SynAmps RT

Full Range EEG and EP Amplifiers

Table of Contents

1 SynAmps RT

SynAmps RT™ User Manual
(P/N 00080650)

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1.1 Contact Information

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@neuroscan.com**, or see the other Support options on our web site (*http://www.neuroscan.com*). Or, if you live in the USA or Canada, please call **1-877-717-3975**. International callers should use **704-749-3200**.

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

1.2 Device Classification

ATTENTION: CONSULT ACCOMPANYING DOCUMENTS BEFORE USING

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

Manufacturer:

Compumedics Neuroscan USA Ltd.
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This equipment has been tested and found to comply with the limits and requirements for a Class A 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 to 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; and 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 00080586
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

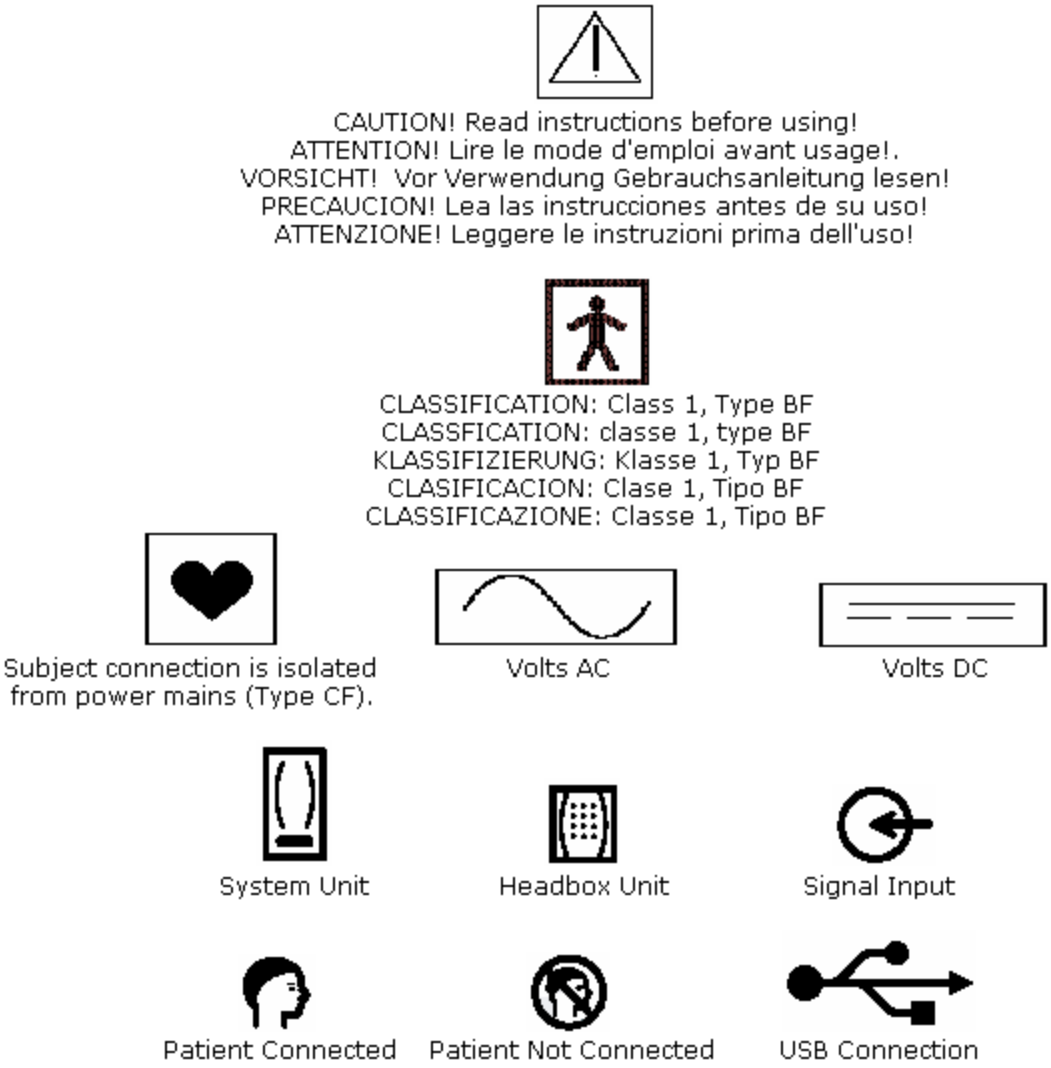
Input:	120-230VAC, 50/60Hz, 10/5A		
Fuses:	T5A 250V (2 each, 5 X 20mm)		
Headbox			
	Weight:	1.5 kg	
	Dimensions:	Height:	4.5 cm
		Width:	18.7 cm
		Depth:	21.8 cm
System Unit			
	Weight:	4.3kg	
	Dimensions	Height:	23.0 cm
		Width:	11.6 cm
		Depth:	32.5 cm
Power Unit			
	Weight:	12.5kg	
	Dimensions	Height:	23.0 cm
		Width:	11.6 cm
		Depth:	32.5 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 RT*:



The *SynAmps RT* 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.
ATTENTION: pour reduire tout risque de choc electrique, ne pas oter le couvercie. S'adresser a un technician qualifie en cas de mauvais fonctionnement.
VORSICHT: Zur Vermeidung der Stromschlaggefahr die Abdeckung nicht entiemen. Wartungsarbeiten sind nur von geschultem Personel vorzunehmen!
PRECAUCION: Para reducir el riesgo de que se produzca un electrochoque, no retire la tapa. Consulte a personal cualilicado para efectuar el servicio!
ATTENZIONE: Per ridurre il rischlo di scossa elettrica non rimouvere il coperchio. Rivolgersi a personale qualificato.

WARNING: For continued protection against fire hazard, replace fuse with same type and rating.
AVERTISSEMENT: pour une protection permanente contre les risques d'incendie, utiliser des fusibles de rechange du meme amperage.
WARNUNG: Zur Wahrung des Schutzes gegen Feuergefahr Sicherung nur durch eine

Sicherung desselben Typs und derselven Leistung emeuem!
ADVERTENCIA: Para obtener una proteccion continuada contra el riesgo de incendio, reemplace el fusible con uno del mismo tipo y potencia.
ATTENZIONE: per una protezione continuativa contro rischi di incendio, sostituire il fisible con uno dello stesso tipo e voltagio.

DANGER: Possible explosion hazard when used in the presence of a flammable anaethetic mixture with air or with oxygen or nitrous oxide.
DANGER: Risque possible d'explosion en cas d'utilisation en presence d'un melange d'anesthesique inflammable et d'air, d'oxygene ou de protoxyde d'azote.
GEFAHR: Mogliche Explosionsgefahr bel Verwendung in Gegenwart von entzundbarer Anasthetikummischung mit Luft oder mit Sauerstoff oder Stickstoffoxid!
PELIGRO: Riesgo posible de explosion cuando se usa cerca de un anestesico inflamable mezclado con aire, con oxigeno o con oxido nitroso.
PERICOLO: Possibile rischio di esplosione se utilizzato in presenza di una miscela di gas inflammabile ed aria oppure ossigeno o protossido d'azoto.

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 *SynAmps RT* system should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the *SynAmps RT* 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 *SynAmps RT* 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 *SynAmps RT* should be prohibited. If portable or mobile RF communications devices are used in the vicinity of the *SynAmps RT* 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.

CAUTION: Grounding continuity should be checked periodically.

CAUTION: This product requires convection cooling. Adequate ventilation is required. Clearance of 2" minimum on any side.

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.

NOTE: **USA and Canada**: Grounding reliability can only be achieved when this

equipment is connected to a receptacle marked "Hospital Only" or "Hospital Grade".

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".

Environment

The *SynAmps RT* 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 *SynAmps RT* 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 *SynAmps RT* 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 *SynAmps RT* device or electrodes to be used with the device.

Repair

There are no user serviceable parts in the *SynAmps RT* 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 *SynAmps RT* 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. No other maintenance or service is required.

Installation Precaution

Proper grounding is important for continued safe use of your *SynAmps RT* system. Ensure that the outlet supplying power to your *SynAmps RT* 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 *SynAmps RT* 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 recommends that the *SynAmps RT* device not be connected to the patient during use of HF surgical equipment.

Electrode Safety

The *SynAmps RT* 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.

2 Introduction

The Compumedics/Neuroscan *SynAmps RT* amplifiers are the latest generation of AC/DC amplifiers designed to record a wide variety of multichannel neurophysiological signals. The *SynAmps RT* are intended for the researcher who needs both a broadband amplifier and a high speed digital acquisition system. A *SynAmps RT* 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.

The *SynAmps RT* differ from the previous *SynAmps*^{2} amplifiers in several ways.

1. Headbox modifications include changes in the capacitors and resistors, as well as changes in the sequence of data processing steps. These changes eliminate spectral spiking that was found under certain conditions with *SynAmps*^{2}, further reduce the overall noise level, and match the filtering effects in DC and AC modes. The functional result is to make ABRs easier to record. Testing has shown that stable ABRs can be detected in as few as 200 to 400 sweeps, using a compressed bandwidth of 100 to 2500Hz, in either DC or AC modes, using a bipolar channel.

