# Geodesic Sensor Net

## Technical Manual

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# Geodesic Sensor Net

## Technical Manual

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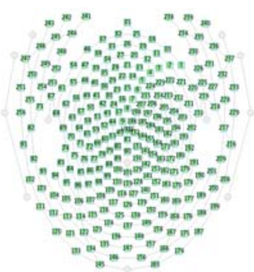


The geodesic structure allows for quick and painless application.

The Geodesic Sensor Net (GSN) from Electrical Geodesics, Inc. (EGI) is the first practical, safe method for quickly placing 32 to 256 electrodes on the human head to acquire dense-array electroencephalography (EEG) data. Its rapid application and comfortable fit, as well as the rich data it provides, make the GSN ideal for a wide range of subjects/patients and applications.

The GSN features EGI's patented dense-array EEG sensors held in a tension structure that stretches over the head. Each line between sensor pairs is a *geodesic*, the shortest distance between two points on the surface of a sphere. The accurate geodesic tesselation of the head surface optimizes the sampling of the electrical field.

The geodesic tension network enables the placement of a large number of electrodes on the scalp in a minimal amount of time. The average application time for a 128-channel GSN is 10 minutes, compared with the more than two hours required by conventional EEG techniques. The GSN's high-impedance electrodes do not call for scalp abrasion, thus increasing patient comfort and decreasing infection risk.

EGI currently offers two versions of the Geodesic Sensor Net: the HydroCel GSN (HCGSN) and GSN 200. This manual discusses the two models together because they share many similarities. General information about their individual properties is provided in Chapter 2, "HCGSN," and Chapter 3, "GSN 200." The models also have different sensor layouts (see Appendix B, "Net Sizing and Sensor Layouts") because the HCGSN is designed to provide more coverage of lower sections of the head. Consequently, EEG files acquired with the older GSN 200 are incompatible with those acquired with the newer HCGSN.

The GSN is an integral part of a Geodesic EEG System (GES), which is a complete package for acquiring and working with EEG data. The other parts are the GES hardware and the Net Station or Neurotravel Win software.

Following are brief descriptions of all the components and the available documentation, posted as PDF files at www.egi.com/documentation.html:

*Hardware related*

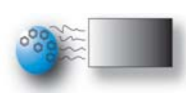
- The Geodesic Sensor Net is EGI's patented device for acquiring electrical signals from the human scalp. This manual, the ***Geodesic Sensor Net Technical Manual***, provides comprehensive descriptions of all GSN features and functions.

- GES hardware is all the system hardware except for the GSN. GES hardware supports the acquisition and processing of EEG data and includes an amplifier, a data-acquisition computer, a monitor, and, in most cases, a cart or travel case. The ***GES Hardware Technical Manual*** provides comprehensive descriptions of all GES hardware components and features.

- The Geodesic Photogrammetry System (GPS) is EGI's photogrammetry-based sensor-registration system. The GPS consists of a geodesic dome structure containing 11 mounted cameras, a steel supporting structure, and the Photogrammetry software feature in Net Station. The ***Geodesic Photogrammetry System Technical Manual*** provides comprehensive descriptions of all GPS components and features.

*Software related*

- The Net Station Acquisition is the component of the Net Station software for acquiring EEG, in conjunction with the dense-array Geodesic Sensor Nets. The ***Net Station Acquisition Technical Manual*** provides comprehensive descriptions of all Acquisition features and functions.



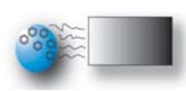
- The Net Station Viewer is the component of Net Station for viewing and navigating EEG data. The ***Net Station Viewer Technical Manual*** provides comprehensive descriptions of all Viewer features and functions.

- The Net Station Waveform Tools is the component of Net Station for performing various operations on EEG data. The ***Net Station Waveform Tools Technical Manual*** provides comprehensive descriptions of all Waveform Tools features and functions.

- The ***Net Station Viewer and Waveform Tools Tutorial*** instructs you in the use of Net Station Viewer and Waveform Tools by guiding you through the analysis of a sample data set. It is not intended to be a comprehensive guide to these components, but it is a good place to start when learning about the software.

- The ***Net Station File Formats Technical Manual*** documents the objects contained in a native Net Station file, the formats of the export files, and other files associated with Net Station.

- Neurotravel Win is EGI's PC-only clinical EEG software application. The ***Neurotravel Win Technical Manual*** describes all Neurotravel features and functions.



These publications contain a good deal of background information on the EEG field. However, they are not intended to represent a complete primer. To get the most out of these manuals, you should have some background in EEG methods.

Each manual assumes you are familiar with the platform for the specific EEG acquisition software program described. For Net Station, the platform is a Macintosh computer; for Neurotravel Win, it is a Windows-based PC.

# About This Manual

This section describes this manual's features, organization, conventions and typography, and use of notes, cautions, and warnings.

## Features

This manual is supplied as a PDF file and in printed form. The hard-copy version has been printed from the PDF so the content of both will match. The hard-copy manual contains mostly grayscale images; the PDF contains color and grayscale images.

## Manual Organization

This manual features a table of contents, list of figures, list of tables, and index, which in the PDF are all hyperlinked to the topics they reference in the manual.

The chapters fall into five main categories:

- *Background*: Chapter 1, "GSN Introduction"; Chapter 2, "HCGSN"; and Chapter 3, "GSN 200," describe the GSN, explaining its features and technology.
- *Safety and maintenance*: Chapter 4, "Safety," and Chapter 5, "Service and Maintenance," provide information on safely using and maintaining your GSN.
- *GSN application and care*: Chapter 6, "Applying the GSN," and Chapter 7, "Rinsing and Disinfecting," provide detailed instructions about applying the Net and caring for it properly after every use.
- *Use-related issues*: Chapter 8, "Connectivities," and Chapter 9, "Replacing GSN Parts," describe issues related to Net use.
- *Troubleshooting and supplies*: Chapter 10, "Net FAQs"; Chapter 11, "Troubleshooting"; and Chapter 12, "Accessories and Supplies," describe common problems and available supplies.

A number of appendixes are also included:

- Appendix A, "Technical Support"
- Appendix B, "Net Sizing and Sensor Layouts"
- Appendix C, "GSN Pinouts"

## Conventions and Typography

- In this manual, the following are treated as synonyms: *Geodesic Sensor Net 200* and *GSN 200*; *HydroCel Geodesic Sensor Net*, *HCGSN*, and *HydroCel GSN*.
- The terms *GSN*, *Net*, and *Geodesic Sensor Net* are generic references to both the GSN 200 and the HCGSN.
- The GSN can be used in research and clinical settings. For convenience, the manual uses the term *subjects* to refer to both subjects and patients.
- In general, a minimal amount of special fonts are used—*italics* for definitions or newly introduced terms, and ***boldface italics*** for important concepts.

## Additional Information

Three different methods are used to convey additional information: notes, cautions, and warnings.

*Note: This indicates information that is helpful in understanding GSN operations.*

***Caution!:*** *This denotes important information that, if unheeded, could hinder use of the product or result in injury or equipment damage.*

***WARNING!:*** *This denotes important information that, if unheeded, could result in serious injury or death.*

# Troubleshooting, Support, and Repair

- Contingent on the cautions and warnings given in Chapter 4, "Safety," user-maintainable and user-serviceable components of the GSN are described in Chapter 5, "Service and Maintenance."
- For replacing electrodes of a GSN 200 or sponges of an HCGSN, consult Chapter 9, "Replacing GSN Parts."
- Chapter 11, "Troubleshooting," is a troubleshooting guide.
- For online updates to this book, check EGI's Documentation page at www.egi.com/documentation.html.
- For GSN technical support, see Appendix A, "Technical Support."

chapter 1

# GSN Introduction

EGI's Geodesic Sensor Net (GSN) is designed to acquire dense-array EEG data using a Geodesic EEG System (GES). This manual, the *Geodesic Sensor Net Technical Manual*, describes the components of the Geodesic Sensor Net, their integration, and use. It is also a maintenance and safety reference.

EGI currently offers two models of Geodesic Sensor Nets (Figure 1-1):

- ***GSN 200***: the classic dense sensor array, available in densities of 64, 128, and 256 channels.
- ***HydroCel GSN (HCGSN)***: a sleeker dense sensor array, available in densities of 32, 64, 128, and 256 channels. The HCGSN features low-profile pedestals, convenient wire management, shielded cables, and prominently marked sensor tops. This model comes in two versions:
    - ° *with sponge inserts*: each pedestal is installed with a sponge, allowing it to use EGI's HydroCel Saline electrolyte solution for 2-hour recordings.
    - ° *without sponge inserts*: each pedestal contains only an electrode (no sponge), which is individually filled by a syringe containing EGI's HydroCel HS electrolyte formulation for 12-hour recordings.

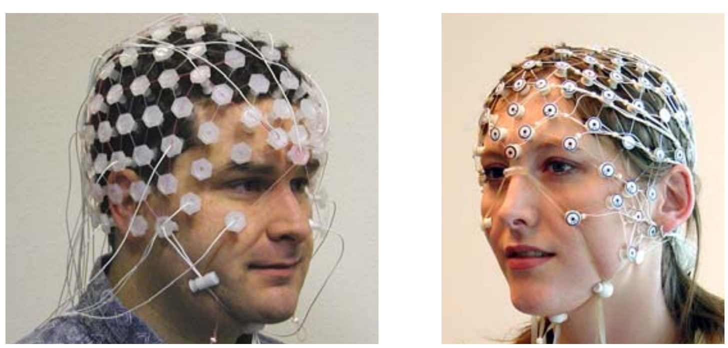


**Figure 1-1.** The GSN 200 (left) and the HCGSN (right)

This manual discusses the GSN 200 and HCGSN together because they share many similarities. References to *Geodesic Sensor Net* or *GSN* apply to both models, unless otherwise noted. General information about their individual properties is provided in Chapter 2, "HCGSN," and Chapter 3, "GSN 200." The models also have different sensor layouts (see Appendix B, "Net Sizing and Sensor Layouts") because the HCGSN is designed to provide more coverage of lower sections of the head. Consequently, EEG files acquired with the older GSN 200 are incompatible with those acquired with the newer HCGSN.

# Safety

A complete list of safety cautions and warnings for the GSN is given in Chapter 4, "Safety." You should read Chapter 4 while learning to use the Net and ***not*** use the Net unless you understand all the cautions and warnings.

# Intended Use

The Geodesic Sensor Net is intended for use in clinical and research settings, by trained technicians, to measure and record the electrical activity of the brain. It is designed to be used on adults, children, and infants. Its intended use is strictly limited to EGI Geodesic EEG Systems, as stated in the applicable regulatory filings.

# GSN Environmental Conditions

The GSN has been designed for use under the environmental conditions given in Table 1-1.

**Table 1-1. Overall operating environment**

| | |
|---|---|
| **Storage temperature** | 0° to 47° C (32° to 116° F) |
| **Operating temperature** | 10° to 35° C (50° to 95° F) |
| **Relative humidity** | 5% to 95% noncondensing |
| **Maximum altitude** | 3,048 m (10,000 feet) |

# Regulatory Compliance

- *Certification*: This medical equipment is certified to EN 60601-1, CSA 22.2 No. 601.1, CSA 22.2 No. 601.2.26, UL 2601, and IEC 60601-2.26. The Geodesic EEG System, of which the GSN is a part, carries the U.S. FDA Pre-market 510k Clearance, Canadian Medical Device License (Homologation d'un instrument medical), European CE Certification, and Japanese Yakuji Approval.
- *Applied Part*: Type BF
- *GSN 200*: Electrical Class I Equipment

# Symbols

Table 1-2 describes the labels and symbols used on the equipment.

