainAmp MR amplifier series

The BrainAmp and BrainAmp MR amplifier series are easy to use, compact and robust. The BrainAmp series is made up of the BrainAmp Standard, BrainAmp DC and BrainAmp ExG, and the MR series comprises the BrainAmp MR, BrainAmp MR plus and BrainAmp ExG MR.

Our amplifiers meet the requirements for reliability, data quality and trouble-free use. There is a huge variety of applications for these amplifiers, including traditional acquisition of EEG and ERP signals, DC acquisition, and the acquisition of polygraph signals such as EMG, ECG and EOG.

Together with their accessories, the amplifiers form a complete, integrated system. When used correctly, according to the *Correct use*, the amplifier system guarantees excellent data quality and the very highest level of comfort and safety for users and subjects alike.

The BrainAmp Standard, BrainAmp DC, BrainAmp MR and BrainAmp MR plus use a referential (i.e. unipolar) measurement principle and are intended for acquiring EEG data with electrode caps.

The BrainAmp ExG and BrainAmp ExG MR use a differential measurement principle and are intended for the bipolar measurement of electrical potentials at the surface of the body (EMG, ECG) as well as for non-electrical measurements (respiration, blood pulse) using electrode input boxes and sensors.

The amplifiers of the MR series can be used in the MR scanner while the scanner is in operation. Only those accessories that have been explicitly approved for this purpose by Brain Products are permitted for use in an MR environment. Further information can be found in ***Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment*** which is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php.?kid=5#dlukat_84.

Intended use

The components of the BrainAmp family are intended to be used for acquiring neuro-/electrophysiological signals (e.g. EEG, EMG, ECG, EOG or signals from other approved sensors) in the context of non-medical applications in order to carry out fundamental or applied research on the basis of neurophysiological methodology and data.

The acquisition of invasive EEG signals is permitted only if

- the acquisition is performed outside of the MR environment,
- the BrainAmp components are powered by the PowerPack (rechargeable battery),
- no other product is electrically connected with the test subject at the same time, and
- no simultaneous electrical stimulation is used.

Invasive electrodes must not be used for recording ECG signals and polygraphic signals with the BrainAmp components.

The components of the BrainAmp family are not medical devices. Use for diagnosis, therapy, monitoring of vital physiological processes (such as cardiovascular functions) or other medical purposes is expressly forbidden.

Correct use

The components of the BrainAmp family are permitted to be used by users in the psychological and neurophysiological research area as well as physicians and medical experts for non-medical applications.

The components of the BrainAmp family are not permitted to be used by unqualified persons (e.g. laymen), persons who cannot read (e.g. due to visual impairment) or understand (e.g. due to a lack of language skills) the manual.

The components of the BrainAmp family are permitted to be used in the following environments: hospitals, clinics, other medical environments, research institutes and other non-medical environments (e.g. at home), provided that all the other stipulations regarding the correct use are met and that the products are used in accordance with their intended use.

The components of the BrainAmp family are not permitted to be used in the following environments:

- vicinity of explosive gases as may be the case in operating theaters, for example,
- oxygen enriched atmospheres,

- underwater (e.g. sea, swimming pool, bath tub) or in environments in which significant amounts of water could enter the components of the BrainAmp family (e.g. under shower, under water-tap).

The components of the BrainAmp family are permitted to be used for healthy and sick adults, children and animals.

Irrespective of any liability on the part of the manufacturer, the relevant national stipulations for operators and other relevant national legislation must be observed.

The user is solely liable for any risks to subjects associated with the investigation, if the product is not used in accordance with the correct use described.

Use together with other products and components

The components of the BrainAmp family may be combined with the following products and co mponents:

For use in and outside of MR scanner rooms[a]:	
Product	**Article number**
GSR-MR Module	BP-02810-MR
RespirationBelt MR	BP-280-0007
3D Acceleration Sensor MR	BP-02820
ExG AUX Box MR Set	BP-110-4000
BrainCap MR	BP-330-4001 (32 channel)

a. Refer to Performing simultaneous EEG-fMRI measurements: Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment for MR safety related labelling.

Not for use in MR scanner rooms	
Product	**Article number**
Passive Ag/AgCl EEG electrodes/caps that are not designed for use in MRI (e.g. BrainCap, 32 channels)	BP-330-1110
actiCAP active EEG electrodes (incl. SplitterBox and ControlBox)	BP-130-1300
Electrode Input Box EIB 64	BP-02200
ExG Input Box (with 16 bipolar ExG channels)	BP-02220
MOVE (32 channel, transmitter and receiver)	BP-08010
StimTrak	BP-110-1000
Temperature sensor	BP-BM-20
TriggerBox	BP-110-9010
TriggerBox Extension	BP-110-9030
Photo sensor	BP-240-1001
Respiration Belt	BP-BM-80
3D Acceleration Sensor	BP-02830
GSR Module	BP-BM-30

Software (on a computer [not to be located in MR scanner room])	
Product	**Article number**
BrainVision Recorder	BP-170-3000
BrainVision RecView	BP-170-2000
BrainVision RecView MRI module	BP-170-2200
actiCAP ControlSoftware[a]	n/a

a. only for BrainAmp Standard and BrainAmp DC.

Requirements to the computer (not to be located in MR scanner room)
The computer to which you connect the amplifier (via the USB adapter) must fulfill EM 62368-1.

In addition to this general overview of the permitted combinations, users must also check that all the conditions applicable to the product in question (e.g. relating to MR compatibility) are fulfilled for the specific combination and specific application (definition of purpose and intended use).

If users combine products other than those listed here then they are responsible for ensuring the safety of test subjects, operating personnel and the environment. If the product data does not immediately make it clear that products can be combined (connected) without danger then the user must contact the relevant manufacturers to ensure that the required safety of all the products involved is not compromised by the intended connection.

Chapter 1 Safety Information

Performing simultaneous EEG-fMRI measurements is subject to strict safety guidelines. The essential conditions for the safe use of the BrainAmp MR amplifiers and accessories in the MR environment are provided as standalone document, ***Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment*** which is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php.?kid=5#dlukat_84.

It is essential that these safety guidelines are followed.

Chapter 2 Installation

This chapter describes the installation steps you must perform regardless of whether you are using the amplifier system under laboratory conditions or in an MR environment (Section 2.1 on page 21).

Section 2.2 on page 34 describes those installation steps which are only relevant if the amplifier system is to be used in a laboratory.

The installation steps that are only relevant for using the amplifiers of the BrainAmp MR series in the context of combined EEG-fMRI measurements are described in Section 2.3 on page 40.

2.1 General installation of the amplifier system

The amplifiers are operated using BrainVision Recorder recording software. Make sure that the most recent version of Recorder is installed on your computer. The most recent version can be found on our website at https://www.brainproducts.com/downloads.php.

The following elements are located on the front panel of all the amplifiers (see Figure 2-1):

- the *Power* LED
- the *Electrode Input* socket for connecting electrode caps and electrodes (see Section 2.1.5)

Figure 2-1. (From bottom to top): Front view of the BrainAmp MR, BrainAmp MR plus and BrainAmp ExG MR amplifiers. The "Power" LED and electrode connector can be found on all three amplifiers. The BrainAmp ExG MR has an additional power output. Note that the BrainAmp ExG MR 8 does not feature this output.

Note that only the BrainAmp ExG/BrainAmp ExG MR with 16 channels is fitted with a power output. The BrainAmp ExG/BrainAmp ExG MR with 8 channels does not feature this output. This power outlet is intended for the connection of the ExG AUX Box.

The pinouts of the power output of the BrainAmp ExG 16 and BrainAmp ExG MR 16 are described in Appendix C on page 73 and on page 68 respectively.

The following elements are located on the rear panel of the amplifiers (see Figure 2-2):

- the *Power* switch for switching the amplifier on and off
- a 2-way connector for fiber optic plugs with locks and protection against polarity reversal
- the *No Sync.* LED

- Integrated 4-way screw-lock power socket

Figure 2-2. Rear view of an amplifier

The amplifier is connected to the computer using a USB 2.0 interface.

To use this interface, first install BrainVision Recorder recording software. When the software has been installed, all the required drivers will be located on your computer.

You will find instructions on installing Recorder in the relevant User Manual.

The following sections provide details on using the USB interface, setting up the power supply using the PowerPack and connecting general accessories.

If you intend using the MR series amplifiers for combined EEG-fMRI measurements, you must perform the following steps outside the MR environment.

2.1.1 Connecting the amplifier using the USB2 Adapter (BUA)

Application in an MR environment – Caution! The USB2 Adapter is not suitable for use in an MR environment. You must therefore always use it outside of the scanner room.

Note that your computer must be equipped with a USB 2.0 port. The USB2 Adapter does not work with a USB 1.0 or USB 1.1 port.

Two versions of the USB2 Adapter are available: The BUA64 for up to 64 channels or a maximum of two amplifiers (see Figure 2-3) and the BUA128 for up to 128 channels or a maximum of four amplifiers.

Figure 2-3. USB2 Adapter for up to 64 channels (top view)

Proceed as follows to use the USB interface:

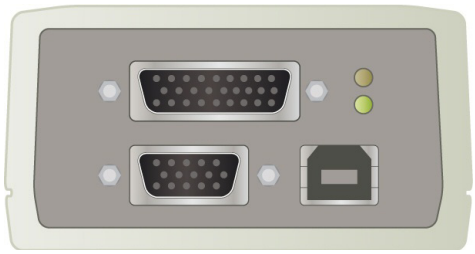
1 Install BrainVision Recorder software as described in the User Manual for Recorder.

2 Connect the USB2 Adapter to the computer using the USB port on the side of the USB2 Adaptor (see Figure 2-4). *Use only the supplied USB cable to do this.*

You will find the pinout for the trigger socket on the USB2 Adapter in Appendix D as of page 79.

You will find a description of the AUX connection pinout in Appendix E on page 81.

Figure 2-4. USB2 Adapter (side view), 26-pin HD D-Sub socket for the trigger cable (top), "AUX" port (bottom left) and "USB" port (bottom right)



3 The computer will inform you that a new hardware component has been detected and will then install the driver for the USB2 Adapter.

Note that Windows® requires that the driver is re-installed for each USB port the first time that the USB2 Adapter is used on a different port.

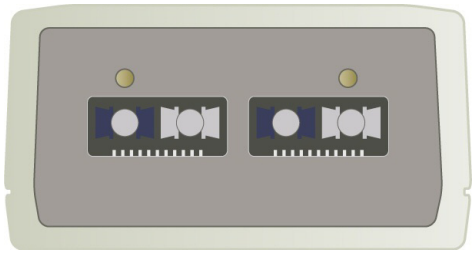
Refer to Section 2.1.2 as of page 26 for detailed information on setting up the power supply using the PowerPack.

4 Connect the amplifier power supply.

The PowerPack must be charged before use. Disconnect the PowerPack from the charger before connecting it to the amplifier.

5 Connect the amplifiers to the relevant connections on the USB2 Adapter using the supplied fiber optic cables (see Figure 2-5). On the BUA64, these are the connections marked *Fiberoptic 1* and *Fiberoptic 2* and on the BUA128, they are the connections marked *Fiberoptic 1* to *Fiberoptic 4*.

Figure 2-5. USB2 Adapter (side view), 2-way connectors for fiber optic plugs with locks and protection against polarity reversal and "no Sync." LEDs



If you are using both unipolar (BrainAmp Standard/BrainAmp DC/BrainAmp MR/MR plus) and bipolar (BrainAmp ExG/BrainAmp ExG MR) amplifiers, always connect the bipolar amplifiers to the USB2 Adapter after the unipolar amplifiers. If, for instance, you are using two BrainAmp MR plus and one BrainAmp ExG MR 16 amplifier, first connect the BrainAmp MR plus amplifiers to the Fiberoptic 1 and Fiberoptic 2 inputs of the BUA128. Then connect the BrainAmp ExG MR amplifier to the Fiberoptic 3 input.

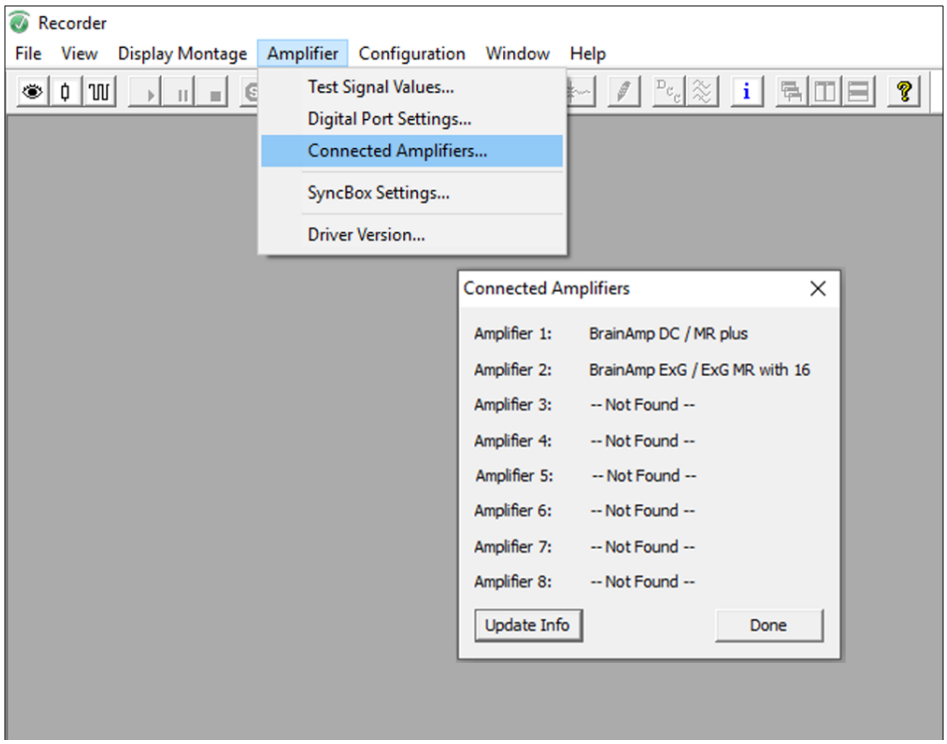
It is possible to use more than four BrainAmps at the same time. For this two USB2 Adapters and a dualBUA Adapter Cable are required. The dualBUA setup is only recommended for laboratory applications and further details can be found on page 76.