   Note
   If you are recording ABRs, we strongly recommend you use a bipolar channel(s) for the recording. The active lead should go to the positive input, and the reference lead should connect to the negative input. You should then use a jumper to connect the negative pin to the Reference jack.

2. The larger change is more of a product conception one, in which the *SynAmps RT* System Unit will be used with a family of Compumedics EEG systems. A more modular approach allows for selecting amplifiers (headboxes) to better fit individual needs, where each uses the same System Unit.

3. A new color scheme differentiates the *SynAmps RT*.

As far as the SCAN software is concerned, the *SynAmps RT* and *SynAmps*^{2} are treated the same and are interchangeable. For example, there is no special designation for *SynAmps RT* in the *ampinstall.exe* program or in the ACQUIRE software - you will see only *SynAmps*^{2}. The drivers are the same.

Listed below are some of the main features for *SynAmps RT*:

- A USB 2.0 interface is used to link the *SynAmps RT* and computer. This single connection serves up to four headboxes for a total of 256 EEG channels (plus additional bipolar and HLI channels) via a single System Unit. A second System Unit can be used for more 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 3.5kHz.

- 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 per headbox. A 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.
- Built in impedance and system checking.
- 24-bit AD conversion provides greater resolution (using the 32-bit SCAN 4.3+ acquisition software).

3 Hardware Installation

Installation of a *SynAmps RT* amplifier is very easy. Here is a summary of the installation steps:

Unpacking the SynAmps RT

The *SynAmps RT* 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 - may be packaged in smaller boxes within the larger box. 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 *SynAmps RT* for repairs.

Open the boxes and check for the following contents:

1. Amplifier/headbox unit(s)
2. Amplifier/headbox cable(s) (15ft.)
3. Cap Connector Shorting plug(s)
4. System Unit(s) (one for every four headboxes)
5. USB cable(s) (15 ft.)
6. Deblocking Interface Cable
7. Isolation Power Unit
8. *SynAmps RT* User Manual
9. Power Unit Manual
10. Warranty Card
11. Declaration of Conformity

Connecting the Components

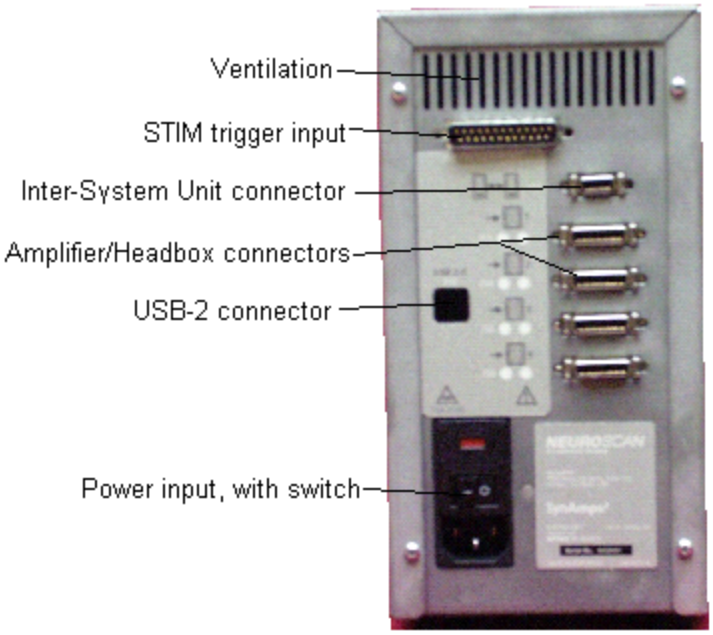
The Amplifier/Headbox provides the interface into which patient electrodes may be connected, and contains amplification and data acquisition circuits. The amplifier converts the analog biological signals to digital ones and sends the data to the host computer. It performs electrode impedance measurements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

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.

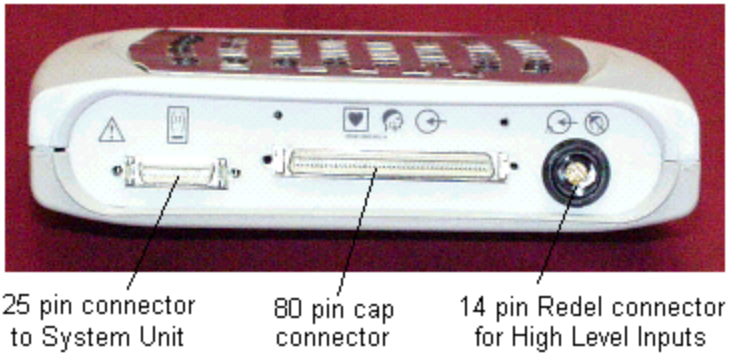
Follow these steps to connect the components:

1. The amplifier/headbox is connected to the System Unit via a 15 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.



Back of System Unit

Make sure the System Unit and SCAN computer are off whenever you connect the USB or headbox cables. Do not "hot swap" the USB cable or headboxes. Use the thumbscrew connections to attach the cables securely.



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 Inter-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.

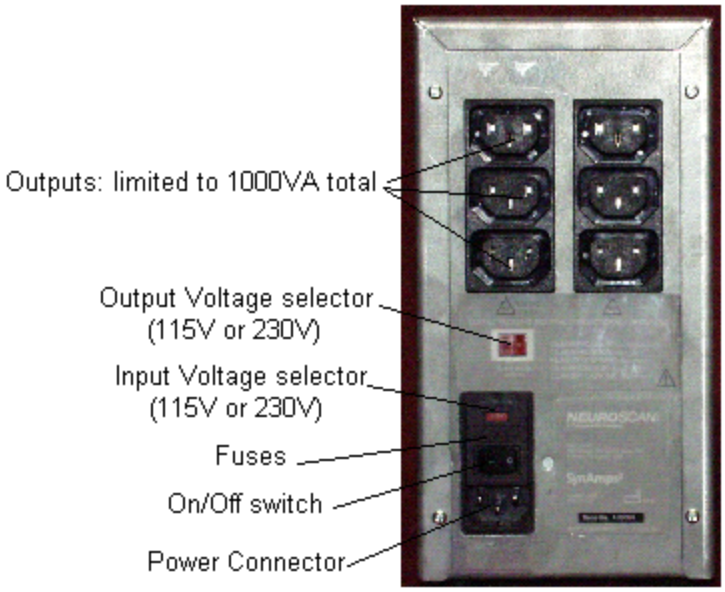
3. If you have a STIM system, connect the STIM-to-SCAN trigger cable to the D-25 trigger input connector on the back of the System Unit (top left connector; see Appendix A for pinout information).

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

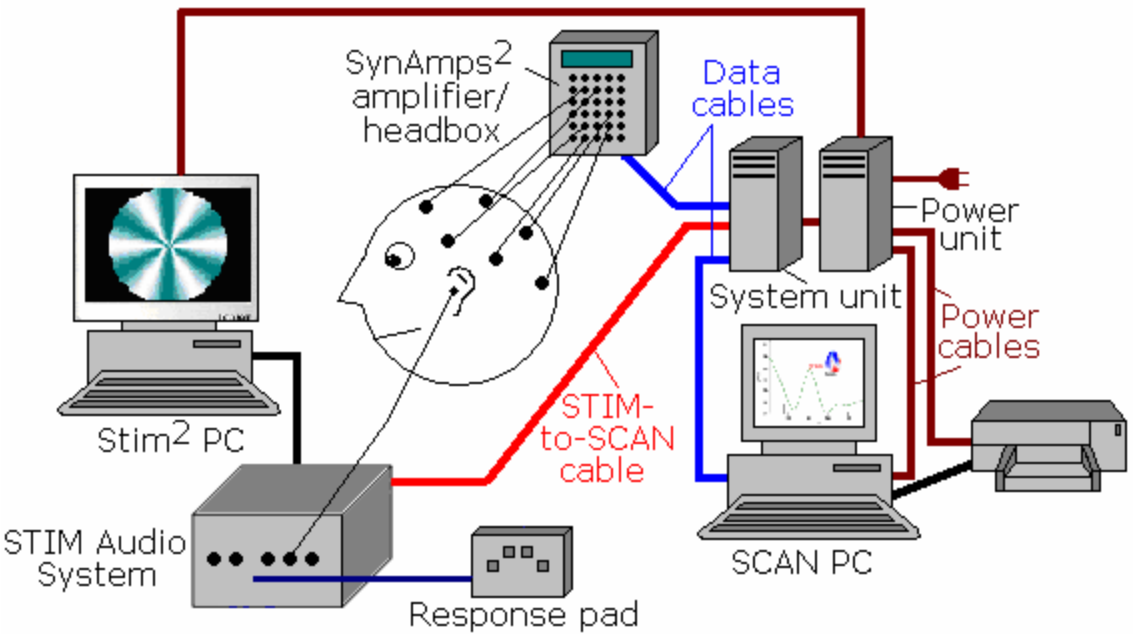
5. Connect the power cable to the back of the System Unit, and connect the other end to one of the plugs in the back of the Power Unit. Note that there is a power switch above the connector on both the System and Power Units; turn them off for the time being.