**Table 1-2. GSN symbols**

| Symbol | Description | Symbol | Description |
|---|---|---|---|
| | Subject-connected part | | Protective earth ground point |
| C US | Labeled component is certified to CSA 601-2-26 and UL 2601 and IEC 60601- | | See accompanying documents. |
| 0366 | Mark indicating that the product is CE compliant. The number 0366 is the EC reference number of the VDE Testing and Certification Institute, the notified body for Electrical Geodesics, Inc. | | |

# Sensor Array Overview

## The Geodesic Advantage

If tension is distributed evenly across the surface of a sphere, such as occurs with a soap bubble, the surface tension is balanced by compression directed from all points on the surface toward the sphere center.

If a single quantity of tension is exerted between all pairs of a network of sensors, the network will adjust the spatial location of each sensor until a single distance spans all pairs. For accurate control of this tension, it must be applied in direct lines between the sensor pairs, and only along those lines. Each line is a *geodesic*, the shortest distance between two points on the surface of a sphere.

An accurate geodesic tessellation of the head surface optimizes the sampling of the electrical field. Accurate surface sampling is essential for the integration of advanced EEG methods, such as electrical source localization, with anatomical magnetic resonance images (MRIs), and with other neuroimaging data, such as functional MRI.

## The GSN Role in a Geodesic EEG System

All GES configurations have a common set of core components: at least one Geodesic Sensor Net, one amplifier, and a data-acquisition computer running EEG acquisition software (Figure 1-2).

Geodesic Sensor Net    Amplifier    Data-acquisition computer

**Figure 1-2.** Core components

## Geodesic Sensor Net

During EEG recordings, subjects wear a GSN. It consists of an array of sensors that tessellates the surface of the head. Small sponges wetted with electrolyte rest against the head. A subject wearing a 128-channel child-sized HCGSN is shown in Figure 1-3.

**Figure 1-3.** Subject wearing an HCGSN

## Amplifier

A 32-, 64-, or 128-channel Net is connected to an amplifier. The 256-channel Net connects to two Net Amps 200 amplifiers or to one Net Amps 300 amplifier.

The amplifiers filter and measure the EEG signals that are picked up by the Net and sample them at millisecond intervals.

The digitized samples are transferred to the data-acquisition computer in real time.

## Acquisition Computer and Software

Packets of data containing digitized EEG samples are sent from the amplifiers to the data-acquisition computer so that the acquisition software can collect them for display and storage to disk.

A functional diagram is shown in Figure 1-4.

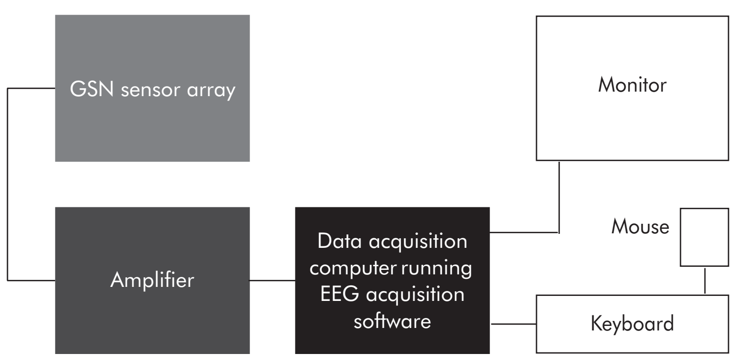



**Figure 1-4.** Functional block diagram of a typical GES

## Basic Operation

Physically, the GSN connects to the amplifier either directly (in the GES 120 or 140) or via a Geodesic Sensor Net interface cable (GSNIC; in the GES 200, 250, or 300). (For more information about the GSNIC, see the *GES Hardware Technical Manual*.)

In the GES 120 or 140, the leads of a 32-channel GSN are bundled and terminate in a connector that plugs into the Hypertronics connector on the front of the Neurotravel amplifier. This is shown in Figure 1-5.

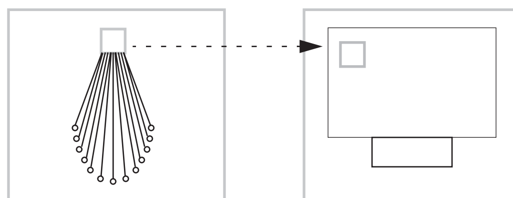


**Figure 1-5.** Sensor array and Neurotravel amplifier

In the GES 200, 250, or 300, the leads of a 64-, 128-, or 256-channel GSN are bundled and terminate in a connector that plugs into one end of the GSNIC. The GSNIC's other end plugs into the Net Amps 200 or 300 amplifier. This is shown in Figure 1-6.

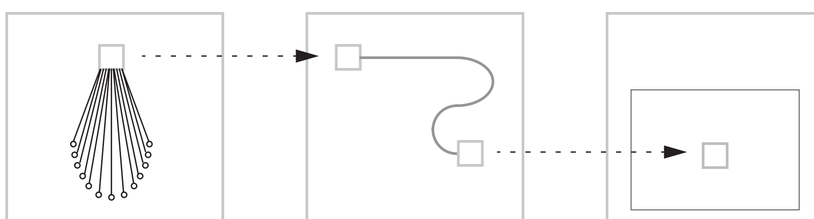


**Figure 1-6.** GSN, GSNIC, and Net Amps amplifier

The GSNIC allows the subject to be positioned conveniently within a meter or two of the amplifier. The GES 200, 250, or 300 ships with a GSNIC that can handle the appropriate sensor density of the users' Nets.

The Net sensors pick up changes in voltage originating at the surface of the subject's head (the EEG), along with a certain amount of electrical noise originating in the room environment. Electrical signals from all the sensors of the Net are received simultaneously by the amplifiers where they are amplified, filtered, sampled, and digitized. As quickly as the samples are acquired, they are packaged and sent to the data-acquisition computer along the Universal Serial Bus (USB) cable (or in the case of the Net Amps 300, the FireWire cable) that connects the amplifier and the data-acquisition computer.

chapter 2

# HCGSN

The HCGSN retains EGI's patented geodesic tessellation of the head (Figure 2-1), which is the hallmark of the Geodesic Sensor Net design. The HCGSN also employs the non-abrasion high-impedance application method used with the GSN 200.

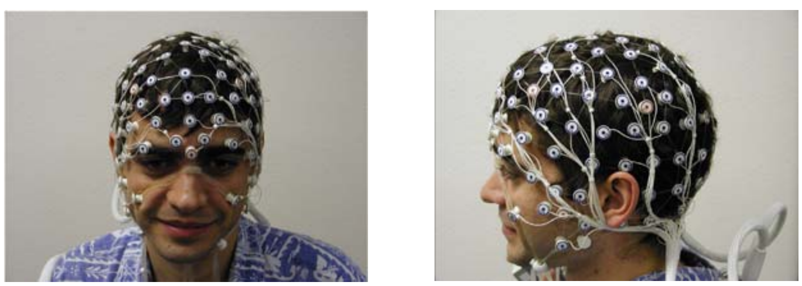


**Figure 2-1.** 128-channel HCGSN, front (left) and side (right) views

The HCGSN comes in two configurations:

- *with sponge inserts*: for standard 2-hour recordings using the HydroCel Saline electrolyte solution (described in "Preparing the Electrolyte Formulation" on page 58)
- *without sponge inserts*: for extended 12-hour recordings using the HydroCel HS electrolyte formulation (described in "Preparing the Electrolyte Formulation" on page 58)

The HCGSN is available in 32-, 64-, 128-, and 256-channel versions, as well as in a variety of sizes (see Appendix B, "Net Sizing and Sensor Layouts," for sizing chart and sensor maps). Because the HCGSN is designed to provide more coverage of lower sections of the head, its sensor layouts are different from those for the GSN 200. Therefore, EEG files acquired with the GSN 200 are incompatible with those acquired with the HCGSN. (For information about the GSN 200, see Chapter 3.)

The 32-channel HCGSN in the GES 120 and 140 is designed for the Neurotravel amplifier; it cannot interface with the Net Amps 200 amplifier used in the GES 200 or 250 or with the Net Amps 300 amplifier used in the GES 300.

Application and care of the HCGSN are similar to those of the GSN 200. Before applying the Net, please read Chapter 7, "Rinsing and Disinfecting,” to learn how to disinfect and dry the GSN after each use. Step-by-step instructions on how to apply the Net are given in Chapter 6, "Applying the GSN.”

Figure 2-2 shows the parts of the HCGSN. Each sensor is wired to an individual pin on the Hypertronics connector.

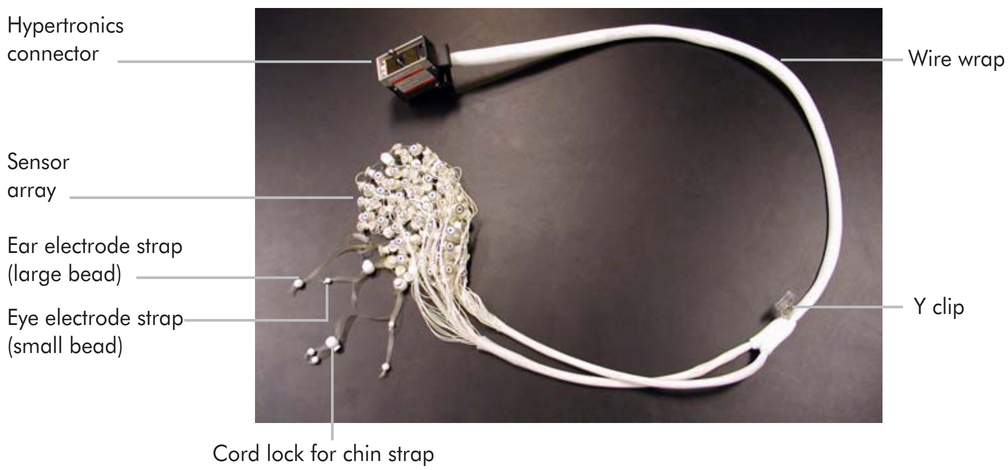



**Figure 2-2.** HCGSN (128-channel model)

The HCGSN features ear and eye electrode bands on both sides of the face to evenly adjust the position and tension of the electrodes near the ears and eyes. It also includes a wire wrap to keep the wires from tangling (similar in function to the sliding wire guide of the GSN 200). In addition, HCGSNs with more than 32 channels feature a Y clip that is secured onto the subject’s collar to relieve the strain of the wires on the Net structure.

The HCGSN also contains stabilizer pedestals to keep the bottom row of pedestals from overturning, and cut-out sections for the ears. Figure 2-3 shows these features and others in front, side, and back views of the HCGSN.