6 After you have connected the amplifier(s) to the USB2 Adapter, switch on the amplifier(s) using the *Power* switch on the back of the amplifier. The *Power* LED lights up on the front of the amplifier.

7 Start Recorder. If the system is working correctly, the *No Sync.* LED located on both the USB2 Adapter and the amplifier goes off. If the LED lights up during the measurement, this indicates that no synchronization has been detected while data is being received and sent. This could indicate that there is either a problem with the fiber-optic cables or their plugs or with the sockets on the USB2 Adapter or the amplifier. Extreme attenuation on the fiber optic cables (if these are too long, for instance) can also result in a failure to detect synchronization.

You can check which amplifiers are connected and what order they are connected in by using the *Amplifier › Connected Amplifiers...* menu item in Recorder. The connected amplifiers are listed as follows (see Figure 2-6).

Figure 2-6. Listing of the connected amplifiers in Recorder



2.1.2 Powering the amplifier using the PowerPack

The PowerPack (see Figure 2-7) has a rechargeable battery.

Figure 2-7. PowerPack, front view

Figure 2-8. PowerPack, rear view

Only use the supplied Charger V9 for charging the PowerPack.

Charging the PowerPack before initial operation

⚠ ***Application in an MR environment – Caution!*** The PowerPack is also intended for use in the MR environment. ***The Charger V9 is, however, not suitable for use in an MR environment. You must therefore always charge the PowerPack outside the MR environment.***

It is possible to charge the battery at temperatures between 10 °C and 30 °C. You should ideally charge the battery at room temperature.

Proceed as follows:

1. Connect the Charger V9 to the blue socket on the front of the PowerPack.
2. Connect the Charger V9 to the line power supply. Only use power sources which match the specifications of the charger.
   - ▷ The *Power* LED (green) shows that power is being supplied to the PowerPack.
   - ▷ The *Charge* LED (yellow) glows when the PowerPack is charged.
3. As soon as the rechargeable battery is fully charged, the yellow *Charge* LED goes out. (Empty batteries may take up to 17 hours to fully charge.)
4. Disconnect the Charger V9 from the PowerPack. (Note that for safety reasons, it is not possible to use an amplifier while the charger is connected.)

⚠ **Damage to property**

If you are charging several PowerPacks at the same time, do not stack them on top of each other in order to prevent them from overheating.

If you do not use the PowerPack immediately after you have charged it, leave it connected to the charger. You should also charge the PowerPack even when you are not using it. The PowerPack can be trickle charged and cannot be overcharged. Keeping the PowerPack charged prevents harmful deep discharge and has no negative impact on the overall service life of the PowerPack.

Rechargeable batteries wear out over time so keep in mind that they may take longer to charge.

Connecting the PowerPack to the amplifier

To use the PowerPack, connect it to the amplifier as follows:

For detailed information on positioning the amplifier and the PowerPack in the scanner room, refer to the separate Performing simultaneous EEG-fMRI measurements Safety Manual.

- Connect the gray socket on the rear of the PowerPack (Figure 2-8 on page 27) with the PowerSupply Adapter using the PowerPack Cable.
- The green *Operate* LED on the rear of the PowerPack indicates that a supply voltage is present.

The PowerPack is now ready to be used.

When fully charged and with two amplifiers connected, the battery life of the PowerPack is around 15 hours, doubling to around 30 hours if only one amplifier is connected. Keep in mind that the battery life is likely to decrease over time. If the operating voltage falls below the permitted minimum voltage of the amplifier, the green *Operate* LED on the rear of the PowerPack goes off.

Using and storing the PowerPack

You can use the PowerPack at temperatures of between 10 °C and 40 °C. To get the best performance from the rechargeable battery, you should always use the PowerPack at room temperature.

Damage to property

Do not expose the PowerPack to temperatures below 0 °C or above 40 °C or to bright sunlight. If the PowerPack is exposed to a temperature of above 40 °C, allow it to cool slowly to its operating temperature. At temperatures below 0 °C, the electrolyte can freeze, which will destroy the battery.

Damage to property

Under no circumstances use third-party accessories, as these can destroy the rechargeable battery. Only use original chargers and accessories from Brain Products.

Personal injury

To avoid injury or burns, never allow metal objects to touch the battery contacts and never short-circuit the battery contacts.

2.1.3 Simultaneous recording of trigger signals via the USB2 Adapter

You will find a description of the digital port pinout in Appendix D as of page 79.

Refer to the Recorder User Manual for information on configuring the digital port.

The USB2 Adapter has a 16-bit digital port for the simultaneous recording of trigger signals. The trigger signals are recorded as markers by Recorder. The interface is designed as a 26-pin HD D-Sub sockets.

The digital port is configured from the Recorder software. The length of the trigger pulse that is required depends on the sampling rate selected in Recorder and must be greater than the length of the sampling interval, otherwise it is not possible to write any markers. For example, at a sampling rate of 5 kHz, the length of the trigger pulse must be > 200 µs.

Note that the digital port only supports pulse mode. Toggle mode is not supported. Also note that the digital port only accepts TTL input signals. Serial input signals are not supported. Note that the TriggerBox can also be used to handle and merge triggers arriving from different sources. For further information about the TriggerBox please contact our technical support team on techsup@brainproducts.com.

Trigger pulse voltages must comply with the TTL specification. *Voltages above the permitted pulse voltage will destroy the digital port.*

Damage to property

Brain Products supplies standard trigger cables with the amplifier system. You can connect the standard trigger cables to the parallel port of the computer on which the stimulation software is running and in this way record stimulation markers. *In this context, note that it is not sensible to install and use the stimulation software on the computer that is used to record the EEG data.*

The digital port of the amplifier system is designed only to receive triggers. *Never connect the USB2 Adapter to the trigger input of stimulation equipment using the trigger cable.*

Personal injury

The standard trigger cables can include an additional BNC interface for an additional trigger output (e.g. volume trigger or TMS trigger).

You will find information on recording volume triggers during combined EEG-fMRI measurements in Section 2.3.

2.1.4 Use of fiber optic cables between the amplifier and the USB2 Adapter

The amplifier and the USB2 Adapter are galvanically isolated by means of duplex fiber optic cables. Ensure that the fiber optic cables are firmly plugged into the amplifier and the USB2 Adapter.

To ensure trouble-free operation, make sure that you route long (20 m) fiber optic cables permanently in cable ducts (in the case of combined EEG-fMRI measurements: from the scanner room to the control room).

Take great care when handling fiber optic cables. *Damaged cables impact negatively on the operational safety of the system.*

Damage to property

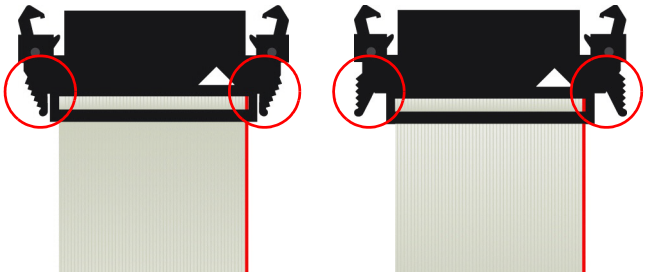
- Avoid sharp bending radiuses (< 25 cm) when storing and using the cables.
- Make sure that you do not tread on or run over fiber optic cables that are lying on the floor.
- Do not touch the exposed ends of the cables in order to avoid soiling and degrading correct operation of the cables.
- We recommend that you do not exceed a maximum cable length of 20 m for the fiber optic cable(s) between the USB2 Adapter and the amplifier(s).

2.1.5 Connecting electrode caps and electrode input boxes

The front panel of the amplifier has a socket marked *Electrode Input* for connecting electrode caps (Laboratory or MR environment) or electrode input boxes (laboratory only). These are connected using the supplied ribbon cables. For BrainAmp systems purchased after April 2020 a round rather than flat ribbon cable is supplied; the connectors are the same on both types of cable. The plugs on the ribbon cables are fitted with clamps and are self-locking. Ensure that the clamps are open before you insert the plug (see Figure 2-9, left). As soon as you push the plug into the socket, the clamps automatically engage to prevent the plug from becoming disconnected inadvertently, e.g. if the ribbon cable is pulled.

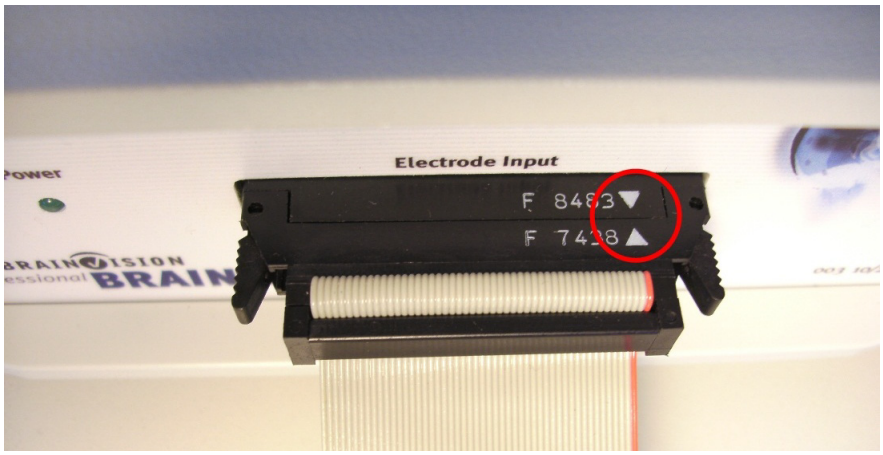
Always ensure that the plug is pushed home fully. The clamps must be engaged and point outwards (see Figure 2-9, right). To remove the plug from the socket, press both clamps at the same time. The plug is released automatically.

Figure 2-9. Open (left) and engaged (right) clamps on the ribbon cable connectors



Furthermore, the connectors on the ribbon cables feature arrows which indicate the orientation with which the connector must be plugged into the socket. Ensure that the arrow on the plug is aligned with the arrow on the *Electrode Input* socket (see Figure 2-10).

Figure 2-10. Arrow on the plugs of the ribbon cables and on the amplifier socket



Electrode caps

You can connect electrode caps to the amplifier in two different ways: Either using multi-way plugs (e.g. BrainCap, BrainCap MR and actiCAP) or using individual plugs (e.g. EasyCap) in combination with an electrode input box (laboratory environment only).

You can connect electrode caps of the BrainCap (MR) type directly to the unipolar amplifiers using the supplied ribbon cable. The actiCAP is connected to the amplifier using the actiCAP ControlBox (laboratory use only). If your cap has more than 32 channels, make sure that you connect the multi-way plugs to the amplifier in the correct sequence (i.e. 1 through 32 to amplifier 1, 33 through 64 to amplifier 2, etc.).

If you are using bipolar amplifiers (BrainAmp ExG/BrainAmp ExG MR with 8 or 16 channels) you need an ExG AUX Box for connecting the bipolar channels and sensors. The ExG AUX Box is connected to the amplifier using the supplied ribbon cable. For laboratory (non-MR) applications it is also possible to use an ExG Input Box for bipolar channels, further information can be found in Section 2.2.2 as of page 37. However, note that if you wish to use sensors (such as the GSR MR module), you require the ExG AUX Box (see Figure 2-11), which has 8 bipolar and 8 AUX channels. Note that it is only possible to use sensors with the BrainAmp ExG/BrainAmp ExG MR 16, and not with the BrainAmp ExG/BrainAmp ExG MR 8.