6. *All components connected to the SCAN and SynAmps RT units MUST be powered by the Power Unit.* Connect the power cables to the computers, monitors, printer, 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 230V*. 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.



Note: Install the SCAN software prior to turning on the *SynAmps RT* amplifiers.



7. After all of the components are connected, turn on the Power Unit, the System Unit(s), and the SCAN computer. The *SynAmps RT* amplifiers should be found as the computer boots, and the next step is to install the drivers for them. If you have installed the software first, the drivers will be found more automatically.

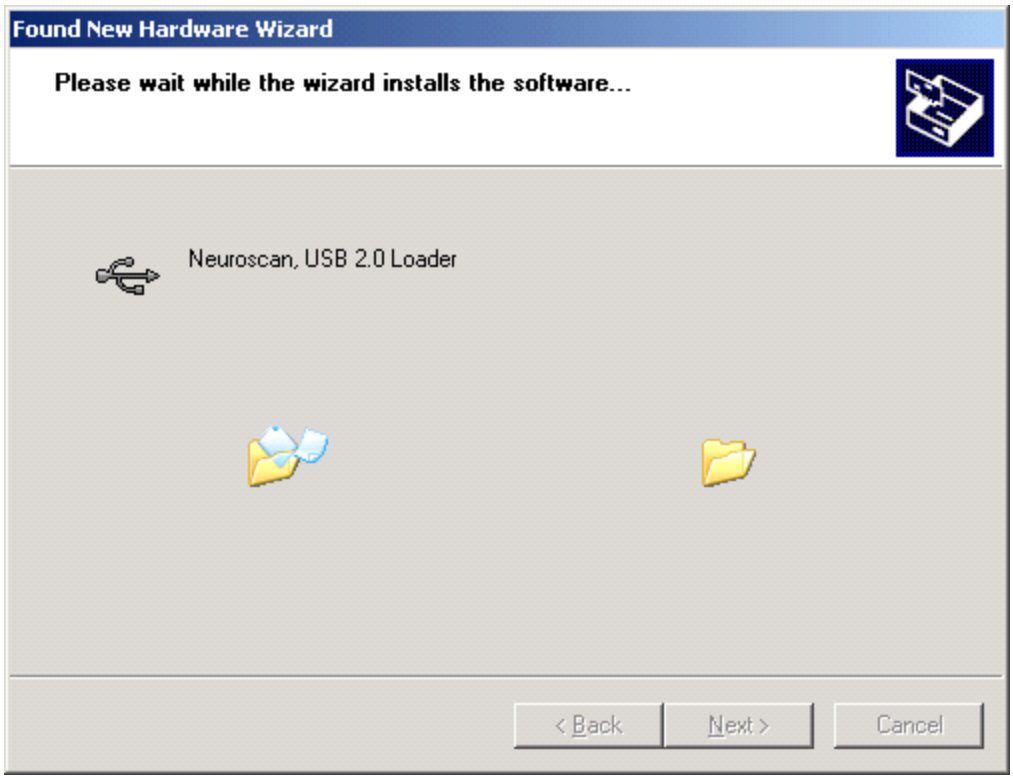
4 Installing the SynAmps RT Drivers

When the SCAN computer first boots after you have connected the *SynAmps RT*, Windows will find the new hardware. Each headbox unit and each System Unit has its

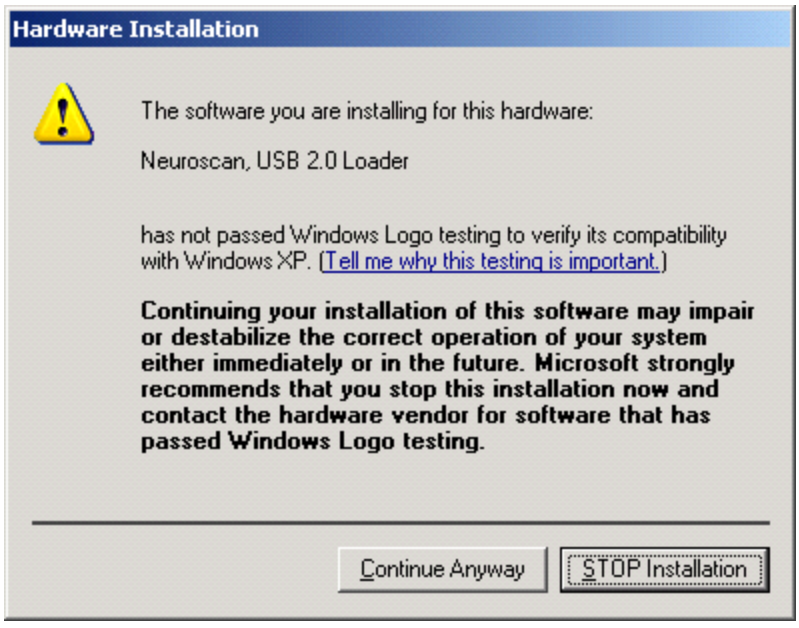
own drivers, so the process below will be repeated several times. If you subsequently change the order of the headboxes, Windows will detect the change and the drivers will need to be installed again. The entire installation of all of the drivers will take several minutes; once done, you will not need to do it again (unless you change the headbox order).

Select the "Install the software automatically" option (the relevant drivers used by *SynAmps RT* are *Syn2Ldr.sys* and *SynAmps2.sys*).

Click Next, and the drivers will be installed.



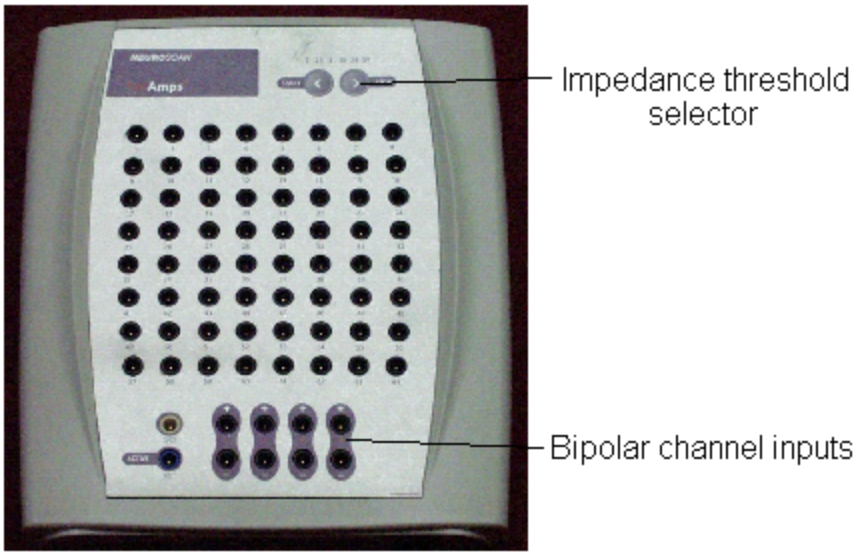
When the following message appears, click Continue Anyway.



Click Finish to complete the installation.

5 The Amplifier/Headbox

Each amplifier/headbox connected to a *SynAmps RT* 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.

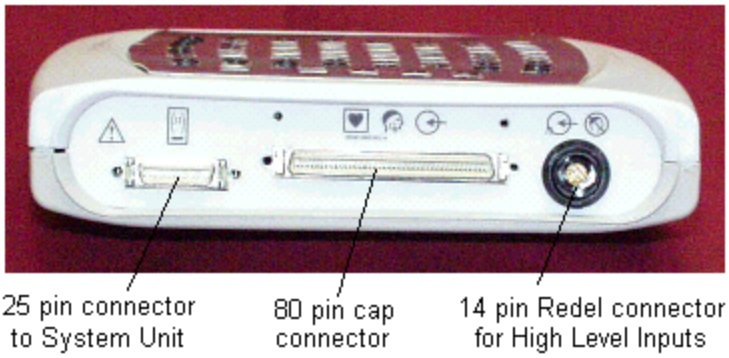


The 64 monopolar channels are laid out in an 8x8 grid on the face of the headbox, and are labeled numerically. The four bipolar channels contain the plus and minus poles.

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 the patient. The HLI ground is connected to the SISO computer ground. 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 $\pm$ 5V). 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 Selector 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 system checks, 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 reference information to all headboxes. It is therefore not necessary to connect the ground and reference jacks across headboxes.

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.

32 Channel Version

The 32 channel version of *SynAmps RT* has the same appearance as the 64 channel version. The difference is that monopolar channels 33-64 have been disabled. The four bipolar and two high level input channels are fully functional. All of the acquisition capabilities are the same as the 64 channel version. The only difference (aside from the number of channels) is that you cannot link the 32 channel version with another 32 channel version, or with a 64 channel version. It is possible to upgrade the 32 channel version to a 64 channel version at a later time, should you decide to do so. (This will require a return to the factory).