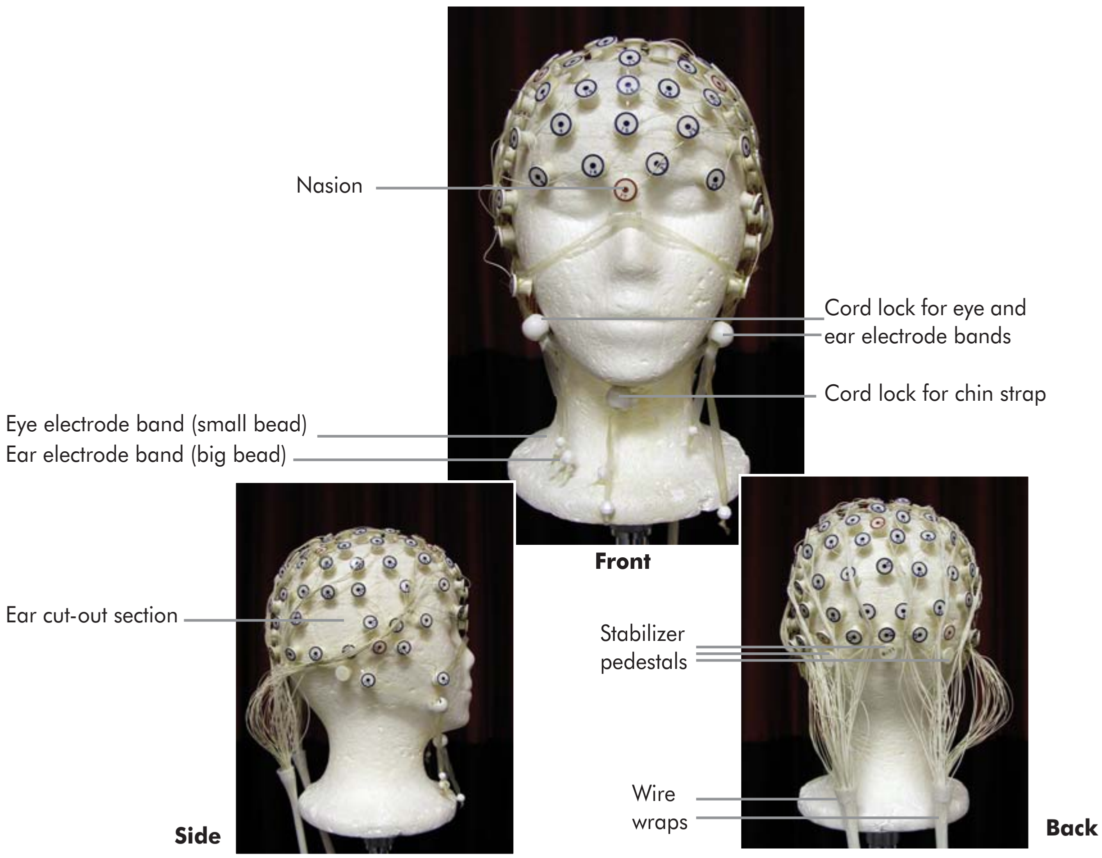



**Figure 2-3.** HCGSN (128-channel model)

# Tension Structure and Pedestal Design

The geodesic tessellation that is the basis of both the HCGSN and GSN 200 provides not only even intersensor distances across the head surface, but also uniform radial compression at each sensor pedestal. The tessellation ensures a rapid, evenly spaced, and comfortable Net application that requires no scalp abrasion.

## Precision Structure

The HCGSN features an innovative elastomer geodesic structure. This structure results in millimeter accuracy in the positioning of the sensors, enhanced head fit, and improved EEG signal quality.

## Low-Profile Pedestal

The HCGSN features a low-profile electrode pedestal, known as the *HydroCel Hydrating Skin Interface Chamber* (Figure 2-4).

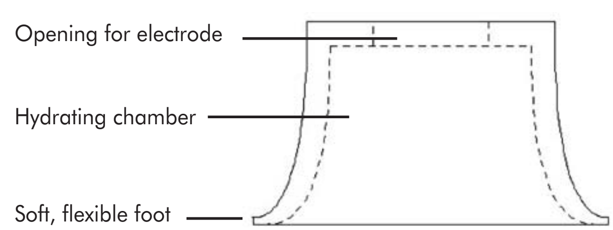



**Figure 2-4.** HydroCel Hydrating Skin Interface Chamber

The low-profile electrode is designed to support both comfort and signal quality for sleep studies, during long-term monitoring, and in confined spaces such as magnetoencephalography dewars. The improved pedestal design achieves the low-profile form factor while maintaining the Net's adaptability to a wide variety of hair types, lengths, and styles.

The pedestal is called a *hydrating skin interface chamber* because it creates a sealed micro-environment that promotes additional comfort and recording duration. The pedestal's soft, flexible foot forms a seal with the skin, encapsulating the *electrolyte* and *electrode* within the chamber. The pedestal foot lifts and rakes the hair during application, positioning the chamber under the hair and directly against the scalp. The pedestal can work with or without sponge inserts.

## Electrolyte Formulations

Long-term monitoring is enabled by both the HCGSN's pedestal design and EGI's electrolyte formulations.

- For 12-hour recording, the HCGSN must contain *no* sponges and must use the HydroCel HS. Individual electrode filling is required.
- For standard 2-hour recordings, the HCGSN must contain sponges and use the HydroCel Saline. For recording with infants, see the "Caution" below.

***Caution!:*** *For very long-term monitoring (e.g., days), EGI recommends removing and reapplying the HCGSN at least every 12 hours to improve comfort and to decrease the risk of skin irritation or breakdown. Careful monitoring of the patient is recommended.*

For full descriptions of the electrolyte formulations, see "Preparing the Electrolyte Formulation" on page 58.

## Electrode Materials

The HCGSN's electrode is designed for low-noise electrophyiological recording. Electrochemical noise, created by varying half-cell potentials at the electrode–electrolyte interface, is minimized by a proprietary technology in which carbon fibers are embedded within a plastic substrate, and then coated with a tough silver-chloride surface.

The electrode leads, called *HydroCel CleanLeads*, have a Teflon-core coaxial design that reduces movement artifacts from *triboelectric* noise (produced by the friction between two objects). In addition, the coaxial shielding decreases the pickup of environmental electromagnetic noise.

More information about the general electrode design is provided in "Features" on page 34.

## Quick Application, Extended Use

As with the GSN 200, pressure is evenly distributed across all sensors in the HCGSN. The enhanced head fit, lower pedestal design, and new HydroCel HS formulation allow the HCGSN to be worn for as long as 12 hours.

All sensors for recording are contained in the HCGSN's structure, making application a quick, one-step process. Typical application times are less than 10 minutes—even for 256-channel HCGSNs—with typical impedances in the 50–100 kΩ range. No special scalp preparation is required.

# Features

## Sensors and Electrodes

Each HCGSN (except for the 32-channel models used with the GES 120 and 140) contains an array of EEG sensors, plus a reference sensor and an isolated common sensor. Each sensor corresponds to an amplifier channel. Sensor maps are shown in Appendix B, "Net Sizing and Sensor Layouts."

(The 32-channel HCGSN for the GES 120 and 140 contains no separate reference sensor because it is designed to interface with the Neurotravel amplifier. In this HCGSN, the average signal on channels 1 and 2 [also known as Fp1 and Fp2] form the reference.)

An *electrode* consists of three linked components: a silver chloride–plated carbon-fiber pellet, connected by a 1-meter-long shielded wire to a Hypertronics-compatible, gold-plated pin (Figure 2-5). The electrode pellet features a wide, flat base.


**Figure 2-5.** Electrode

Each electrode pellet is set into the bore of the HydroCel Hydrating Skin Interface Chamber, a soft, plastic pedestal (Figure 2-6).

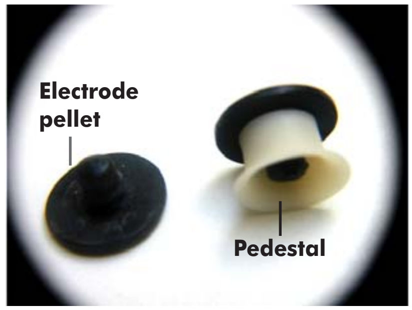
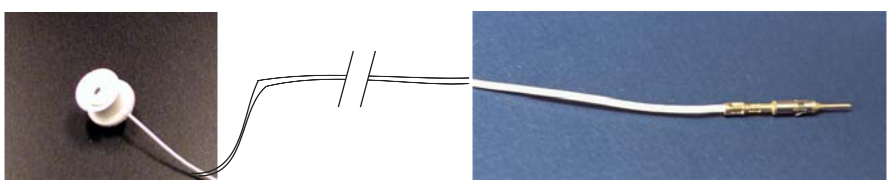



**Figure 2-6.** Pedestal and electrode

If the HCGSN has sponge inserts, then each electrode is surrounded by a sponge that is wetted with liquid electrolyte during operation. With this Net, the wetted sponge protrudes slightly from the one end of the pedestal and the lead wire emerges from the base of the electrode pellet.

By definition, a *sensor* (Figure 2-7) consists of a pedestal and an electrode.



Sponge, pedestal, and electrode pellet

Hypertronics pin

**Figure 2-7.** Sensor connected by wire to pin

Cutting the pedestal assembly of the sensor down the middle makes its construction easier to see (Figure 2-8).

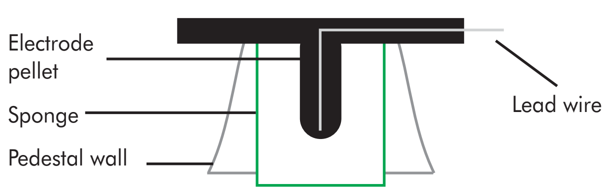



**Figure 2-8.** Sensor cut-away view

## Sensor Array

The geodesic tension structure is die cut from a polyurethane sheet. The resulting polyurethane web features holes for the sensors, which are "snapped on." An electrode pellet is first inserted into its corresponding hole; then, a pedestal is snapped on the other side of the hole, securing the sensor in place in the Net structure.

## Smart Nets

Users of GES 200, 250, or 300 can be aided by "Smart Net" technology. This feature enables Net Station to sense what type of GSN is connected to the Net Amps (see "Smart Nets" on page 87). (The GES 120 and 140 do not contain or require "Smart Net" technology.)

# Sizing

The HCGSN is available in various sizes based on head circumference (Figure 2-9). Instructions for choosing a suitably sized Net are covered in Chapter 6, "Applying the GSN." A sizing chart is located in Appendix B, "Net Sizing and Sensor Layouts."

**Figure 2-9.** The HCGSN comes in adult (left) and child (right) sizes

# Infant Nets

**Figure 2-10.** Outrider sensor

Infant GSNs feature a slightly different structure from the pediatric and adult models. Infant HCGSNs and GSN 200s do not contain built-in inferior orbital sensors but are made so that you can use optional, separate outrider orbital sensors (Figure 2-10). The orbital sensors plug into the special GSN Hypertronics plug that is part of every infant GSN.


**Figure 2-11.** Elefix gel

If used, orbital sensors are attached to the face of the infant by means of medical tape or a gel such as Elefix (Figure 2-11), which is supplied by EGI.

The Hypertronics connector for an infant GSN has jacks for connecting outrider sensors. Table 2-1 lists the number of jacks for each infant HCGSN model and the channels to which they map.

**Table 2-1. Infant HCGSN outrider sensors**

| GSN model | Number of jacks | Map to channels . . . |
|---|---|---|
| 32 channel infant HCGSN | 4 | 29, 30, 31, and 32 |
| 64 channel infant HCGSN | 4 | 61, 62, 63, and 64 |
| 128 channel infant HCGSN | 4 | 125, 126, 127, and 128 |

When you use an infant GSN, short to isolated common any jack on the connector that does not have an outrider sensor plugged into it.

***Caution!:*** *EGI recommends limiting recordings of infants to only 1 hour to decrease the risk of skin irritation or breakdown. Constant monitoring of the infant is required to prevent choking or strangling, and to allow for frequent examination for skin irritation. EGI recommends checking for skin pressure points, overturned sensors, and redness under the chin strap every 15 minutes to maximize infant comfort.*

# Repair

## Sponge Replacement

Field replacement of sponges in the HCGSN is described in Chapter 9, "Replacing GSN Parts."

## Other Repairs

Repairs other than sponge replacement for the HCGSN must be performed by a trained Net technician and will require the Net to be returned to EGI for servicing (see Appendix A, "Technical Support"). Please disinfect the Net (see page 81) before returning it to EGI.

# Recycling and Disposal of Nets

See "Component Recycling and Disposal" on page 56.

# For More HCGSN Information

- Service and maintenance information is found in Chapter 5, "Service and Maintenance."
- Complete instructions on how to apply the Net are given in Chapter 6, "Applying the GSN."
- Complete instructions on how to rinse and disinfect the Net after each use are given in Chapter 7, "Rinsing and Disinfecting."
- Sponge replacement instructions for the HCGSN are provided in Chapter 9, "Replacing GSN Parts."
- Sizing and sensor maps are in Appendix B, "Net Sizing and Sensor Layouts."

chapter 3

# GSN 200

The GSN 200 features EGI's patented dense-array EEG sensors held in a tension structure that stretches over the subject's head (Figure 3-1). The sensors' contact with the surface of the head is achieved using electrolyte-wetted sponges and without abrasion of the scalp. The GSN 200 uses EGI's HydroCel Saline electrolyte solution, which is described on page 59.