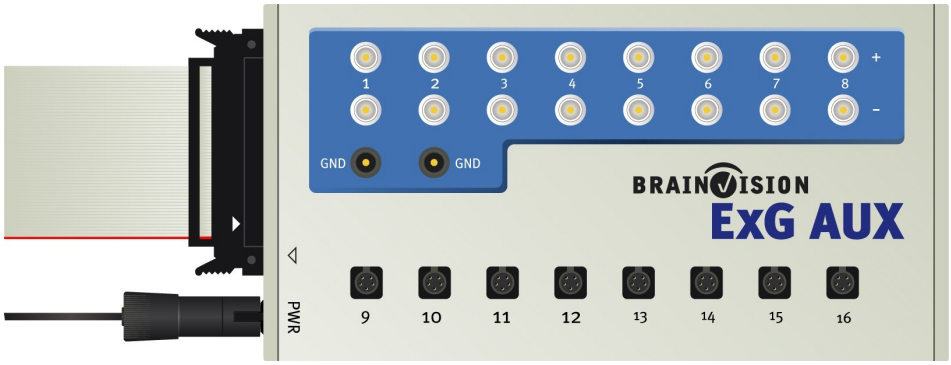
If you are using your BrainAmp ExG MR 8 or BrainAmp ExG MR 16 for Carbon Wire Loop (CWL) measurements, you do not require the ExG AUX box, the connector box for the CWLs can be connected to the BrainAmp ExG MR with the supplied ribbon cable. A detailed explanation for how to set up the Recorder workspace for CWL measurements can be found in the Recorder manual.

Note that it is only possible to use sensors with the BrainAmp ExG/BrainAmp ExG MR 16, and not with the BrainAmp ExG/BrainAmp ExG MR 8.

You will find instructions for configuring the AUX inputs in Recorder User Manual.

You will find a description of the pinouts of the sensor connections and the *PWR* connector of the ExG AUX Box in Appendix C on page 69.

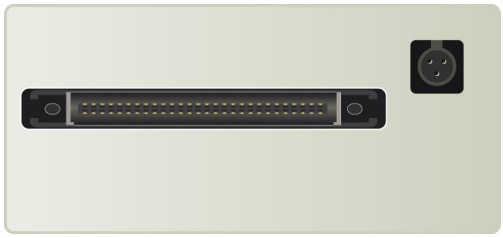
Figure 2-11. ExG AUX Box (top view) with 8 bipolar inputs (1 through 8) and 8 AUX inputs (9 through 16)



The pinouts of the power output of the BrainAmp ExG 16 and BrainAmp ExG MR 16 are described in Appendix C on page 73 and on page 68 respectively.

To supply the sensors with power, connect the *PWR* input of the ExG AUX Box (see Figure 2-12) to the power output of the BrainAmp ExG/BrainAmp ExG MR 16 bipolar amplifier using the supplied 3-way power cable. The power output is marked *4.5 V DC Output*.

Figure 2-12. ExG AUX Box (side view), connection for ribbon cable (left) and "PWR" input for the power supply (right)

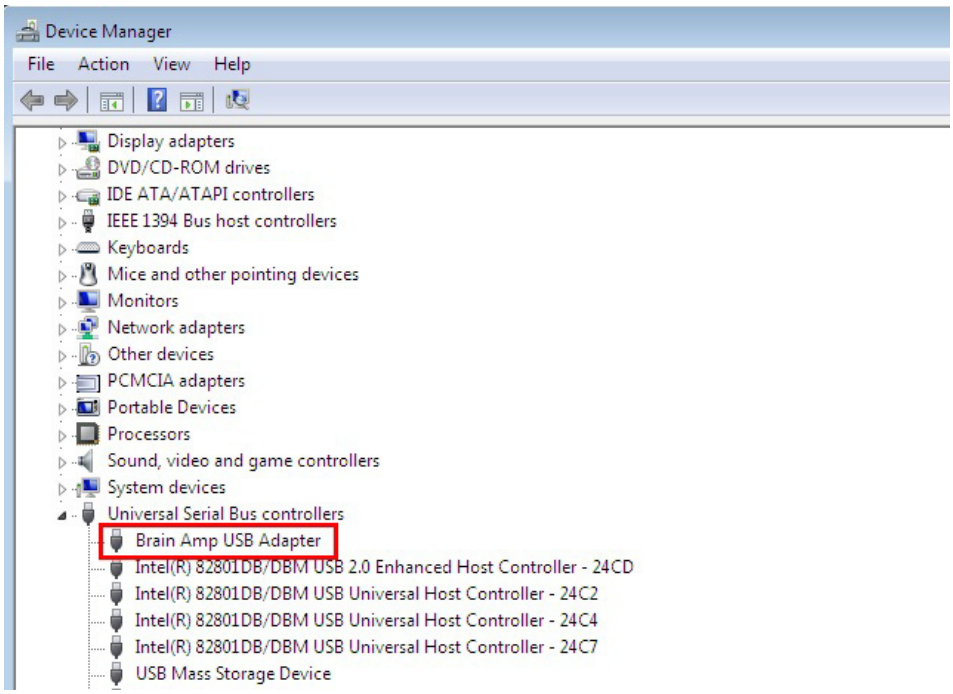


2.1.6 Checking the installation on operating system level

To check whether installation has been successful on the Windows® level, open the Device Manager from the Control Panel.

The USB2 Adapter appears as the *Brain Amp USB Adapter* in the *Universal Serial Bus controllers* section in the Device Manager (see Figure 2-13).

Figure 2-13. Windows® Device Manager, showing the USB2 Adapter



2.1.7 Checking the installation at the level of the recording software

To check whether the connected amplifiers are detected correctly by Recorder and are ready for operation, proceed as follows:

1. Connect the amplifier(s) to the USB2 Adapter.
2. Connect the USB2 Adapter to your computer (see Section 2.1.1 as of page 23).
3. Switch on the amplifier(s). The *Power* LED on the front panel of the amplifier lights up (green).
4. Choose *Amplifier › Connected Amplifiers...* from the menu.
5. The *Connected Amplifiers* menu in Recorder lists the amplifiers which are connected and ready for operation (see Figure 2-6).

2.2 Installation instructions for items specific to the laboratory environment.

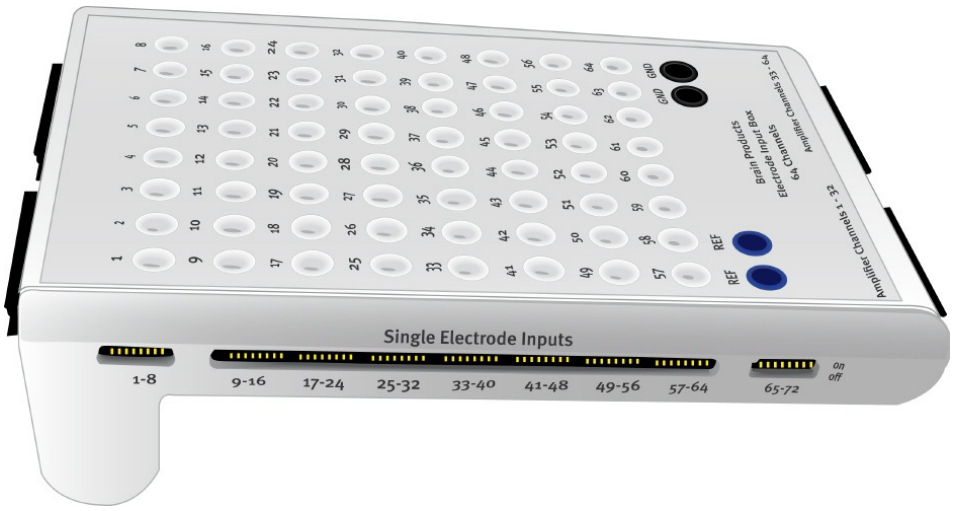
Some items in the BrainAmp family are exclusively for use in the laboratory environment; they are MR Unsafe and were not designed for use in the MR environment. This section of the manual describes these items that are only to be used under laboratory conditions.

2.2.1 *Electrode Input Box EIB64-A*

> ⚠ ***The Electrode Input Box EIB64-A is designed only for acquiring EEG signals under laboratory conditions. You must therefore never use it in the context of combined EEG-fMRI measurements.***

The Electrode Input Box EIB64-A (see Figure 2-14) allows you to connect not only individual electrodes, but also electrode caps with multi-way plugs to the amplifier.

Figure 2-14. Electrode Input Box EIB64-A



Individual electrodes

The individual electrodes are plugged into the corresponding 64 individual inputs provided.

⚠ **Damage to property**

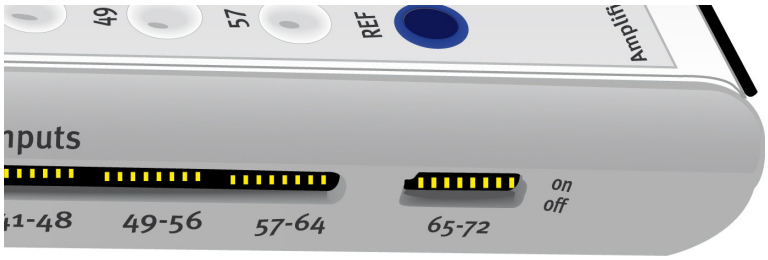
You should use only standard commercially available individual electrodes with safety socket connectors (1.5 mm touchproof connector in accordance with DIN 42802).

Electrode caps with multi-way plugs

You connect electrode caps with multi-way plugs to the inputs marked *Cap Electrodes 1 – 32* and *Cap Electrodes 33 – 64*.

There are DIP switches located on the side of the box (see Figure 2-15). These are used to select the signal from the electrode connected through the multi-way plug for each channel individually. The *off* position denotes that both the individual electrode and the electrode connected using the multi-way plug are used. The *on* position denotes that only the signal from the individual electrode is used (factory setting).

Figure 2-15. DIP switches on the Electrode Input Box



If you do not wish to use the electrodes connected using the multi-way plug, you must switch the DIP switch for the relevant electrode to *on*. Choose this setting in order to disable a faulty electrode in the cap that is connected using the multi-way plug and to make measurements for this channel using an individual electrode.

Connection to the amplifier

The supplied ribbon cable is used to connect the Electrode Input Box EIB64-A to the amplifier: Connect the cable to the *Electrode Input* socket on the amplifier and then connect the amplifier to the *Amplifier Channels 1 – 32* output of the Electrode Input Box EIB64-A. The *Amplifier Channels 33 – 64* output is for use with the optional second amplifier.

If you require more than 64 channels or more than two amplifiers for your experimental setup, and therefore need to use several EIB64-A boxes, you must ensure that the boxes are assigned to the amplifiers correctly and connect the two reference electrodes to each other and the two ground electrodes to each other (see Figure 2-16 f.).

Figure 2-16. Two EIB64-A Electrode Input Boxes with the reference and ground electrodes connected to each other (top view)

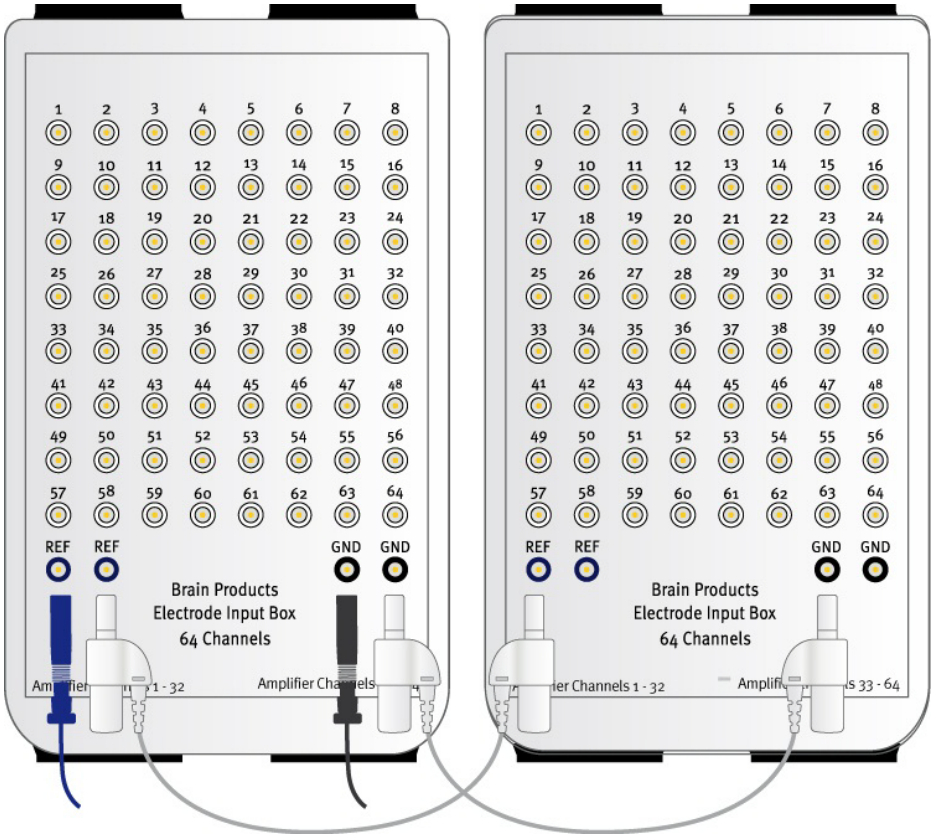
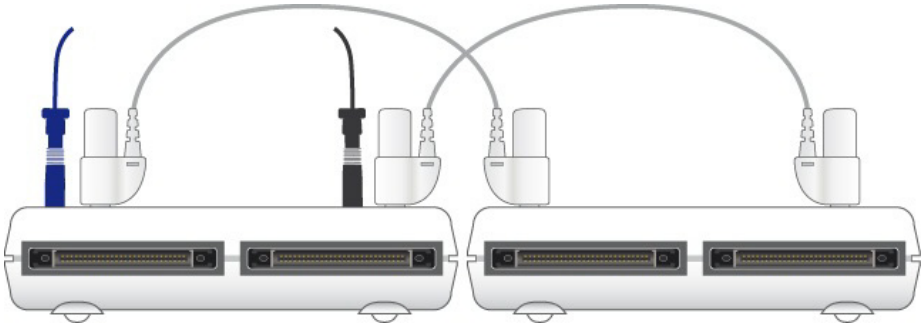


