SynAmps^{2TM}

P/N 00080650

User's Guide

Compumedics Neuroscan

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For Technical Support.....

If you have any questions or problems, please contact Technical Support through any of the following routes.

If you live outside the USA or Canada, and purchased your system through one of our international distributors, please contact the **distributor** first, especially if your system is under warranty.

In all other cases, please use **techsup@neuro.com**, or see the other Support options on our web site (*http://www.neuro.com/neuroscan/support.htm*).

Or, if you live in the USA or Canada, please call **1-800 474-7875**. International callers should use **915-845-5600, ext 223**.

For Sales related questions, please contact your local distributor, or contact us at **sales@neuro.com**.

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Device Classification

ATTENTION: CONSULT ACCOMPANYING DOCUMENTS BEFORE USING

The SynAmps2™ Model 8050 EEG amplifier and data acquisition system is a line-powered instrument designed to meet the applicable requirements of IEC601-1:1988. The SynAmps2 should be used only according to the manufacturer's instructions. Replacement parts and accessories may be obtained from the manufacturer.

Manufacturer: Compumedics Neuroscan
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This equipment has been tested and found to comply with the limits and requirements for a Class B device per EN60601-1-2. These limits and requirements are designed to provide reasonable protection under conditions of normal use from interference with and by other devices. There is, however, no guarantee that interference will not result from operation of this device in proximity or connected to some other device. If interference occurs, the user or operator is encouraged to try and correct the interference by one or more of the following measures: (1) Change the orientation of the two devices relative to one another. (2) Increase the separation between the two devices. (3) Check the power source and grounding for the two devices. (4) Consult the dealer, Neuroscan Technical Support, or an experienced technician for help.

The safety and electromagnetic compatibility of this system was tested with the following accessories, parts, and associated devices. The user or operator is cautioned to ensure that when using accessories, parts, or associated devices other than those listed, that the safety and electromagnetic compatibility of the system is maintained.

1) Neuroscan SCAN Computer P/N 0010915 or 0010914
2) Headbox Cable – P/N 00080580
3) Deblock Interface Cable P/N 00081300

Classification per IEC601-1:1988

The device is ordinary equipment not protected against ingress of water and should not be used in the presence of any spilled liquids. It is not designed to be suitable for use in the presence of a flammable anesthetic mixture of air and oxygen or nitrous oxide. The device is capable of continuous operation.

Class and degree of protection against electrical shock is Class 1, Type CF.

Technical Description

Input:	120-230VAC, 47-63Hz, 5A		
Fuses:	2 each 5A 250V 5 X 20mm Type 'T'		
Headbox			
	Weight:		1.5 kg
	Dimensions:	Height:	4.3 cm
		Width:	17.8 cm
		Depth:	21.4 cm
System Unit			
	Weight:		4.2kg
	Dimensions	Height:	22.6 cm
		Width:	11.6 cm
		Depth:	27.9 cm
Power Unit			
	Weight:		12.5kg
	Dimensions	Height:	22.6 cm
		Width:	11.6 cm
		Depth:	27.9 cm

Shipping and Storage Maximum Limits

-20° C to +70° C, 10% to 100% humidity, non-condensing RH, 500 hPa to 1060 hPa. After unpacking, allow devices to adjust to room temperature for at least two hours prior to interconnection and application of power.

Operational Limits

+15°C to +30°C, 25% to 95% humidity, non-condensing RH, 700hPa to 1060hPa pressure.

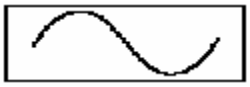
Warnings and Precautions

Instructions
Read instructions before operating the device.

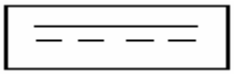
Symbols
The following symbols are found on the SynAmps^2:

Attention! Read instructions before using!

Subject connection is isolated from power mains.



Volts AC



Volts DC

The SynAmps² operates using line voltages which are present inside the enclosure and so is marked "CAUTION: To reduce risk of electric shock, do not remove cover. Refer servicing to qualified personnel."

This device is not equipped with appropriate alarms required for use in monitoring clinical parameters of a patient where it is necessary to alert the user of situations which could lead to death or severe deterioration of the patient's state of health.

WARNING: The SynAmps² system should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the SynAmps² system should be observed to verify normal operation in the configuration in which it will be used.

WARNING: Connection to the High-Level Input Connector (J3 on the headbox REF 00080460) may result in increased EMISSIONS or decreased IMMUNITY of the SynAmps² system. Care should be taken by the user or operator to verify normal operation with a cable attached to the High Level Input Connector.

CAUTION: MEDICAL ELECTRICAL EQUIPMENT needs special precautions regarding EMC (ElectroMagnetic Compatibility) and needs to be installed and put into service according to the EMC information provided in the ACCOMPANYING DOCUMENTS.

CAUTION: Portable and mobile RF communications equipment can affect MEDICAL ELECTRICAL EQUIPMENT. Use of this type of equipment in

close proximity to the SynAmps² should be prohibited. If portable or mobile RF communications devices are used in the vicinity of the SynAmps² the user or operator should verify normal operation of the device.

Neuroscan does not specify a minimum amplitude or value of the patient physiological signal.

DANGER: Risques d'explosion si cet apparail est utilisé à proximité d'anesthesiques inflammables ou en présence de gaz ou de liquides inflammables.

REMARQUE: **USA et Canada**, la fiabilité de la mise à la masse de cet équipment ne peut ètre réalisé que si celui-ci est connecté à une price marquée "Hôpital Suelement" ou "Classe Hôpital".

ATTENTION: Ce product doit ètre refroidit par convection. Une ventilation appropriée est indespensable. Un espace de 2" (5cm) doit ètre laissé libre de chaque côté.

ATTENTION: Pour réduire les risques de choc électrique, ne pas ouvrir le bôitiér de protection. Aucune functionalite necessaire à l'utilisateur ne se trouve a l'intérieur.

Environment

The SynAmps² is designed to be used in a clinical laboratory or office environment. Extremes of humidity, temperature, or pressure should be avoided. The device should not be used in a location where contact with liquids is possible, and if liquids are spilled on or in the area of the device, it should not be used until it can be ensured that the fluid or its residue will not affect device operation. Questions should be directed to the manufacturer or its representatives.

Cleaning Instructions

The SynAmps² enclosure may be cleaned with a damp sponge or cloth and mild nonabrasive cleanser. Take care to ensure that liquid does not spill in or on the device. Do not use abrasives or detergents.

Sterilization and Cleaning of Patient-Contact Parts

Parts for contact with the patient such as electrodes are not supplied as part of the SynAmps² system. The manufacturer's instructions should be followed for sterilization and cleaning of the parts used. Some devices are designed for

onetime use only, and no attempt should be made to reuse them, whether sterilization has been attempted or not. Contact Neuroscan technical support if you have questions about sterilization or cleaning of the SynAmps² device or electrodes to be used with the device.

Repair

There are no user serviceable parts in the SynAmps² amplifier system. Fuses in the System Unit power input module and in the Power Unit power input module should be replaced with the type and rating indicated on the back panel label. Contact your dealer or Neuroscan Technical Support if you believe the SynAmps² system is in need of repair.

Maintenance

Neuroscan suggests that the earth and patient leakage currents be tested at least once per year to ensure continued safe use of the device. Also at least once per year, visually inspect the device, including the power cord. Replace any worn or frayed cables, and contact your dealer or Neuroscan technical support if you have concerns about what you see. This inspection interval may be shortened for devices that are moved often or experience unusually heavy use. Periodic calibration of the device, using internal or external sources, is recommended. The calibration procedure is described in the Calibration section below. No other maintenance or service is required.

Installation Precaution

Proper grounding is important for continued safe use of your SynAmps² system. Ensure that the outlet supplying power to your SynAmps² is grounded, and that the power cords supplied with your system are used. Other devices in the same patient area should be at the same ground potential, and should preferably use the same branch circuit. See the Hardware and Software Installation directions below for more details.

Power Source Characteristics

The SynAmps² amplifier is designed, produced, and tested to ensure reliable operation when connected to power systems having normal variability. If you believe that your power system may experience excessive noise or variability, Neuroscan recommends use of a power conditioner.

Interconnection with Other Devices

Care should be taken when multiple devices are connected to a patient, or when devices are connected together. Leakage currents for individual devices may sum to values higher than expected for single devices. In particular care should be taken when connecting Information Technology (computer) equipment to Medical equipment. Allowable leakage current levels for IT equipment are higher than for Medical equipment.

Use With HF Surgical Equipment

This device does not contain protection against burning of the patient when used with high frequency (HF) surgical equipment. Neuroscan can recommends that the SynAmps² device not be connected to the patient during use of HF surgical equipment.

Electrode Safety

The SynAmps² amplifier inputs and attached electrodes are Type CF, which means in part that they are not connected to Earth Ground or Chassis Ground. Maintain this separation from Earth Ground by ensuring that the electrodes and any conductive parts of their connectors do not touch conductive parts, including the system enclosure or other grounded devices.

Introduction

The Neuroscan SynAmps² are AC/DC amplifiers designed to record a wide variety of multichannel neurophysiological signals. The SynAmps² are intended for the researcher who needs both a broadband amplifier and a high speed digital acquisition system. A SynAmps² contains the analog components needed to amplify low level neurophysiological signals and the digital components needed to digitize, digitally filter, log external events, and transfer data to a host computer. This design allows for high speed acquisition of signals from multiple electrode sites. This distributed processing approach allows data to be acquired at much higher rates with greater precision from more channels than could be obtained from a single computer performing the same task. Listed below are some of the features of the SynAmps²:

- A USB 2.0 interface is used to link the SynAmps² and computer. One USB 2.0 chain can be used to connect up to four headboxes for a total of 256 EEG channels (plus

additional bipolar and HLI channels). An additional USB 2.0 chain can be used to achieve a higher number of channels (depending on your computer's speed and the AD rate).

- Real-time digital filtering provides a wide range of filter settings from DC to 3.0kHz.
- Sampling rates up to 20kHz from 1 to 64 EEG channels on a single headbox. Sampling rate is independent of the number of headboxes attached to a system.
- 64 monopolar, 4 bipolar, and 2 high-level input channels. An high density connector on the headbox is provided for quick connection to electrode cap arrays.
- Amplification and acquisition in the headbox near the subject to reduce noise pickup.
- Amplification stages are matched to the A/D input range to give resolutions to 0.019uV/bit in DC mode, and 0.993uV/bit in AC mode
- Built in impedance and calibration checking.
- 24-bit AD conversion provides greater resolution (and flows seamlessly into the 32-bit SCAN 4.3 acquisition software)

Hardware Installation

Installation of a SynAmps² amplifier is very easy. Here is a summary of the steps that you will need to perform:

Unpacking the SynAmps²

The SynAmps² has been shipped in containers designed to reduce damage due to shipping. Please retain these boxes and their contents in case you need to return the system for any reason.

The three main components - Amplifier/headbox, System Unit, and Power Unit - are packaged in smaller boxes within the larger box.

Open the boxes and check for the following contents:

1. Amplifier/headbox unit(s)
2. System Unit(s)
3. Power Unit
4. Amplifier/headbox cable(s)
5. USB cable(s)
6. Shorting plug(s) for calibration
7. Deblocking Interface Cable

As you remove the components from the boxes, examine them for any obvious damage due to shipment. Save the boxes in case you need to return the SynAmps² for repairs.

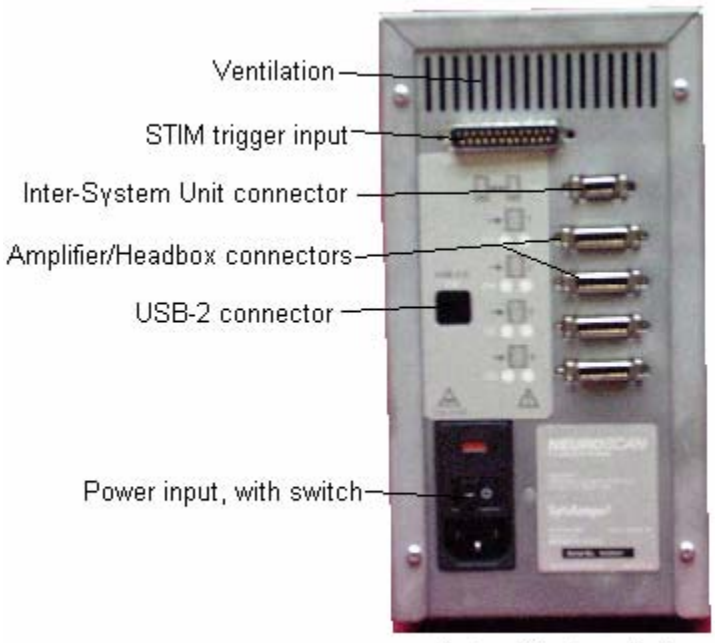
Connecting the Components

Turn off and unplug all computers, monitors, printers, etc. before connecting the SynAmps² to the rest of the system. This is for the initial connection of components only, allowing you to specify the drivers when the SynAmps² is first detected (if needed). After that step has been completed, the order in which you turn components on does not matter.

The Headbox provides the interface into which patient electrodes may be connected, and contains amplification and data acquisition circuits. The amplifier converts the analog biological signals to digital ones and sends the data to the host computer. It performs electrode impedance measurements internal calibration.

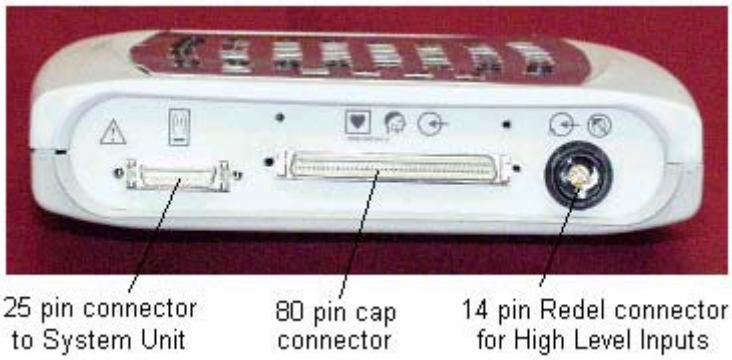
The System Unit serves as an interface between the Headbox and the host computer, as well as providing distribution of power, controls, and data to multiple Headboxes. Additionally the System Unit provides user access to functions such as input triggers, synchronization signals, and other user interface functions. The System Unit is line powered through the Power Unit.

The Power Unit provides isolation through a transformer from line power. Input and output voltages are selected via switches. All IT (Information Technology) devices attached to the system must be powered through the Power Unit.



Back of System Unit

1. The amplifier/headbox is connected to the System Unit via a long (15 or 30 foot) cable. If you received more than one amplifier/headbox unit, there will be a cable for each one. One end should be plugged into the headbox connector (J1), and the other end should be plugged into the System Unit. Please refer to Appendix B for additional connection information.

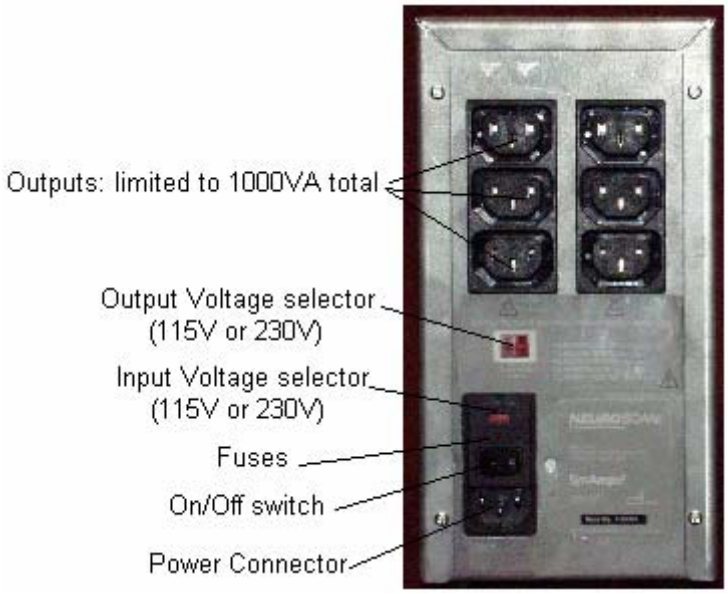


2. On the back of the System Unit, there is a connector (top right) for synchronizing acquisition between two System Units (please refer to Appendix B for connection information, if needed). This connector is also involved if you are using the Deblocking option. Included with the System Unit is a Deblocking Interface Cable (P/N 00081300). One end of the cable connects to the System Unit / System Unit connector on the back of the System Unit, and the other connects to the peripheral device sending the TTL pulse. Please see the **Triggering** section below for more details.

3. If you have a STIM system, connect the STIM-to-SCAN trigger cable to the D-25 trigger input connector on the back of the System Unit (top left connector; see Appendix A for pinout information).