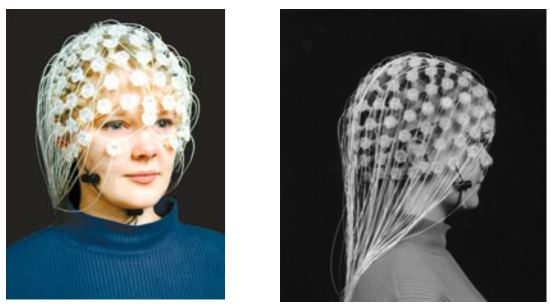


**Figure 3-1.** 128-channel GSN 200, front and side views

The GSN 200 comes in three densities (64, 128, and 256 channels), and in a variety of sizes (see Appendix B, "Net Sizing and Sensor Layouts," for sizing chart and sensor maps). The sensor layouts for the GSN 200 are different from those for the HCGSN; consequently, EEG files acquired with the GSN 200 are incompatible with those acquired with the HCGSN. (For information about the HCGSN, see Chapter 2.)

Application and servicing of the GSN 200 are similar to those of the HCGSN. Complete instructions on how to apply the Net are given in Chapter 6, "Applying the GSN." You should also study Chapter 7, "Rinsing and Disinfecting," to understand how to rinse, disinfect, and dry GSNs before and after application.

Figure 3-2 shows the parts of the GSN 200. Note that each sensor is wired to an individual pin on the Hypertronics connector. Figure 3-3 shows front, side, and back views of the GSN 200. Most of the wire management is done manually, by grouping wires together with plastic stays.


**Figure 3-2.** GSN 200 (256-channel model)

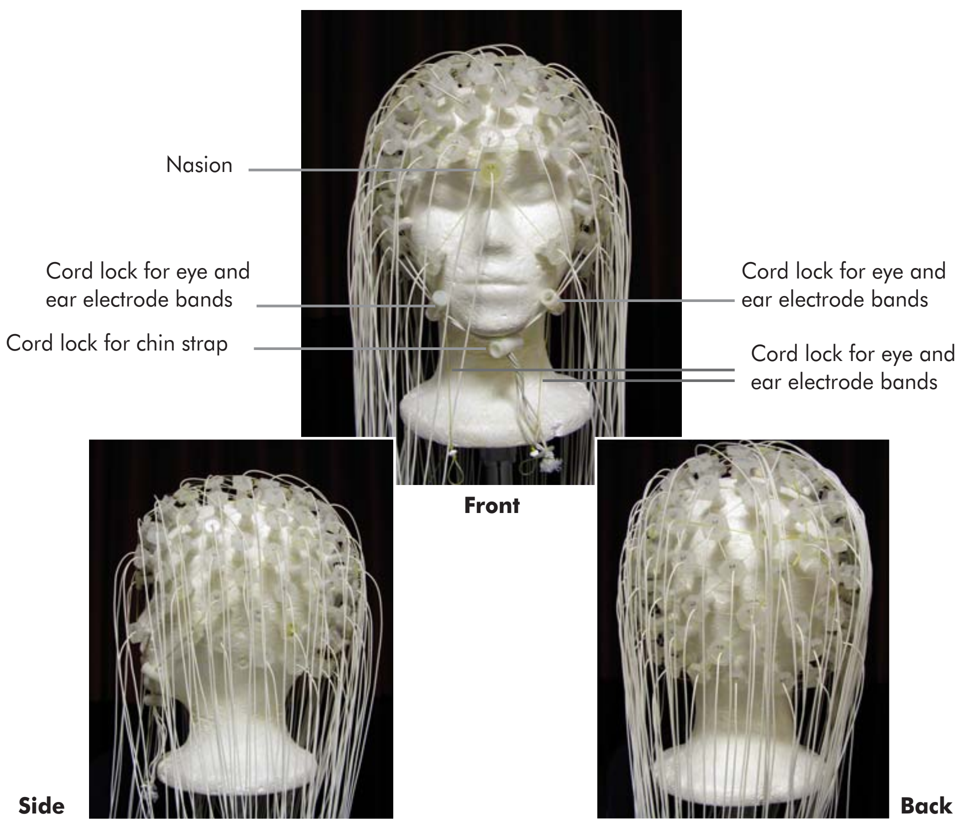


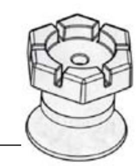

**Figure 3-3.** GSN 200 (128-channel model), without wire management

# Tension Structure and Pedestal Design

The sensors that make up the GSN 200 are sewn into a geodesic structure using durable polyurethane elastomer threads that form the tension lines of multiple icosahedra.

As the GSN 200 is stretched over a subject's head, the sensors make electrical contact with the scalp and are held firmly in place, normal to the head surface, by the geodesic tension network. Pressure is evenly distributed across all sensors, providing a comfortable array that can be worn for several hours.

The foot or scalp end of the sensor pedestal is flared, causing the pedestal to lift and rake the hair as it is moved against the head. This produces a self-seating action, so that the pedestal sponge, with its load of electrolyte, is inserted beneath the hair, directly against the scalp.




All sensors for recording (except eye channels on infant GSN 200s), plus reference and isolated common, are contained in the Net's structure, making application a rapid, one-step process. Typical application times are less than 10 minutes—even for 256-channel GSN 200s—with impedances in the 10–50 kΩ range for the GSN 200.

The GSN 200 is designed for use with HydroCel Saline, which is EGI's classic potassium chloride saline and surfactant solution. No special scalp preparation is required, and no electrolyte gel residue is left in the hair following the recording session.

# Features

## Sensors and Electrodes

Each GSN 200 contains an array of 64, 128, or 256 EEG sensors, plus a reference sensor and an isolated common sensor. Each sensor corresponds to an amplifier channel. Sensor maps are shown in Appendix B, "Net Sizing and Sensor Layouts." Inside each sensor is a sintered silver/silver chloride or silver chloride–plated carbon pellet connected by a 1-meter-long insulated lead wire to a Hypertronics-compatible, gold-plated pin.

Collectively, the pellet, wire, and pin form an electrode (Figure 3-4).

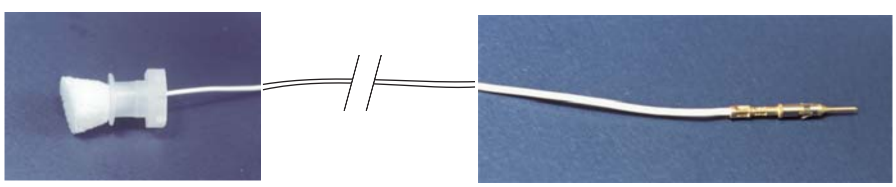

**Figure 3-4.** Electrode

Surrounding each electrode pellet is a sponge that, during operation of the GSN 200, is wetted with liquid electrolyte. The pellet and sponge are set inside the bore of a plastic pedestal consisting of three parts that snap together (Figure 3-5).


**Figure 3-5.** Pedestal components

The wetted sponge protrudes from the one end of the pedestal and the lead wire emerges from the other end through a small hole in the pedestal cap.

By definition, a *sensor* (Figure 3-6) consists of a pedestal and an electrode.



Sponge, pedestal, and electrode pellet

Hypertronics pin

**Figure 3-6.** Sensor

Cutting the pedestal assembly of the sensor down the middle makes its construction easier to see (Figure 3-7).

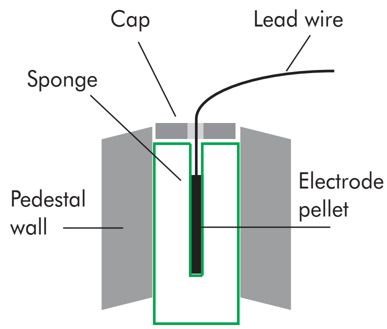



**Figure 3-7.** Sensor cut-away view

# Sensor Array

The GSN 200 sensor leads are bundled with the aid of a sliding wire guide, which they pass through on their way to terminating at the Hypertronics connector of the sensor array.

Sensors are sewn into a geodesic tension structure of elastomer thread. The cap of the pedestal functions as a snap-in, hold-down device that fixes the sensor in position in the GSN 200.

# Ag/AgCl Electrode Pellet

The custom-made electrodes used in the GSN 200 have been fabricated using a silver/ silver chloride or silver chloride–plated carbon electrode pellet. These materials have low-drift properties.

# Smart Nets

Users of GES 200, 250, or 300 can be aided by “Smart Net” technology. This feature enables Net Station to sense what type of GSN is connected to the Net Amps (see “Smart Nets” on page 87). (The GES 120 and 140 do not contain or require “Smart Net” technology.)

# Sizing

The GSN 200 is available in 14 sizes based on head circumference. Instructions for choosing a suitably sized Net are covered in Chapter 6, "Applying the GSN." A sizing chart is located in Appendix B, "Net Sizing and Sensor Layouts."

# Infant Nets

Infant GSN 200s do not contain built-in inferior orbital sensors but are made so that you can use optional, separate outrider orbital sensors (Figure 3-8). The orbital sensors plug into the special GSN Hypertronics plug that is part of every infant GSN.

**Figure 3-8.** Outrider sensor

If used, orbital sensors are attached to the face of the infant by means of medical tape or a gel such as Elefix, which is supplied by EGI.

The Hypertronics connector for an infant GSN has jacks for connecting outrider sensors. Table 3-1 lists the number of jacks for each infant GSN 200 model and the channels to which they map.

**Table 3-1. Infant GSN 200outrider sensors**

| GSN model | Number of jacks | Map to channels . . . |
|---|---|---|
| 64 channel infant GSN 200 | 2 | 63 and 64 |
| 128 channel infant GSN 200 | 4 | 125, 126, 127, and 128 |

When you use an infant GSN 200, short to isolated common any jack on the connector that does not have an outrider sensor plugged into it. Figure 3-9 shows both sides of the special connector for the 64-channel infant GSN 200, with a shorting strap connecting the channel 63 and channel 64 outrider jacks to the isolated common jack.


**Figure 3-9.** Infant Net special Hypertronics connector, with outrider jacks strapped to isolated common

The shorting strap (supplied by EGI) used for this connection is shown on the left side of Figure 3-10. The special connector for the 128-channel infant GSN 200 (not shown) requires a different shorting strap if no outrider sensors are going to be used. The right side of Figure 3-10 shows the shorting strap (also supplied by EGI) for use with a 128-channel infant GSN 200.

**Figure 3-10.** Shorting straps for 64- and 128-channel infant GSN 200

***Caution!:*** *EGI recommends limiting recordings of infants to only 1 hour to decrease the risk of skin irritation or breakdown. Constant monitoring of the infant is required to prevent choking or strangling, and to allow for frequent examination for skin irritation. EGI recommends checking for skin pressure points, overturned sensors, and redness under the chin strap every 15 minutes to maximize infant comfort.*

# Repair

## Electrode Replacement

Field replacement of electrodes in the GSN 200 is described in Chapter 9, "Replacing GSN Parts."

## Other Repairs

Repairs other than electrode replacement for the GSN 200 must be performed by a trained Net technician and will require the Net to be returned to EGI for servicing (see Appendix A, "Technical Support"). Please disinfect the Net (see page 81) before returning it to EGI.

## Avoid Tangling

When unpacking, storing, soaking, rinsing, or disinfecting the GSN 200, take care that it does not become tangled. Specifically, do not permit the connector or the sensor array to pass through the wires of the sensor lead bundle (Figure 3-11).

**Figure 3-11.** Avoid passing connector or sensor end of GSN 200 through lead bundle

# Recycling and Disposal of Nets

See "Component Recycling and Disposal" on page 56.