Figure 2-17. Two EIB64-A boxes with the reference and ground electrodes connected to each other (side view)



2.2.2 ExG Input Box

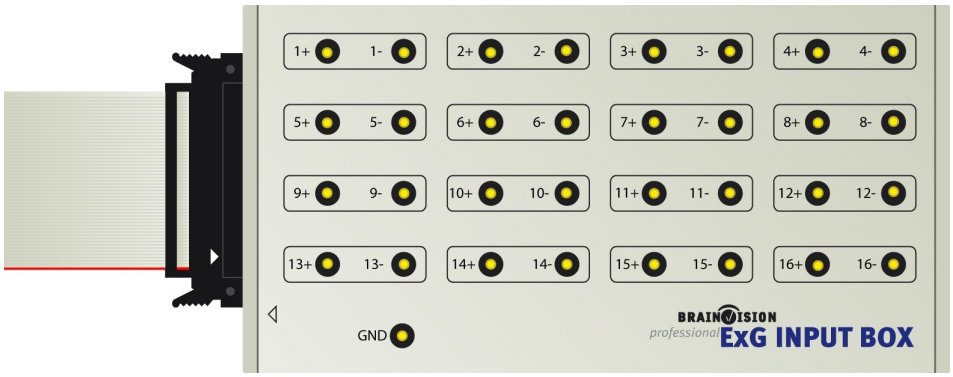
The ExG Input Box is designed only for acquiring EEG signals under laboratory conditions. You must therefore never use it in the context of combined EEG-fMRI measurements.

The ExG Input Box (see Figure 2-18) allows you to connect individual electrodes to the BrainAmp ExG/BrainAmp ExG MR amplifier. Connect the ExG Input Box to the amplifier using the ribbon cable supplied.

Damage to property

You should use only standard commercially available individual electrodes with safety socket connectors (1.5 mm touchproof connector in accordance with DIN 42802).

Figure 2-18. ExG Input Box



2.2.3 Interface for transcranial magnetic stimulation (TMS)

TMS trigger signals

If you are recording EEGs during TMS, you should record the trigger signals of the TMS stimulator.

TMS stimulators generally provide these trigger signals as TTL trigger pulses at BNC outputs. The length of the TTL trigger pulses must be longer than the sampling interval of the EEG recording. (At a sampling rate of 5 kHz, the length of the trigger pulse must be > 200 µs.) For further information refer to the user documentation provided with your TMS stimulator.

If the trigger pulse is of sufficient length, you can use the trigger cable. On the one hand, this allows an HD D-Sub connector on the digital port of the USB2 Adapter to be connected to the BNC output of the TMS stimulator. On the other hand, it allows stimulation systems to be connected to the parallel port of the computer.

Note that the digital port of the amplifier system is designed only to receive triggers.

Personal injury

Never connect the USB2 Adapter to the trigger input of stimulation equipment using the trigger cable.

If the length of the TTL trigger pulses from the TMS stimulator is shorter than the sampling interval of the EEG recording, the TriggerBox offers a stretching function for the 8th and 16th bits which can be used for this purpose.

It is possible to block the amplifier input for the duration of the TTL trigger pulses. You can use this method for simultaneous acquisition of TMS and EEG data. In order to do so, you require a special trigger cable. In this event, please contact our technical support team. You will find the contact details for our technical support team on page 11.

TMS synchronization

You can phase synchronize the clock signals of the TMS stimulator and the EEG amplifier using TMS stimulators of the type "PowerMag Research". For details, refer to the PowerMag user documentation.

2.2.4 Combining more than four amplifiers with the dualBUA Adapter Cable.

You have the option of combining two USB2 Adapters and thus using up to eight amplifiers in your experimental setup. However, we do not recommend this for use in the MR environment.

Please note that it is not possible to combine two BUA64s; use one BUA128 if you wish to use a total of four amplifiers. There are two possible combinations of USB2 Adapters (see Table 2-1).

Table 2-1. Possible combinations of two USB2 Adapters in an experimental setup

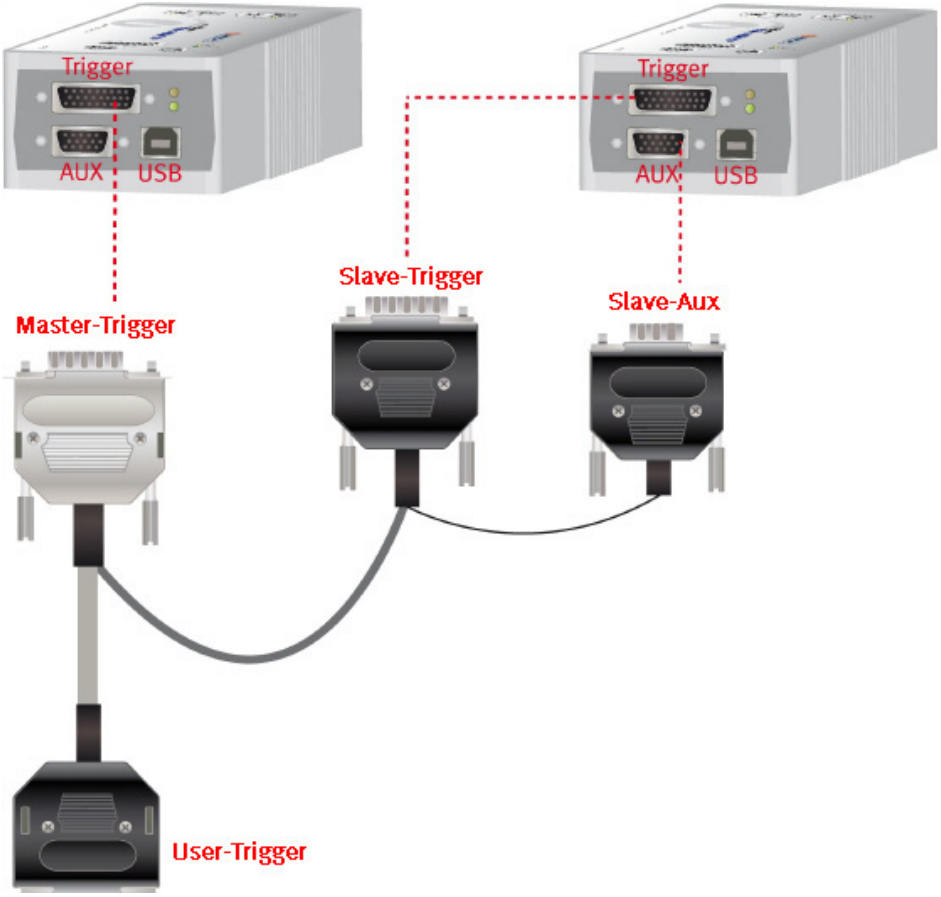
First USB2 Adapter	Second USB2 Adapter
BUA128	BUA64
BUA128	BUA128

To use two USB2 Adapters, in addition to the general installation procedure described in Section 2.1.1 on page 23, you need the supplied dualBUA Adapter Cable (see Figure 2-19).

Proceed as follows:

- **a** Connect the dualBUA Adapter Cable to the relevant trigger connection (see Figure 2-19) of each of the first and second USB2 Adapters.
- **b** Then connect the dualBUA Adapter Cable to the AUX connection of the second USB2 Adapter.
- **c** Tighten the securing screws on all the connectors of the dualBUA Adapter Cable.
- **d** Then connect the two USB2 Adapters to your computer using the supplied USB cables.

Figure 2-19. Connecting two USB2 Adapters using the dualBUA Adapter Cable



If you are using two USB2 Adapters in your experimental setup, you must ensure that all the fiber optic connections on the first USB2 Adapter are occupied before you connect the amplifiers to the second USB2 Adapter. If you do not do this, Recorder will issue a warning.

If, for instance, you wish to use six amplifiers in your experimental setup, it is not possible to connect three amplifiers to the first USB2 Adapter and the other three amplifiers to the second USB2 Adapter. Instead, you must connect the first four amplifiers to the first USB2 Adapter and the remaining two amplifiers to the second USB2 Adapter. The fiber optic connections (and hence the channels) are counted in ascending sequence, as illustrated in Table 2-2.

Table 2-2. Assignment of the channels to the USB2 Adapters in an experimental setup with six amplifiers, one BUA128 and one BUA64

BUA no.	Fiber optic connection	Channel numbers
1	Fiberoptic 1	1 to 32
	Fiberoptic 2	33 to 64
	Fiberoptic 3	65 to 96
	Fiberoptic 4	97 to 128
2	Fiberoptic 1	129 to 160
	Fiberoptic 2	161 to 192

2.3 Installation instructions for items specific to the MR environment for simultaneous EEG-fMRI

This section describes the installation steps that are required if you want to perform combined EEG-fMRI measurements. These mainly relate to the interfaces to the scanner. These interfaces synchronize the systems using the SyncBox and to allow the simultaneous recording of volume triggers provided by the scanner.

Refer to ***Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment*** for detailed information on the safe use of the amplifier system in the MR environment. It is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php.?kid=5#dlukat_84.

You will find information on the software configuration for the SyncBox in Recorder User Manual.

The technical data for the SyncBox can be found in the BrainAmp Operating and Reference Manual for use in laboratory environment.

2.3.1 Synchronizing the systems using the SyncBox

The SyncBox is used in order to synchronize the sampling rate of the amplifier with the scanner clock system. The aim is to achieve phase synchronicity between the two clock systems. This facilitates optimum correction of scanner related artifacts in the EEG data.

The SyncBox system comprises the SyncBox Main Unit (see Figure 2-26 on page 45) and the SyncBox Scanner Interface (interface between the Main Unit and the MR scanner, see Figure 2-21 on page 43).

The SyncBox Scanner Interface directly receives pulses coming from the scanner's gradient clock board. The frequency of the incoming signal must be a maximum of 30 MHz and must be

an integer multiple of 5 kHz. It is equipped with two BNC connector plugs. (Note that, Siemens scanners do not use BNC connectors and require a special adapter that is supplied with the SyncBox.)

The SyncBox system is not suitable for use in an MR environment. You must therefore always use the SyncBox Main Unit, SyncBox Scanner Interface and associated cables outside the scanner room.

Personal injury

Always route the cables to the SyncBox Main Unit and the SyncBox Scanner Interface outside the scanner room.

The SyncBox Scanner Interface galvanically isolates the SyncBox Main Unit from the scanner in order to prevent any negative impact on the scanner clock system. *Nevertheless, as the operator of the scanner, you must obtain the scanner manufacturer's official approval for establishing a connection of this type. Furthermore, you should check with the scanner manufacturer or local technician to make sure that you have selected the correct clock output before using the SyncBox system.* Certificates from scanner manufacturers are available on request.

Installing the recording software

You require Version 1.10 or higher of Recorder in order to operate the SyncBox system. If this version is not installed on your computer, install the most recent version of Recorder before connecting the SyncBox to the computer.

Connecting the SyncBox to the scanner and the amplifier

Proceed as follows to install the SyncBox system:

1. Connect the SyncBox Main Unit to the computer using the USB cable supplied.

   Note that your computer must be equipped with a USB 2.0 port. The SyncBox will not function with a USB 1.0 or USB 1.1 port.

2. The computer detects the SyncBox using the Windows® plug-&-play function and informs you that it has detected a new hardware component.