The 32 channel version has labels on the front and back saying it is a 32 channel system.

Unused Channels

If you are using fewer than the 64 channels in the headbox of the *SynAmps RT*, you should either leave the unused ones open, or else jump them to Reference, depending on the situation.

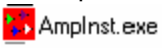
1. Under normal recording conditions, that is, normal background environmental noise conditions for recording EEG, it is NOT necessary to short the unused channels to Reference. There is no impact if the unused channels are left open. The amplifier was constructed to handle normal environmental (radiated) noise impinging on open channels without any impact on the quality of the recordings in the used channels.

2. In more hostile recording environments, or when the signals to be recorded are small (as in near threshold auditory brainstem response recordings, or in many cases where ABRs are recorded in non-Faraday cage surroundings), it is often essential to terminate the unused channels by shorting those connections back to Reference.

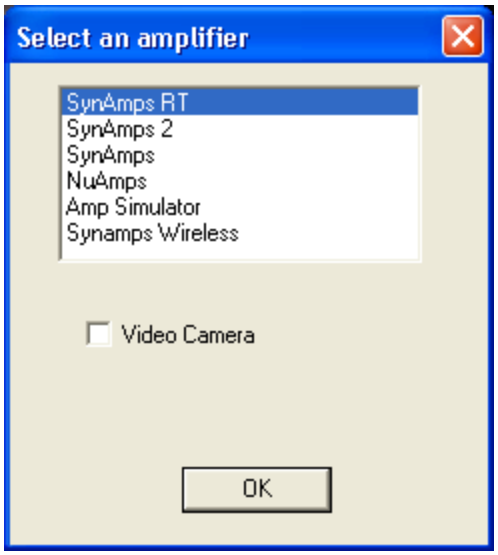
At all times in the *SynAmps RT*, all amplifier channels are active regardless of the number selected for use in a recording. Therefore it is essential in environments that contain unusually high levels of radiated noise (or conversely very low-level sub-microvolt EEG/ERPs such as auditory brainstem responses) that the un-terminated channels be prevented from free floating, especially if there are open channels such as in a situation, for example, when fewer than 64 channels are gelled on a 64 channel MagLink system. With the *SynAmp RT* in the MRI, for example, RF generated during a Scan sequence is radiated back into the amplifier down the non-terminated channels and can be effectively de-modulated down into the EEG frequency range of interest.

The *SynAmps RT* minimizes this issue by adding two layers of additional filtering on each channel to minimize this effect; (a) RF filtering at the front of each channel and (b) additional maximum cutoff low pass filtering on each monopolar channel.

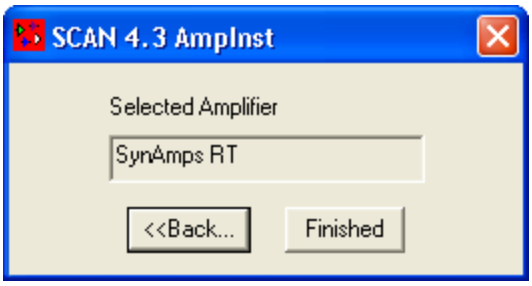
6 Installing the SynAmps RT as the Amplifier for SCAN

After you have installed the driver for the *SynAmps RT*, you need to install *SynAmps RT* as the amplifier 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 Scan4.5 folder and double click on the 

program, or run the program from **Start** → **All Programs** → **Scan 4.5**. The SCAN 4.5 "Select an Amplifier" window will appear. Select **SynAmps 2**, enable the **Video Camera** option if you are using one, and click **OK**.



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



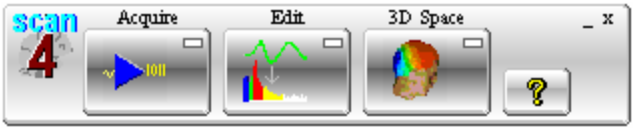
The program takes a fraction of a second to run; it is creating or modifying the registry.

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

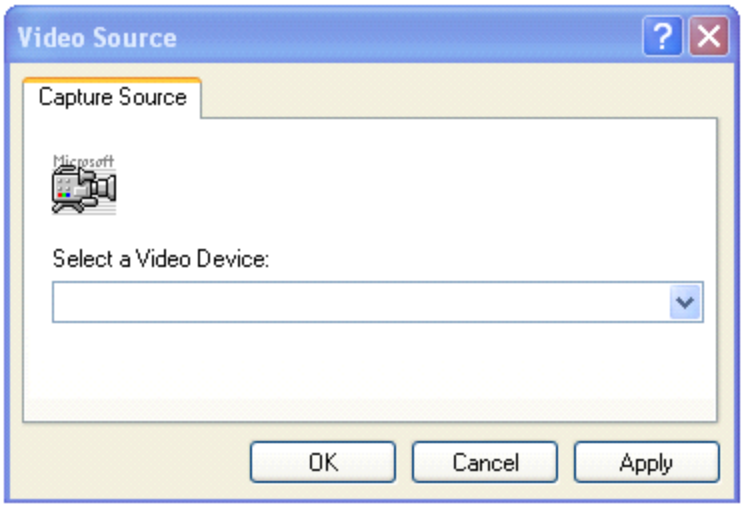
Make sure that the software lock provided with the SCAN CD is connected to the USB port (or parallel, depending on the type of lock you received) on your computer.

Double-click the SCAN 4.5 icon 

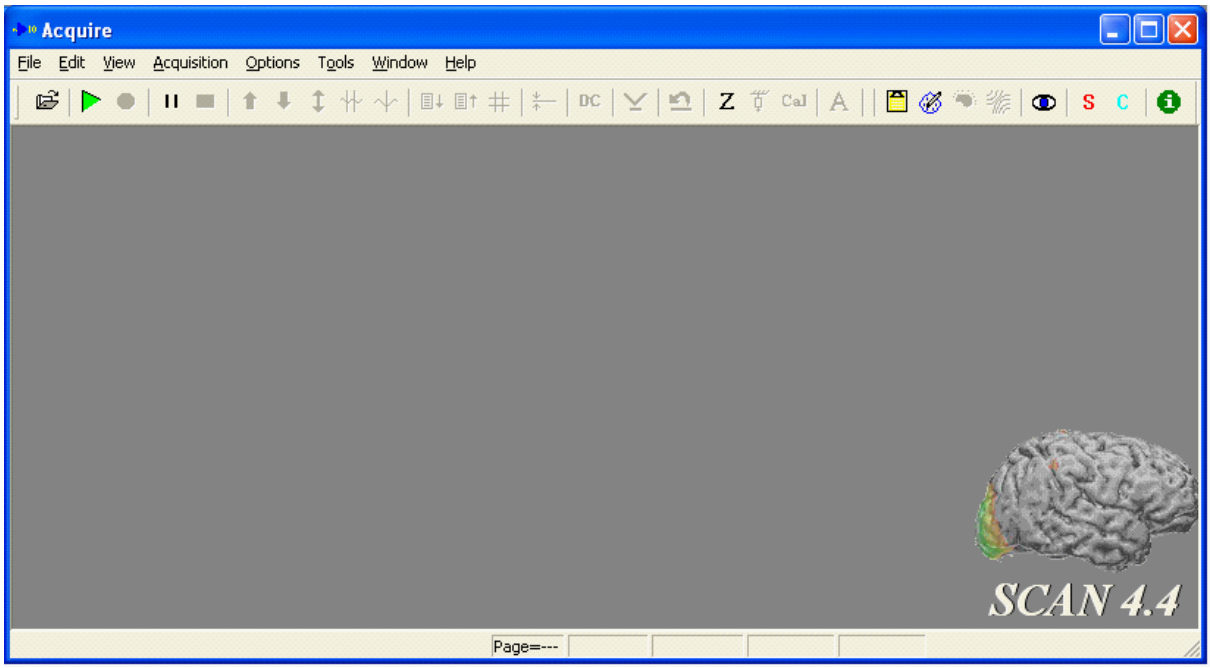
, and then click on the ACQUIRE icon 
from the Program Launcher to start the ACQUIRE program.



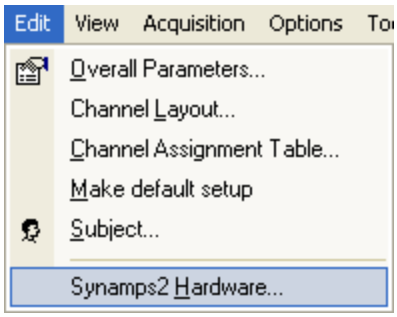
If you enabled the Video Device option, you will be asked to select the device you are using. Click the pull-down list to select the camera, and click OK.