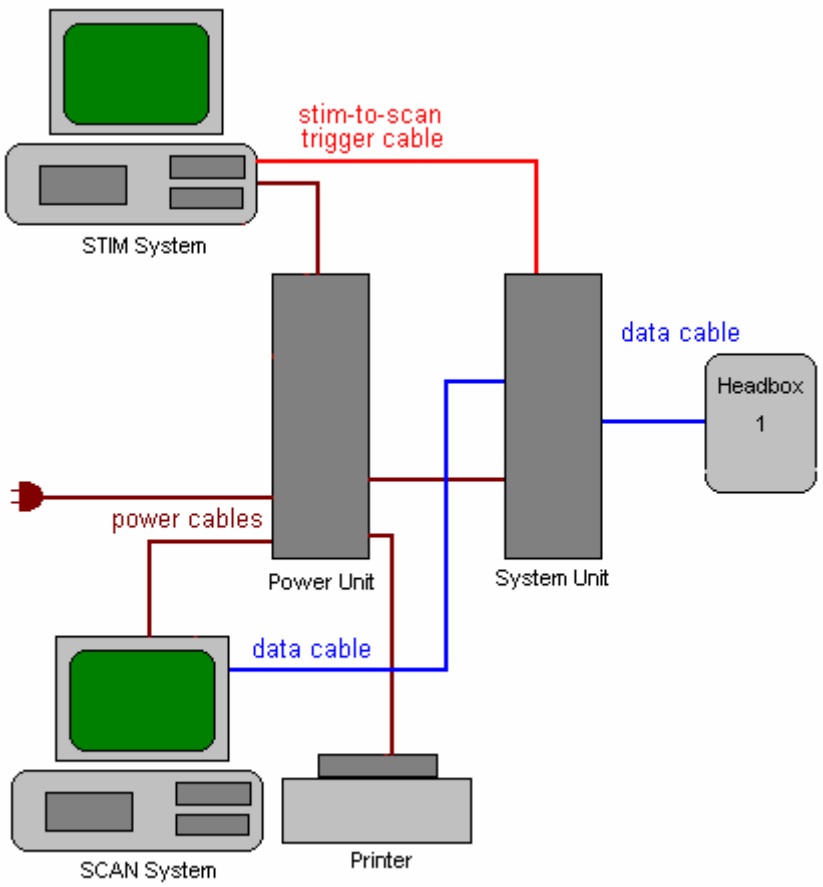
4. Connect the USB 2.0 cable to the back of the System Unit and to the back of the SCAN computer.

5. Connect the power cable to the back of the System Unit, and connect the other end to one of the plugs in the back of the Power Unit. Note that there is a power switch above the connector on both the System and Power Units; turn them off for the time being.



6. *All components connected to the SCAN, STIM and SynAmps^2 units MUST be powered by the Power Unit.* Connect the power cables to the computers, monitors, printer, STIM box, and System Unit(s) to the upper power connectors on the back of the Power Unit. *Make sure you have the input and output voltages set correctly for 115 or 230 Volts*. Connect the AC power cable from the back of the Power Unit to a grounded AC wall plug. Verify that there is a true earth ground in the building (otherwise, you may experience 50Hz or 60Hz line noise interference in the recordings). The completely connected system is shown below.

The Power Unit contains an isolation transformer that is rated up to 1000 watts. While that should be sufficient to safely power the components mentioned, you should verify that you are not surpassing that limit. A fully loaded System Unit with four amplifier/headboxes attached consumes a maximum of 150W. The demand will come primarily from your computer(s), monitor(s) and any peripherals. The wattage demands are usually displayed on the back of the components (or in their documentation). Neuroscan is not responsible for damage to the Power Unit resulting from an overload.



SynAmps2 Configuration

7. After all of the components are connected, turn on the Power Unit, the System Unit(s), and the SCAN computer. The SynAmps² amplifiers should be found as the computer boots, and the next step is to install the driver for them.

Installing the SynAmps² Driver

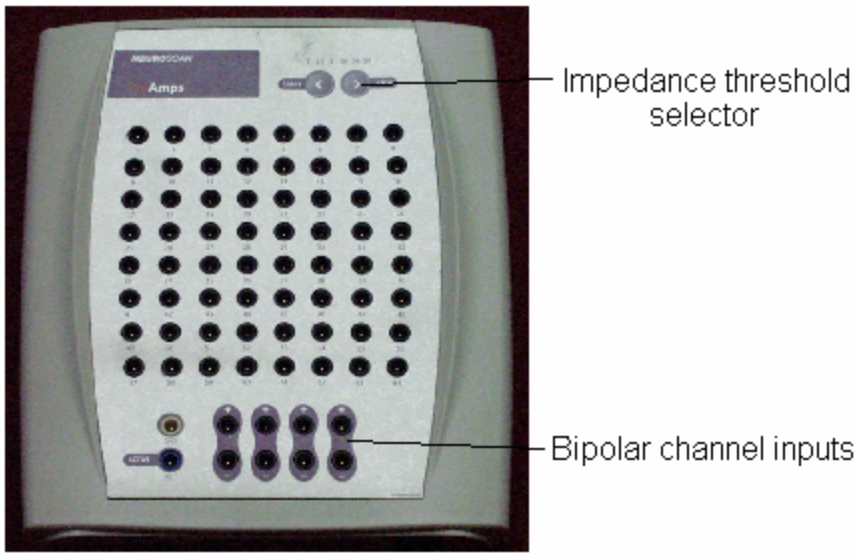
When the SCAN computer first boots after you have connected the SynAmps², Windows should find the new hardware. If instead you connect the SynAmps² USB 2.0 cable while the SCAN PC is on, you should see the same message. The drivers will either be installed automatically, or you will be directed to install them (the relevant ones used by SynAmps² are Syn2Ldr.sys and SynAmps².sys).

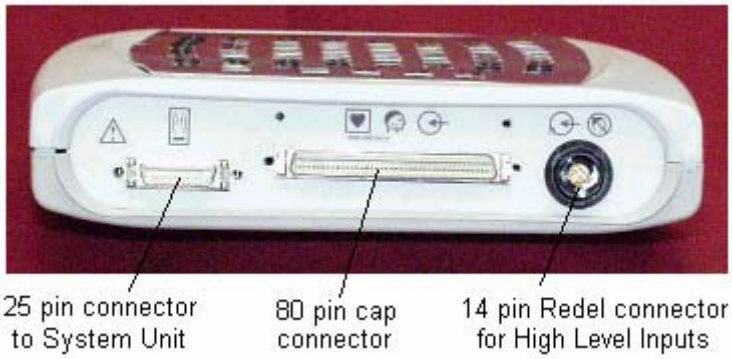
The Amplifier/Headbox

Each amplifier/headbox connected to a SynAmps² provides 64 monopolar, 4 bipolar, and 2 high level inputs channels. The amplifier/headbox unit also provides amplification, AD conversion, filtering and other signal processing.

The 64 monopolar channels are laid out in an 8x8 grid on the face of the headbox, and are labeled numerically. The four bipolar channels contain the plus and minus poles. The differential, or bipolar inputs are used for EOG, EMG, and EKG channel recordings.

The High Level Inputs (HLI's) are noncephalic leads that are galvanically isolated from both the patient and the SISO (computer) connections. They are typically used to input analog voltage outputs from peripheral psychophysiological devices, where the signal levels are far in excess of standard biologic signals (the input range of the HLI's is ± 5Vs). The HLI's are located on the bottom edge of the headbox (14 pin Redel connector; J3). Please refer to HLI section below for pinout and connection information.





The Impedance Threshold lets you select one of six impedance thresholds. Impedances in excess of the level you set will be indicated by a lit LED for that channel label.

The 80 pin connector (J2) on the bottom edge of the headbox is for the electrode cap. During calibration, you must connect the shorting plug in place of the electrode cap. The pinout information for your cap is included with the documentation you received with the cap. The pinout information for the 80 pin connector is contained in Appendix C.

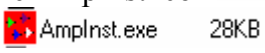
Connecting Multiple Headboxes

The current Quik-Caps are wired to send the ground and reference information to all headboxes. It is therefore not necessary to connect the ground and reference jacks across headboxes. If you are using older caps, or individual electrodes instead of caps, you will need to connect the headboxes together. Jumper the ground of one headbox to the ground of next headbox and repeat this procedure for all headboxes. Do the same for the reference connections.

Note: Do not apply multiple ground or multiple reference electrodes just because there are multiple headboxes.

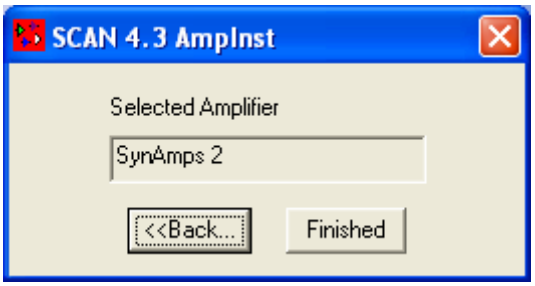
Note: You should ALWAYS connect the reference electrode to the subject even if you use a different channel for the reference, or if you select the common average reference.

Installing the SynAmps² as the Amplifier for SCAN

After you have installed the driver for the SynAmps², you need to install SynAmps² as the amplifiers used in the SCAN software. This is done by running the ampinstall.exe program. If you do not have the AmpInst icon  on your desktop, go to the Scan4.3 folder and double click on the 

program, or run the program from Start/Run/etc. The SCAN 4.3 "Select an Amplifier" window will appear. Select SynAmps² and click OK.

You will then see the SCAN 4.3 AmpInst screen. Click <<Back... to select a different amplifier, or click Finished.



The program takes a fraction of a second to run; it is creating or modifying the scan43.ini file in the \WINDOWS or \WINNT directory. When the SCAN 4.3 Amp/Inst window reappears, click the Done button. If you wish to change the amplifiers or the A/D card, run the Uninstall option, then run Install with the new selection, and click Done when finished.

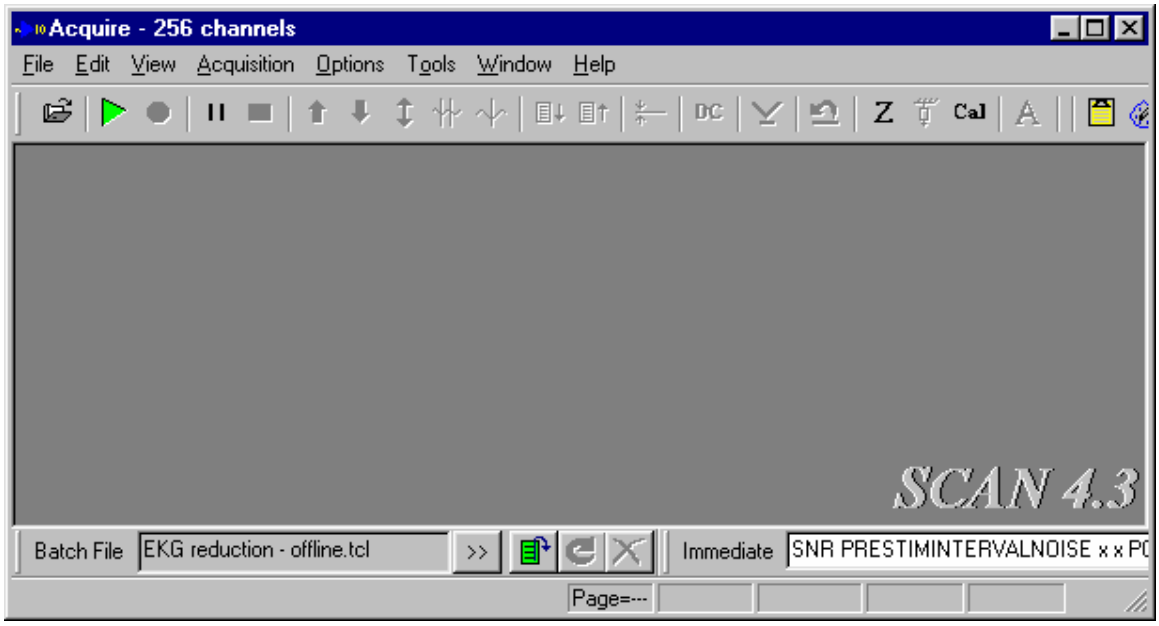
To verify that the computer and amplifiers are communicating correctly, please do the following.

Make sure that the software lock provided with the SCAN CD is connected to the parallel port (or USB, depending on the type of lock you received) of your computer.

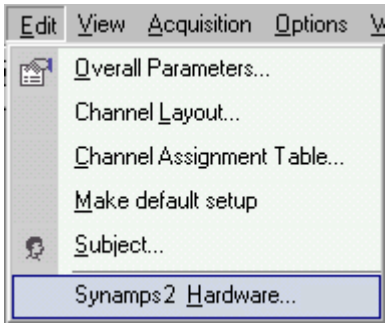
Double-click the SCAN 4.3 icon 

, and then click on the ACQUIRE icon  from the Program Launcher to start the ACQUIRE program.

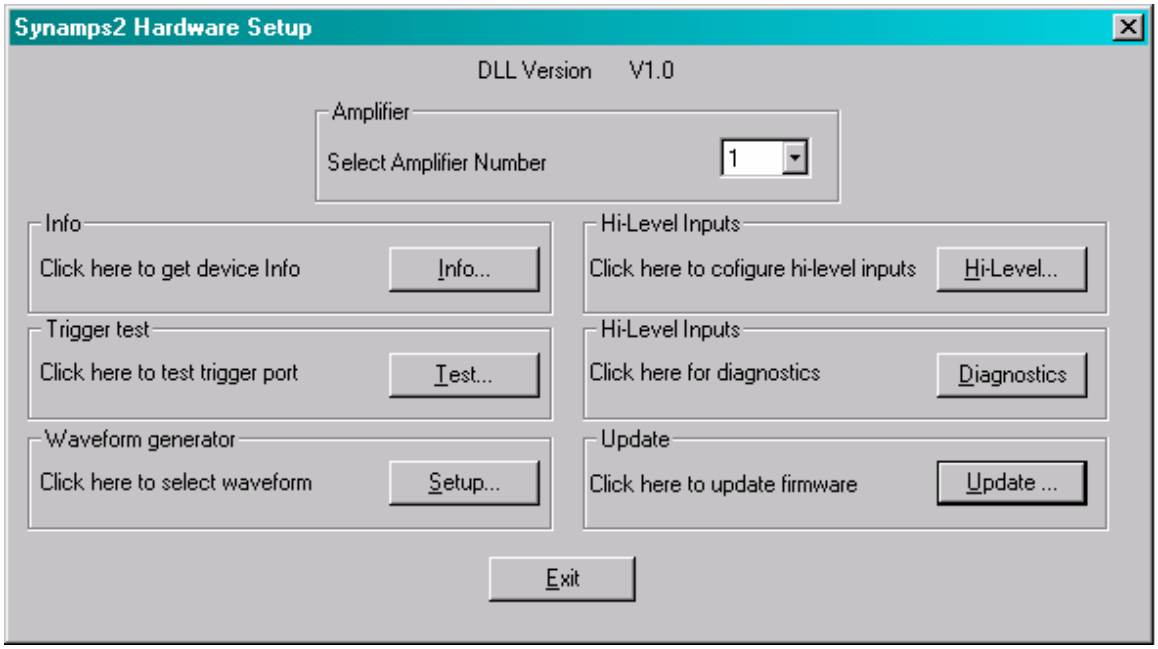
The Main screen will appear.



Click Edit, and at the bottom of the pull-down menu you should see the SynAmps² Hardware option.



Select that option, and a dialog box will appear. THIS WILL CHANGE



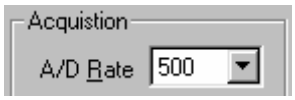
In multiple systems it is possible to query each amplifier by clicking on the drop-down arrow and selecting the desired SynAmps². If your SynAmps² and PC are communicating correctly you will see the dates and version information in the Info... fields. If not, there is a communication problem with the SynAmps². In most cases, this is resolved by installing the correct drivers (see **Installing the SynAmps² Driver** above). If you still have communication problems, contact techsup@neuro.com.

Configuring the SynAmps² in the ACQUIRE Program

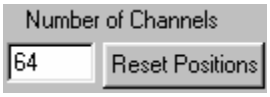
The configuration of the SynAmps² is accomplished within the ACQUIRE program, and the parameters are saved in a "setup file" (.ast extension). Go into the ACQUIRE part of the program, select a setup file from the ones provided, or create your own from scratch. The complete operation of the ACQUIRE program is contained in the ACQUIRE manual. *Settings specific to SynAmps² are described below*. Go to Edit, then Overall Parameters, and select the Amplifiers tab to begin.