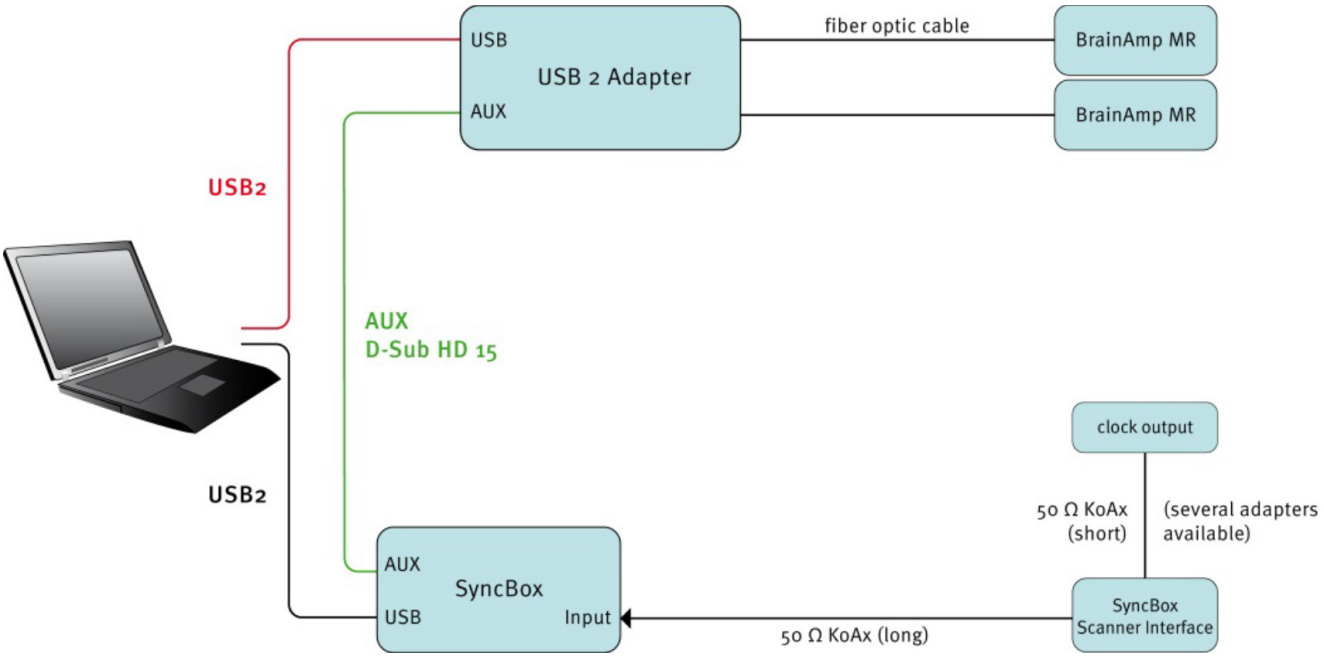
3. Allow the installation program to search for a suitable driver, which is located in the folder *C:\Windows\System32\Setup\Brain Products\BrainAmp*.

4. The driver is installed automatically.

   Note that Windows® requires that the driver is re-installed for each USB port the first time that the SyncBox is used on a different port.

Figure 2-20 shows a diagram of the connections between the SyncBox Main Unit, SyncBox Scanner Interface, amplifier and scanner.

Figure 2-20. Connections between the SyncBox Main Unit, SyncBox Scanner Interface, amplifier and scanner



The SyncBox is supplied with a short and a long 50 Ohm coaxial cable that you can use to connect the SyncBox system to the scanner. Proceed as follows:

You will also find instructions for connecting the SyncBox on our web site at https://www.brainproducts.com/downloads.php ("How to Set-Up the SyncBox").

1 Connect one end of the short 50 Ohm coaxial cable to the clock signal output of the scanner.

2 Connect the other end of the short 50 Ohm coaxial cable to the *Input* port of the SyncBox Scanner Interface (see Figure 2-22).

3 Connect one end of the long 50 Ohm coaxial cable to the *Output* port of the SyncBox Scanner Interface (see Figure 2-23).

4 Connect the other end of the long 50 Ohm coaxial cable to the *Input* port of the SyncBox Main Unit (see Figure 2-24).

   When the connection to the SyncBox Main Unit is established, the *PWR* LED on the *Output* port of the SyncBox Scanner Interface lights up green. The SyncBox Scanner Interface is now ready for operation.

5 The SyncBox Main Unit has a number of connectors on either side. Connect the BNC cable from the SyncBox Scanner Interface to the 50 Ohm BNC connector labeled *Input* (see Figure 2-24).

   Next to the BNC *Input* port, there is a 15-pin HD D-Sub output labeled *AUX*.

   The *Signal* LED is also on this side of the SyncBox Main Unit. It lights up yellow when the SyncBox Main Unit receives a signal from the SyncBox Scanner Interface.

6 On the other side of the SyncBox Main Unit there are two ports and the *PWR* LED (see Figure 2-25). The *AUX* port is the counterpart to the HD D-Sub output labeled *AUX*. Connect this port to the *AUX* output of the USB2 Adapter using the supplied short cable with two 15-pin HD D-Sub plugs. This connection is required for SyncBox operation since the SyncBox Main Unit and SyncBox Scanner Interface are supplied with power via this cable. The clock signal generated in the SyncBox Main Unit for the amplifier is also transferred to the USB2 Adapter via this cable.

7 Finally, connect the USB port of the SyncBox Main Unit (see Figure 2-25) to the computer using the USB cable supplied. See Figure 2-26 for an overview of cables connected to the SyncBox Main Unit.

Figure 2-21. SyncBox Scanner Interface with cables connected (top view)

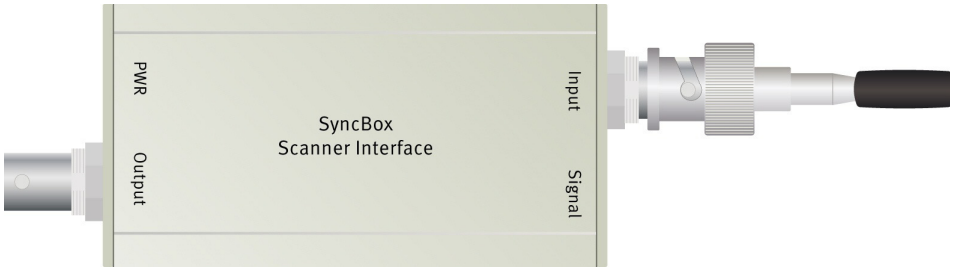


Figure 2-22. SyncBox Scanner Interface (side view), yellow "PWR" LED (left) and "Input" port for connection to the scanner (right)

Figure 2-23. SyncBox Scanner Interface (side view), green "Signal" LED (left) and "Output" port for connection to the SyncBox Main Unit (right)

Figure 2-24. SyncBox Main Unit (side view), "Input" port for connection to the SyncBox Scanner Interface (left) and "AUX" socket for peripheral components (right)

Figure 2-25. SyncBox Main Unit (side view), "AUX" socket for connection to the USB2 Adapter (left) and "USB" socket for connection to the computer (right)

Figure 2-26. SyncBox Main Unit with cables connected (top view)

2.3.2 Recording volume triggers (volume markers) using the trigger cable

Correction of scanner artifacts is facilitated if volume triggers (volume markers) are recorded together with the EEG data. Volume triggers identify the start of an imaging volume (or in some cases a slice). They are generally supplied by the scanner hardware in the form of electrical or optical pulses. The volume triggers are recorded as markers by Recorder.

Note that toggle mode is not supported.

If the volume trigger is supplied as an electrical pulse (TTL), you can connect the supplied trigger cable directly to the volume trigger output of the scanner if the pulse length is sufficient (> 200 µs at an amplifier sampling rate of 5 kHz). If the pulse length is not sufficient, the TriggerBox offers a stretching function for the 8th and 16th bits which can be used for this purpose.

2.3.3 Conversion of optical trigger pulses

If the scanner supplies an optical pulse rather than an electrical pulse, you must convert it to an electrical pulse using a converter.

A converter such as this allows you to connect the trigger input of the USB2 Adapter to the optical volume trigger output of the scanner. Note that the TriggerBox offers an optical input which can be used for this purpose. For further information on the TriggerBox please contact our technical support team on techsup@brainproducts.com.

2.3.4 Testing of the interfaces between the scanner and amplifier system

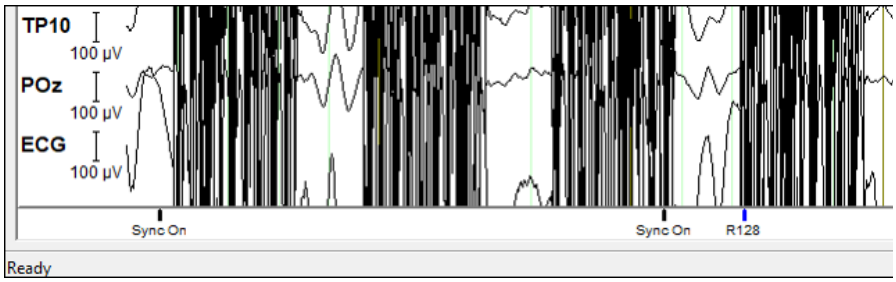
Before starting the measurement, check whether the two interfaces to the scanner (clock signal via SyncBox and volume trigger via trigger cable) are working properly. To do this, connect a least one amplifier to the USB2 Adapter.

Note that it is necessary to connect the SyncBox to the scanner clock system in order to check synchronization and triggering. It is not, however, necessary for the amplifier to be located in the scanner room. Neither is it necessary to connect an electrode cap.

Clock synchronization is indicated on the SyncBox Scanner Interface (green *Signal* LED), and "Sync On" markers are written in monitoring mode in Recorder (see Figure 2-27).

Start a functional MRI sequence to check whether volume triggers are being recorded. In monitoring mode in Recorder you should see the volume triggers at the bottom of the display. (see Figure 2-27).

Figure 2-27. "Sync On" markers and (example) volume markers in the EEG data (in Monitoring mode in Recorder)



Chapter 3 Operation of the amplifier system

The amplifier and its accessories have been tested for electrical safety as per IEC 60601-1. Nevertheless, conductive parts of the electrodes and their connectors, including the neutral electrode, must not come into contact with other conductive parts including ground.

If several components are connected to each other, additional hazards may arise, for instance as a result of the accumulation of discharge currents. If you connect our products together with other products – including non-medical devices – this results in a new overall system. The responsibility for error-free and safe operation lies with you as the operator of the overall system.

If you have any questions about setting up the system or about particular combinations of products, you can contact your dealer or our technical support team at any time. You will find the contact details for our technical support team on page 11.

3.1 Operation of the amplifier system in a laboratory environment

3.1.1 Shutting down the amplifier under normal conditions

Proceed as follows to shut down the amplifier:

1. Switch off the power supply to the amplifier.
2. Disconnect the electrode cap from the amplifier.
3. Remove the electrode cap from the person's head. To do this, hold the loop of the chinstrap and pull the cap backwards over the person's head.

3.1.2 Shutting down the amplifier in emergencies

If you need to break off acquisition due to an emergency, proceed as follows:

1. Disconnect the electrode cap from the amplifier.
2. Remove the electrode cap from the person's head. To do this, hold the loop of the chinstrap and pull the cap backwards over the person's head.

You should also pay attention to the BrainCap Operating Instructions or the user documentation for the electrode caps which you use.

3.2 Operation of the amplifier system in an MR environment

3.2.3 3.2.1 Shutting down the amplifier under normal conditions

1. Switch off the amplifier and disconnect amplifier from battery (Power-Pack).
2. Disconnect the electrode cap, sensors and other equipment from the amplifier(s).
3. Move the scanner table.
4. Remove the head coil.
5. Help the subject up from the scanner bed and escort them from the room.
6. Remove the cap and sensors from the subject.

3.2.4 Release the test subject from the scanner in an emergency

If you are required to stop the experiment and release the subject from the scanner in an emergency situation please do the following:

1. Stop the scan.
2. Disconnect the electrode cap, sensors and other equipment from the amplifier(s).
3. Move the scanner table out of the bore.
4. Remove the head coil.
5. Help the subject up from the scanner bed and escort them from the room.
6. Remove the cap and sensors from the subject.

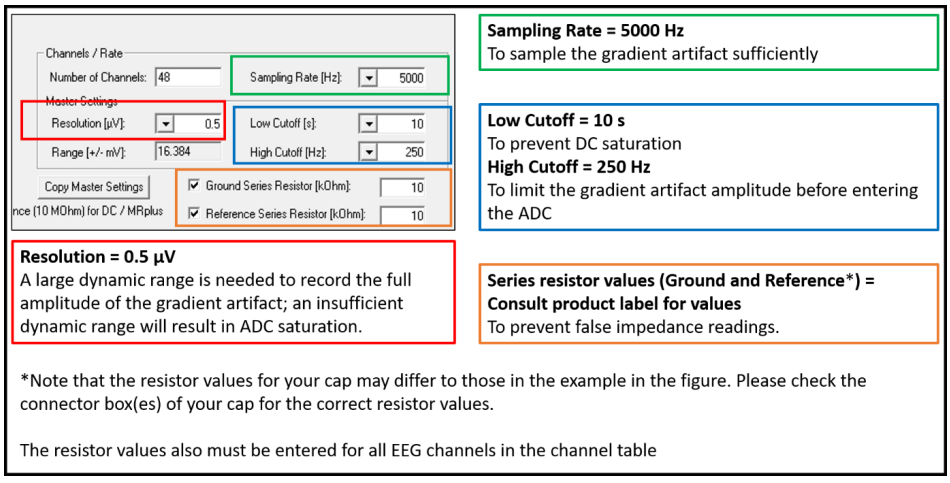
Chapter 4 Optimizing the data quality for combined EEG-fMRI measurements with the BrainAmp MR / MR plus

The experimental setup has an impact on safety for EEG-fMRI recordings and this topic is covered in detail in ***Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment*** which is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php.?kid=5#dlukat_84. Here we cover aspects of the setup that are related to optimizing data quality.