# For More GSN 200 Information

- Service and maintenance information is found in Chapter 5, "Service and Maintenance.”
- Complete instructions on how to apply the Net are given in Chapter 6, "Applying the GSN.”
- Complete instructions on how to rinse and disinfect the Net after each use are given in Chapter 7, "Rinsing and Disinfecting.”
- Electrode replacement instructions for the GSN 200 are provided in Chapter 9, "Replacing GSN Parts.”
- Sizing and sensor maps are in Appendix B, "Net Sizing and Sensor Layouts.”

chapter 4

# SAFETY

This chapter provides an overview of safety cautions and warnings related to the Geodesic Sensor Net. The information in this chapter applies to *both* the GSN 200 and HCGSN models, unless otherwise noted.

***It is important to use the GSN only according to the manufacturer's instructions and to use only EGI electrodes and parts. All GSNs are intended for use only with EGI Geodesic EEG Systems.***

## General Safety

***WARNING!:*** *Do not connect the Geodesic Sensor Net to any device or electrical source other than that specifically authorized by the manufacturer and never use the GSN without trained supervision. Accidental connection to a power source could result in death. Refer all servicing to the manufacturer or other qualified personnel.*

The primary variable for determining the severity of electric shock is the electric current that passes through the body. This current depends on the voltage and the resistance of the path it follows through the body. The following table provides a general framework for shock effects *(Source: Nave & Nave,* Physics for the Health Sciences*, 3rd Ed. W.B. Saunders, 1985; also at http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html)*.

| Electric current (1-second contact) | Physiological effect | Voltage required to produce the current with assumed body resistance: 100,000 Ohms | 1,000 Ohms |
|---|---|---|---|
| 1 mA | Threshold of feeling, tingling sensation | 100 V | 1 V |
| 5 mA | Accepted as maximum harmless current | 500 V | 5 V |
| 10–20 mA | Beginning of sustained muscular contraction ("can't let go" current) | 1,000 V | 10 V |
| 100–300 mA | Ventricular fibrillation, fatal if continued. Respiratory function continues | 10,000 V | 100 V |
| 6 A | Sustained ventricular contraction followed by normal heart rhythm (defibrillation). Temporary respiratory paralysis and possibly burns | 600,000 V | 6,000 V |

# Skin Irritation

***Caution!:*** *For very long-term monitoring (e.g., days), EGI recommends removing and reapplying the HCGSN at least every 12 hours to improve comfort and to decrease the risk of skin irritation or breakdown. Careful monitoring of the patient is recommended.*

***Caution!:*** *EGI recommends limiting recordings of infants to only 1 hour to decrease the risk of skin irritation or breakdown. Constant monitoring of the infant is required to prevent choking or strangling, and to allow for frequent examination for skin irritation. EGI recommends checking for skin pressure points, overturned sensors, and redness under the chin strap every 15 minutes to maximize infant comfort.*

# Subject Cross-Contamination

***WARNING!:*** *To prevent subject cross-contamination, make sure that the towels used by the subject and those used with the GSN are kept separate. Do not use the same towel to dry the subject's face or hair, and then to pat the Net dry. Also do not use the same towel for more than one subject.*

# Cords, Connectors, and Cables

Following are ***WARNINGs*** regarding the GSN's cords, connectors, and cables. As stated in the Preface, warnings denote important information that, if unheeded, could result in serious injury or death:

- ***Inspect your connectors and cables***. To reduce the risk of electrical shock, discontinue use of worn or damaged electrical connectors and cables.

# Electrolyte

Electrolyte solutions (including those used by the GSN) are excellent electrical conductors. Implement and maintain disciplined procedures so that there is no chance of spilling electrolyte on any electronic equipment, including the system.

# Lightning

***Caution!:*** *System isolation is designed to protect the subject even if a high-voltage source is accidentally applied to either the subject or the system. However, because of the large, unpredictable electrical charges involved in a lightning strike, disconnect the subject and discontinue the data-acquisition session during a thunderstorm.*

chapter 5

# Service and Maintenance

This chapter summarizes some of the main service and maintenance issues related to the Geodesic Sensor Net. The information in this chapter applies to *both* the GSN 200 and HCGSN models, unless otherwise noted.

## Geodesic Sensor Net

The GSN is shipped to you in a clean, disinfected condition. Attention to the maintenance instructions in this section will prolong the Net's service life, ensure accurate data collection, and minimize any risk of damage or infection.

### Average GSN Life Span

The life span of the Geodesic Sensor Net will vary depending on general care, frequency of use, and environmental differences.

Most GSNs will last **two years**. Lightly used Nets will last considerably longer than their average life spans.

Tips for extending the useful life of a Net:

- Do not overstretch the Net.
- Never leave the Net in disinfectant for more than 10 minutes.
- Thoroughly rinse and disinfect after each use.
- Store the Net out of direct sunlight or UV sources.
- Send the Net to EGI for an annual inspection.

## Caring for Your GSN

After each use, rinse, disinfect, rinse again, and dry the Net. Chapter 7, "Rinsing and Disinfecting," provides step-by-step instructions.

Throughout these processes, protect the connector end of the Net from contact with all liquids. It is helpful to place a plastic bag over the connector during this process.

Please post the Laminated Rinsing/Disinfecting Placard (page 117) provided by EGI in a highly visible location.

Following are some important ***CAUTIONS*** that must be heeded to prevent personal injury or equipment damage:

- ***Keep buckets separated***. Do not confuse or swap the electrolyte and disinfectant buckets.
- ***Don't disinfect for too long***. Do not leave the Net immersed in disinfectant for extended periods of time. Set a timer to alert you that the Net has been in the disinfectant for the recommended amount of time.
- ***Agitate the Net while disinfecting***. Agitate the Net in the solution for at least 2–3 minutes to ensure thorough disinfection of the sensor array (move the Net in the liquid by lifting it up and down, or shake the bucket).
- ***No strong solvents***. Do not use acetone or other strong solvents on the Geodesic Sensor Net.
- ***No rubbing alcohol***. Isopropyl alcohol will cause the sponges to disintegrate.
- ***Keep connector dry***. Do not immerse or rinse the Net connector.
- ***Do not autoclave any part of the Geodesic Sensor Net***. Most epoxies and cable insulations will not withstand steam sterilization.

## Screening Subjects/Patients

The Net should be applied only to subjects/patients who have dry, freshly washed hair that contain no styling products such as gel or hair spray. In general, EGI recommends that subjects/patients use no hair treatments beyond basic shampoo (for example, heavy conditioners can cause higher impedances).

Request that subjects wear no facial foundation on the day of the session; the makeup may stain the sponges of the GSN.

Do not apply the GSN to subjects/patients who have:

- lice
- corn rows
- dreadlocks
- nonpermanent hair dye

This section provides only general guidelines. Specific screening criteria may vary, depending on the laboratory or clinic.

## Electrolyte Formulations

The Geodesic Sensor Net uses mild electrolyte formulations for electrode application. These formulations include the HydroCel Saline (potassium chloride based) and the HydroCel HS (hydrogel). The HydroCel Saline and HS are in powder form and must be mixed with water.

The following tips will help ensure that the electrolyte formulations do not adversely affect the condition of your GSN:

- With the HydroCel Saline and HydroCel HS, use warm, *distilled* water.
- With the HydroCel Saline and HydroCel HS, mix the solution only in the designated "electrolyte formulation" plastic bucket from the Net Support Kit.
- With the HydroCel Saline, put the powder in the bucket *first*, before adding water.
- With the HydroCel HS, put the water in the bucket *first,* then slowly add the powder stirring constantly. If lumps develop, press them against the side of the bucket to break them up. If necessary, allow the solution to sit for one hour to hydrate properly. Do not allow it to sit for too long (for example, several hours), or the solution will become runny. If this happens, you will need to mix up a fresh match of HydroCel HS solution.
- See "Preparing the Electrolyte Formulation" on page 58 for full details about each HydroCel formulation.

## Net Repairs

Individual electrodes of the GSN 200 sometimes require removal and replacement. To assess whether an electrode needs to be replaced, see “Faulty Sensors” on page 112. For instructions on replacing electrodes in the GSN 200, see Chapter 9, "Replacing GSN Parts.”

Individual sponges may fall out of the HCGSN pedestals. For instructions on replacing sponges in the HCGSN, see Chapter 9, "Replacing GSN Parts.”

If a Net needs servicing or refurbishment, contact EGI Technical Support (Appendix A). All Nets returned to EGI for repair undergo thorough examination and testing, including electrode testing, structural evaluation and repair, pinout verification, and disinfecting. A repair report detailing all work accompanies the Net when EGI returns it to the customer. Other services are available on request. Please disinfect the Net (see page 81) before returning it to EGI.

Some wear over time is normal (refer back to “Average GSN Life Span” on page 53 for tips on extending the life span). Elastomer breaks in the GSN can be repaired by EGI Technical Support.

# Cable and Connector Checks

- Periodically inspect all cables and connectors for wear or damage.
- Do not use cables and connectors that fail inspection.
- See “Cords, Connectors, and Cables” on page 51.

# Component Recycling and Disposal

***Caution!:*** *Please comply with local regulations with regard to recycling or disposing of EGI components, consumables, and accessories.*

You may return components to EGI for recycling or disposal, if desired. Contact support@egi.com to arrange for this service. Please disinfect the Net (see page 81) before returning it to EGI.

chapter 6

# Applying the GSN

This chapter describes the Geodesic Sensor Net application process, which includes:

- gathering needed supplies,
- preparing the electrolyte formulation,
- making head measurements,
- applying the GSN to the subject's head, and
- removing it.

Instructions for rinsing, disinfecting, and drying the Net are provided in Chapter 7, "Rinsing and Disinfecting."

The instructions in this chapter apply to both the GSN 200 and HCGSN models, unless otherwise noted. Applying either GSN model is not difficult, but some instruction and practice are necessary. For best results, you should also review EGI's Net application movie; for instructions on how to download it from EGI's website, contact support@egi.com.

In general, we recommend that you practice applying a "dry" Net (that is, one without electrolyte) on a colleague repeatedly, until you can achieve accurate and evenly spaced applications consistently. For application instructions, see "Initial Application" on page 66, "Initial Adjustments" on page 69, and "Verification and Additional Adjustments" on page 71.

## Planning

Ask the subject to arrive with freshly washed, but not wet, hair. Request that the subject not use any hair products (gels or hair spray, for example) or any facial foundation on the day of the session.

*Caution!: Consider **not** accepting subjects who use nonpermanent hair dye, which can also stain the GSN. Though the staining has no effect on performance, it can have a dramatic impact on Net appearance.*

Before your subject arrives, make the following preparations.

- Prepare a fresh batch of electrolyte formulation (for step-by-step instructions, see “Preparing the Electrolyte Formulation” on page 58).
- Have available a measuring tape, pipettes, syringes, china markers, and three clean towels (each approximately 40 x 60 centimeters). EGI offers a Net Support Kit (see Chapter 12, "Accessories and Supplies”) that contains these items.
- Have Nets on hand in a variety of sizes to ensure that you have one that fits the subject. Be sure that each Net has undergone a disinfecting, rinsing, and drying regime as described in Chapter 7, "Rinsing and Disinfecting.”

*WARNING!: Never apply a Net that has not been properly cleaned, disinfected, and rinsed.*

*Note: It is ideal but **not** necessary for the Net to be dry before using it on another subject. If you do use a Net that is **not** dry, be sure to squeeze each sponge as it soaks in the electrolyte, to facilitate intake.*

# Preparing the Electrolyte Formulation

For the electrolyte formulations, use only the designated “electrolyte formulation” plastic bucket from the Net Support Kit.

*WARNING!: Do not reuse electrolyte formulations between subjects or sessions. Dispose of them according to your institution’s guidelines.*

EGI offers two electrolyte formulations:

- *HydroCel Saline (with sponge insert)*: For standard (2-hour) recordings, this is the classic potassium chloride saline and surfactant solution used for rapid application. The HydroCel Saline comes in powder form and must be mixed with water before using. No subject cleanup is required.