Amplifier Settings

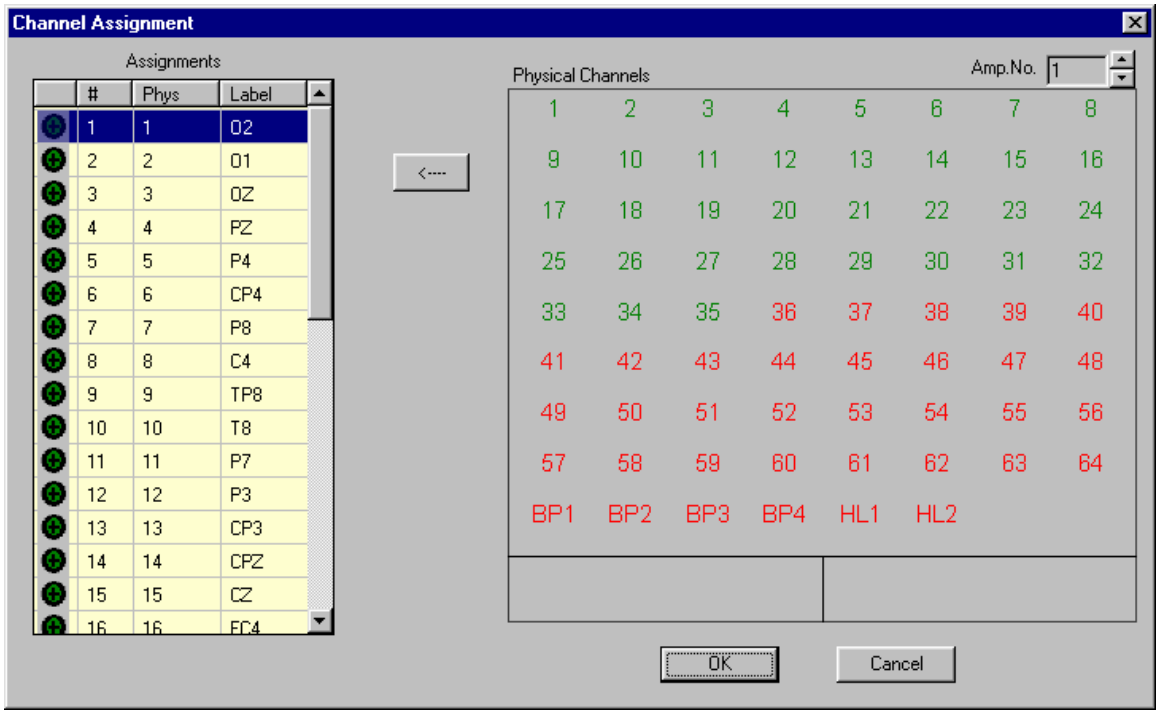
AD Rate. The maximum AD rate with SynAmps² is 20 kHz for any number of channels. The SynAmps² AD converters over-sample by 64x, making the effective sampling rate greater than 20 kHz. However, for the digitized data, the maximum rate is 20 kHz. Click the pull-down arrow to see the available AD rates.



Number of Channels. Enter the *total* number of desired channels, including any bipolar and HLI channels. If you are adding channels to whatever is displayed in the setup file you retrieved, you will likely need to click the Reset Positions button.



Example. Let's say you want to have 32 EEG channels, plus two bipolar channels for EOG artifact, and one HLI. Enter 35 for the number of channels, and click Reset Positions. Select any other amplifier settings you want (AC/DC, filters, etc.). Then go to the Channel Assignment page. Chances are that the EEG channels shown are not the ones you want, and no bipolar or HLI channels are selected.

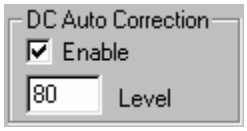


The SynAmps² is hardwired, that is, Physical channel 1 is always O2 (assuming you are using an electrode cap).

AC/DC option. With SynAmps², you have the option to record in true DC mode, or to record in AC mode. With the AC mode enabled, a decoupling single pole RC high-pass filter (.05 Hz , -6dB/octave/pole) is switched into the signal path.

This filter will remove most problems associated with battery potentials generated by electrodes.

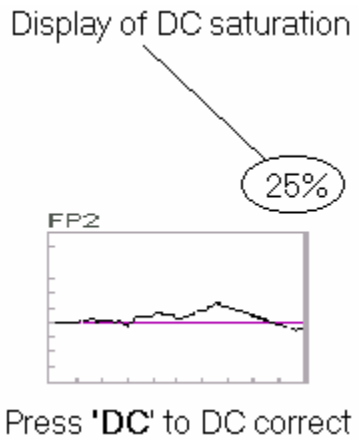
DC correction (DC mode only)
In DC mode, the SynAmps² are DC coupled broadband amplifiers. High-pass values other than DC are simulated by filtering. As a consequence, changes in the DC level at the input stage of the amplifier can eventually lead to amplifier saturation. To compensate for saturation, offset correction is provided in the headbox. The degree of saturation is monitored and can be corrected either manually or automatically from the ACQUIRE program. This section describes the control of DC offset.



The current level of DC saturation is displayed as a percentage from -100% to +100%. This percentage represents the dynamic range of the amplifiers and is shown to the right of the electrode label in the single-sweep and continuous display modes of ACQUIRE.

Saturation levels under ±69% will be displayed in white. Levels between ±70 and ±89 will be displayed in yellow. Levels beyond ±90 will be displayed in red.

Manual correction of DC offset
At any time during a recording you can press the DC icon from the Tool Bar to correct the DC offset. *Note - One button press is usually sufficient to correct DC offset.* ***Do not hold the DC button down to correct the offset*** . The program will compute the current DC level for each channel over a 40 ms interval and subtract it by placing an offset on the input stage for each channel. If you are recording with a DC high pass value, you will see an immediate change in the waveforms and the saturation value will change to a value at or near zero. The success of the correction will depend on the accuracy of the DC estimate and the correction step size. High gain levels such as 1000 or 2500, for example, may not precisely zero the DC offset displayed on the screen. This does not mean that the correction is inaccurate or near saturation. Refer to the



saturation value to estimate the success or failure to correct DC offset. Factors such as drift in the electrodes and high impedances can interfere with the ability of the system to DC correct.

Note - If you rely on manual correction of DC, you must monitor all channels for saturation regardless of high-pass filter settings.

Note - In the Edit module, the program will not create an epoch if that interval contains a DC correction. You should use these sparingly. If you have persistent DC problems, it is better to resolve the problem at the electrode level, rather than by using excessive DC corrections.

It is also necessary to perform DC corrections on channels with high-pass values other than DC. This is because all connections from the electrodes to the A-to-D converters are DC-coupled. High-pass filtering is performed by a program running in the headbox rather than by an electronic hardware filter.

Automatic correction of DC offset
High-pass settings other than DC do not require manual control of DC offset correction. Offset correction can be performed automatically to avoid the possibility of saturation. Follow these steps to perform DC correction:

Load a setup file in Acquire
In the ACQUIRE module, load an existing setup file or set up your electrodes and parameters manually.

Go to Edit/Overall Parameters/Amplifiers
Click on Edit, then Overall Parameters, then select the Amplifiers tab. In the lower left hand corner of the display you will see the AC/DC field, and under that click the DC Correction field (check mark will appear). Enter the percent saturation level (i.e., 80%)

from the keyboard. This value will determine the threshold for a DC correction. If any channel in the montage exceeds the threshold, a correction will be performed automatically. (See the Note above regarding excessive use of the DC correction).

On some AC coupled systems, high-pass values below .1 Hz are often available as an approximation to DC. If you are interested in slow potentials, there is no need for these values since the SynAmps² is a DC coupled system. The advantages to recording slow potentials with a DC high-pass are two fold.

First, **DC amplifiers are less prone to impulse artifact**. The recovery time of an AC coupled system (actual or simulated as is the case on the SynAmps²) can be described by the time constant of the system. The time constant is the time needed by an amplifier to decay to 37% of the peak response to a sudden impulse. To calculate the time constant of a simple filter use the following formula where T is the time constant and f is the cutoff frequency:

$$T = \frac{1}{2 \cdot \pi \cdot f}$$

This formula can be used to determine the effects of high-pass filter values you may have on your recordings. For example, if the amplifier encounters an impulse artifact with a 0.01Hz high-pass filter, it will require 16 seconds before the system returns to 37% of the original amplitude! If you are using such a filter setting so as to approximate DC, we strongly recommend that a DC value be employed. The DC setting is insensitive to impulse artifact. The SynAmps² is not affected by even the most substantial of artifacts such as those generated by somatosensory and magnetic stimulators when recording in the DC mode.

AC coupled systems that employ long time constants such as .01Hz can be very unstable and are highly susceptible to sudden impulses (movement artifact) causing the subsequent smoothing of the impulse, consequently, these amplifiers saturate and need an external reset circuit to restore the system.

Second, a **DC recording can always be refiltered with different high-pass values**. Digital filtering can be applied to the data to examine the effects of different high-pass values. This is not true, however, if the data have been acquired with an AC coupled system. You will have to accept whatever high-pass values were originally used to sample the data. In addition, digital filtering (provided in both EDIT and ACQUIRE modules) can offer sharper frequency cutoffs without the phase shift of an analog filter.

The available filter values for the SynAmps² were selected to encompass a broad range of filter settings that are often employed in neurophysiology. For example, short (10 milliseconds) latency evoked potentials such as the auditory brainstem evoked response are often recorded at high digitization rates with a low-pass of 3kHz and high-pass of 150 Hz. Examination of the above tables shows that a low pass of 3kHz is available for the highest digitization rate. To take the other extreme, long (seconds) latency cortical responses such as the motor potential or the contingent negative variation are often recorded with low (200 or 500Hz) digitization rates with a low-pass below 100Hz and a high-pass at DC. The filter table offers these values at digitization rates at or below 10kHz.

DC Electrode Considerations

The wide dynamic range of the SynAmps² amplifier means you should never experience saturation due to electrode DC effects. It is still possible, for example, with dissimilar metal combinations to produce offsets greater than the 333mV amplifier input range.

The DC capability of the SynAmps² amplifier presents special requirements that most electrophysiologists more familiar with AC coupled systems may not have encountered. When the amplifier is placed in the DC mode, battery potentials generated from electrodes are not dissipated by the decoupling capacitors found in AC only systems. Electrode combinations generating battery potentials greater than ±333 mVs will saturate the amplifier. Saturation will become evident when the amplifier displays a flat line with no apparent activity. **If your electrodes show a consistent DC shift that climbs quickly to saturation, then your electrodes are not suitable for DC recordings.** There are several rules to follow when selecting electrodes to avoid these problems:

1. **Never use different combinations of paste/gel and or electrodes.** For example, a common error is to use one type of electrode and paste in a monopolar derivation (i.e., electrode cap and gel) and a different electrode and or paste on the reference lead. By using different metals and electrolytes a battery potential has been created and the electrodes will drift. If you have the same electrode materials and gel and you are still experiencing saturation, then double check your electrodes. They may not be made out of identical material. Measure the DC voltages across these leads and you will find a large offset potential.

2. **Keep the interface between the skin and electrode consistent**. For example, with an electrode cap the interface with the skin is a nonconductive plastic and the conductive gel. The gel makes contact with the electrode. If you place a reference electrode directly on the subject's skin for a reference, you have created a

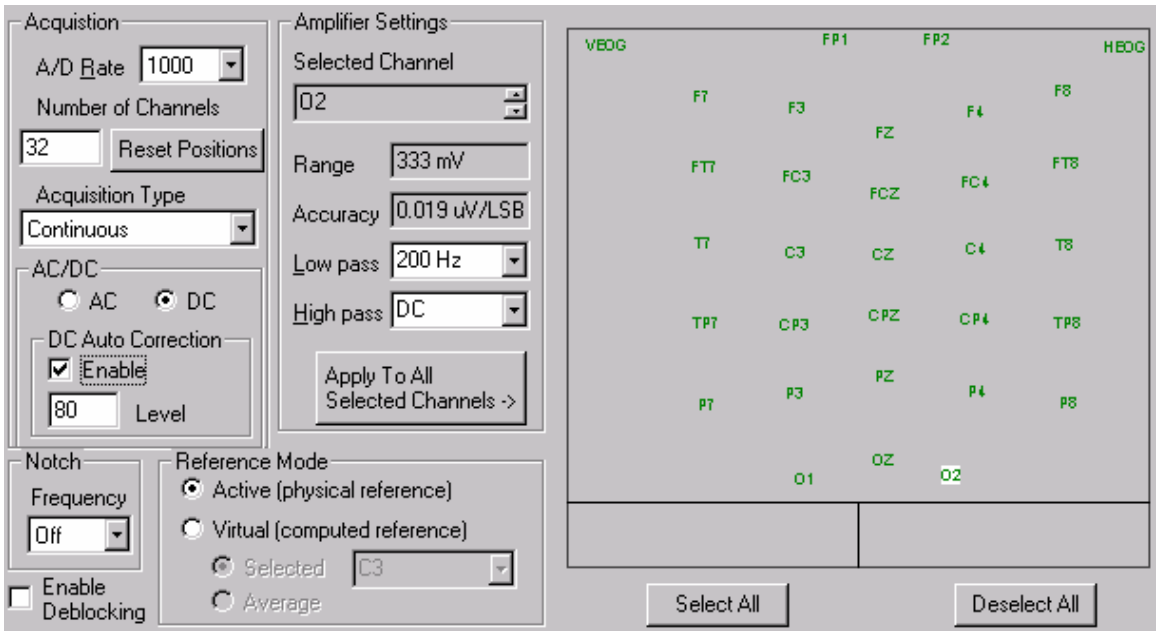
different interface. You now have a gel plus metal to skin interface. The best way to avoid this problem is to obtain a separate but identical electrode to employ as a reference. Another technique is to separate the metal from the skin with an adhesive electrode collar. *Note - drift problems with the reference electrodes in multichannel recordings are usually observed across all monopolar derived electrodes.*

3. **Select metals that are known to produce the smallest battery potentials.** Sintered Ag/AgCl electrodes are probably the best. We have also found tin electrodes to be acceptable. They will produce more drift, but the drift is monotonic and can be corrected using the DC offset transform in the EDIT module of SCAN.

4. **The DC level is relatively independent of the electrode impedance.** If you have set your electrode impedances to the standard 5kOhms or less and your electrode is still drifting, additional work on the impedance will usually have no effect (except on the subject!). Since the primary source of battery potentials is the interface between the gel and electrode and not the skin, further work on the gel to skin interface will probably not help. This is a good time to replace the electrode or examine the metal to wire solder joint (another potentially large source of battery potentials).

5. **Record in a comfortable and cool environment**. Sweat potentials can be a major problem for DC recordings. They produce transient and unpredictable results.

Amplifier Settings. The Filter characteristics of the SynAmps² are controlled from the Amplifier display screen. These settings are stored with the setup file for ACQUIRE. Thus, if you change a particular setting on the amplifier, you must resave your setup file if you want these values to reappear the next time you run the system. The SynAmps² receives these values prior to acquisition. You may notice that the system will display a sequence of messages when you change a gain or filter setting from the control panel. This is because the SynAmps² receives all of its instructions through the USB 2.0 communication port. If the values have not changed then it will begin data display immediately. If, however, the values have changed, then new values will be downloaded, and there will be a brief delay while this occurs.



These fields allow you to set the Filter settings for the individual amplifier channels. The basic operation consists of entering the new values, selecting the channels that you wish to modify, and then applying the modifications. In practice, you may find it easier to select the channels, then enter the new settings and apply them. Either method will work.

The right side of the window is used to select the channels that you wish to modify. Channels can be selected, or deselected, by double clicking the mouse on a channel (green is selected and red is deselected), or you can use the Select All and Deselect All buttons to affect all channels.

A single selected channel will show a white background behind the electrode label 1, and the label will be displayed in the Selected Channel 1 field. You can use the up and down arrow buttons to select a individual electrode, or, click the mouse button once on an electrode label.

When you have selected the channels that you wish to modify, enter the desired Low Pass and High Pass filter settings in the Amplifier Settings fields. Then click the Apply To All Selected Channels -> button to apply the changes.

You may verify the changes you have made by clicking an electrode label once and looking at the values in the Amplifier Settings display. Click the OK button to return to the main screen in ACQUIRE, or click Cancel to leave the screen without applying the changes you have made.

Range and *Accuracy* information is displayed in the adjacent fields to the right. The Range values indicate the upper and lower voltage limits for each channel - if the incoming voltage exceeds these limits, the channel will clip or saturate. The Range for SynAmps² in DC mode is ±333 mVs. In AC mode, it is 1.7 mVs. The difference is due to the relationship between Gain and the Range: the lower the Gain, the broader the Range. In DC mode, the Gain is 14.83x. In AC mode, it is 2966x. Therefore the Range in DC mode is much broader.

Accuracy refers to the precision of voltage measurement along the y-axis. The value displayed indicates the resolution, or accuracy, in microvolts . If the resolution is, for example, .06 uV, then the voltage resolution will be in .06 uV steps. This is similar to the dwell time on the x-axis, or, in other words, the *time* difference between adjacent data points. Accuracy is the least measurable *voltage* difference between points. (32 bits are available to "describe" voltage, that is, 2 to the 32nd power minus 1 discrete voltage values are possible per data point). The Accuracy is thus interactive with the Gain. In DC mode, the Accuracy is 0.019 uVs; in AC mode it is 0.993 uVs.