MR imaging and EEG recording have a reciprocal impact on data quality. Fortunately, artifacts in the MR data caused by the amplifier and the electrode cap are not significant. They do not present a problem for MR image quality or image processing in EEG-fMRI studies. This is due to the materials used and the construction of the amplifier and its accessories being optimized for use in the MR environment. This has been certified accordingly by Siemens and Philips, two of the leading manufacturers of MR scanners. However, the EEG data are significantly affected by scanner related artifacts resulting from changes in the strength and direction of the magnetic fields used during scanning or from movement of the equipment or volunteer in the static magnetic field. The quality of artifact correction, using the Artifact Average Subtraction (AAS) method, depends on several factors that we can optimize during the setup of the experiment. These include:

- Synchronization of the scanner and amplifier systems by means of the SyncBox (see Section 1.1 as of page 17)
- Recording of volume triggers (volume markers) provided by the scanner (see Section 2.3.2 on page 45)
- Correct amplifier settings in the Recorder workspace. An example is given in Figure 4-1 and further details can be found in the BrainVision Recorder user manual:

Figure 4-1. Configuration of the amplifier settings in a Recorder workspace for simultaneous EEG-fMRI recordings



- Record in AC mode unless the DC component of the signal is essential to answering your research question (in DC mode, you must enter appropriate parameters for DC offset cor-

rection: further details can be found in the Recorder user manual). Note that DC mode is only available for the BrainAmp MR plus, and not the BrainAmp MR.

- Do not use any software filters when recording the data (e.g. the Raw data saving filters and the Display filters)
- Make sure impedance is low at all electrodes. Also check that a plausible physiological signal is present for each channel; this is the best way to see whether you have a good connection between the electrode and your volunteer.
- All cables must be as short as possible and be routed in a straight line along the Z axis (head-foot axis) of the scanner.
- Makes sure cables are routed taut and straight. For example, if you are using more than one amplifier you can secure the incoming ribbon cables flush with each other using tape.
- Operation of the scanner causes vibrations that can be transmitted to the amplifier(s) and/or cables. Avoid vibrations by securing the amplifier(s) and cables with sandbags or tape.
- Many factors can cause interference in the EEG data. It is worth taking some time to identify sources of noise in your scanning environment. Here are some things to consider:
  - In some scanners the helium pump can cause electrical noise. If this is the case, consider switching off the helium pump during simultaneous EEG-fMRI measurements. Note that this should be discussed with the person responsible for the scanner at your facility or with the scanner manufacturer.
  - The air conditioning in the scanner bore can also cause electrical interference. If this is the case, you can consider switching it off, but keep in mind any effect that this will have on patient comfort.
  - Other equipment in the scanner room, for example medical monitoring equipment if you do your research in a medical facility, could cause interference in the EEG data; check the environment for possible sources.
  - Surrounding environment (e.g. footsteps, elevators close by)
- Where possible select suitable test subjects who are made familiar with the experimental setup and the recording environment.
- Make sure the test subject is positioned comfortably and minimise head movement by using cushions or padding inside the head coil (as you would for a regular MRI scan).
- Always explain to the test subjects that it is theoretically possible for the electrodes and cables to heat up and that they can press the emergency bell if they experience this.
- Follow all usual guidelines and recommendations for MRI measurements in terms of making sure that the test subject is safe and comfortable during the experiment.

Chapter 5 Maintenance, cleaning, functional testing and disposal

5.1 Safety checks and maintenance

The operator is not obliged to undertake regular safety-related checks of our equipment in accordance with applicable national regulations.

Repairs or repeat testing as laid down in VDE 0751-1/IEC 62353 may only be carried out by Brain Products.

In principle, the amplifier is completely maintenance-free. However, it is recommended that you apply the test signal at regular intervals (approx. once a month) in order to ensure that the product is functioning correctly.

If any pins or connections on the products are dirty or if you should notice any damage on the products, return them to Brain Products. You will find the contact details for our technical support team on page 11.

5.2 Function check

Application in an MR environment – Caution! Prior to January 2014, the signal tester is not suitable for use in an MR environment. From January 2014 the signal testers are labeled as MR Conditional and can be used in the MR environment under the conditions described in Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment. Please check the label on your device to see whether it can be used in the MR environment.

You can use the supplied signal tester and test signal mode in Recorder to check whether any channels are no longer functioning correctly.

Note that there is a separate signal tester for the BrainAmp/BrainAmp DC/BrainAmp MR/BrainAmp MR plus and for the BrainAmp ExG/BrainAmp ExG MR (see Figure 5-1 and Figure 5-2). The signal tester for the BrainAmp ExG/BrainAmp ExG MR is explicitly labeled *ExG*. Always use the appropriate signal tester for testing the amplifier.

Figure 5-1. Signal tester for BrainAmp Standard, BrainAmp DC, BrainAmp MR and BrainAmp MR plus

Figure 5-2. Signal tester for BrainAmp ExG and BrainAmp ExG MR

During the signal test, a test signal is injected into all input channels of the amplifier using the signal tester. If the representation of individual channels in Recorder deviates from that of the rest, you should check whether the settings for these channels differ from those used for the other channels in the workspace you are using. For detailed information on configuring workspaces, refer to the Recorder User Manual. If you have any questions in this regard, please contact our technical support team. You will find the contact details on page 11.

If you are not fully convinced of the results of the functional test using the signal tester, record the data delivered by the signal tester and send it to our technical support team.

Prepare recording of the test signal as follows:

1 Set up a test workspace as described in the User Manual for Recorder and make the following settings in the workspace:

   a *Number of Channels* text box: 32 channels for the unipolar amplifiers BrainAmp Standard, BrainAmp DC, BrainAmp MR and BrainAmp MR plus (see Figure 5-3) or 8 or 16 channels for the BrainAmp ExG (MR) 8 or BrainAmp ExG (MR) 16 (see Figure 5-4).

Figure 5-3. Specifying the number of channels in the Recorder workspace for the BrainAmp MR amplifier test

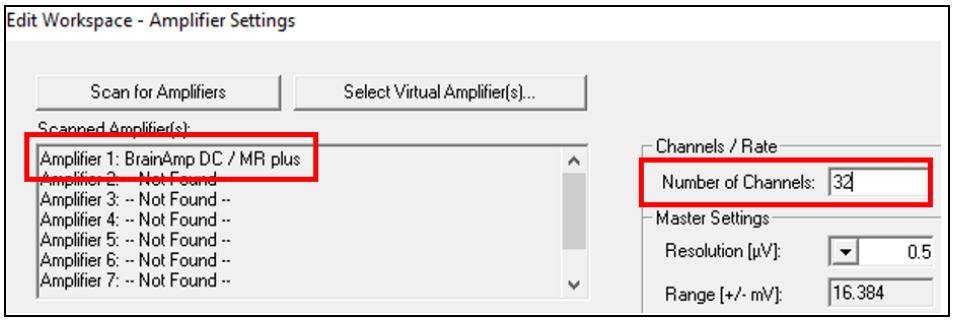
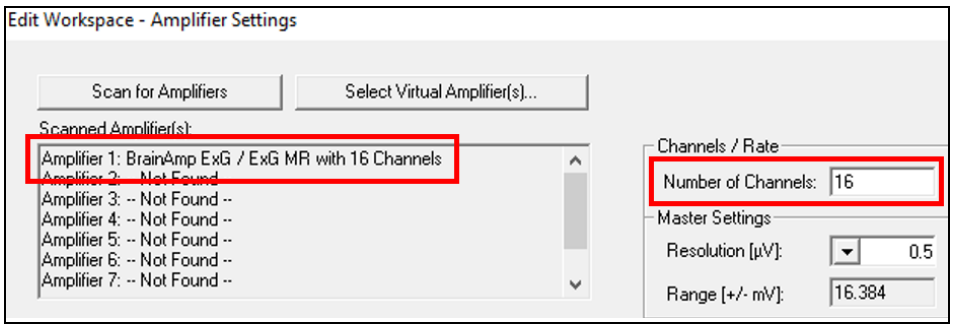


Figure 5-4. Specifying the number of channels in the Recorder workspace for the BrainAmp ExG MR 8 amplifier test



   b *Sampling Rate [Hz]* = 5000 Hz

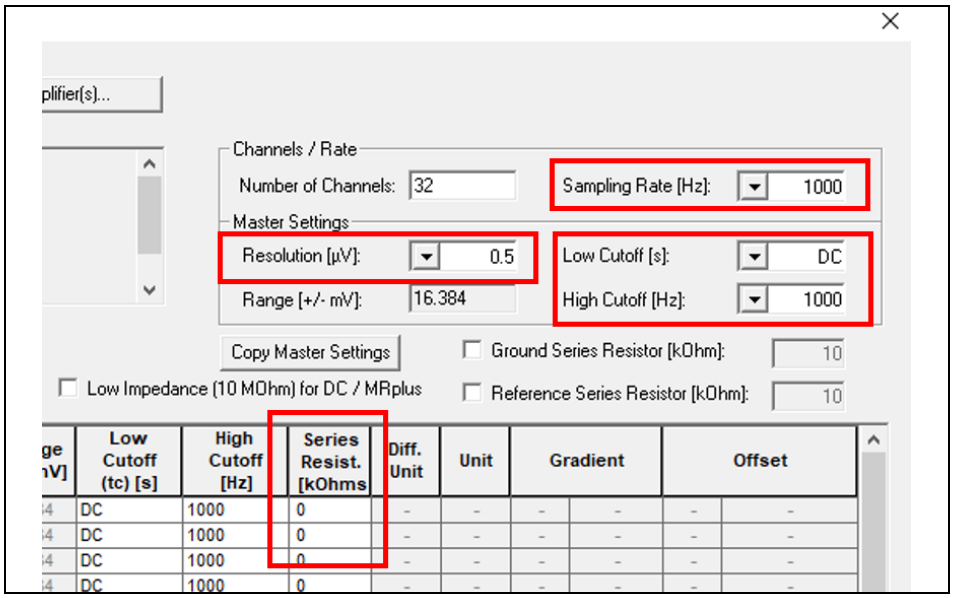
c *Low Cutoff [s]* = DC

d *High Cutoff [Hz]* = 1000 Hz

e *Resolution [µV]* = 0.5

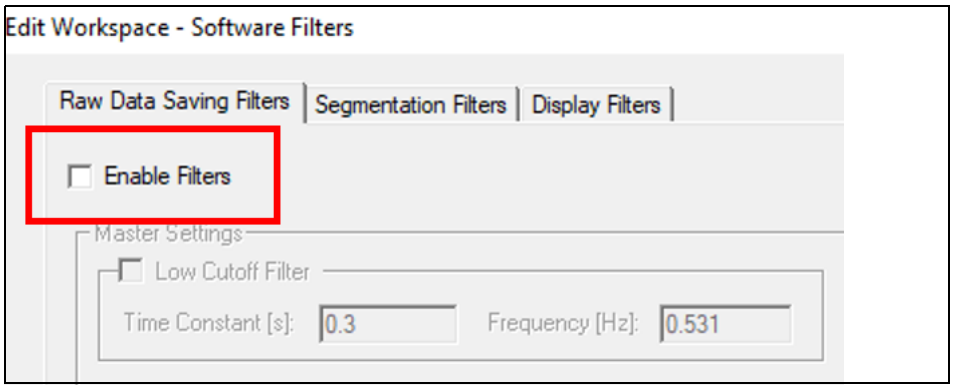
f Series resistors (EEG, REF, GND) = 0 kOhm

Figure 5-5. Settings in the Recorder workspace for the sampling rate, filter, resolution and series resistors



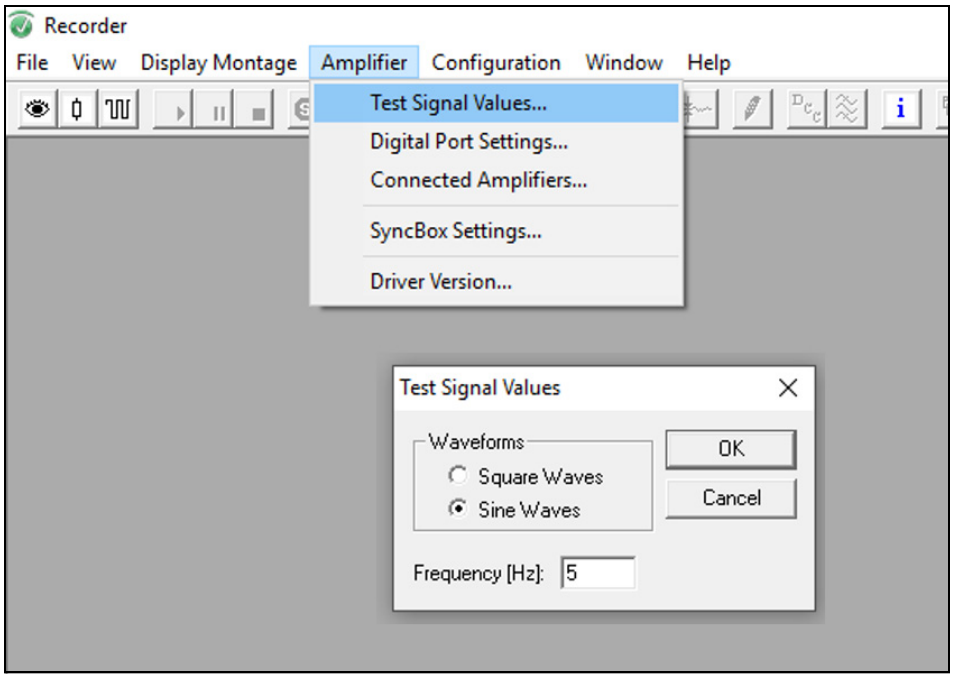
g Disable the *Raw Data Saving Filter* option (see Figure 5-6).