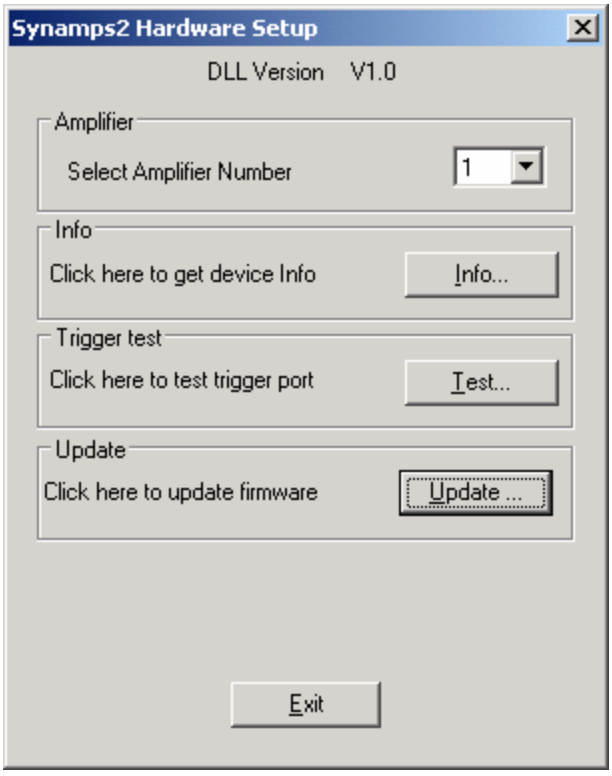
The Main screen will appear.



Select **Edit** → **SynAmps² Hardware**.



In multiple systems it is possible to query each amplifier by clicking on the drop-down arrow and selecting the desired *SynAmps RT*. If your *SynAmps RT* 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 *SynAmps RT*. 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@neuroscan.com.

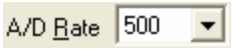


7 Configuring the SynAmps RT in the ACQUIRE Program

The configuration of the *SynAmps RT* 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 and the *Scan Tutorials*. *Settings specific to SynAmps RT are described below*. The parameters are set in **Edit** → **Overall Parameters** → **Amplifiers (SN2)**.

7.1 Amplifier Settings

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

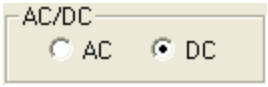


Number of Channels. Enter the *total* number of desired channels, including any bipolar and HLI channels.

A setup file is provided for each cap with preset channel assignments to match the cap. Therefore, you do not need to create the complete setup file; it is usually easiest to modify an existing setup file, if your recordings differ from the preset channels.

If you have the 32 channel version of *SynAmps RT*, you will get an error message if you enter a value greater than 38 (32 monopolar, four bipolar, and two high level input channels) for the Number of Channels.

AC/DC option. With *SynAmps RT*, 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 (.05Hz, -6dB/octave/pole) is switched into the signal path. This filter will remove most problems associated with battery potentials generated by electrodes.



On some other AC coupled systems, high-pass values below .1Hz are often available as an approximation to DC. If you are interested in slow potentials, there is no need for these values since the *SynAmps RT* 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 *SynAmps RT*) 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 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 *SynAmps RT* 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 *SynAmps RT* 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 3.5kHz and high-pass of 150Hz. Examination of the tables below (under Filter Values) shows that a low pass of 3.5kHz 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 tables offer these values at digitization rates at or below 10kHz.

7.1.1 DC Electrode Considerations

The wide dynamic range of the *SynAmps RT* 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 ±200mV amplifier input range.

The DC capability of the *SynAmps RT* 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 ±200mV 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 rubber 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.*

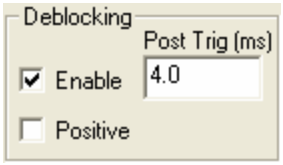
3. **Select metals that are known to produce the smallest battery potentials.** Sintered Ag/AgCl electrodes are probably the best. We have also found tin electrodes to be acceptable. They will produce more drift, but the drift is monotonic and can be corrected using the DC offset transform in the EDIT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

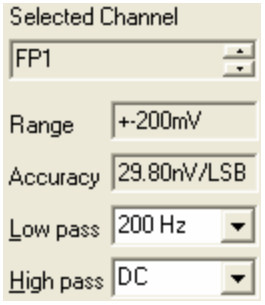
7.2 Deblocking

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. Set the deblock time in the Post Trig (ms) field.



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 5V) between pulses. In other words, the default condition uses negative logic, and deblocking will occur when the TTL pulse goes to 0V. If you select the Positive option, the system will use positive logic. That is, the resting state is 0, and deblocking will occur when the TTL pulse goes to 5V.

Amplifier Settings. The Filter characteristics of the *SynAmps RT* are controlled from the **Amplifiers (SN2)** options under **Edit** → **Overall Parameters**.



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 *SynAmps RT* receives these values prior to acquisition. 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 channel display 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  , and the label will be displayed in the 

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 *SynAmps RT* in DC mode is ±200mV. In AC mode, it is ±1mV. 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 10x. In AC mode, it is 2010x. 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, .06μV, then the voltage resolution will be in .06μV 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. The "Accuracy" value displayed, computed from the number of bits and input range, does not indicate the actual accuracy that is available. This has a maximum, given the intrinsic noise of the system, but will also be highly influenced by the environment.

7.3 Filter Values

Filtering on the *SynAmps RT*, 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 *SynAmps RT*:

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** tab under **Edit** → **Overall Parameters**. Potential low-pass filter values are 30, 40, 50, 70, 100, 200, 500, 1000, 1500, 2000, 2500, 3000, and 3500Hz. The maximum low-pass value available to the user will be at least 1/5th of the current digitization rate. For example, the maximum value for a digitization rate of 1000Hz would be 200Hz. Listed 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								
3500								

[1] same for 2.5K
[2] same for 1.25K

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 shows the high-pass (low cutoff frequency) filter values. Values range from DC to 300Hz. Digital high-pass values start from 0.1Hz. Researchers interested in lower frequencies (i.e., .01Hz) 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 *SynAmps RT* one does not have to "approximate DC" since the amplifier is a DC system. Shown are the high-pass filter values.

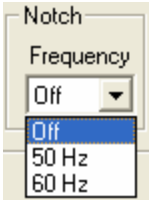
High-pass filter values

<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 60Hz 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 50-60Hz 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 **Amplifiers (SN2)** options under **Edit** → **Overall Parameters**.

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 60Hz 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.

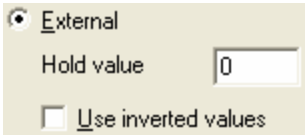
Monitors - Video monitors are now a common device in the neurophysiological laboratory. Unfortunately, they can also be a serious source of interference. Most monitors radiate more from the sides than the front. If you suspect interference from your monitor, try moving the orientation of the screen. 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., 16.667ms 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.

7.4 Triggering

All event marking and triggering on the *SynAmps RT* 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 *SynAmps RT*).

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.

7.5 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 RT* 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 *SynAmps RT*. The HLIs are isolated from the patient connections. The HLI ground is connected to the System Unit ground (computer ground).

There are several places in the ACQUIRE program that are relevant for configuring the HLIs. These include the **Amplifiers (SN2)** options (under **Edit** → **Overall Parameters**), the **High Level Inputs** options (under **Edit** → **Overall Parameters**), the **Channel Assignment Table**, and **Channel Layout**. 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 area for configuring the HLIs
Channel Assignment Table - used to select the HLI channels
Channel Layout - used to size and position the HLI displays

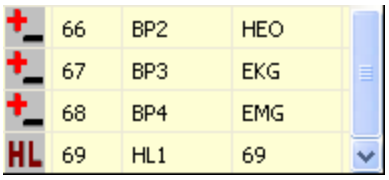
Example. Let's say you are using the supplied *Synamps2 Quik-Cap64.ast* setup file (in the SynAmps2 folder), and you want to add a HLI channel to record pupil diameter. The analog voltage output of the pupillometer ranges from 0 to 5V, where 0V = 0mm, and 5V = 15mm.

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

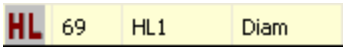
2. Click the **Amplifiers (SN2)** tab. In the Number of Channels field, enter **69** in place of 68.

3. Go to **Edit** → **Channel Assignment Table**, and scroll to the bottom of the list. In this case, the 69th channel was assumed to be a HLI channel - that is

the next unassigned channel in the display.

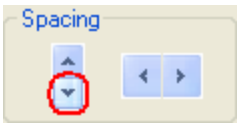


4. Double-click the "69" in the channel Label column, and enter a new label, such as "**Diam**". Then click **OK** to leave the Channel Assignment Table.



5. Go to **Edit** → **Channel Layout**. You may not see the new Diam electrode display. If not, the position is out of the display area. Click 

, and try clicking the down arrow for Spacing to collapse the electrode displays vertically. In this case, the "Diam" is found well below the others. Drag it to the range of the others, and use the Spacing up arrow to return to the original positions.



6. 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 8 below*). Then click **OK** to exit the Channel Layout.

7. Return to the **Amplifiers (SN2)** options, and you will see the new HLI channel in the channel 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.