Filter Values

Filtering on the SynAmps², other than the AC coupling in AC mode, is performed by a program running on the host computer. The nature of these digital filters is dependent on coefficients sent down from the host system. Selecting different filter values determines the coefficients and consequently the filter characteristics of the system. Listed below are the current low-pass (High frequency cutoff) values installed in the SynAmps²:

Low-pass Filters

Low-pass filter values are dependent on the digitization rate. The upper end of the low-pass filter is set to about 1/5th of the current digitization rate, so that data are five times oversampled. The digitization rate is set in the 'Amplifiers' screen of 'Edit.' under 'Overall Parameters...'. Potential low-pass filter values are 30, 40, 50, 70, 100, 200, 500, 1000, 1500, 2000, 2500, and 3000 Hz. The maximum low-pass value available to the user will be 1/5th of the current digitization rate. For example, the maximum value for a digitization rate of 1000Hz would be 200Hz. Listed below are the low pass filter values available at each digitization rate:

Digitization Rate (Hz)

20K	10K	5K	2K[1]	1K[2]	500	250	200	100
30	30	30	30	30	30	30	30	30
40	40	40	40	40	40	40	40	
50	50	50	50	50	50	50		
70	70	70	70	70	70			
100	100	100	100	100	100			
200	200	200	200	200				
500	500	500	500					
1000	1000	1000						
1500	1500							
2000	2000							
2500								
3000[3]								

[1] same for 2.5K
[2] same for 1.25K
[3] filter is -9dB

Note - At cutoff frequencies, the voltage gain is approximately -6dB, except as otherwise noted.. The slopes are greater than or equal to -12dB/octave.

High-pass Filters

The table below shows the high-pass (low cutoff frequency) filter values. Values range from DC to 300 Hz. Digital high-pass values start from 0.1 Hz. Researchers interested in lower frequencies (i.e., .01 Hz) should record with the DC setting. A filter setting of .01Hz in the past has been used as an approximation to true DC recordings. With the SynAmps² one does not have to "approximate DC" since the amplifier is a DC system. Shown below are the high-pass filter values:

High-pass filter values

<1kHz	1kHz	1.25kHz-2.5kHz	5&10kHz	20kHz
DC	DC	DC	DC	DC
.05[1]	.05[1]	.05[1]	.05[1]	.05[1]
.1	.1	---	---	---
.15	.15	---	---	---
.3	.3	---	---	---
1	1	1	1	---
5	5	5	5	5
---	10	10	10	10
---	30	30	30	30
---	100	100	100	100
---	---	---	150	150
---	---	---	300	300

[1] - AC coupled mode only

Notch Filters and Noise

Narrow band notch filters centered at 50 and 60 Hz are available to reduce main power frequency interference. Although these filters are very sharp and affect a narrow range of the EEG spectrum, caution should be exercised in their use. Many evoked potentials have energy in the 50-60 Hz band and data may be significantly distorted. Notch filters should not be used routinely. Rather, attempts to reduce noise in the recording environment should be made first

before adding a notch filter. The option for the filter is found on the Amplifier screen under Edit, under Overall Parameters..., from the Acquire main menu bar.

60 Hz (50 Hz) Interference - Here are a few quick things to check if you have significant interference in your data:

Impedance of leads - Impedances of all leads should be below 5kOhms.

Impedance of ground lead - It is important that a solid ground lead be placed on the subject. The ground lead is used by the amplifiers to reject common-mode interference such as 50 and 60 Hz main frequencies. Double check this lead to be sure it is securely attached.

Power cables - Make sure that there are no power or video cables near the subject or the headbox cable. Although signals coming from the headbox are amplified, draping a power cable over the headbox or headbox cable will produce interference.

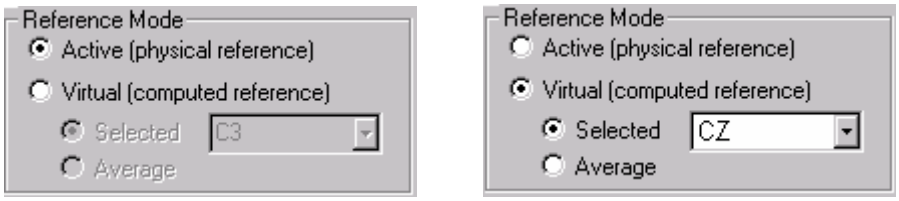
Monitors - Video monitors are now a common device in the neurophysiological laboratory. Unfortunately, they can also be a serious source of interference. Most monitors radiate more from the sides than the front. If you suspect interference from your monitor, try moving the orientation of the screen. It should vary with orientation. Another clue that a monitor is emitting noise is a clear pulse with an interval corresponding to the refresh rate of the screen (i.e., 16.667 ms for a 60Hz refresh rate). It should be noted that the newer low radiation monitors have significantly reduced noise radiation.

Other noise sources - Watch out for anything in the surrounding area of your laboratory that can generate an electromagnetic field. Any device with a large electric motor (centrifuges, freezers, elevators, large fans) or transformers (X-ray machines) is a potential problem. Also, check to make sure that you have a good and 'quiet' ground connection within your

building. A high quality milligauss meter can be used to measure these fields.

Reference Mode

The SynAmps² is a "referenceless" acquisition amplifier. That is, EEG is recorded with only the ground as a reference. The actual Reference channel(s) can be recorded as a separate EEG channel. The Reference is subtracted from the active channels prior to the display of the EEG data, so the EEG data that you see have the reference applied. Therefore, you have the ability to select the reference from among the EEG channels that you are recording, or to use a common average reference. In the Reference Mode section, there are Active and Virtual options.



The Active option uses the hard-wired reference from the cap, for exanple, M1. The EEG data that are displayed will have that channel as the reference.

If you select Virtual, you then have the option to select any single channel for the reference, or to select the common average of all channels for the reference.

Enable Deblocking

The **Deblocking** feature should be enabled to reduce stimulus artifact, such as, SEP stimulation artifact. You must be in **DC Mode** to use Deblocking. Deblocking essentially suspends acquisition for a [typically brief] span of time. For example, deblocking can be used to suspend acquisition during the few ms's in which an SEP stimulus artifact is present.

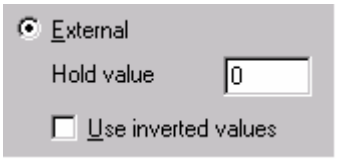
Deblocking is controlled by a TTL signal sent from the peripheral device to the System Unit using the Deblocking Interface cable P/N 00081300 (included with the System Unit package). This cable connects to the Inter-System Unit connector on the back of the System Unit. The duration of the TTL pulse should be no longer than the duration of the artifact (data are lost during the span in which deblocking is employed). The Deblocking pulse must return to the original response bit resting state (typically 5Vs) between pulses.

Triggering

All event marking and triggering on the SynAmps² are managed by a special parallel port located on the back panel of the System Unit. This parallel port is

identical to the parallel port used by previous SCAN interfaces. To make connections to this port the reader is referred to **Appendix A**. (Voltage Triggering is not an option with SynAmps²).

External Triggering. When interfacing with the STIM system, select the **External** option. In most circumstances the **Hold value** will be zero. Whether you **Use inverted values** or not depends on several things. With new systems you generally do not need to invert the triggers. If you do not see any triggers in Acquire, or if you are using an older LabMaster STIM system, try it with the **Use invert values** option checked.



High Level Inputs

In years past, it was possible to input psychophysiological signals from peripheral devices, such as GSR, EKG, respiration amplifiers, directly into the SynAmps headbox (assuming the voltages were attenuated to physiologically normal levels). This practice, however, can create safety issues in certain situations, such as in a hospital setting where a patient is connected to multiple devices, and where grounded metal may be within reach. In other situations, problems may arise between fixed grounds used by the other devices and the SynAmps floating ground at the headbox. Consequently, psychophysiological signals arising from peripheral devices should only be connected through the High Level Inputs (HLIs) on the bottom edge of the SynAmps².

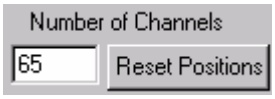
There are several places in the ACQUIRE program that are relevant for configuring the HLIs. These include the **Amplifiers (SN2)** tab (Edit, Overall Parameters), the **High Level Inputs** tab (Edit, Overall Parameters), the **Channel Assignment Table** (under Edit), **Channel Layout** (under Edit), and **SynAmps² Hardware** (under Edit). We will use an example to describe the various settings shortly. Briefly, the various dialog screens are used as follows:

Amplifiers (SN2) - select the number of channels, including the HLIs; set Filtering for HLIs (if any)
High Level Inputs - main screen for configuring the HLIs
Channel Assignment Table - used to select the HLI channels
Channel Layout - used to size and position the HLI displays
SynAmps2 Hardware - used for diagnostic testing of the HLIs

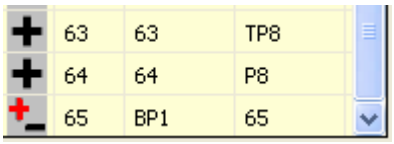
Example. Let's say you are using the supplied 64 channel setup file (in the SynAmps2 folder) for SynAmps², and you want to add a HLI channel to record pupil diameter. The analog voltage output of the pupillometer ranges from 0 to 5Vs, where 0Vs = 0mms, and 5Vs = 15mms.

1. Retrieve the setup file. (The most recently retrieved setup file will always be loaded when you enter ACQUIRE).

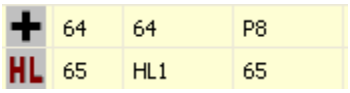
2. Go to Edit, Overall Parameters, and click the **Amplifiers (SN2)** tab. In the Number of Channels field, enter 65 in place of 64, and click OK.

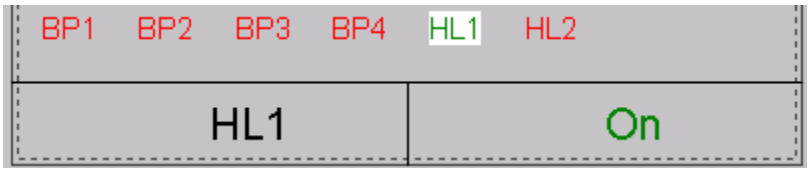


3. Go to Edit, **Channel Assignment Table**, and scroll to the bottom of the list. In this case, the 65th channel was assumed to be a bipolar channel - that is the next unassigned channel in the display.

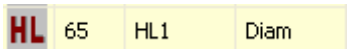


4. Click the  area to highlight the entire line, and then double-click HL1 on the Physical channel display (or click once and then click the Add button). You will see the HLI symbol  appear for channel 65, and the HL1 channel will be "On".

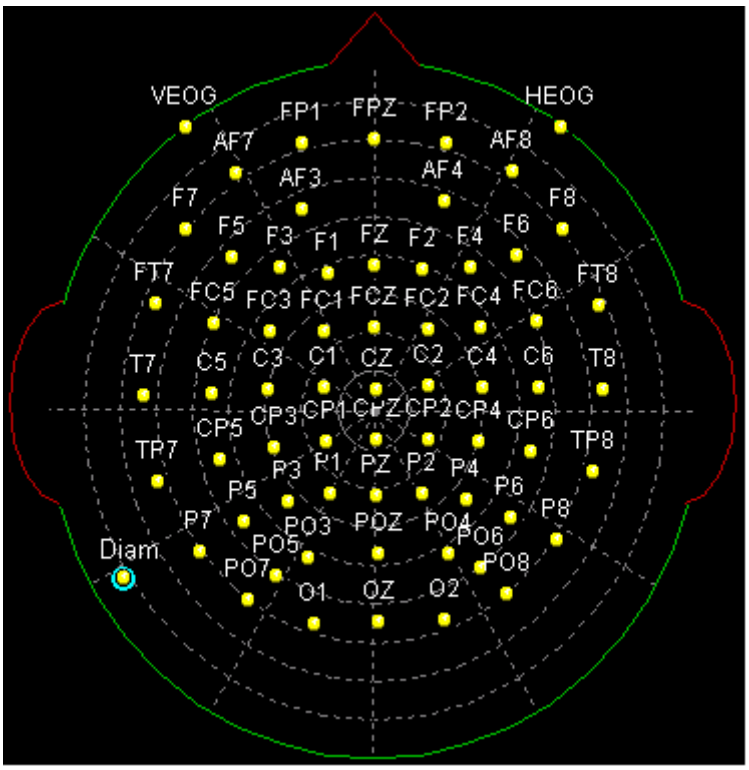


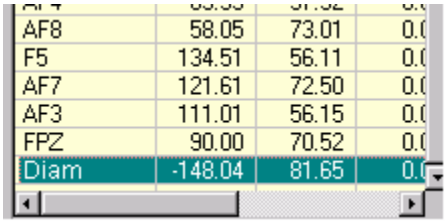


5. Click the "65" in the channel Label column, and enter a new label, such as "Diam". Then click OK to leave the Channel Assignment Table.



6. Under Edit, click Channel Layout, and then click the "10-20 Positions" button. Scroll down to the bottom of the electrode list and highlight the "Diam" electrode you created. You will then see its electrode circled in the "radar" display. Drag it to a new location.



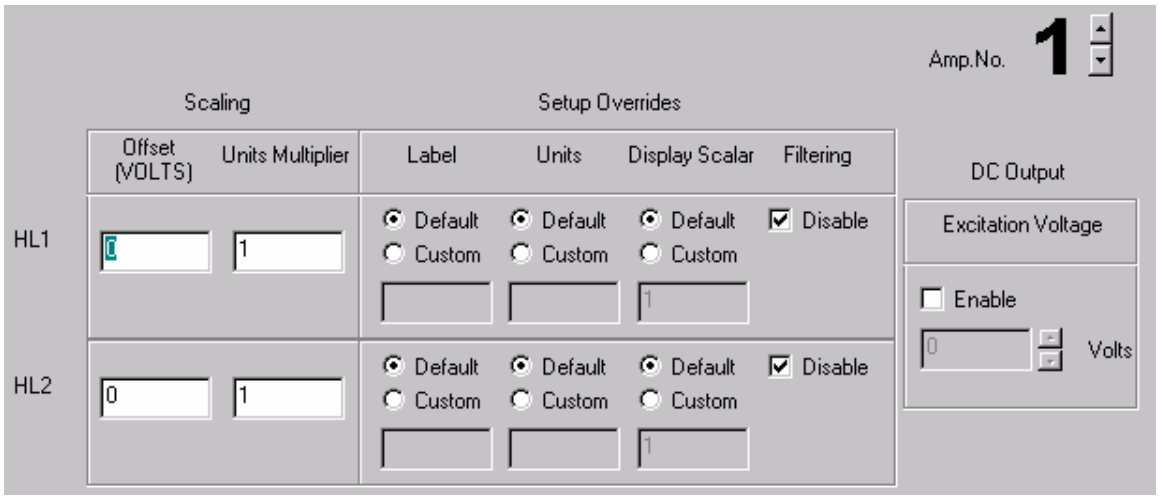


AF8	58.05	73.01	0.0
F5	134.51	56.11	0.0
AF7	121.61	72.50	0.0
AF3	111.01	56.15	0.0
FPZ	90.00	70.52	0.0
Diam	-148.04	81.65	0.0

7. Click OK to return to the **Channel Layout** screen. You will then see the new electrode display for the HLI channel. Size and position it as desired. (*Note: you may set the display Scalar here, if needed, or in Step 9 below*). Then click OK to exit the Channel Layout.

8. Return to Edit, Overall Parameters, **Amplifiers (SN2)**, and you will see the new HLI channel in the montage display. If you want to apply a filter to the HLI channel, select the channel and set the filter as desired. In most cases you will *NOT* want to filter the HLI. Apply a filter only if you are sure you need to do so.

9. Next, click the **High Level Inputs** tab. For this example, we will assume you have a single amplifier; if you have more than one, the process is the same - just select the amplifier containing the HLI that you are configuring.



Offset [VOLTS] / Units Multiplier. The Offset and Units Multiplier fields are used to configure the SCAN software to interpret the voltages from the external devices in a meaningful way. The Offset [Volts] is the value that must be added to the output voltage corresponding to the zero value to make it 0. The Units Multiplier is applied to your data to make the readout equivalent to some real world value.

In some cases, these will be fairly obvious to determine. In our example, the analog voltage output of the pupillometer ranges from 0 to 5Vs, where 0Vs = 0mms, and 5Vs = 15mms. The Offset is zero, and the Multiplier is 3.

In other examples, let's say you have a pressure monitoring device that outputs a signal from -1 to +1V, where -1V represents -50psi and +1V is +50psi. In that case, there is no Offset (enter 0), and the Units Multiplier would be 50 (the raw voltage points are multiplied by 50 to make the results meaningful). Or, say you have a device that outputs a signal from 0 to 10V, where 0 indicates -50psi and 10V indicates +50psi. In that case, the Offset is -5V, and the Multiplier would be 10.

In some cases, the Offset and Multiplier may be less obvious, and you may need to compute them using the formulae:

$$m = (y1 - y0) / (x1 - x0) \quad \text{and} \quad b = (y1 / m) - x1,$$

where m is the Units Multiplier, y1 and y0 are the upper and lower values of the "real world" units, x1 and x0 are the upper and lower limits of the voltage range, and b is the Offset value.

Consider the case of a peripheral temperature measuring device. The analog voltage output of the device ranges from 0 to 5Vs, where 0V = 60 degrees, and 5V = 110 degrees. Therefore, x0 = 0, x1 = 5, y0 = 60, and y1 = 110.