Figure 5-6. Disabling the "Raw Data Saving Filters" option



2 Choose Sine Waves as the test signal form and 5 Hz as the frequency (see Figure 5-7).

Figure 5-7: Specifying the form and frequency of the test signal



3 Only ever connect one amplifier at a time to the computer port.

4 Use the ribbon cable to connect the signal tester to the amplifier's *Electrode Input* socket.

Note that there is a separate signal tester for the BrainAmp Standard/BrainAmp DC/BrainAmp MR/BrainAmp MR plus and for the BrainAmp ExG/BrainAmp ExG MR (see Figure 5-1 and Figure 5-2 on page 52).

5 Start Recorder in test signal mode. Check that all channels are receiving a signal. The test signal has a voltage of approximately 100 μV_{pp} in sinusoidal mode and approximately 50 μV_{pp} in square-wave mode. It is recommended that you check these values on a regular basis.

The test signal is not calibrated. It can only be used for a global function test but not to check the specified measurement precision of the product.

6 Record data for 30 seconds. Use the serial number of the amplifier as the name of the EEG file. (You will find the serial number on a label on the amplifier.)

To make the results of the signal test available to our technical support team, proceed as follows:

1 Create one ZIP archive file for each amplifier (containing the files with the following extensions: .vhdr, .eeg, .vmrk).

2 To ensure that your firewall does not block the archive file, change the file name extension to .piz.

3 Send the archive files to our technical support team together with a description of the problem.

5.3 Cleaning

5.3.1 Amplifier, accessories and connection cables

Never clean the products when the test subject is connected to them or when they are connected to the power supply.

Personal injury

You can clean the amplifiers and accessories with a damp cloth and domestic detergent. If necessary, you can also use compressed air to clean out the plugs and sockets of the products.

Do not, however, bring the plugs and sockets into contact with moisture (never wipe them with a damp cloth).

Damage to property

Never clean the amplifier and its accessories under running water. Do not use any other cleaning agents or any sterilization methods.

Damage to property

5.3.2 Electrode caps and electrodes

Store the electrodes in a dry, dark place.

Clean the cap and electrodes under running water using a toothbrush. If the water in your region is hard, you should then rinse the electrodes in distilled water. Dry the electrodes and cap gently by wrapping them in a towel. Any residual dampness can dry in the air. Avoid washing the chest and chin straps and the contact surfaces of the cable connectors each time, as this will reduce their service life.

If you wish to disinfect the cap and the electrodes, soak them for approximately 15 minutes in a 3% Perfektan TB solution. Please do not forget to rinse them under running water afterwards.

If the Ag/AgCl pellet in the electrodes has come into contact with greasy material (e.g. perspiring fingers), you can clean it using alcohol.

A brown oxidation film can form on the Ag/AgCl pellet of electrodes that have been inadequately cleaned or that are only used rarely. Carefully brush or rub the film off using a non-metallic material (abrasive paste, fine emery paper). The sinter pellet is solid and 1 mm thick, which means that the surface can be restored several times without detriment. Then clean the electrodes as described.

The sinter electrodes are not particularly suitable for ultrasound cleaning. You should therefore use this method as rarely as possible.

Do not use any hot sterilization methods (e.g. autoclave) since this may damage the electrode cable insulation.

Damage to property

Chlorination of the electrodes is unnecessary and has a detrimental effect on their function.

The electric cables have been designed for limited tension forces. *Avoid any other stresses such as knotting and crushing.*

If you have significant difficulties achieving acceptable resistances when you place the electrodes, replace the affected electrode with a different one (non-MR caps only. BrainCap MRs must be returned to Brain Products for repair/electrode replacement).

5.3.3 *Using a disinfectant*

For Electrodes

For active and passive electrodes, electrode caps and sensor electrodes, using “Perfektan TB” disinfecting agent (within the EU) and “Envirocide” disinfecting agent (outside of the EU) is recommended. Please adhere to the recommended exposure time and safety precautions as stated by the manufacturer of these products. Be sure to always rinse equipment thoroughly after disinfection procedures and let air dry. Please note that stronger agents will speed up deterioration of products.

For Surfaces

For disinfecting the surfaces of products (amplifiers, batteries, adapter boxes, etc.), we recommend wiping them down with a tissue drenched in a 70% concentration of isopropyl alcohol (commonly called isopropanol or 2-propanol) for at least 30 seconds.

If you are unable to purchase the products mentioned above in your region, a disinfecting product with similar proportions and active ingredients would be recommended.

5.4 Disposing of the amplifier and accessories

As soon as the products and their accessories and cables have reached the end of their service life, dispose of them in accordance with the relevant national regulations. In Germany, for example, the legislation governing electrical and electronic equipment (known as the ElektroG) is applicable. In the EU and EFTA, the WEEE Directive 2002/96/EC on Waste Electrical and Electronic Equipment applies.

Do not dispose of your products, accessories and cables with ordinary household waste.

Subject to the proviso that only original equipment supplied by Brain Products is involved, Brain Products will accept return of the equipment and handle disposal on request.

Appendix A Product identification

Product[a]	Article number
BrainAmp MR	BP-01200
BrainAmp MR plus	BP-01300
BrainAmp ExG MR	BP-01375
BrainAmp Standard	BP-01000
BrainAmp DC	BP-01100
BrainAmp ExG	BP-01355
USB 2 Adapter (BUA128)	BP-02050
SyncBox	BP-02675
PowerPack	BP-02610
PowerPack Charger V9	BP-215-1000
Signaltester	BP-210-4010
Signaltester ExG	BP-210-4000
DualBUA	BP-02070
Optical fiber cable (20m)	BP-02310
BAC cable (30cm)	BP-02400-NN
BAC 10 cm bundled	BP-345-2000

a. Refer to, ***Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment*** which is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php?kid=5#dlukat_84.

Manufacturer:

Brain Products GmbH
Zeppelinstraße 7
82205 Gilching
Germany
Phone: +49 8105 73384 - 0
Fax: +49 8105 73384 - 505
Web site: https://www.brainproducts.com
Email: techsup@brainproducts.com

CE marking	The Brain Products GmbH confirms the electromagnetic compatibility (EMC) of this product according to the Directive 2014/30/ EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility. The Brain Products GmbH confirms the RoHS compliance of this product according to Directive 2011/65/EU of the European Parliament and the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast published in the Official Journal of the European Union on 1 July 2011) as well as all its amendments up to and including the Commission delegated directive (EU) 2015/863 of 31 March 2015 (published in the official Journal of the European Union on 4 June 2015).
Electrical safety according to IEC 60601**:**	Protection class II
Warranty:	The terms of warranty can be found on our web site at: www.brainproducts.com/contact.php

Appendix B Explanation of the markings on the products

Observe the manual.

These labels indicate that defective products must not be disposed of with household waste. Dispose of in accordance with national regulations or return the product and its accessories to the manufacturer.

This mark confirms compliance with the environmental requirements for electronic products (only applies to China).

MR Unsafe: An item which poses unacceptable risks to the patient, medical staff or other persons within the MR environment.*

MR Conditional: An item with demonstrated safety in the MR environment within defined conditions. At a minimum, address the conditions of the static magnetic field, the switched gradient magnetic field and the radio frequency fields. Additional conditions, including specific configurations of the item, may be required.*

MR Safe: An item that poses no known hazards resulting from exposure to any MR environment. MR Safe items are composed of materials that are electrically nonconductive, nonmetallic, and nonmagnetic'.*

The Brain Products GmbH confirms the electromagnetic compatibility (EMC) of this product according to the Directive 2014/30/ EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility.

The Brain Products GmbH confirms the RoHS compliance of this product according to Directive 2011/65/EU of the European Parliament and the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast published in the Official Journal of the European Union on 1 July 2011) as well as all its amendments up to and including the Commission delegated directive (EU) 2015/863 of 31 March 2015 (published in the official Journal of the European Union on 4 June 2015).

* Definitions from ASTM international standard F2503-13

Appendix C Technical data

Common characteristics of all amplifiers

Amplitude accuracy:	± 2%
Bit width of the A/D converter (EEG and AUX):	16 bit
Sampling rate:	5 kHz per channel
DC offset tolerance:	± 300 mV
Signal transmission:	Optically coupled using duplex fiber optic cables
Operating time between charges:	Typically 30 hours with one amplifier, 15 hours with two amplifiers
Power consumption:	≤ 150 mA in operation (see individual amplifiers); typically 7 mA in standby mode
Dimensions (H x W x D):	Approx. 68 mm x 160 mm x 187 mm for BrainAmp Standard, DC, ExG, MR, MR plus, ExG MR and PowerPack
Weight:	Approx. 1.1 kg for BrainAmp Standard, DC, ExG, MR, MR plus, ExG MR and PowerPack
Integrated impedance measurement:	Present; measurement includes ground electrode and reference electrode
Unlocking function:	Present
Locking of unused channels:	Present

Components suitable for the scanner room[1]

BrainAmp MR

Number of channels:	32
Channel type/reference:	Referential channels/acquisition of a reference using a single electrode (unipolar)
Input impedance:	10 MOhm (for DC)
Input noise:	≤ 1 μV_{pp}
Common-mode rejection (CMR):	≥ 90 dB
Low-cutoff frequency (high-pass)/time constant: Filter type:	0.016 Hz/10 s First-order filter with 6 dB/octave
High-cutoff frequency (low-pass): Filter type:	250 Hz Fifth-order Butterworth filter with 30 dB/octave
Measuring range:	± 16.384 mV
Resolution:	0.5 µV per bit
Power supply:	PowerPack (external rechargeable battery)
Suitability for use in the scanner room:	Yes

BrainAmp MR plus

Number of channels:	32
Channel type/reference:	Referential channels/acquisition of a reference using a single electrode (unipolar)
Input impedance:	Switchable: 10 MOhm/10 GOhm (for DC)
Input noise:	≤ 1 μV_{pp}
Common-mode rejection (CMR):	≥ 110 dB
Low-cutoff frequency (high-pass): Filter type:	0 Hz in DC mode or 0.016 Hz/10 s in AC mode; switchable between AC and DC modes First-order filter with 6 dB/octave

1. Under the conditions described in Performing simultaneous EEG-fMRI measurements - Conditions for the safe use of BrainAmp MR amplifiers and accessories in the MR environment which is available for download on the Brain Products website at https://www.brainproducts.com/downloads.php.?kid=5#dlukat_84.

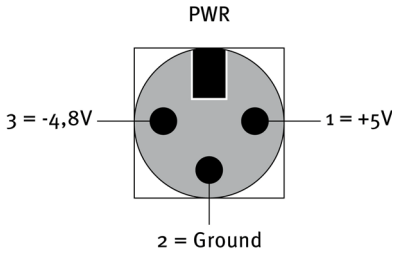
High-cutoff frequency (low-pass): Filter type:	1000 Hz/250 Hz (switchable for the resolutions 0.1 µV/0.5 µV per bit) Fifth-order Butterworth filter with 30 dB/octave
Measuring range:	± 3.28 mV/± 16.384 mV/± 327.68 mV (switchable)
Resolution:	0.1 µV/0.5 µV/10.0 µV per bit (switchable)
Power supply:	PowerPack (external rechargeable battery)
Suitability for use in the scanner room:	Yes

BrainAmp ExG MR

Number of channels:	8 or 16
Channel type:	8 bipolar or 8 bipolar + 8 AUX
Input impedance:	10 MOhm (for DC)
Input noise:	≤ 2 μV_{pp}
Common-mode rejection (CMR):	≥ 100 dB
Low-cutoff frequency (high-pass)/time constant: Filter type:	0 Hz in DC mode or 0.016 Hz/10 s in AC mode; switchable between AC and DC modes First-order filter with 6 dB/octave
High-cutoff frequency (low-pass): Filter type:	1000 Hz/250 Hz (switchable for the resolutions 0.1 µV/0.5 µV per bit) Fifth-order Butterworth filter with 30 dB/octave
Measuring range:	± 3.28 mV/± 16.384 mV/± 327.68 mV (switchable)
Resolution:	0.1 µV/0.5 µV/10.0 µV per bit (switchable)
Power supply:	PowerPack (external rechargeable battery)
Suitability for use in the scanner room:	Yes

Only for BrainAmp ExG MR 16 with additional power supply:

Figure C-1. BrainAmp ExG MR 16, connector for power supply (socket)



PowerPack

Number of amplifiers supplied:	1 or 2
Charging voltage:	9 V DC
Charging current	670 mA
Rated capacity:	6500 mAh
Dimensions (H x W x D):	Approx. 68 mm x 160 mm x 187 mm
Weight:	Approx. 1.9 kg
Output voltage:	5.6 V DC
Output current:	300 mA
Total operating time:	Approx. 4000 hours
Operating time for one amplifier:	> 30 hours (with a fully charged, new battery)
Operating time for two amplifiers:	> 15 hours (with a fully charged, new battery)
Charging:	Using external charger (Charger V9); only outside the scanner room
Charging time:	Approx. 17 hours (with empty battery at room temperature)
Rechargeable battery type:	Lead gel rechargeable battery
Charging temperature range:	10°C to 30°C
Electrical protection class:	II
Suitability for use in the scanner room:	Yes