- *HydroCel HS (without sponge insert)*: For extended (12-hour) recordings, this is a hydrogel formulation that requires individual electrode filling. The HydroCel HS comes in powder form and must be mixed with water before using. No shampoo is required for cleanup.

Use these solutions only on EGI Geodesic EEG Systems. The GSN 200 and the HCGSN with sponge inserts use only the HydroCel Saline; the HCGSN without sponge inserts uses only the HydroCel HS.

## HydroCel Saline

The HydroCel Saline is EGI's classic potassium chloride electrolyte solution designed for standard (2-hour) recordings.

1. Place 10 cc. (2 teaspoons or 11 grams) of granular or powdered potassium chloride (KCl) into the electrolyte/rinse bucket.
2. Add 1,000 cc. (1 liter or 4.23 cups) of warm distilled water, no warmer than 37° C.
3. Add 5 cc. (1 teaspoon) of Johnson's Baby Shampoo.
4. Stir the ingredients vigorously, until the KCl is completely dissolved.

## HydroCel HS

The HydroCel HS is EGI's hydrogel-based formulation designed for extended (12-hour) recordings. An HCGSN without sponge inserts can use this formulation. A syringe must be used to load the electrolyte into each spongeless pedestal.

The HydroCel HS packet contains 1.0 gram of the HydroCel HS powder. The formulation is biodegradable and nontoxic.

1. Add 250 cc. (or mL) of warm, distilled water, no warmer than 37° C into the small HydroCel HS bucket provided with the Net.
2. Open the HydroCel HS packet and slowly stir the contents into the water. If lumps develop, press them against the side of the container to break them up. If the solution remains lumpy, let the solution sit for one hour to hydrate properly.
3. The solution is ready when the powder is completely dissolved.

Do not allow the HydroCel HS solution to sit for too long (e.g., several hours), or the solution will become runny. If this occurs, mix up a new batch of HydroCel HS.

# Head Measurement

Before applying the Geodesic Sensor Net to the subject's head, you must make several head measurements to:

- calculate the proper Net size
- determine the vertex point

## Net Size

Before applying the GSN to the subject, measure the circumference of the subject's head to determine the appropriate Net size, using Table B-1 on page 121 and Table B-2 on page 122 as references. (As the tables indicate, the GSN 200 and HCGSN models have slightly different sizing.)

Take this measurement several times to ensure accuracy.

The circumference is the largest part of the head. With a measuring tape, measure head circumference at the *glabella* (the brow ridge) and 2.5 cm. (1 in.) ***above*** the *inion* (the bump on the back of the skull); see Figure 6-1.

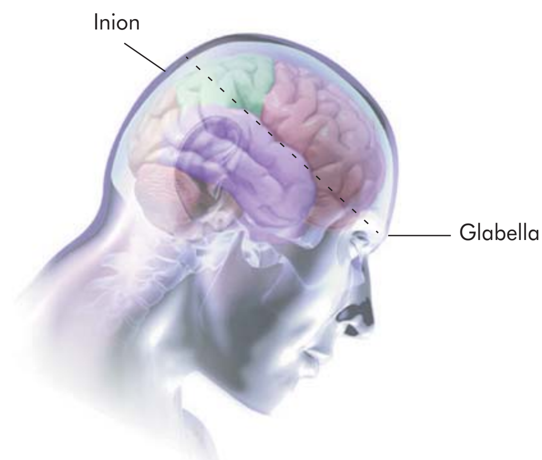



**Figure 6-1.** Measuring head circumference

Adult size ranges for the GSN 200 are:

- small (53.5–55 cm.)
- medium (55.5–58 cm.)
- large (more than 58.5 cm.)

Adult size ranges for the HCGSN are:

- small (54–56 cm.)
- medium (56–58 cm.)
- large (more than 58 cm.)

To perform this measurement:

1. Ask the subject to use his or her index finger to secure one end of the measuring tape to the glabella.

2. Run the tape along the side of the head, above the ear, toward the back and 2.5 cm. (1 in.) above the inion, around the other side and above the other ear, and back to the glabella.

# Vertex Point

The *vertex*, on the top of the head, is the midpoint between the *nasion* (the indented area where the bridge of the nose meets the skull) and *inion*, centered between the *preauricular points* (the indented area in front of each ear flap, where the jaw meets the skull); see Figure 6-2. The vertex is also called the *Cz* in the international 10-20 system.

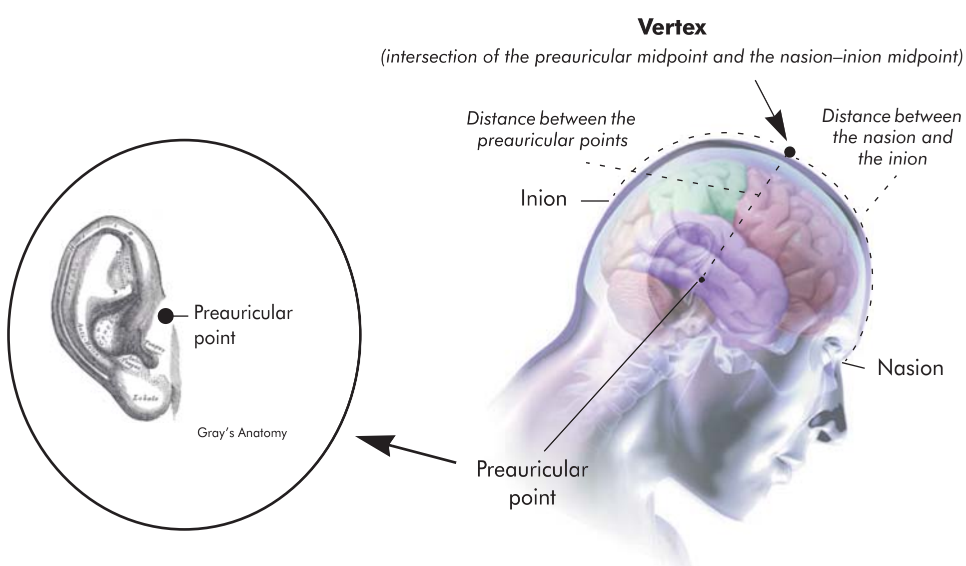



**Figure 6-2.** Skull landmarks

This section describes how to locate and mark the vertex.

1. Ask the subject to use his or her index finger to secure one end of the measuring tape to the nasion.

2. Run the tape over the top of the head until it reaches the inion, and note the distance (Figure 6-3). Locate the halfway point and use a china marker to draw a short line—perpendicular to the tape—on the subject's head.

**Figure 6-3.** Measure from the nasion to the inion

3. Measure the distance between the preauricular points, extending the measuring tape across the top of the head over the line made in Step 2 (Figure 6-4). Locate the halfway point and draw a short line—perpendicular to the tape—on the subject's head. Note where this line crosses the nasion–inion midpoint line. This intersection is the location of the vertex, now marked with an X.

**Figure 6-4.** Measure between the preauricular points

*Note: When marking the scalp, minimize discomfort to the subject by holding the china marker so that its tip makes a shallow angle with the scalp surface. Gently move the tip across the scalp with light pressure to make a line.*

# Net Application

This section discusses how to apply the Net and adjust it for a proper fit. Steps include soaking the Net in electrolyte solution (if the GSN has sponge inserts), holding the Net correctly before application, applying the Net safely to the subject's head, adjusting the Net to the relevant skull landmarks, and verifying its position on the head. All of these steps are necessary to ensure an accurate EEG recording.

***Caution!:*** *Ask the subject to remove earrings, glasses, barrettes, and hair ties. Earrings can be especially uncomfortable with an HCGSN applied. Glasses can be replaced after Net application, as needed.*

## Soaking the Net in Electrolyte

During this stage, do *not* soak the Net longer than necessary and *do* protect the Hypertronics connector from contact with liquids. The following instructions apply to the GSN 200 and the HCGSN *with* sponge inserts; for the HCGSN *without* sponge inserts, follow only Steps 3–5 (remembering to protect the connector from liquids), and then proceed to the next section, "Proper Position of Hands" on page 64.

**1** Dip the sensor end of the Net into the "electrolyte" bucket (Figure 6-5); be careful to prevent the Hypertronics connector from coming in contact with the electrolyte.

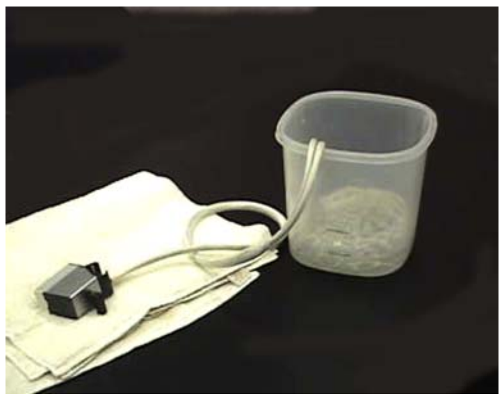


**Figure 6-5.** Placing the sensor end of the Net in the electrolyte bucket

**2** Soak the sensors of the Net in electrolyte for at least 5 minutes to ensure adequate wetting of the sponges. Gentle agitation of the Net facilitates the process.

***Caution!:*** *Throughout the application process, protect the connector end of the Net from contact with liquids.*

**3** Give the subject a towel to catch electrolyte drips.

**4** For subjects with long hair, ask them to brush their hair back, so that it falls toward the back of the head, away from the face.

**5** Drape a towel over the subject's shoulders.

**6** Lift the Net vertically out of the electrolyte bucket, waiting a moment for the Net to drip excess electrolyte back into the container (Figure 6-6).

**Figure 6-6.** Lifting the Net out of the electrolyte bucket

**7** For the *GSN 200*, hold the Net over a towel and gently touch the sensors against the towel a few times to further remove excess electrolyte. ***For the HCGSN, do not touch the sensors against the towel (the sponges in the HCGSN are smaller and soak up less electrolyte).***

*Note: Do not squeeze or press the sponges to remove excess electrolyte, because the sponges may become depleted of electrolyte. It is harmless for some dripping to occur, as long as the Hypertronics connector remains dry.*

***WARNING!:*** *To prevent subject cross-contamination, make sure that the towels used by the subject and those used with the GSN are kept separate. Do not use the same towel to dry the subject's face or hair, and then to pat the Net dry. Also do not use the same towel for more than one subject.*

## Proper Position of Hands

Proper positioning of the hands is important because it enables you to stretch the Geodesic Sensor Net over the subject's head without unduly straining the tension structure and to remove your hands easily from the Net, once it is applied.

**1** Hold the GSN draped over both hands and become acquainted with the Net's orientation:

- Locate the front of the Net, which is identifiable by the face straps, including the chin strap, eye electrode straps, and ear electrode straps. (The HCGSN also features red labels on the nasion and *cardinal* sensors, as shown in

Figure 6-7; cardinal sensors are located at the vertices of the major triangles and used in EGI's Geodesic Photogrammetry System).

**Figure 6-7.** The HCGSN features red pedestals for the nasion and cardinal points

- Locate the back of the Net (this is where the wires exit the sensor array for the HCGSN).

**2** Place your hands *underneath* the face straps and hold the GSN so that you are touching the underside of the Net (in other words, your hands are in contact with the pedestal feet).

**3** Locate the nasion sensor (which is colored in both the GSN 200 and the HCGSN), which is situated on a multistring *perimeter band*, one of the strongest parts of the Net.

**4** On either side of the nasion, count two electrodes out and hook your thumbs underneath the strings of the perimeter band (Figure 6-8). (Note: if you are applying a 256-channel Net, you should count *three* electrodes out.) Table 6-1 lists the correct thumb positions for various sensor densities.