Solving for m,

$$m = (110-60)/(5-0), \quad \text{or } m = 10$$

Solving for b,

$$b = (110/10) - 5, \text{ or } b = 6$$

Therefore, the Offset is 6 and the Units Multiplier is 10.

Label. Label is the electrode label that you entered in Step 5. The Default label is the one you entered at that point. You can change it by clicking Custom, and entering a new Label. This will override any previous label you entered.

Units. You can set the Units displayed on the Y-axis as needed to make them meaningful for the HLI data. The Default units are the autoscaled nVs, uVs, mVs etc. To change it, click Custom and then enter whatever units are meaningful (for example, enter "mm", or "psi"). *Note, the labels should not contain any spaces, and there is a 10 character maximum.*

Display Scalar. The Display Scalar is the same at the Scalar seen in the Channel Layout dialog screen (Step 7). These settings allow you to alter the display scaling factor specifically for the HLI channel(s), thus increasing or decreasing their amplitudes in relation to changes in the other EEG channels. The scalar multiplies the global scale factor. For example, if the global scale factor is 2 (the number displayed on the Status Bar and affected by the Up and Down arrows on the Toolbar), and the scalar value is 2, then the display will be multiplied by a factor of 4. The scalar setting affects the screen display only, and has no effect on the stored data. The Default value is the value displayed on the Channel Layout display; a Custom value you enter for the Display Scalar will override the value set on the Channel Layout display.

Filtering. The default state is disabled, since in most cases you do not want to filter the HLIs. If you enable the Filtering option, then whatever filtering you assign to the HLI channels under Overall Parameters / Amplifiers (Step 8) will be applied to the HLIs. Be careful doing this, since in most cases you do not want to filter the analog voltage output from the peripheral device. If you select the default Disable option, this will override any filter settings that were made on the Amplifiers page, and no Filtering will be applied.

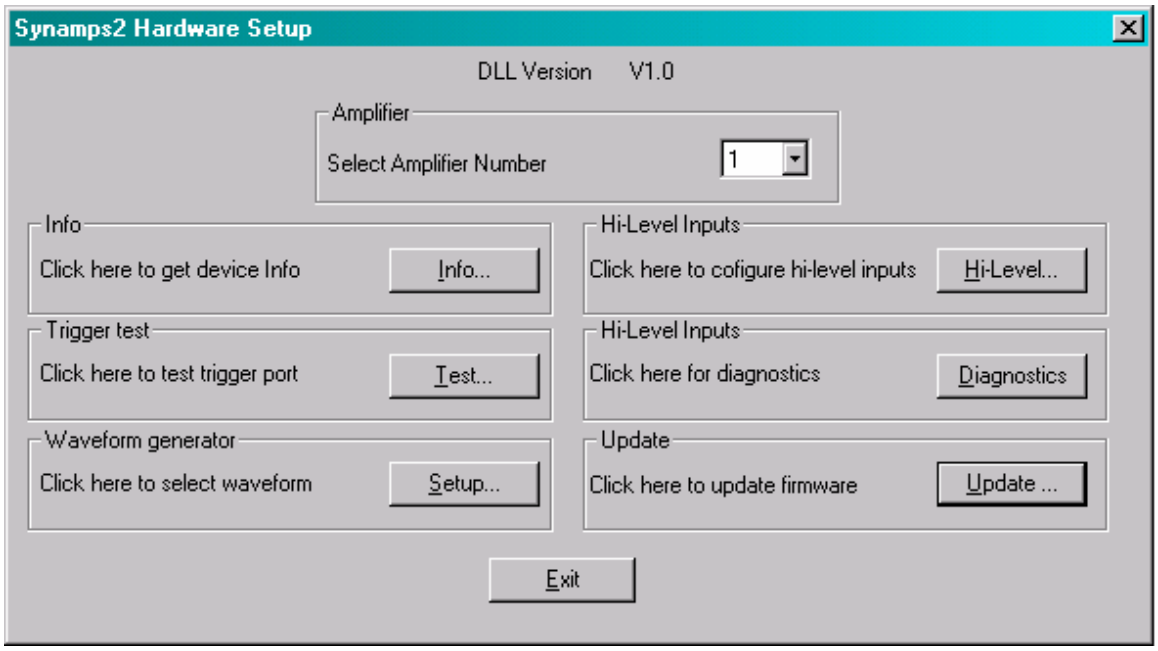
Leave it disabled for this example.

Excitation Voltage (Volts). Some transducers require an excitation voltage in order to operate. The SynAmps² is capable of producing a differential output. That is, it has a positive, negative and ground output. The voltage on the output is always symmetrical about the ground (e.g., -5 to +5Vs, -1 to +1Vs, but not -1 to +5Vs). Enable the field and enter the voltage you want to use. There is one independent voltage source per amplifier/headbox (see the pinout information below). The maximum voltage is 9V. If you need an excitation voltage, please consult your device specifications.

In our example, there is no excitation voltage. Leave it disabled.

10. The HLI is now completely configured, and you should save the setup file with the HLI configuration. Click the Save As button at the bottom of the Setup display, or click File, Save Setup.

11. Lastly, if you are having problems with the HLI, or just wish to test it, go to Edit, SynAmps² Hardware, and click the Diagnostics button under High Level inputs.



REDO

EXPLAIN WHAT THIS DOES LATER

Additional Information

Input voltages. The High Level Inputs have a *full scale range of +/- 5Vs*. Beyond that damage can occur, so be careful to verify the output voltages of the peripheral devices *before* connecting them to the SynAmps². If the output voltages are, for example, +/- 10Vs, we recommend that you use a 3:1 voltage divider.

14 pin Redel connector. The pin connections for the connectors for the High Level Inputs are:

1	Hi-Level Channel 1 Active (positive) Input
2	Positive Sensor DC Supply (software programmable voltage out)
3	Signal Ground
4	Hi-Level Channel 2 Active (positive) Input
5	No Connection
6	No Connection
7	Hi-Level Channel 2 Reference (negative) Input
8	Signal Ground
9	Negative Sensor DC Supply (software programmable voltage out)
10	Hi-Level Channel 1 Reference (negative) Input
11	Signal Ground
12	Signal Ground
13	Signal Ground
14	Signal Ground

All peripheral psychophysiological devices should have a common ground among them.

Precautions

For maximum protection to the SynAmps², we recommend that the following precautions be followed routinely.

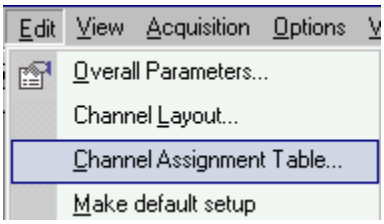
- When connecting the peripheral equipment to the SynAmps², have the SynAmps² and the devices turned *OFF*. Turn the SynAmps² on *first* - **always** - and then turn on the other components.
- Connect and disconnect the electrodes/transducers to the subject with the devices turned *ON*.
- Turn the other devices off *first* - **always** - and then turn the SynAmps² off.
- Be very careful with *static charges*. For example, if you are disconnecting an electrode from a subject, and happen to discharge a static charge through the system, it could damage one of the boards in the SynAmps².
- Do *not* exceed the input voltages described above.

Reassignment of Channels

It is possible to re-map the order in which channels are sampled within a single SynAmps². There are several instances in which you might want to do this. For example, the channel order is defined by the hard-wiring in the cap. If you list the channels numerically, in order of the Physical Channel numbers, this might not give you the channel order that you want. You can change the channel order by using the Channel Order option, or you can remap the channels in the Channel Assignment Table.

Step 1- Select or create a setup file in ACQUIRE with the total number of electrodes required (or go to Edit / Overall Parameters and the Amplifiers tab to set the number of channels as desired).

Step 2 - Then go to the **Channel Assignment Table**.



Step 3- Click on the channel field labeled '**Phys**' and enter the channel number that will result in the order that you want (channel 1 reassigned to channel 10 in the example below). In this example, channel 10 will now have physical channel 1. Repeat this step until all desired channels have been reassigned.

#	Phys	Label
1	10	O2
2	2	O1
3	3	OZ
4	4	PZ
5	5	P4

Step 4 - Click **OK** to assign the channels.

Step 5 - Save the setup file to make your changes permanent.

Note - If channels are to be deleted, be sure to remove the unwanted channels before assigning channels.

Similarly, you may want to select only some of the channels to use. For example, let's say you have a 64 channel cap, but you only want to record the basic 10-20 system electrodes. From the documentation you received with the cap (or from a setup file that matches your cap), you can see which physical channels carry which electrodes. Select the 10-20 channels, order them as you wish, and save the setup file. (Be sure to set the desired number of channels in the Amplifiers tab first).

Note that if you have more than one headbox, *you must use all of the channels from the first headbox* if you plan to use some or all of the channels from the second headbox. Similarly, if you have more than two headboxes, you must use all of the channels from all of the first headboxes, and then use some or all of the channels from the last one. In other words, you can only leave "holes" (unused channels) in the last headbox.

If there are channels in the first headbox you are forced to record, even though you do not want them, record them as "Bad" channels - "Hide" them, if desired - and then use the Delete Bad Channels option in EDIT to create a new CNT file without the Bad channels.

Calibration

REDO CALIBRATION - NO LONGER POSSIBLE _ ONLY P/F RESULTS

It is possible to calibrate or verify the gain characteristics of the SynAmps² in two ways: internally, in which a square wave of known frequency and amplitude is injected into the input stage of the system by the SynAmps²; or externally, in which a wave of known frequency and amplitude is injected via an external source such as an attenuated signal from a signal generator. For both methods, calibration values are stored in the form of a scalar value for each channel. Normally, this value is close to 1.0, indicating a one-to-one transfer of signal amplitude. However, small variations in gain between channels can be compensated for in software by performing the calibration procedure.

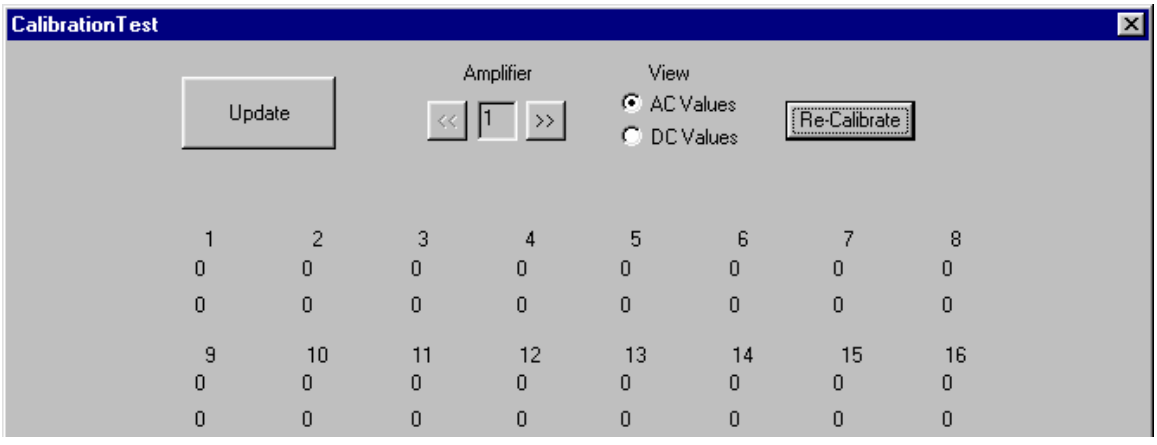
Internal Calibration

To perform internal calibration follow these steps:

Step 1 - Connect the shorting plug to the cap connector on the headbox (all headboxes if you have more than one). With nothing plugged into the BNC connector on the shorting plug, all channels will be shorted. (The BNC connector can be used to send a common signal to all channels. There is a 1000:1 attenuation in the shorting plug, with 10 ohm and 10k ohm resistors making a divider, thus creating a shorting impedance of 10 Ohms).

Step 2 - Click on the **Calibration** item under Acquisition from the Acquire main menu, or click the calibration icon 

from the Toolbar. The Calibration Settings display screen will appear (section shown below).



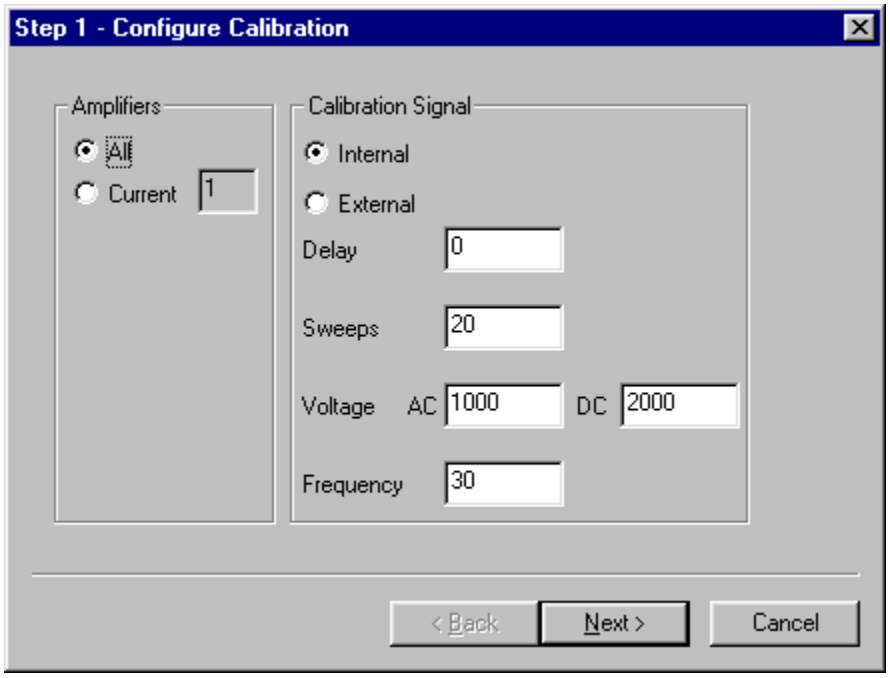
At the top of the display, note that you can select from among multiple amplifier/headbox units. You can also select to display the AC or DC values.

The values that are displayed for each channel are the AC or DC (depending on which you have selected) **Factor** and **Offset** values. The values seen are the ones *currently stored in the headbox*. The upper value is the correction Factor. This is the value that is used to compensate for any variation from the expected value. For example, if the expected voltage equals the measured voltage, then the Factor is 1.0. If the measured voltage is slightly lower, then the Factor may be slightly greater than 1.0. The incoming voltages are multiplied by the Factor to make the correction.

The Offset - AC or DC - is the millivolt DC offset from 0V. It is always expressed as a positive number. There can be an offset in AC calibration, because the front end filter is applied *before* the last gain stage (and prior to AC filtering in the DLL file). Any imbalance in an opamp will show up as an offset.

Recalibration. Click the 

button to begin the calibration process. You will see the Step 1 dialog box.



Here you have the option to recalibrate all of the amplifier/headboxes, or just the currently selected one. The next choice is Internal or External calibration. With the Internal option, the SynAmps² will generate the calibration signal using the Voltage and Frequency you select. With the External option, you can use your own signal generator.

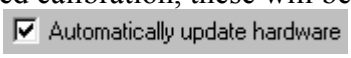
Delay. Each time the SynAmps² is accessed, there is a brief period during which the signals are not fully stable. The Delay option will automatically exclude that time span - typically about 5 seconds.

Sweeps. The duration of the sweep is fixed, but the number of sweeps is variable. We recommend 20 sweeps as a sufficient number to get a valid estimate for correction.

Voltage. There are separate voltages for AC and DC calibration because 1) the signals should encompass 70 to 80% of the dynamic range, and 2) the range is different for AC and DC modes (because the Gain is different; AC Gain = 2,966 and DC Gain = 14.83). We recommend voltages of 1000 for AC and 2000 for DC (this will likely change).

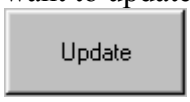
Frequency. Enter the desired frequency in this field. The frequency should be within the range of the activity of interest. For regular EEG recordings, therefore, we recommend 30Hz. With External calibration, this field is not relevant (and is grayed out).

After entering the values (or accepting the recommended defaults), click Next to continue. You will see a reminder to connect the shorting plugs to all headboxes. The Factors will be meaningless if the shorting plugs are not connected.

You will then see the Update Hardware display. If you have any channels that failed calibration, these will be listed in the display. If the channels are all good, the 

field will be enabled automatically. All you need to do then is click OK to update the hardware with the new calibration Factor values. You will see these when you are returned to the Calibration Test display.

If any channels failed, the 

field will not be enabled. Click OK to return to the Calibration Test display. You can then decide if you want to update the hardware anyway, which is accomplished by clicking the 

button. If you do not update the hardware, the previously stored values will be retained.

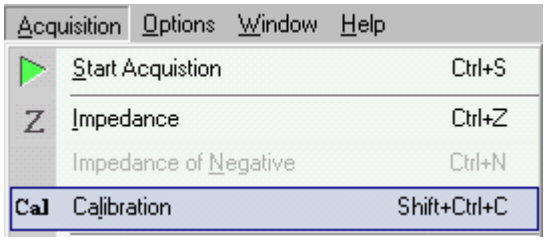
The Calibration process itself takes a few moments. That is because X sweeps must be acquired four times: AC Factor, AC Offset, DC Factor and DC offset.