ExG AUX Box

Number of channels:	8 ExG channels and 8 AUX channels
Channel type:	ExG: bipolar (for electrophysiological ExG signals); connection: touchproof in accordance with DIN 42802) AUX: bipolar (for sensors); connection: see Figure C-2
Use	Only with BrainAmp ExG and BrainAmp ExG MR. The lower 8 channels of the ExG amplifier are assigned to the 8 bipolar channels and the upper 8 channels are assigned to the 8 AUX channels in the ExG/AUX Box. The AUX channels are only available with the 16-channel ExG with power output.
Input voltage range of the 8 bipolar ExG channels:	Corresponds to the input impedance of the connected amplifier (passed through 1:1)
Input voltage range of the 8 AUX channels:	± 4.8 VDC
Input impedance of the 8 bipolar ExG channels:	See specifications for the input impedance of the connected ExG amplifier
Input impedance of the 8 bipolar AUX channels against ground: Differential input impedance of the 8 bipolar AUX channels:	Rev. 01: 23 kOhm (for DC), Rev. 02: 1000 kOhm (for DC)Rev. 01: 46 kOhm (for DC), Rev. 02: 2000 kOhm (for DC)
Supply voltage at the AUX channels:	+4.8 V,: 20 mA -4.8 V: 10 mA (maximum output current for all AUX channels)
Dimensions (H x W x D):	Approx. 137 mm x 70 mm x 38 mm
Weight:	Approx. 145 g
Suitability for use in the scanner room:	Yes

Figure C-2. ExG AUX Box, pinout of the sensor connectors (socket), type: Binder 719

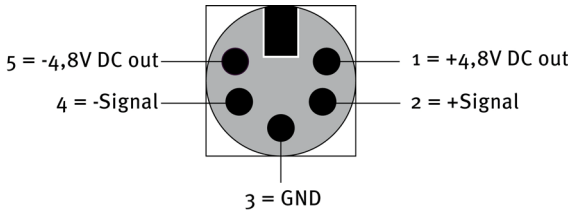
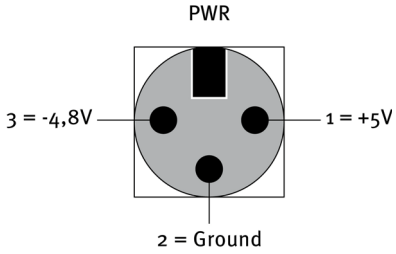


Figure C-3. ExG AUX Box, pinout of the power supply (socket), type: Binder 719



Components not suitable for the scanner room

BrainAmp Standard

Number of channels:	32
Channel type/reference:	Referential channels/acquisition of a reference using a single electrode (unipolar)
Input impedance:	10 MOhm (for DC)
Input noise:	≤ 2 μV_{pp}
Common-mode rejection (CMR):	≥ 90 dB
Low-cutoff frequency (high-pass)/time constant: Filter type:	0.016 Hz/10 s First-order filter with 6 dB/octave
High-cutoff frequency (low-pass): Filter type:	1000 Hz Fifth-order Butterworth filter with 30 dB/octave
Measuring range:	± 3.28 mV
Resolution:	0.1 µV per bit
Power supply:	PowerPack (external rechargeable battery)
Power consumption:	Max. 110 mA
Suitability for use in the scanner room:	No

BrainAmp DC

Number of channels:	32
Channel type/reference:	Referential channels/acquisition of a reference using a single electrode (unipolar)
Input impedance:	Switchable: 10 MOhm / 10 GOhm (for DC)
Input noise:	≤ 1 μV_{pp}
Common-mode rejection (CMR):	≥ 110 dB
Low-cutoff frequency (high-pass)/time constant: Filter type:	0 Hz in DC mode or 0.016 Hz/10 s in AC mode; switchable between AC and DC modes First-order filter with 6 dB/octave
High-cutoff frequency (low-pass): Filter type:	1000 Hz/250 Hz (switchable for the resolutions 0.1 µV/0.5 µV per bit) Fifth-order Butterworth filter with 30 dB/octave

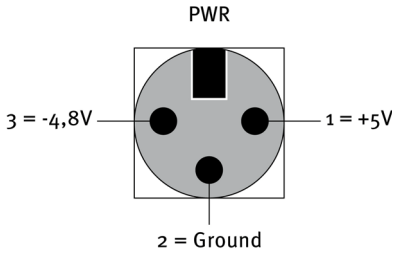
Measuring range:	± 3.28 mV/± 16.384 mV/± 327.68 mV (switchable)
Resolution:	0.1 µV/0.5 µV/10.0 µV per bit (switchable)
Power supply:	PowerPack (external rechargeable battery)
Power consumption:	Max. 130 mA
Suitability for use in the scanner room:	No

BrainAmp ExG

Number of channels:	8 or 16
Channel type:	8 bipolar or 8 bipolar + 8 AUX
Input impedance:	10 MOhm (for DC)
Input noise:	≤ 2 μV_{pp}
Common-mode rejection (CMR):	≥ 100 dB
Low-cutoff frequency (high-pass)/time constant: Filter type:	0 Hz in DC mode or 0.016 Hz/10 s in AC mode; switchable between AC and DC modes First-order filter with 6 dB/octave
High-cutoff frequency (low-pass): Filter type:	1000 Hz/250 Hz (switchable for the resolutions 0.1 µV/0.5 µV per bit) Fifth-order Butterworth filter with 30 dB/octave
Measuring range:	± 3.28 mV/± 16.384 mV/± 327.68 mV (switchable)
Resolution:	0.1 µV/0.5 µV/10.0 µV per bit (switchable)
Power supply:	PowerPack (external rechargeable battery)
Power consumption:	Max. 110 mA (8 channels)/120 mA (16 channels)
Suitability for use in the scanner room:	No

Only for BrainAmp ExG 16 with additional power supply:

Figure C-4. BrainAmp ExG 16, connector for power supply (socket)



SyncBox Main Unit

Input voltage:	5 V DC
Power consumption (via USB):	< 150 mA
Properties of the input signal:	0.4 V_{pp} to 5 V_{pp}, hysteresis approx. 150 mV
Frequency of the input signal:	Max. 30 MHz
Input impedance (on the scanner side):	50 Ohm, BNC socket
Required input signal shape:	Sine or square
Computer interface:	USB 2.0
Length of the connecting cable:	Max. 20 m
Suitability for use in the scanner room:	No, but can be used in the control room
Dimensions:	Approx. 132 mm x 70 mm x 30 mm (without connections)
Weight:	Approx. 160 g

SyncBox Scanner Interface

Power supply:	Via SyncBox Main Unit
Input (on the scanner side):	50 Ohm, BNC socket
Output:	50 Ohm, BNC socket
Galvanic isolation:	Yes, dielectric strength > 4 kV
Length of the connecting cable:	30 cm

Dimensions:	Approx. 90 mm x 45 mm x 25 mm
Weight:	Approx. 80 g

Charger V9 (charger for the PowerPack)

Input voltage range:	100 to 240 V AC, 50/60 Hz
Rated power consumption:	Max. 145 mA
Output voltage:	9 V DC
Output current:	Max. 670 mA
Suitability for use in the scanner room:	No, but can be used in the control room
Weight:	Approx. 130 g (without power adapter)

Electrode Input Box EIB64-A

Number of channels:	64 (plus 2x ground, 2x reference)
Dimensions (H x W x D):	Approx. 67 mm x 102 mm x 175 mm
Weight:	Approx. 200 g
Suitability for use in the scanner room:	No

ExG Input Box

Number of channels:	16
Channel type:	Bipolar
Dimensions (H x W x D):	Approx. 137 mm x 70 mm x 38 mm
Weight:	Approx. 145 g
Suitability for use in the scanner room:	No

Interfaces for connecting the amplifiers to the computer

USB interface: USB2 Adapter (BUA)

Number of channels supported:	64 or 128 channels or two or four 32-channel amplifiers
USB port:	2.0
Power consumption with 64 channels:	Typically 280 mA
Power consumption with 128 channels:	Typically 400 to 500 mA
Trigger bit width:	16 bit (total for trigger inputs and outputs)
Trigger connection:	Via 26-pin HD D-Sub socket (see Appendix D as of page 79)
Amplifier connection:	Via duplex fiber optic cable
Dimensions:	Approx. 150 mm x 80 mm x 45 mm
Weight:	Approx. 260 g
AUX connection:	Via 15-pin HD D-Sub socket (see Appendix E on page 81)

USB interface: dualUSB2 Adapter (dualBUA)

The dualUSB2 Adapter comprises two USB2 Adapters and a dualBUA Adapter Cable.

Number of channels supported:	Up to 256 channels or up to eight 32-channel amplifiers
Trigger bit width:	16 bit (total for trigger inputs and outputs)
Trigger connection:	Via 26-pin HD D-Sub socket (see Appendix D as of page 79)
Amplifier connection:	Via duplex fiber optic cable
Dimensions:	Twice the size of a USB2 Adapter
Weight:	Approx. 520 g (two USB2 Adapters) + approx. 140 g (dualBUA Adapter Cable)

Appendix D Pinout of the trigger socket (digital port)

The trigger socket for the input of external synchronization pulses such as trigger and reaction time markers is located on the front of the USB2 Adapter (labeled *Trigger In*). This is a 26-pin HD D-Sub connector. The input ports are TTL-CMOS ports.

Table D-1 shows the pinout and the assignment of the 16 digital inputs to stimulus information (S markers) and response information (R markers) as interpreted by Recorder for positive logic. If several bits are set simultaneously at the stimulus input, their values are added together. For example, if D01 (S 2) and D05 (S 32) are set simultaneously, this results in the stimulus S 34. The same applies for combinations of response bits. You will find details on configuration in the Recorder User Manual.

The third and fourth columns show which contacts on the connectors (25-pin D-Sub/LPT and BNC connectors) of standard trigger cables are connected to which contacts of the trigger socket (digital port).

Table D-1. Pinout of the trigger socket (digital port) on USB2 Adapter

Pin on 26-pin HD D-Sub trigger socket (digital port)	Function	25-pin D-Sub/LPT on trigger cable	BNC connector on trigger cable
1	Ground	25	Ground
2	D01 (S 2)	3	
3	D03 (S 8)	5	
4	D05 (S 32)	7	
5	D07 (S128)	9	
6	D09 (R 2)		
7	D11 (R 8)		
8	D13 (R 32)		
9	D15 (R128)		Signal
10	Unused		
11	Unused		
12	VCC +3.3 V		
13	Unused		
14	D00 (S 1)	2	
15	D02 (S 4)	4	
16	D04 (S 16)	6	
17	D06 (S 64)	8	
18	D08 (R 1)		
19	D10 (R 4)		

Table D-1. Pinout of the trigger socket (digital port) on USB2 Adapter

Pin on 26-pin HD D-Sub trigger socket (digital port)	Function	25-pin D-Sub/LPT on trigger cable	BNC connector on trigger cable
20	D12 (R 16)		
21	D14 (R 64)		
22	Ground		
23	Block+		
24	Block-		
25	5 kHz out		
26	Unused		

Appendix E Pinout of the AUX socket on the USB2 Adapter

Table E-1. Pinout of the 15-pin AUX socket on the USB2 Adapter

Pin no.	Function
1	ADCLK
2	DASCLK
3	$\overline{\text{ADCS}}$
4	SDA
5	SCL
6	DIN
7	DADIN A
8	DADIN B
9	+5 V
10	Ground (GND)
11	UEXT
12	AUX 1
13	5 kHz (clock frequency for PLL)
14	DOUT
15	$\overline{\text{DACS}}$

Appendix F Ambient conditions

The following ambient conditions must be satisfied for operation, transport and storage:

Amplifier and accessories (*excluding PowerPack*):

Operation	Temperature range: 10 °C to 40 °C (50 °F to 104 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa
Transport	Temperature range: 0 °C to 60 °C (32 °F to 140 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa
Storage	Temperature range: 0 °C to 60 °C (32 °F to 140 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa

PowerPack:

Operation	Temperature range: 10 °C to 40 °C (50 °F to 104 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa
Charging	Temperature range: 10 °C to 30 °C (50 °F to 86 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa
Transport	Temperature range: 0 °C to 60 °C (32 °F to 140 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa
Storage	Temperature range: 0 °C to 40 °C (32 °F to 104 °F) Relative humidity: 30 to 85 %, non-condensing Atmospheric air pressure: 700 hPa to 1060 hPa

Appendix G Note on the use of invasive electrodes

In accordance with electrical safety testing as per IEC 60601-1, the amplifier has been approved as protection class II, application type BF (body floating).

The tested discharge currents permit use of the amplifier under laboratory conditions in combination with specially authorized invasive electrodes on the central nervous system provided that:

- Power is supplied to the BrainAmp components by the PowerPack.
- No other product is simultaneously electrically connected to the test subject.
- No simultaneous stimulation is used (ERP).

Never use the invasive electrodes in an MR environment.

Personal injury

Under no circumstances use a defibrillator if the test subject feels unwell but is still connected to the invasive electrodes.

The invasive electrodes must not be used for recording ECG signals and polygraph signals with the BrainAmp components.

Please note that invasive electrodes must be medical products of class III.