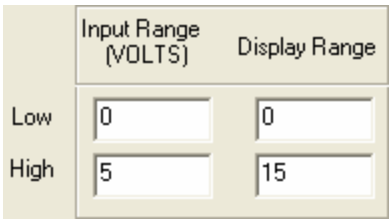
8. Next, click the **High Level Inputs** tab. For this example, we will assume you have a single amplifier; if you have more than one, the process is the same - just select the amplifier containing the HLI that you are configuring.

Channel. Select the HLI channel to be configured. If you have multiple amplifiers chained together, you will see HLIs for all of the amplifiers (HL1, HL2, HL3, HL4, etc.).

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 entering a new Label. This will override any previous label you entered.

Scaling
Input Range / Display Range. The **Input Range** and **Display Range** fields

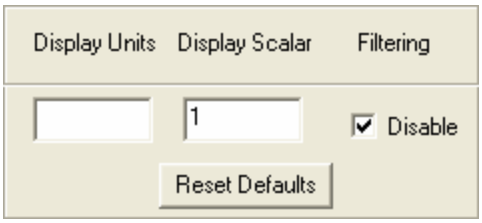
are used to configure the SCAN software to interpret the voltages from the external devices in a meaningful way. The Input Range is the voltage range that will be input into the amplifiers. Valid voltages are between +/- 5V. The Display Range is the range of values that will be displayed on the screen in ACQUIRE.



To continue the example, we said that the analog voltage output of the pupillometer ranges from 0 to 5V, where 0V = 0mm, and 5V = 15mm. Enter the values as shown in the Scaling section.

Setup Overrides

Display 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 nV, μV, mV etc. To change it, enter whatever units are meaningful in the field (for example, enter "mm", or "psi"). *Note, the labels should not contain any spaces, and there is a 10 character maximum.*



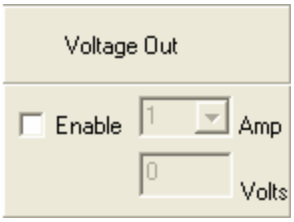
Display Scalar. The Display Scalar is the same at the Scalar seen in the Channel Layout dialog screen (Step 6). These settings allow you to alter the display scaling factor specifically for the HLI channel(s), thus increasing or decreasing their amplitudes in relation to changes in the other EEG channels. 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** 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.

Reset Defaults. Click the Reset Defaults button to return the fields to the default settings (mV, a Scalar of 1, and Disabled Filtering).

DC Output
Some transducers require a DC voltage in order to operate. The *SynAmps RT* 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 and +5V, -1 and +1V, but not -1 and +5V). 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 DC output begins at the start of acquisition, and ends when acquisition is terminated. The maximum voltage is 9V. If you need a DC voltage, please consult your device specifications.



9. 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.

Additional Information

Input voltages. The High Level Inputs have a *full scale range of +/- 5V*. Beyond that damage can occur, so be careful to verify the output voltages of the peripheral devices *before* connecting them to the *SynAmps RT*. If the output voltages are, for example, +/- 10V, 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

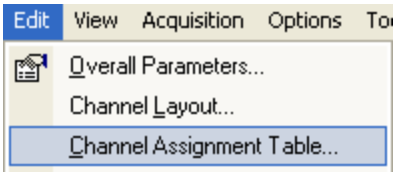
We recommend that the following precautions be followed routinely.

- Connect and disconnect the electrodes/transducers to the subject with the devices turned *ON*.
- Be very careful with *static charges*. For example, if you are disconnecting an electrode, and send a static charge through the system, the boards in the *SynAmps RT* could be damaged.
- Do *not* exceed the input voltages described above.

8 Reassignment of Channels

It is possible to re-map the order in which channels are sampled within a single *SynAmps RT*. 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** → **Amplifiers** tab to set the number of channels as desired).



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

Step 3. Double-click 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	02
2	2	01
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 them 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.

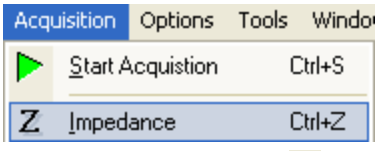
9 Calibration

With modern amplifiers like *SynAmps RT*, there is no need for calibration by the user. The factory set calibration is more precise than any software correction that could be applied. (The amplifier performance does not degrade; it is either performing accurately, or there will be signs of obvious hardware failure).

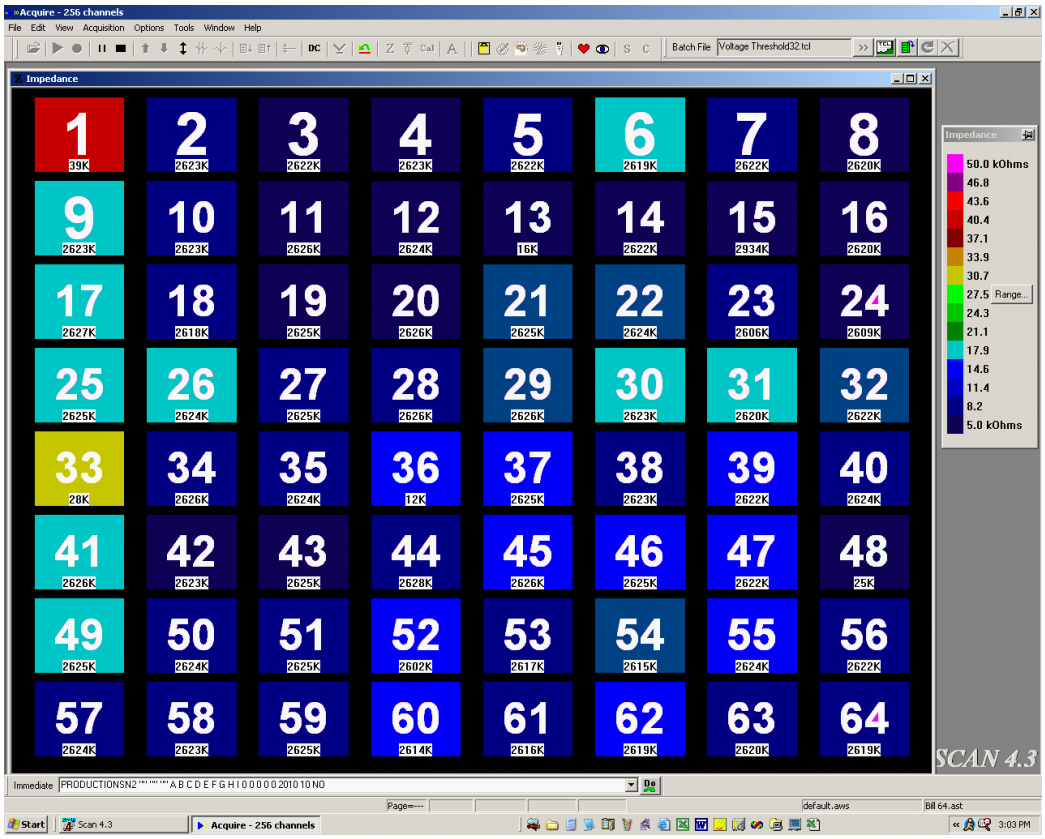
10 Impedance

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. 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.

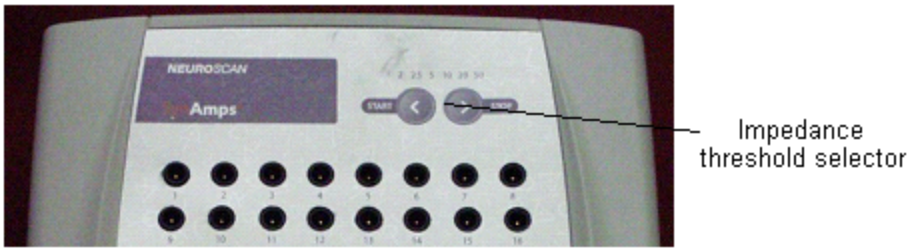
Step 2. Click the 

option under **Acquisition** from the Main Menu bar, or click the Impedance icon Z. The 'Impedance' display screen will appear.

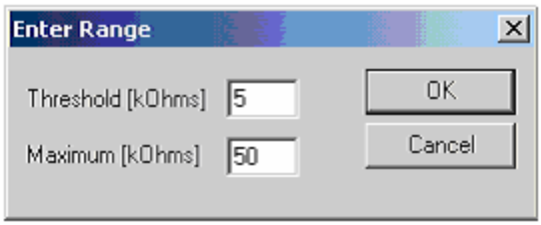


The impedance of an electrode, or the opposition of AC current flow, is the result of the complex interaction between skin, electrolyte and electrode. Measured impedance will vary according to the transfer function of this junction.

On the face of the headbox is an Impedance threshold selector. Use the < and > buttons to select an Impedance threshold. The selected threshold will light up. Threshold options include 2.0, 2.5, 5.0, 10.0, 20.0 and 30.0kOhms. 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 values. The default Threshold value is 5kOhms and the Maximum value is set to 50kOhms. To change these, click on the **Range** button and enter the desired values. Then click OK.