NOTE: The calibration values are only valid for the setup file you selected. Do not calibrate with one setup file, and then switch to a different setup file for your recordings. This is especially true if you switch from AC to DC, or DC to AC in the setup files.

External Calibration

External calibration assumes that an external voltage is applied across the positive and negative ends of the amplifiers. This is most easily accomplished by injecting the signal into the BNC connector on the back of the shorting plug. (There is a 1000:1 attenuation in the shorting plug, with 10 ohm and 10k ohm resistors making a divider, thus creating a shorting impedance of 10 Ohms).

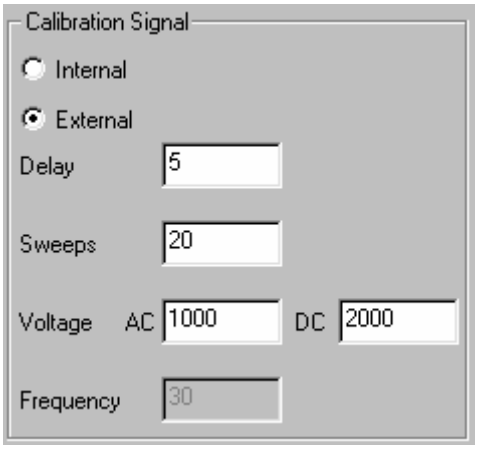
Step 1 - Connect the shorting plug to the cap connector, and connect your signal generator to the BNC connector on the shorting plug. The voltage should be in the ± 2V range. Please follow steps 2-6 to perform external calibration.

Step 2 - Click on the 

item under Acquisition from the Acquire main menu, or click the Calibration icon 

. The Calibration Test display screen will appear. Click 

, and then select the **External** option.



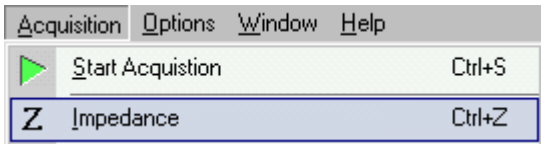
NOTE: The calibration values are only valid for the setup file you selected. Do not calibrate with one setup file, and then switch to a different setup file for your recordings.)

Impedance

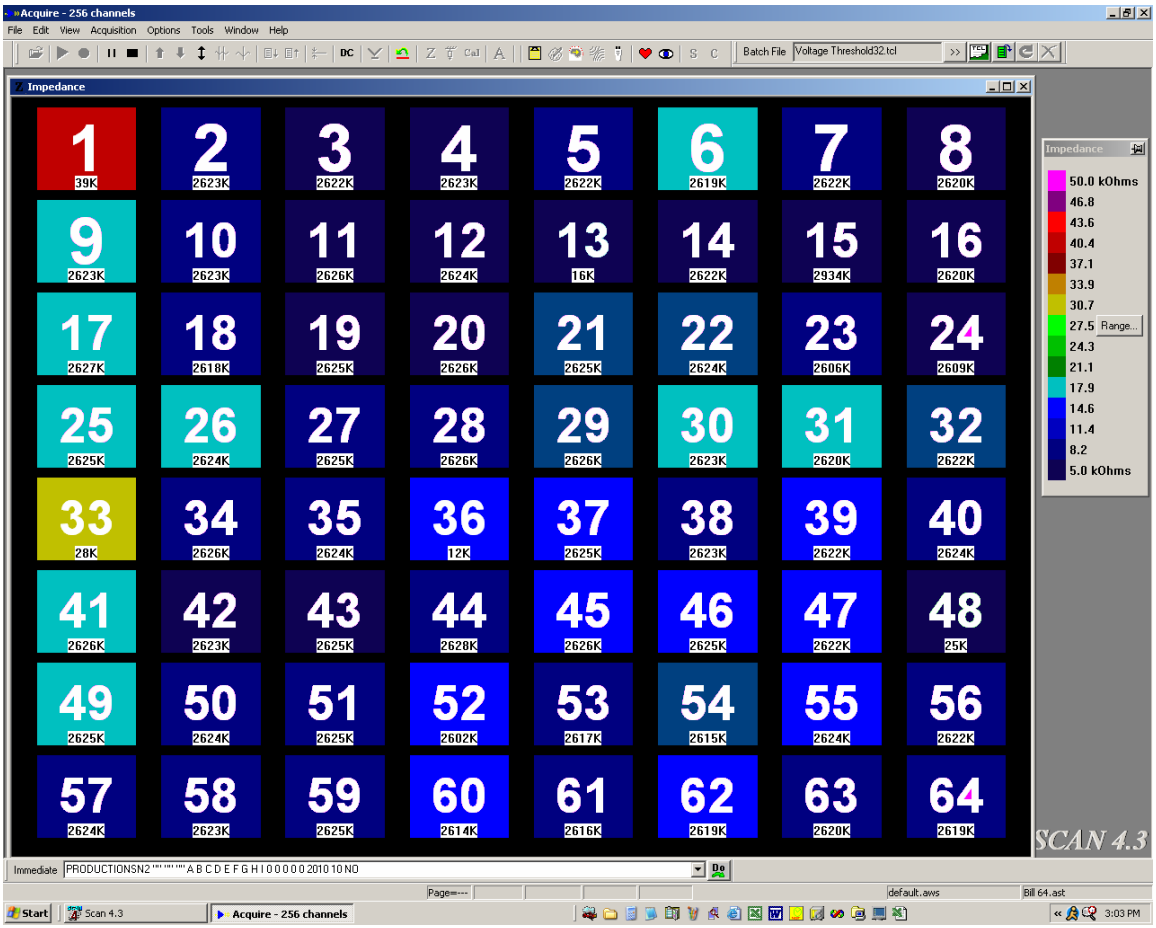
Electrode impedances can be checked at any time while the subject is connected to the headbox. Monopolar (inputs 1-64) and bipolar (positive inputs B1-B4) leads are measured against the ground lead. This means that the impedance of the reference(s) can

also be measured (which is not possible with SynAmps). The negative leads of the bipolar channels are compared to the positive leads. Impedance values are displayed in color form at each electrode. Follow these steps to check electrode impedance:

Step 1 - Place leads on the subject with standard electrode application techniques.

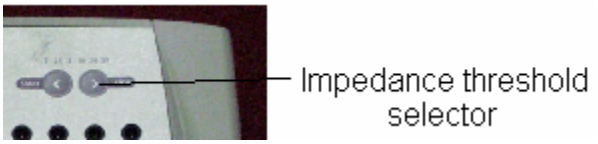
Step 2 - Click on the 

option under Acquisition from the Acquire main menu bar, or click the Impedance icon Z. The 'Impedance' display screen will appear.



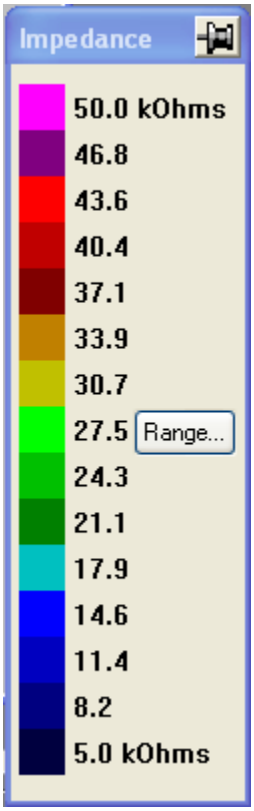
The impedance of an electrode, or the opposition of AC current flow, is the result of the complex interaction between skin, electrolyte and electrode. Measured impedance will vary according to the transfer function of this junction.

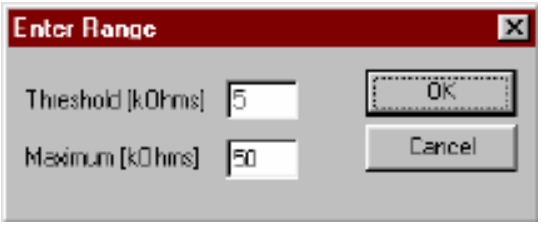
On the face of the headbox is an Impedance threshold selector. Use the < and >



buttons to select an Impedance threshold. If the impedance for a given channel exceeds the threshold, that channel on the headbox will light up.

Step 3 - Enter the threshold and maximum displayed impedance value. The default threshold value is 5kOhms and the maximum value is set to 50 kOhms. To change these, click on the **Range** button and enter the desired values. Then click OK.





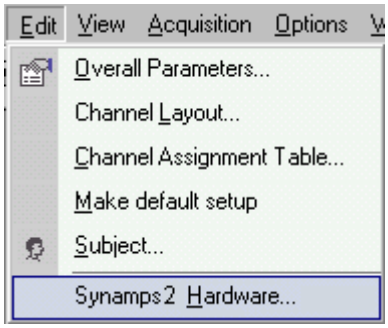
Step 4 - Impedance testing will begin when the Impedance screen is displayed. The impedance operation uses a 30Hz sine wave. The color-coded impedances will be displayed for each electrode according to the color of the display.

Remote Impedance testing. You can also test the impedances from the headbox itself, without using the Impedance routine in ACQUIRE. You need to at least open the ACQUIRE program, however. Then press the Start button on the headbox (the same as the < button), and the electrode labels should light up (assuming their impedances are greater than the value set with the indicator). Set the indicator to the desired Threshold (for example, 5kOhms). The electrode lights will turn off as the channel impedance goes below the threshold. To stop impedance testing remotely, press the Stop button (>) and *hold it for at least two seconds* to turn off the impedance function at the headbox.

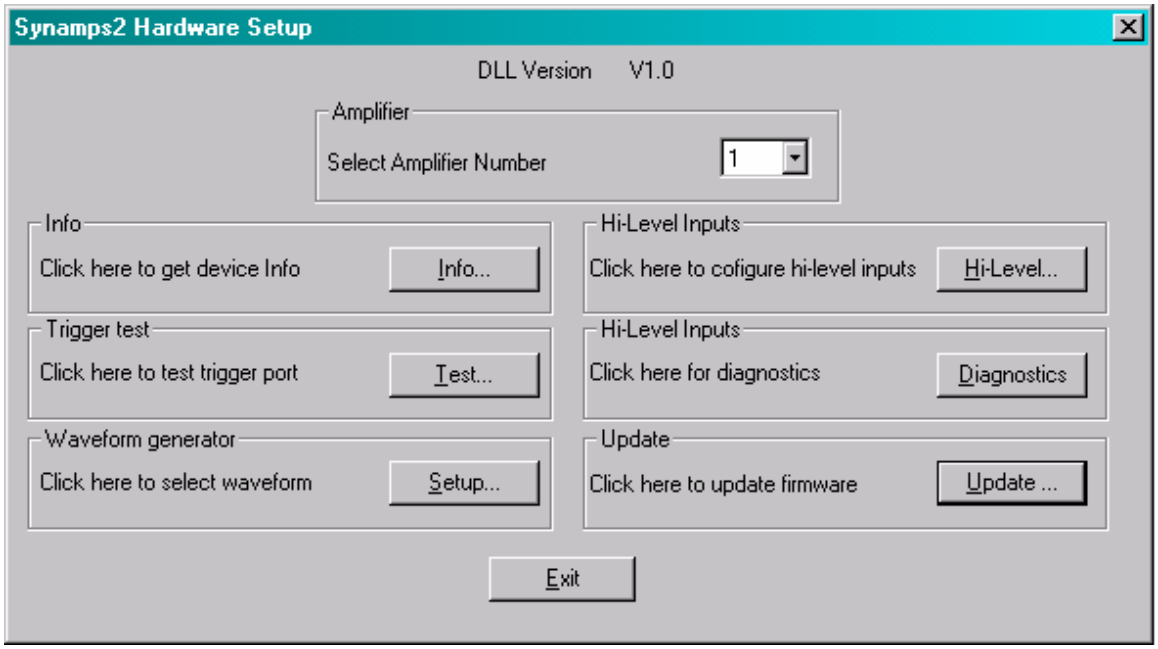
To test the impedance of negative leads (bipolar channels), you should click the "Impedance negative electrodes" button  on the Toolbar in Acquire. This will only apply to the negative inputs of channels B1-B4. Do not use this option for monopolar leads 1-64, as incorrect values will result.

Diagnostic and Related Information

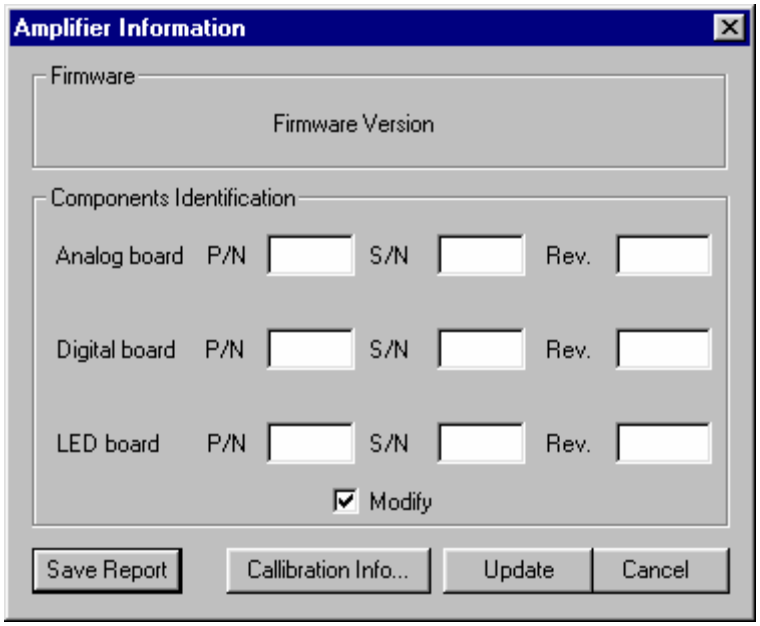
To access some diagnostic and other information, click Edit, then SynAmps² Hardware.



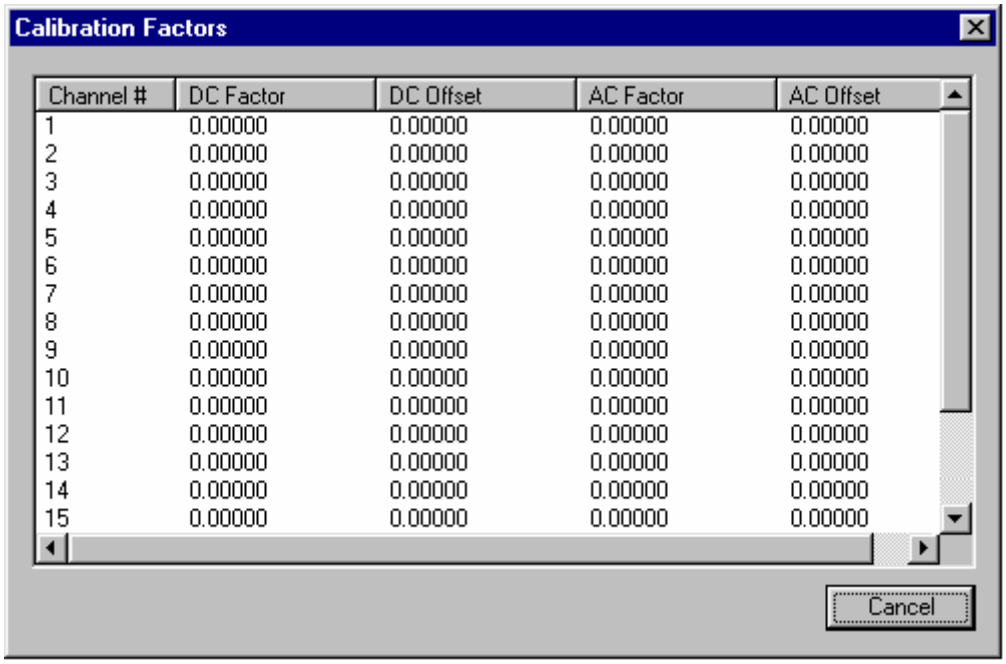
The SynAmps² Hardware Setup dialog box will appear. THIS WILL CHANGE



Info. This option returns information about hardware versions in the amplifier/headbox, and is used for diagnostic purposes only.