**Table 6-1. Thumb placement when applying Net**

| GSN number of channels | Left thumb between sensor numbers: | Right thumb between sensor numbers: |
|---|---|---|
| 32-channel HCGSN | unnumbered sensors* | unnumbered sensors* |
| 64-channel HCGSN | 17 and unnumbered sensor** | 1 and unnumbered sensor** |
| 128-channel HCGSN | 1 and 8 | 25 and 32 |
| 256-channel HCGSN | 1 and 10 | 46 and 54 |
| 64-channel GSN 200 | 1 and 60 | 14 and 19 |
| 128-channel GSN 200 | 1 and 8 | 26 and 33 |
| 256-channel GSN 200 | 1 and 10 | 45 and 53 |

* Figure B-1 on page 123 shows proper thumb placement for the 32-channel HCGSN.
** Figure B-2 on page 124 shows proper thumb placement for the 64-channel HCGSN.

**Figure 6-8.** Place thumbs under the Net's perimeter band

**5** Let the Net hang *only* from your thumbs and visually check the structure for any tangling.

**6** Hook your little fingers into the lowest band at the back of the Net, which is the perimeter band. (If your hands are small, hook your little fingers into the perimeter band of the Net as far back as you can reach.)

**7** Stretch the Net by using your thumbs and little fingers that are hooked into the perimeter band and open the perimeter so that it forms a circle. (For support, you can straighten your other fingers inside the Net, lightly touching the structure with only the fingertips.) Adjust your hands, as needed.

**8** Gently flip the Net upright so that you are ready to apply it to the subject's head.

# Initial Application

In general, a good application results from standing directly in front of the subject, stretching the perimeter band to the proper size, and applying the Net by pulling straight downward over the subject's head.

The HCGSN features a tighter web structure than the GSN 200, which can make it challenging to achieve an evenly spaced application. As mentioned at the beginning of this chapter, we recommend that you practice applying a "dry" Net (one without electrolyte) on a colleague. Evenly spaced electrodes are important for data analysis such as grand averaging.

***Caution!:*** *Especially for LTM applications, monitoring of the subject or patient for comfort and skin irritation is recommended. See the "Caution" on page 33 for more information.*

1 Ask the subject to notify you of any discomfort or irritation from the Net.

2 Ask the subject or an assistant to hold the Hypertronics connector during the initial application (an assistant can hold the connector behind the subject's head or the subject can hold the connector against one shoulder).

3 Ask the subject to close his or her eyes and to keep them closed until told otherwise.

***Caution!:*** *The subject's eyes must remain closed during application and removal of the Net, and whenever you adjust the positions of sensors in the vicinity of the eyes. Failure to follow this procedure can result in serious injury.*

4 Stretch the perimeter band to a size just larger than the subject's head. Do this by spreading out your thumbs and little fingers so that the perimeter band forms a circle (Figure 6-9). Do not overstretch the Net, as this could damage the geodesic tension structure.

**Figure 6-9.** Stretch the perimeter band with thumbs and little fingers

5 Keeping moderate tension on the perimeter band with your thumbs and little fingers, set the GSN on the subject's head so that the colored vertex sensor lies on the vertex mark on the head.

6 Slowly pull straight downward with your thumbs and little fingers, keeping the *vertex* electrode over the vertex and the *nasion* electrode aligned with the nasion. Standing directly in front of the subject makes this easier.

***Caution!:*** *During this procedure, the chin strap and orbital (eye and ear) sensors must be pulled down over the subject's face (Figure 6-10 and Figure 6-11). The subject's eyes must be closed during this procedure because a sensor or the chin strap could accidentally make contact with an eye as the structure is lowered.*

**Figure 6-10.** Slowly bring the band down over the head

**Figure 6-11.** Check position of Net before disengaging your hands

**7** Check the positioning of the Net (Figure 6-11), and then disengage your hands.

*Note: A common mistake is to remove your hands before the back of the GSN is properly lowered over the head.*

**8** Verify that the subject's eyes are closed, then gently move the chin strap underneath the subject's chin and secure it using the cord lock.

## Initial Adjustments

The HCGSN has a snugger fit than the GSN 200, so make sure:

1. The ears are not caught in the ear cut-out sections.

2. Sensors are not impinging on the eyes; adjust eye bands, as needed.

3. The front bands around the eyes are not impinging on the eyes; adjust bands, as needed.

4. Cord locks are not resting on the jaw bone; adjust bands, as needed.

Hint: When adjusting the bands, move the ear and eye band beads closer to the chin strap bead.

The initial adjustments usually involve adjusting sensors so that the ears and eyes are comfortable, righting overturned sensors to sit perpendicular to the scalp, and using the face straps to adjust the chin strap, eye electrodes, and ear electrodes so that most of the tension of the geodesic structure is directed downward.

Also, be sure to check for even spacing of the sensors. If the sensors are unevenly spaced, you may need to reapply the Net.

**1** Make sure the ears are not pinned down by the Net structure, adjusting as necessary. (The HCGSN features cut-out sections for the ears; the ears should sit completely in these sections and the bottoms of these sections should not pinch the bottoms of the ears. See Figure 6-12.)

**Figure 6-12.** The HCGSN features cutouts for the ears

**2** Check the back of the Net, making sure the sensors are perpendicular to the scalp (Figure 6-13).

**Figure 6-13.** Upturn tilted sensors; check the back of the head

**3** Check for symmetry by standing directly in front of the subject and making sure that the nasion sensor is aligned with the nasion. If adjustment is needed (for an example, see Figure 6-14, where the nasion is off-center), grasp large sections of the Net on both sides of the head, and shift in the correct direction (Figure 6-15).

**Figure 6-14.** The nasion is too far to the subject's left

**Figure 6-15.** Adjust Net position by grabbing large sections and shifting them uniformly

**4** Check that the vertex sensor is positioned on top of the vertex mark and adjust, if needed.

**5** Adjust the elastic lines of the chin strap via the cord locks. Correct tension is achieved when the chin strap is comfortably and securely located under the subject's chin. You may need to reposition it to allow for comfort and the use of a chin rest. ***Once the chin strap is in place, the subject may open his or her eyes***.

**6** Next, adjust the orbital (ear and eye) sensors (Figure 6-16). Cord locks on either side of the subject's cheeks independently adjust the lines retaining the infra- and extraorbital sensors, which slide along elastomer or polyurethane bands.

To retain any changes made, hold the bands firmly while moving the cord locks.

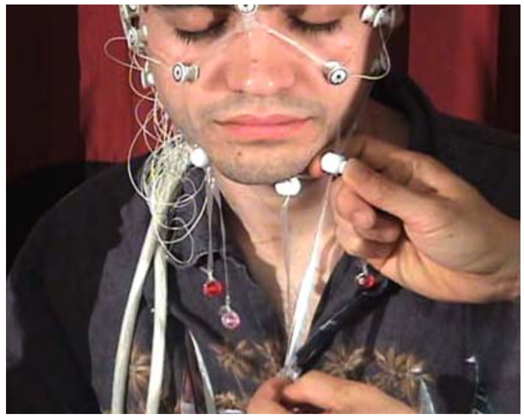


**Figure 6-16.** Adjust the orbital straps (128-channel HCGSN)

7 Ask the subject to look straight ahead. Adjust the tension on these lines until the infraorbital sensors fall directly below the pupils (roughly over the infraorbital foramen) and the extraorbital sensors fall just to the side of the outside corner of the eye (roughly over the frontal process of the zygomatic bone, or *cheekbone*). Adjust the orbital sensors by sliding them along the bands.

## Verification and Additional Adjustments

1 Make sure that gross placement of the Net is correct. Four color-coded sensor locations (including the vertex, nasion, and mastoids) help in verifying placement and symmetry.

2 Check that a straight line of electrodes mark the center of the back of the head.

3 Check lateral symmetry by confirming that the mastoid sensors fall at the same location behind each ear (Figure 6-17).

**Figure 6-17.** Check mastoid sensor positions (128-channel HCGSN)

**4** If minor adjustments are necessary, gently move the sensors *in groups* on each side of the head (Figure 6-18). Do not attempt to move the entire Net by pulling on single sensors.

**Figure 6-18.** Adjust big sections of the Net on both sides of the head

**5** If the position of the Net is off by more than 1 cm. (0.4 in.) in any direction, remove it and repeat the application procedure.

**6** Ensure good contact between the sponges and the scalp by using moderate pressure to move each sensor on the scalp in a side-to-side or circular motion (Figure 6-19). The brief (1–2 second) movement of each sensor is necessary to establish contact and, for most subjects, painless. However, some subjects have sensitive skin, so be attentive to any discomfort the subject may experience.

(Skip Step 6 if you are using an HCGSN without sponge inserts. You perform this step later, after filling the pedestal with electrolyte formulation, which is described on page 74.)

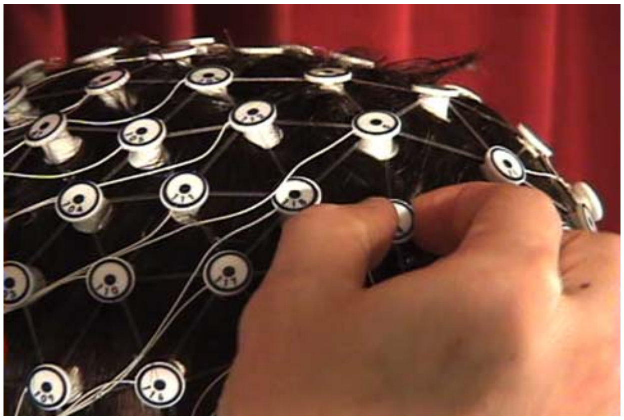


**Figure 6-19.** Move each sensor side to side or in a circle to establish scalp contact

**7** Visually verify that each sensor sponge is sitting on the scalp, not on hair. In some cases, such as for subjects with unusually thick hair, a pipette or eye dropper can help displace hair from under the sponge. If a sponge is unusually dry, rewet it with a pipette of electrolyte.

**8** Follow a consistent order while working on sensor placement.

**9** Properly positioned sensors (Figure 6-20) should stand perpendicular to the scalp.

**Figure 6-20.** A properly applied Net

10 If you are applying an HCGSN with more than 32 channels, secure the Y clip to the subject's collar (Figure 6-21).

**Figure 6-21.** Secure the Y clip to the collar

# Filling Pedestals with HydroCel HS

This section applies only to ***HCGSNs without sponge inserts***. After applying the Net to the subject, you must now use a syringe to fill each pedestal with HydroCel HS (refer to "HydroCel HS" on page 59, if needed). This section provides step-by-step instructions.

If you are using a GSN 200 or an HCGSN with sponge inserts, skip this section.

1 Fill a provided syringe from the Net Support Kit (see Chapter 12, "Accessories and Supplies") half-full with the HydroCel HS formulation.

2 Locate the Reference sensor and move it in a side-to-side motion for 1–2 seconds to part the hair. The goal is to part the hair, not irritate the scalp, so ask the subject to notify you if he or she experiences any discomfort.

(Although you can start with any pedestal, EGI recommends beginning with the Reference, proceeding to Common, and then working in numerical order starting with sensor 1.)

3 Gently turn over the Reference sensor and fill the spongeless chamber with HydroCel HS.

4 Carefully turn the pedestal upright on the head, making sure the sensor is resting on the scalp, not the hair.

5 Repeat Steps 2–4 with the Common sensor.

6 Then repeat Steps 2–4 with sensor 1, sensor 2, and so on numerically, continuing until each pedestal of the HCGSN contains HydroCel HS, refilling the syringe when needed.

# Removal

During removal, always peel the GSN back from the subject and let the Net hang freely. For the GSN 200, avoid passing the connector or the sensor end of the Net through the sensor lead bundle (see Figure 3-11 on page 46).

1 Ask the subject to close his or her eyes and to keep them closed until told otherwise.

2 Loosen the chin strap by pinching the cord lock under the chin and sliding it down the chin strap (Figure 6-22).

**Figure 6-22.** Initial removal of the Net from the subject's face

**3** Carefully lift the chin strap up and away from the face, and take hold of the eye electrodes as you gently lift the Net away and up off the subject's face (Figure 6-23; see A–D).