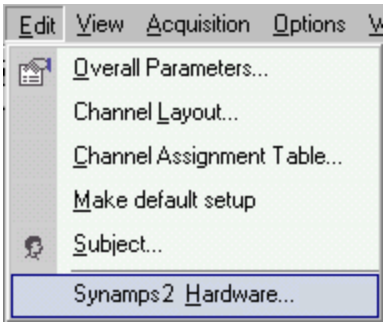


Step 4. Impedance testing will begin when the Impedance screen is displayed. The impedance operation uses a 30Hz sine wave. The color-coded impedances will be displayed for each electrode according to the color of the display.

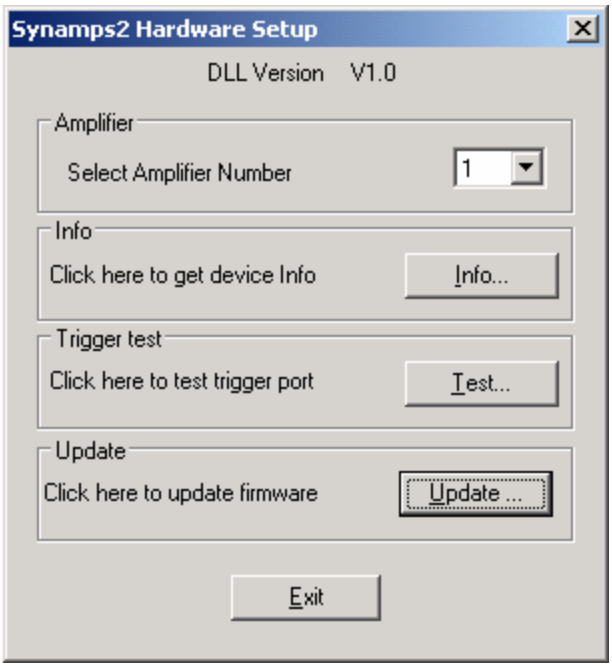
Remote Impedance testing. You can also test the impedances from the headbox itself, without using the Impedance routine in ACQUIRE. You need to at least open the ACQUIRE program, however. Then press the Start button on the headbox (the same as the < button), and the electrode labels should light up (assuming 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.

11 Diagnostic and Related Information

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



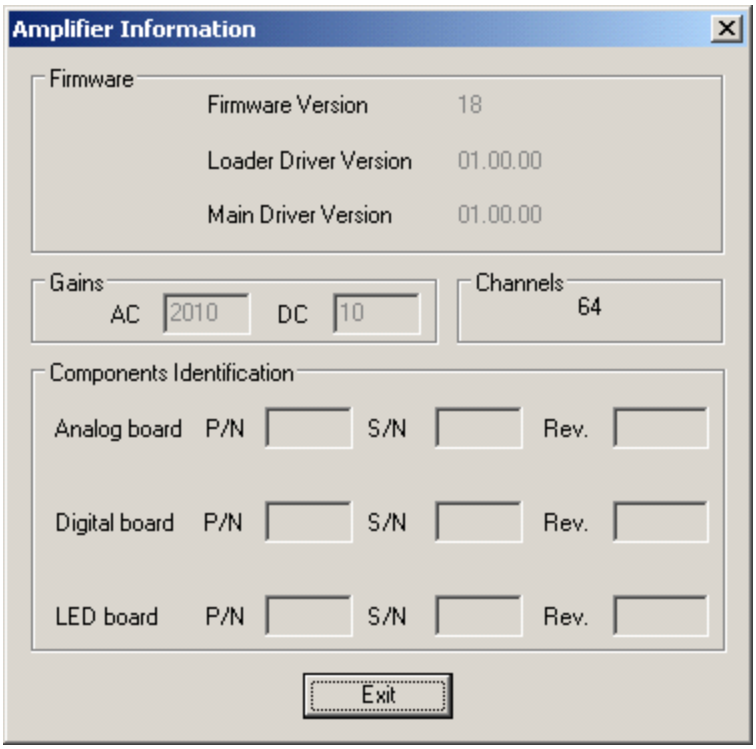
The SynAmps² Hardware Setup dialog box will appear.



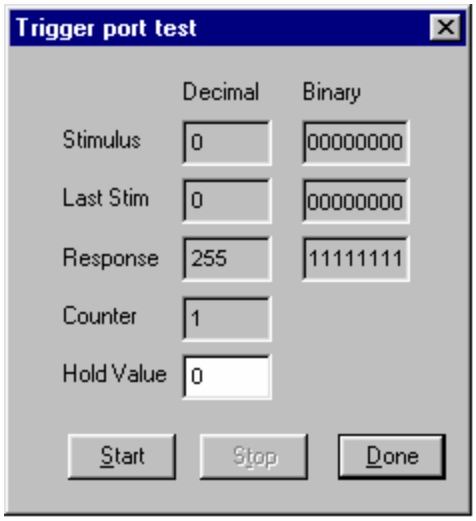
Amplifier. If you have multiple amplifier/headboxes connected, select the one that you wish to see.

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. This information may be needed should you need to contact Technical Support.



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; bit 7 is on the far left.

Click the **Start** button in the Trigger port 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 in the decimal field, and the activated bits will flash in the binary field.
Last Stim. The Last Stim fields will show the type code in decimal and binary of the most recently received trigger.

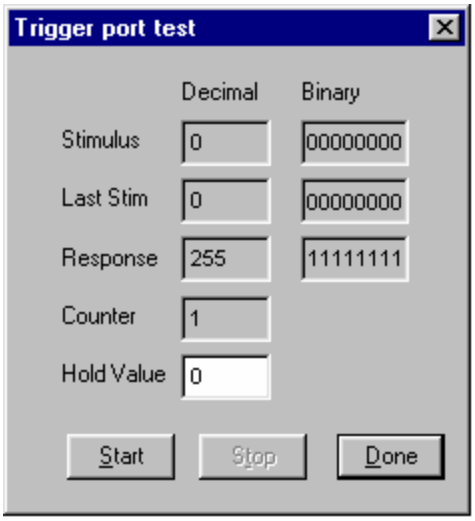
Response. The Response decimal field will show the inverted value of the response pad triggers (i.e., 255). Pressing the response pad buttons should show decimal values of 254, 253, 251, and 247, corresponding to buttons 1-4, and type codes of 1, 2, 4 and 8, respectively. The binary field will be all 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). The first 4 columns can be 0's in some situations, and this is not necessarily a cause for concern (they are generally not used).

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 values shown.

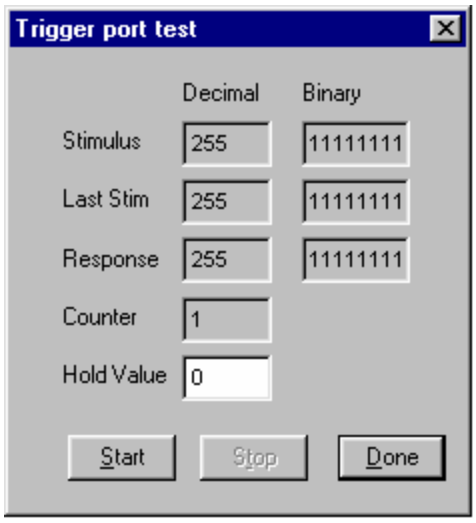


In its "resting" state, note that the Stimulus bits are at zero, and the Response bits are held high (all 1's). Summing the 8 response bits gives the 255 Decimal value. The Hold Value should be 0.

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 *SynAmps RT*.

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 *SynAmps RT* 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 *SynAmps RT* (and a probable return to the service center). If this looks normal, connect the stim-to-scan cable to the *SynAmps RT*, 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 (**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.

12 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 *SynAmps RT*, 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.

13 Electrode Safety

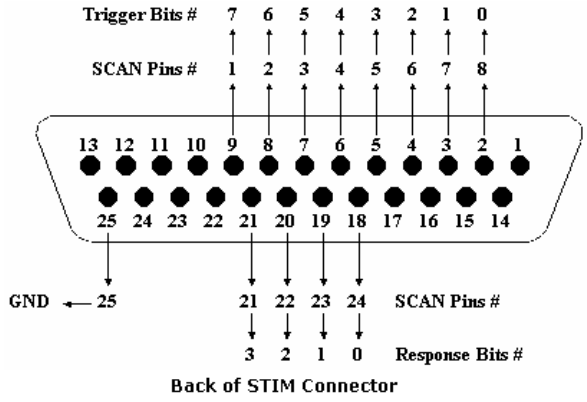
The *SynAmps RT* amplifier inputs and attached electrodes are Type CF, which means in part that they are not connected to Earth Ground or Chassis Ground. Maintain this separation from Earth Ground by ensuring that the electrodes and any conductive parts of their connectors do not touch conductive parts,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

14 MRI Environment Recording Configurations

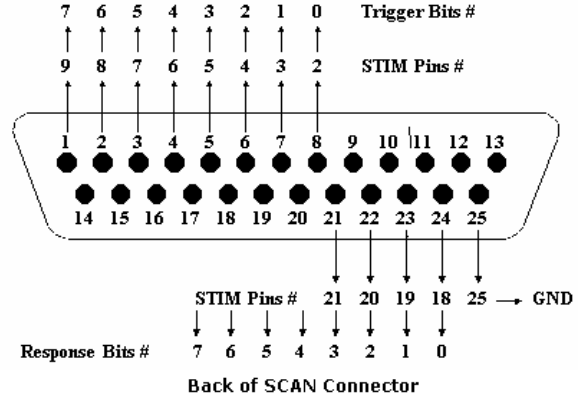
The *SynAmps RT* is part of the MagLink RT system that is used to record EEG within the MR chamber. Both the system unit and all headboxes must be outside of the MR chamber, in the control room. See the *MagLink RT* manual for more details.