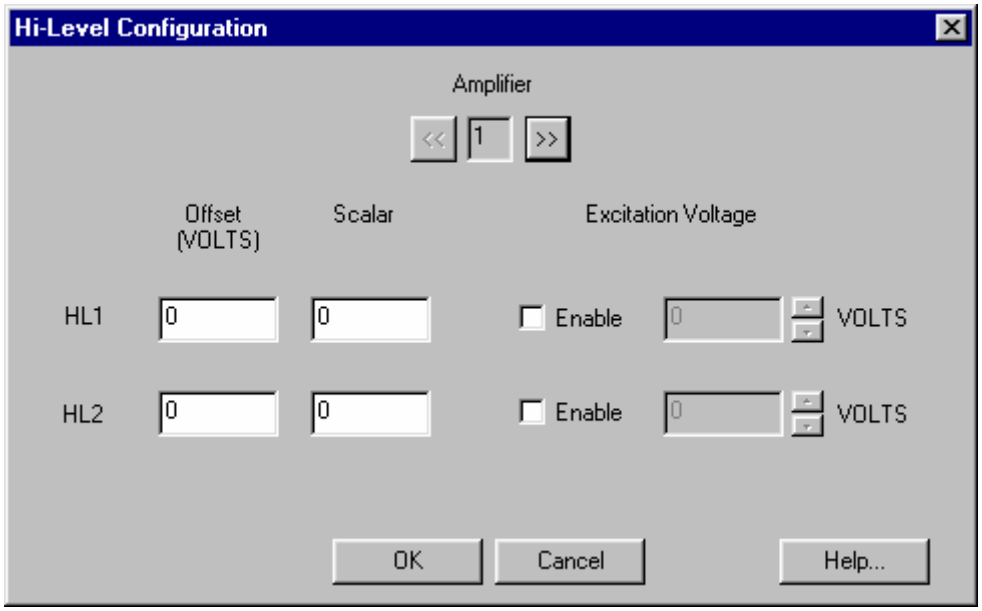
With your amplifiers connected, you will see the part number, serial number and revision for the analog, digital and LED boards. Do not attempt to modify or update the information unless so directed by Technical Support. Click the Calibration Info button to see the following display. With amplifiers connected, you will see genuine values in the fields.



The DC Factor and AC Factor values are the correction factors to compensate for slight variations among amplifiers. Typically, these will be approximately 1.0 (0.9 to 1.1). The DC and AC Offsets should be within a range to be determined (see the Calibration section below for more information).

The information can be saved to a text file by clicking the Save Report button.

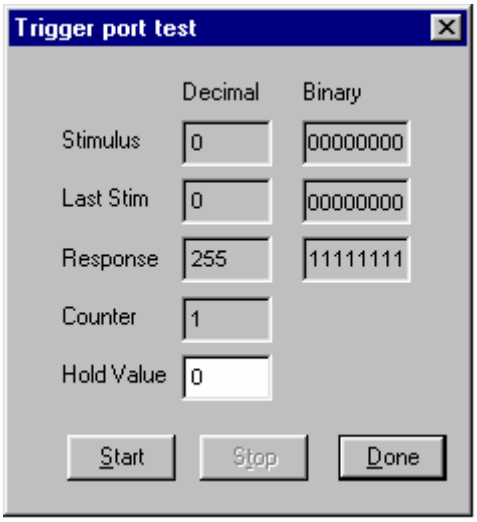
High Level Inputs. REMOVE THIS SECTION??? This option allows you to configure the High Level Inputs (HLIs).



There are two HLIs per amplifier/headbox: HL1 and HL2. If you have multiple amplifier/headboxes, you can select these individually, and then configure the HLIs independently for those channels.

For each channel, you may modify the Offset voltage, the Scalar, and the Excitation Voltage (see the High Level Input section below for additional information).

Trigger test. Trigger test provides a way to test the incoming stimulus and response triggers from STIM, or other stimulus presentation software. Click on the Trigger test button and you will see the Trigger port test display.



The Decimal column will show the type code numbers that are sent from STIM. The Binary column will show the bits as they change. Bit 0 is on the far right side of the display, and bit 7 is on the far left side.

Click the **Start** button in the Trigger post test display, and start one of the STIM programs (so it is sending triggers).

Stimulus. The Stimulus fields display the stimulus trigger type codes received. With STIM running, you will see brief flashes in the Stimulus decimal and binary fields with each trigger received. If you increase the pulse duration in the STIM software to, for example, 100ms, you will see the triggers somewhat more clearly. The type code number will flash on the decimal field, and the activated bits will flash on the binary field.

Last Stim. The Last Stim fields will show the type code in decimal and binary of the most recently received trigger.

Response. The Response decimal field will show the inverted value of the response pad triggers (i.e., 255). Pressing the response pad buttons should

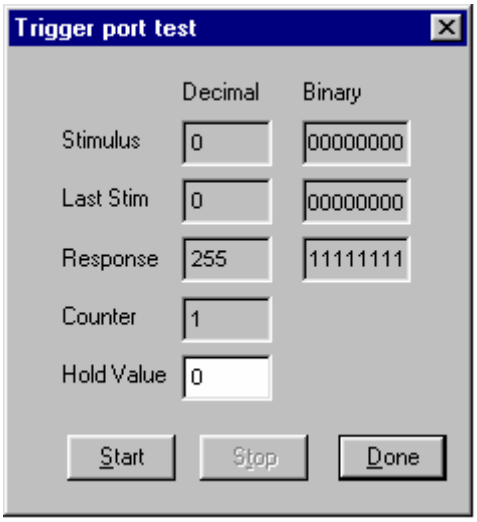
show decimal values of 254, 253, 251, and 247, corresponding to buttons 1-4, and type codes of 1, 2, 4 and 8, respectively. The binary field will be all 1's until a button is pressed, then the corresponding 1 will become a 0 (uses the 4 columns on the right side of the display).

Counter. The Counter will show the accumulated number of stimulus and response triggers received.

Hold Value. The Hold (bit pattern) value determines what value of the signal at the trigger port will initiate a sweep; a value other than the Hold value will trigger acquisition. With new STIM systems, the Hold value should be zero. If you see a different value, please contact Technical Support. If you have an older LabMaster STIM system, and do not see any triggers with a Hold value of zero, you need to invert the trigger codes. Do this by entering 255 for the Hold value from the keyboard (you will also need to click the **Use inverted values** field under Edit/Overall Parameters/Triggers; see Triggering section below). If you still do not see triggers, contact Technical Support.

Press the **Stop** button to stop registration of the triggers, and press the **Done** button to exit Trigger port test.

To use Trigger test diagnostically, *the STIM system should be turned on with the stim-to-scan cable connected*. Go to Trigger test, and click the Start button. You should see the following values.

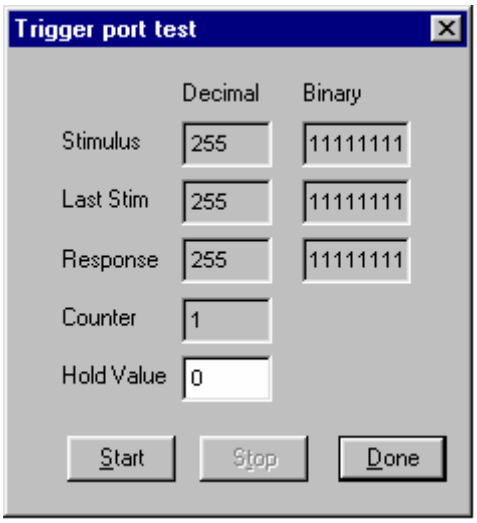


In its “resting” state, note that the Stimulus bits are at zero, and the Response bits are held high (all 1’s). Summing the 8 response bits gives the 255 Decimal value. The Hold Value should be 0.

If you see, for example, one (or more) of the stimulus bits held high (1), that will cause all other incoming triggers to be ignored (no triggers). A workaround is to take whatever number it shows in the Stimulus field, and enter that as the Hold value. For example, if the 4th bit is stuck (8), enter 8 as the Hold value. (The events seen in ACQUIRE will be altered accordingly - this is a temporary workaround until the real problem is repaired). The cause could be a problem in the STIM box, the stim-to-scan cable, or in the SynAmps².

With other stimulus systems connected, you might see all response bits at 0, or maybe the four left bits at 0. They all need to be high in the resting state. Then it is a question of whether you want to record responses or not. If you do not want responses, then you should not plug anything into those pins on the trigger connector in the back of the System Unit (pins 17-24). The natural resting state of the SynAmps² is high, so they will be OK. If you do want responses, they must use inverted logic, where the resting state is high, and the trigger pulse goes to zero. If pins 17-20 are zero, clip whatever lines are going into those pins - they are not needed for responses (but they do need to be held high).

To help isolate the cause of abnormal bits, disconnect the stim-to-scan cable (or other trigger cable if you do not have STIM) from the back of the System Unit. Start Trigger port test, and you should see the following values.

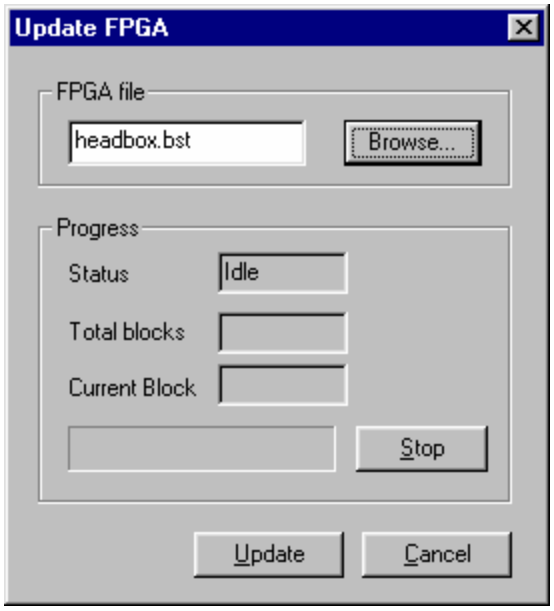


All of the bits should be high. If any are at zero, that points to a problem in the SynAmps² (and a probable return to El Paso). If this looks normal, connect the stim-to-scan cable to the SynAmps², and disconnect it from the stim box. It should still look like the picture above. If it does not, there is a problem in the cable. If it still looks normal, then the problem is likely on the STIM side.

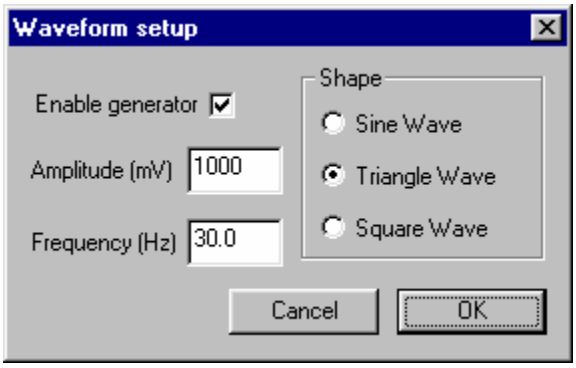
When you are testing for triggers in ACQUIRE, using the Single Window display to see the triggers in a continuous file, be sure you have NOT enabled the “Use

inverted values" field in the setup file (look under Edit, Overall Parameters, Triggers).

Update. This option is used to update the Firmware on the EEPROM in the amplifier/headbox. Do NOT attempt to use this unless so directed by Technical Support. Selecting the option displays the following screen. Use the Browse button to locate the new headbox.bst file. Then click the Update button, and you will see the progress of the file transfer.



Waveform generator. The waveform generator is used to create a sine, triangle or square wave having a user determined amplitude and frequency. Enable the generator, enter the desired amplitude and frequency, select a wave shape, and then click OK.



In ACQUIRE, click the green arrow  to see the generated waveform.

Subject Ground

The subject ground should be placed as close as possible to the recording electrodes. Under most circumstances this location is somewhere on the head. The subject ground is used to reject common mode noise. Therefore, by placing the ground near the recording electrodes the common mode rejection ability of the amplifier is optimized. Avoid placing the ground at distal sites (arms and legs). An older technique often used to reduce stimulus artifact was to place the ground near the stimulating site. This procedure should not be used on the SynAmps², and doing so will degrade system performance. Do NOT add a second subject ground. A ground loop could result, thus introducing 50Hz or 60Hz noise in the recordings.

Electrode Safety

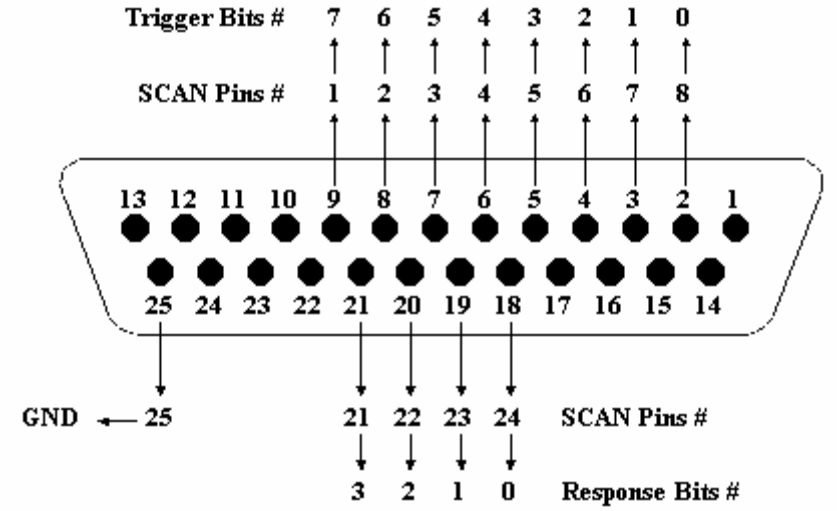
The SynAmps² amplifier inputs and attached electrodes are Type CF, which means in part that they are not connected to Earth Ground or Chassis Ground. Maintain this separation from Earth Ground by ensuring that the electrodes and any conductive parts of their connectors do not touch conductive parts, including the system enclosure or other grounded devices.

MRI Environment Recording Configurations

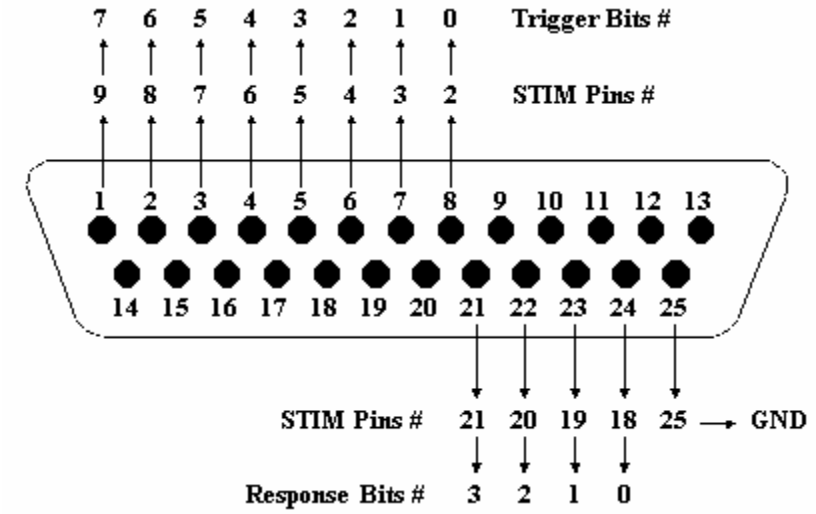
The SynAmps² system can be used to record EEG from subjects in undergoing an MRI scan. The MagLink product is used to get signals from the subject out of the MR room, and the SynAmps² system is used to record from there. Both the system unit and all headboxes must be outside of the MR room.

Appendix A
Trigger Port Interfacing

The method of triggering between the SCAN and STIM systems is to connect the Parallel I/O ports on the back of the SCAN and STIM interfaces by means of a STIM-to-SCAN cable. This cable is provided to customers who purchase STIM systems. A STIM-to-SCAN cable is a 25-line cable with a female connector at the end marked SCAN and a male connector at the end marked STIM. Below is a diagram of the connections within a STIM-to-SCAN cable.



Back of STIM Connector



Back of SCAN Connector

Stimulus pins

The stimulus pins with SynAmps² work slightly different from SynAmps and NuAmps. With SynAmps², the TTL pulses from the stimulus presentation system do NOT have to return to zero voltage between pulses. For example, you could send TTLs of 1 (bit 0), then immediately add bit 1 to give a 3, and then add bit 3 to give a type code of 11 - without ever returning the bits to zero. The exception is when you have a series of events that are the same, such as 1, 1, 1... In that case, the voltage must return to zero between TTL pulses. It is also possible to have access to the TTL pulse offset time, as well as the onset time.

Response pad pins

On the back of the STIM connector the response pad lines are 21, 20, 19 and 18, carrying response bits 3, 2, 1 and 0. On the back of the SCAN connector the response pad lines are 21, 22, 23, and 24, carrying response bits 3, 2, 1 and 0. There are actually 8 response

pad bits that can be used for additional responses (although the STIM response pad only uses the first 4). Looking at the back of the SCAN connector, the 4 additional bits are pins 17-20, carrying bits 7-4, respectively).

Response pin 17, bit 7, is used for Deblocking. This pin is connected to the Inter-System Unit connector, and it is that connector that is used for Deblocking, with the Interface Cable provided (P/N 00081300). The TTL signals should be at least 2.5 Vs and not more than 5 Vs. The pulses must return to the original response resting voltage (typically 5Vs) between pulses.

Pinout summary

In list form, the SCAN side connector and pinouts are as follows. Note that pins 14 and 15 carry +5Vs DC.