15 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 *SynAmps RT* work slightly different from *SynAmps* and *NuAmps*. With *SynAmps RT*, 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 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 2.5V and not more than 5V. The pulses must return to the original response resting voltage (typically 5V) between pulses.

Pinout summary

In list form, the SCAN side connector and pinouts are as follows. Note that pins 14 and 15 carry +5V 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 *SynAmps RT* 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 *SynAmps RT* 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 *SynAmps RT*. 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 *SynAmps RT* 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 above.

(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 *SynAmps RT* System Unit 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 *SynAmps RT*.

General

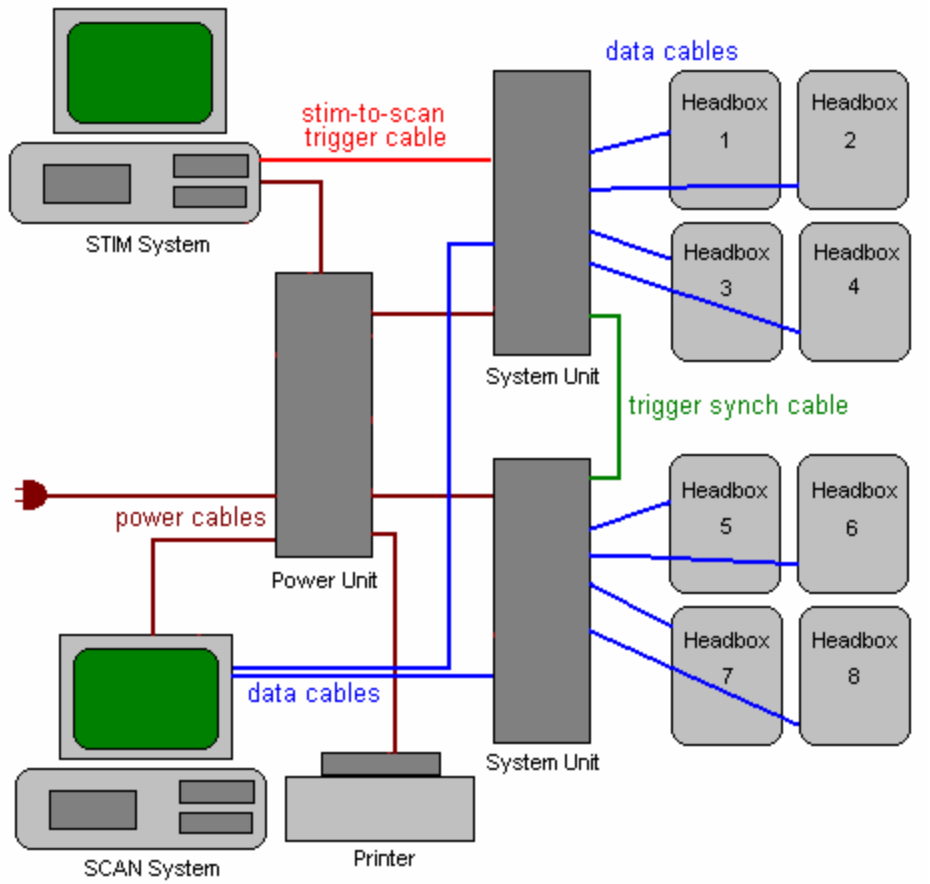
(2, 3) Problem - The SCAN system and the STIM system or other stimulus generating device may be connected to different power supplies, resulting in a ground loop.

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.

16 Appendix B: Configuring Multiple SynAmps RTs

Configuring multiple *SynAmps RT* 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). (The 32 channel version of *SynAmps RT* cannot be linked).



Multi-SynAmps^2 Configuration

If you have multiple headboxes and you are using a SynAmps RT 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.

17 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

18 Appendix D: Guidance and Declaration

Table I.

Guidance and manufacturer's declaration – electromagnetic emissions		
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.		
Emissions Test	**Compliance**	**Electromagnetic environment - guidance**
RF emissions CISPR 11	Group 1	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.
RF emissions CISPR 11	Class A	
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Complies	

Table II.

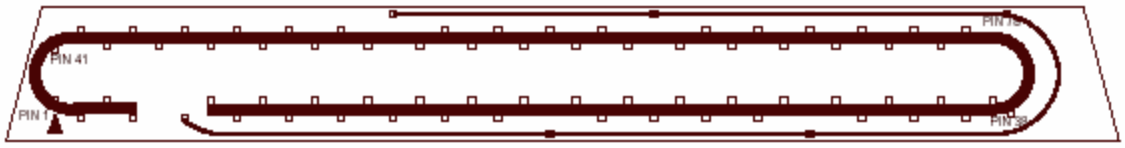
Recommended separation distances between portable and mobile RF communications equipment and the SynAmps²			
The SynAmps² is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the SynAmps² can help prevent electromagnetic interference 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 $d = 1,2 * \sqrt{P}$	**80 MHz to 800 MHz** $d = 1,2 * \sqrt{P}$	**800 MHz to 2,5 GHz** $d = 2,3 * \sqrt{P}$
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.

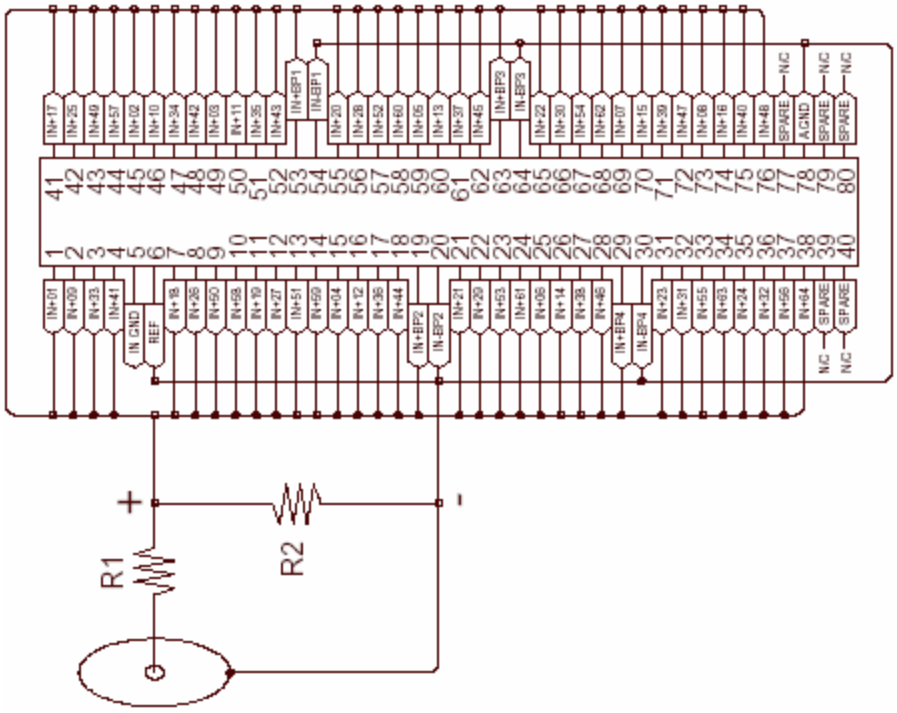
Guidance and manufacturer's declaration – electromagnetic immunity			
The SynAmps² system is intended for use in the electromagnetic environment specified below. The customer or user of the SynAmps² system should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**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	$d = 1,2 * \sqrt{P}$
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m 80 MHz to 2,5 GHz	$d = 1,2 * \sqrt{P}$ 80 MHz to 800 MHz $d = 2,3 * \sqrt{P}$ 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.			

19 Appendix E: Shorting Plug Details

The shorting plug for *SynAmps RT* is: 1) not wired the same as that used with *SynAmps*, and 2) provides functions in addition to shorting the pins together. The primary use of the shorting plug is for inputting the same test signal to all channels. 10Ohm shorting impedance is applied within the plug. The BNC connector on the back of the plug is used to inject a signal (from an external signal generator) to all amplifiers in the headbox. The diagrams below show the shorting method, the connector pinouts, and the resistor information.



Pins are soldered as indicated for shorting.



Pin-out of the 80 pin connector.

RESISTOR TABLE

DIVIDER RATIO	R1	R2
1 TO 1	SHORT	OPEN
1000 TO 1	10.0K	10 OHMS
2000 TO 1	20.0K	10 OHMS
10000 TO 1	100.0 K	10 OHMS