1) System Unit Connector: D25 Male, Metal Shell, AMP or equivalent
2) Mating connector: D25 Female, Metal Shell, AMP or equivalent
3) Pinout:

1 Trigger In 07	11 Undefined	21 Response In 03
2 Trigger In 06	12 Undefined	22 Response In 02
3 Trigger In 05	13 Undefined	23 Response In 01
4 Trigger In 04	14 +5VDC	24 Response In 00
5 Trigger In 03	15 +5VDC	25 Ground
6 Trigger In 02	16 Undefined	
7 Trigger In 01	17 Response In 07	
8 Trigger In 00	18 Response In 06	
9 Undefined	19 Response In 05	
10 Undefined	20 Response In 04	

Matching Port Logic

The logic used to trigger your system can be either positive or negative. Positive logic is defined as a transition from the zero state (ground) to a one state (5 volts TTL). Negative logic is defined as a transition from the one state to the zero state. The SynAmps² employs positive logic on the stimulus port and negative logic on the stim pad (response port). *Note - the STIM response pad lines must be held to positive levels during the resting state or the device will not respond. If not connected these lines are 'pulled-up' to high levels.*

Because SynAmps² uses positive logic on the stimulus port, the numbers received by the trigger port from older 100kHz based STIM systems (identified by the two large ribbon cables exiting the back of the computer labeled J6 and J11) need to be inverted back into positive logic to match the SynAmps². This is accomplished by the **Use inverted values** option in Acquire, under Setup / Edit / Triggers (see Acquire manual). In general, if trigger codes do not match (i.e., a 1 generates a 254) then the **Use inverted values** option should be used.

Troubleshooting

If you encounter problems with triggering, there are a number of procedures that you can follow to determine the cause of the problem. Most triggering problems are simple to correct. Listed below are some common causes of triggering problems and instructions on how to correct each one. A complete list of potential trigger problem sources is found in Appendix C of the Installation and Orientation manual (or overview manual). The most common problems are listed first.

If you are having triggering difficulty, it is a good idea to go through this list from the beginning to narrow down the problem. Triggering problems present themselves in three forms:

1) no trigger pulses are received by the SCAN system

2) incorrect type codes are received by the SCAN system

3) stimulus triggers are missed intermittently

Causes of triggering difficulty:

Software configuration

(1,2) Problem - The threshold value may be set incorrectly, resulting in spontaneous acquisition of sweeps by the ACQUIRE program.

Solution - For STIM-to-SCAN triggering between I/O ports on the backs of the STIM and SCAN interface modules, a threshold value of 0 (zero) should be used.

(3) Problem - The Interstimulus interval is shorter than the acquisition interval. In other words, a second stimulus is occurring before ACQUIRE has finished recording the epoch associated with the first stimulus.

Solution - Determine the length of epoch that is necessary for your EEG recording. The shortest ISI in your stimulus presentation setup should be larger than the poststimulus portion of this epoch. A stimulus that is associated with a trigger pulse should never be presented during the time that ACQUIRE is recording an epoch. If it is, the trigger pulse will be missed by ACQUIRE. Note that this problem can be avoided by acquiring data continuously (without gaps).

(1,3) Problem - The dwell time (the inverse of the digitization rate) of the ACQUIRE system is too short, and the program misses some short duration trigger pulses in continuous mode only.

Solution - The digitization rate that is set in the "Acquisition values" screen of your setup file determines what should be the minimum duration of the trigger pulse generated by STIM or another device. The dwell time is defined as 1/digitization rate. This value

should be larger than the trigger pulse duration. If it is smaller, then ACQUIRE may miss some trigger pulses as a result of sampling error.

Cable

(1, 2, 3) Problem - The wrong type of cable is being used.

Solution - Use only the STIM-to-SCAN cable between the SynAmps² and the STIM Audio System.

(1, 2, 3) Problem - The cable may be damaged internally.

Solution - If ACQUIRE is not receiving pulses at all, or if the numbers coming across do not correspond to those that are being sent out from the STIM computer, then the cable may be at fault. Test the continuity of the leads using the pinouts shown in Appendix A.

(1, 2, 3) Problem - The cable is not plugged in completely.

Solution - Press firmly on the connectors at each end to insure that they are securely in place.

(1, 2) Problem - The cable is not plugged into the right port on the SCAN system or on the STIM system or other device.

Solution - Be sure that you have the cable plugged into the port that you think you have it plugged into. On the SCAN side, it plugs into the back of the SynAmps² in the Trigger port. On the STIM side, it plugs into the back of the STIM Audio System in the Trigger port. Neither end plugs into a PC.

Solution - It is recommended that you plug the cable directly into the ports instead of running it through a switching unit.

Port

(1) Problem - The port may have a static charge built up in it or some other temporary defect.

Solution - If the cable seems to be intact and the software is configured correctly, then the port itself may be causing the problem. Sometimes a port gets into a temporary state in which it will not function for the purpose of triggering. This state can be corrected by powering down and then powering up the SynAmps².

General

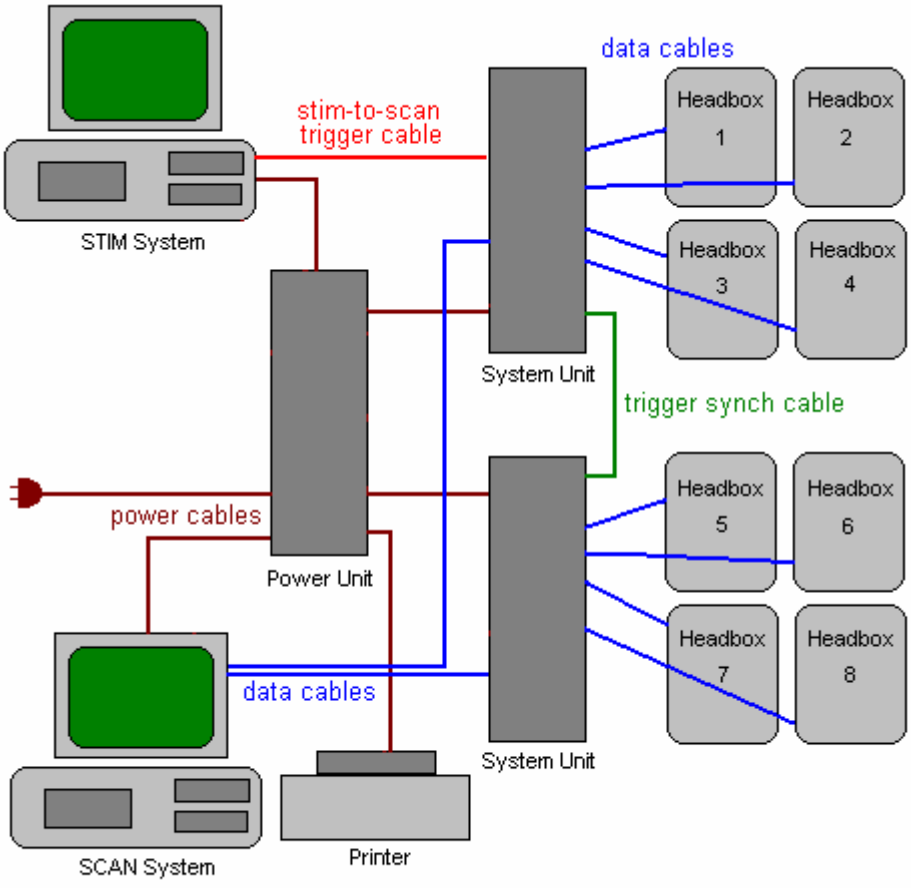
(2, 3) Problem - The SCAN system and the STIM system or other stimulus generating device may be connected to different power supplies, resulting in a ground loop.

Solution - Connect the SCAN system and the STIM system (or other stimulus device) to the Power Unit.

If these steps do not resolve the trigger problem, refer also to Appendix C in the Installation and Orientation manual.

Appendix B
Configuring Multiple SynAmps²

Configuring multiple SynAmps² headboxes is a fairly easy operation. Each System Unit powers up to four headboxes. Connect units 1-4 to the indicated connectors on the back of the System Unit. If you received two System Units, connect headboxes 5-8 to the indicated connectors on the back of the second System Unit. The two System Units are connected via the acquisition synchronization cable (labeled on the back of the System Units).



Multi-SynAmps² Configuration

If you have multiple headboxes and you are using a SynAmps² Quik-Cap from Neuroscan, it is not necessary to connect the ground and reference leads across headboxes. This is done automatically in the caps.

The System Units are connected to the SCAN PC by means of two USB 2.0 cables, one for each System Unit. The first System Unit is connected to the STIM system via the STIM-to-SCAN trigger cable, which connects to the Trigger Input connector on the back of the first System Unit.

Connect power cables from the Power Unit to each of the System Units. The Power Unit contains an isolation transformer, and therefore ALL components that will be connected to the system must be powered by the Power Unit. This includes the STIM and SCAN PCs, their monitors, the STIM audio box, and any peripherals (such as a printer).

The isolation transformer is rated up to 1000 watts. While that should be sufficient to safely power the components mentioned, you should verify that you are not surpassing that limit. The System Unit, headbox, and STIM Audio System Unit each draw less than 10 watts. The demand will come primarily from your computer(s), monitor(s) and any peripherals. The wattage demands are usually displayed on the back of the components (or in their documentation). Neuroscan is not responsible for damage to the Power Unit resulting from an overload.

Lastly, connect the Power Unit to a three-prong wall receptacle with a verified true earth ground. If there is not a true earth ground, you increase the potential for line noise interference.

Appendix C
Electrode Cap Connector Pinout

Located on the side of the headbox is an 80 pin connector that can be used to connect to predetermined electrode arrays. Shown below are the pinouts for this connector.

1) Headbox connector: 3M 80-Position 0.050 MDR Connector, P/N N10280-52E2VC
2) Mating connector: 3M 80-Position 0.050 MDR Wiremount P/N 10180-6000EC
3) Pinout:

Pin	Signal	Pin	Signal	Pin	Signal
01	Channel 01	27	Channel 38	53	Bipolar +1
02	Channel 09	28	Channel 46	54	Bipolar --1
03	Channel 33	29	Bipolar +4	55	Channel 20
04	Channel 41	30	Bipolar --4	56	Channel 28
05	Patient Ground	31	Channel 23	57	Channel 52
06	Reference	32	Channel 31	58	Channel 60
07	Channel 18	33	Channel 55	59	Channel 05
08	Channel 26	34	Channel 63	60	Channel 13
09	Channel 50	35	Channel 24	61	Channel 37
10	Channel 58	36	Channel 32	62	Channel 45
11	Channel 19	37	Channel 56	63	Bipolar +3
12	Channel 27	38	Channel 64	64	Bipolar --3

13	Channel 51	39	Spare	65	Channel 22
14	Channel 59	40	Spare	66	Channel 30
15	Channel 04	41	Channel 17	67	Channel 54
16	Channel 12	42	Channel 25	68	Channel 62
17	Channel 36	43	Channel 49	69	Channel 07
18	Channel 44	44	Channel 57	70	Channel 15
19	Bipolar +2	45	Channel 02	71	Channel 39
20	Bipolar --2	46	Channel 10	72	Channel 47
21	Channel 21	47	Channel 34	73	Channel 08
22	Channel 29	48	Channel 42	74	Channel 16
23	Channel 53	49	Channel 03	75	Channel 40
24	Channel 61	50	Channel 11	76	Channel 48
25	Channel 06	51	Channel 35	77	Spare
26	Channel 14	52	Channel 43	78	Spare
				79	Spare
				80	Spare

Appendix D
Comparison of SynAmps and SynAmps²

Our original amplifiers were SynAmps, released in 1993. For those familiar with SynAmps, there are several significant differences between SynAmps and SynAmps². Because of these differences, the two amplifiers cannot be combined into a single system.

- *Number of channels*. SynAmps have 28 monopolar and 4 bipolar channels, and the bipolar channels could be configured for use as monopolar channels. High level inputs (for connecting other devices such as analog signals from EKG, GSR, etc. devices) required custom ordered inputs. SynAmps² have 64 monopolar channels and 4 bipolar channels. Two high level input channels are included (and SynAmps² with high level inputs will be CE marked). SynAmps², therefore, actually have 70 channels. SynAmps² headboxes can be linked to achieve up to 512 channel recordings (depending on your computer and AD rate).

- *Communication with SCAN PC*. SynAmps is a SCSI peripheral, which requires installation of a SCSI Adapter board in the SCAN computer. SynAmps² is a USB 2.0 device, and requires no additional hardware on the SCAN computer.

- *Digitization Rates*. SynAmps have AD rates up to 100kHz for 4 channels, 50kHz for 8 channels, or 20kHz for 32 channels. SynAmps² have a maximum AD rate of 20kHz for all channels. SynAmps and SynAmps² have identical bandwidths of 0-3kHz. The use of improved A/D converters in SynAmps² eliminates the need for extensive over-sampling.

- *DC/AC Selection*. With SynAmps, AC coupling is a secondary step; all recordings are DC, with or without AC coupling. With SynAmps², there is the option for true DC or AC recordings. The SynAmps² provides a

significantly increased input range, which allows for far more DC drifting before clipping or saturation occurs.

- *Gain settings*. SynAmps² digitizes to 24 bits whereas the SynAmps uses 16, giving the SynAmps² better resolution across a broader input range.

- *Analog Outputs*. SynAmps can be configured to output the analog signals; this is not an option with SynAmps².

- *Unused Channels*. Unused channels on the SynAmps need to be shorted to the Ref channel using jumpers. It is not necessary to short unused channels with SynAmps².

- *Impedance Measurement*. With SynAmps², it is possible to measure the impedance at the Ref channel, which is not possible with SynAmps. With SynAmps², it is also possible to measure the impedance between any two electrodes.

- *Internal Architecture*. With the original SynAmps, you have access to the internal boards, cables, etc., for diagnostic purposes (when so directed by Technical Support). With SynAmps², there are no user-accessible components in the headbox, nor any need to open the headbox for diagnostic or other reasons.

Appendix E
Guidance and Declaration

Table I.

<table>
<tr><th colspan="3">Guidance and manufacturer's declaration – electromagnetic emissions</th></tr>
<tr><td colspan="3">The SynAmps² system is intended for use in the electromagnetic environment specified below. The customer or the user of the SynAmps² system should assure that it is used in such an environment.</td></tr>
<tr><th>Emissions Test</th><th>Compliance</th><th>Electromagnetic environment - guidance</th></tr>
<tr><td>RF emissions

CISPR 11</td><td>Group 1</td><td>The SynAmps² uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.</td></tr>
<tr><td>RF emissions

CISPR 11</td><td>Class B</td><td rowspan="3">The SynAmps² is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.</td></tr>
<tr><td>Harmonic emissions

IEC 61000-3-2</td><td>Class A</td></tr>
<tr><td>Voltage fluctuations/ flicker emissions

IEC 61000-3-3</td><td>Complies</td></tr>
</table>

Table II.

Recommended separation distances between portable and mobile RF communications equipment and the SynAmps²

The SynAmps² is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the SynAmps² can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the SynAmps² as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter W	**Separation distance according to frequency of transmitter** m		
	150 kHz to 80 MHz $d = 1,2 * \text{sqrt}(P)$	**80 MHz to 800 MHz** $d = 1,2 * \text{sqrt}(P)$	**800 MHz to 2,5 GHz** $d = 2,3 * \text{sqrt}(P)$
0,01	0,12	0,12	0,23
0,1	0,38	0,38	0,73
1	1,2	1,2	2,3
10	3,8	3,8	7,3
100	12	12	23

For transmitters rated at a maximum output power not listed above, the recommended separation distance *d* in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Table III.

Guidance and manufacturer's declaration – electromagnetic immunity

The SynAmps² system is intended for use in the electromagnetic environment specified below. The customer or the user of the SynAmps² system should assure that it is used in such an environment.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment - guidance
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±6 kV contact ±8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	±2 kV for power supply lines ±1 kV for input/output lines	±2 kV for power supply lines ±1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±1 kV differential mode ±2 kV common mode	±1 kV differential mode ±2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC61000-4-11	<5 % U_T (>95 % dip in U_T) for 0.5 cycle 40 % U_T (60% dip in U_T) for 5 cycles 70 % U_T (30% dip in U_T) for 25 cycles <5 % U_T (>95% dip in U_T) for 5 sec	<5 % U_T (>95 % dip in U_T) for 0.5 cycle 40 % U_T (60% dip in U_T) for 5 cycles 70 % U_T (30% dip in U_T) for 25 cycles <5 % U_T (>95% dip in U_T) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment. If the user of the SynAmps² system requires continued operation during power mains interruptions, it is recommended that the SynAmps² system be powered from an uninterruptible power supply or a battery.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.

NOTE: U_T is the a.c. mains voltage prior to application of the test level.

Table IV.

Guidance and manufacturer's declaration – electromagnetic immunity			
The SynAmps² system is intended for use in the electromagnetic environment specified below. The customer or user of the SynAmps² system should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment - guidance**
			Portable and mobile RF communications equipment should be used no closer to any part of the SynAmps² system, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. **Recommended separation distance**
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 Vrms 150 kHz to 80 MHz	$d = 1,2 * \text{sqrt}(P)$
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m 80 MHz to 2,5 GHz	$d = 1,2 * \text{sqrt}(P)$ 80 MHz to 800 MHz $d = 2,3 * \text{sqrt}(P)$ 800 MHz to 2,5 GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in metres (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b] Interference may occur in the vicinity of equipment marked with the following symbol: 
NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the SynAmps² is used exceeds the applicable RF compliance level above, the SynAmps² should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the SynAmps².

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.