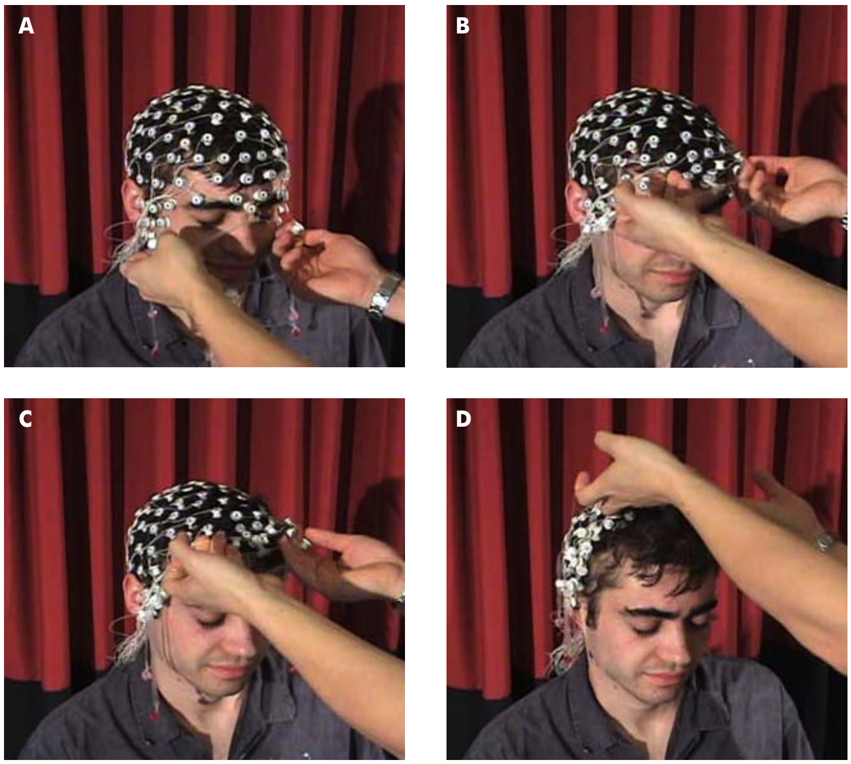



**Figure 6-23.** Peeling the Net from the subject's face

*Note: With an HCGSN, be sure the ears do not get caught on the edges of the ear cut-out sections and the nose does not get caught on the chin strap.*

**4** Lift the Net over the eyes, making sure to grab the front band over the forehead.

**5** Holding on to both the chin strap and the front band, continue peeling the Net back and away from the subject's head.

**6** The subject can now open his or her eyes. (If an HCGSN had been applied, the subject may exhibit some suction-like marks on exposed skin. These are not painful and generally disappear within 15 minutes.)

7 After the Net is removed, let the sensor end drop free while you hold the connector. The Net should hang freely.

8 Careful attention to this removal procedure will prevent wires from becoming tangled and will make the Net easier to clean and apply next time.

9 The GSN 200 has been constructed with a sliding wire guide to help keep the electrode wires tangle free. Anytime the Net is not being applied to a subject, including during rinsing and disinfecting (see "Caring for Your GSN" on page 52), the wire guide should be slid down toward the sensor array. When applying the GSN 200 to a subject, slide the wire guide up toward the connector and apply the Net in the usual manner. (The HCGSN wires are organized with a sleek wrap, which keeps them from tangling.)

10 Follow the instructions in Chapter 7 to disinfect and rinse the Net, then hang it over the drying rack with the connector higher than the sensors. Do not package or transport damp Nets. Do not get the Hypertronics connector wet.

# Rinsing and Disinfecting

This chapter describes the processes of rinsing, disinfecting, rinsing again, and drying the Net, which is performed after each use. Proper handling of the Net during these stages is important to ensuring the health and longevity of your Net. The information in this chapter applies to *both* the GSN 200 and HCGSN models, unless otherwise noted.

***Caution!:*** *Proper care of your Net depends on following the instructions in this chapter. Failure to do so could result in degradation of your Geodesic Sensor Net.*

## Rinsing

The following instructions apply to *all* GSN models: GSN 200s, HCGSNs with sponge inserts, and HCGSNs without sponge inserts. The HCGSNs without sponge inserts require some additional care; see “Rinsing (HydroCel HS)” on page 80.

1. Fill the plastic bucket marked “Electrolyte” about half full with clean, warm *tap* water. Do not use hot or boiling water. Submerge the sensor end of the Net in the water.

2. Gently agitate the Net in the water for 10–20 seconds. Drain the water and refill the rinse bucket. Further agitate the Net, pressing the sponge tips with your palm to cycle water through them, if applicable. Repeat this rinse-and-drain process a total of four times.

3. Remove the Net from the rinse bucket and remove the excess water by patting the sponge tips (or electrode cups, if spongeless) with a clean dry towel.

# Rinsing (HydroCel HS)

HCGSNs without sponge inserts use the HydroCel HS, a hydrogel formulation that is viscous in nature and must be thoroughly removed from the Net. See the following "Caution."

*Caution!:* *It is very important that the user carefully and completely clean the HCGSN before allowing the Net to dry. Dried-on HydroCel HS may permanently damage the appearance and/or function of the Net. This damage is* ***not*** *covered under warranty.*

Removing the HydroCel HS from the HCGSN requires additional steps. After rinsing the Net per the instructions provided in "Rinsing" on page 79, follow these steps:

1. Turn the Net inside-out.
2. Rinse the electrode cups under warm running water until all HydroCel HS is removed.
3. Inspect the electrode pellets to confirm that all HydroCel HS residue is removed from ***all*** electrode locations.

If HydroCel HS residue becomes dried onto the Net:

1. Soak the afflicted Net in hot salt water (30 cc. or 2 tablespoons of KCl or NaCl. for each liter of water) for 30 minutes or more.
2. Rinse as described in Steps 1–3 (above).
3. Repeat soaking and rinsing procedure until the Net is clean.

# Disinfecting

Control III is the only disinfectant solution recommended by EGI. Control III is available from:

Maril Products, Inc., 320 West 6th Street, Suite A, Tustin, CA 92780, USA, +714 544-7711, fax: +714 544-4830, control3@earthlink.net.

1 Prepare the disinfecting solution by adding 15 cc. (1 tablespoon or 0.5 oz.) Control III to 1.9 liters (2 quarts) of *tap* water in the disinfectant bucket. Make sure the bucket is labeled "Disinfectant."

2 Mark the disinfectant bucket with the expiration date each time a new batch is prepared. According to the manufacturer, a solution of Control III may be reused for up to two weeks. Keep a lid on the bucket when the disinfectant is not being used.

*Note: Carefully read the instructions that come with Control III for additional precautionary statements and directions.*

3 Soak the Net in disinfectant solution in the plastic bucket marked "Disinfectant" for 10 minutes.

4 While the Net is soaking, ***agitate*** it in the solution for at least 2–3 minutes to ensure thorough disinfection of the sensor array (move the Net in the liquid, or shake the bucket).

5 Do not leave the Net immersed in disinfectant for long periods of time because this may cause damage. Use a timer. *It is a good idea to take the timer with you if you are going to leave the area where the Net is soaking.*

# Second Rinse

1 Remove the Net from the disinfectant and repeat the warm water rinse (see page 79) three times to remove the disinfectant solution.

# Drying

1 Remove excess moisture from sponge tips by patting them with a dry towel.

2 Store the Net by hanging it so that air can circulate around the exposed sponge tips. Be sure to hang the Net so that the connector is higher than the Net to prevent drips from falling on or into the connector.

3 Do not store the Net in bright sunlight or other sources of ultraviolet light because UV rays damage Net elastomer over time.

*Note: It is ideal but **not** necessary for the Net to be dry before using it on another subject. If you do use a Net that is **not** dry, be sure to squeeze each sponge as it soaks in the electrolyte, to facilitate intake.*

# Cleaning the Sponges

Under normal conditions, cleaning the GSN with mild shampoo or detergent is unnecessary. However, if rinsing and disinfecting fail to adequately remove particles from the sponges, then the following procedure is recommended.

1 Add 10cc. (2 teaspoons) of Johnson's Baby Shampoo to the plastic bucket marked "Electrolyte."

2 Fill the bucket about half full with clean, warm *tap* water. Do not use hot or boiling water.

3 Stir the ingredients vigorously, until the shampoo is dissolved.

4 Submerge the sensor end of the Net in the water.

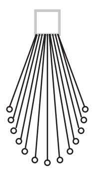
5 Gently agitate the Net in the water for 10–20 seconds, pressing the sponge tips with your palm to cycle the water through them.

6 Rinse the Net, following the instructions on page 79.

For tougher cases, you may need to apply a small amount of shampoo directly onto the affected sponges, rub gently with your finger, and follow the rinsing instructions on page 79.

chapter 8

# CONNECTIVITIES



The GSN

This chapter covers the receptacles, cables, and other connectors that are part of each Geodesic Sensor Net. Before connecting or disconnecting GSN components, please be sure you have read Chapter 4, "Safety." Regularly check cables and connectors for wear or damage.

***WARNING!:*** *To reduce the risk of electrical shock, discontinue use of worn or damaged electrical connectors and cables.*

## GSN and GSNIC

The multipin connector on the GSN is a Hypertronics plug with a custom pinout. The GSNIC features a Hypertronics receptacle for connecting a GSN, and a single or double Hypertronics plug at its other end. Do not link the Hypertronics connectors to any device, interface cable, or interconnector except as described in this manual. Pinout tables for these connectors are located in Appendix C, "GSN Pinouts."

## Hypertronics Connector

EGI's Nets use half-turn, quick-disconnect multicontact connectors with Hypertac high-performance, low-insertion-force, gold-plated contacts (Figure 8-1 shows the receptacle; Figure 8-2 shows the plug).

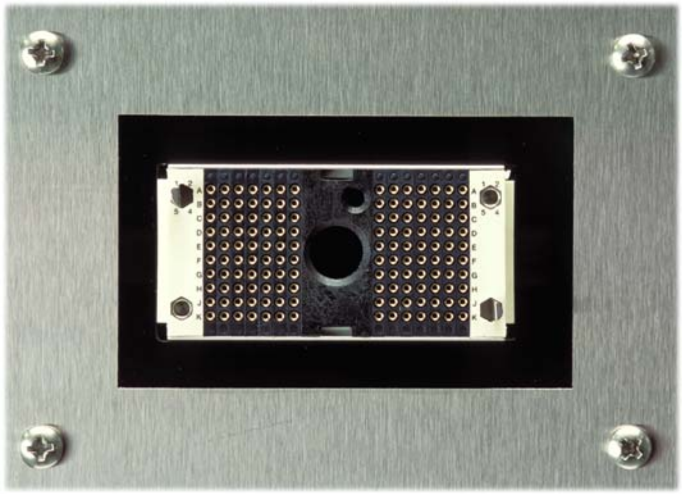


**Figure 8-1.** Multicontact Hypertronics receptacle (128-channel Net Amps 200 amplifier)

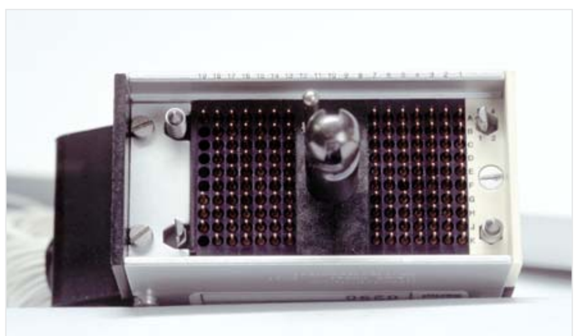


**Figure 8-2.** Hypertronics plug of 128-channel GSN

# Components Using the Hypertronics Connector

The system connections that use the Hypertronics connector are shown in Figure 1-6 on page 26. The GSN and amplifiers connect to the Geodesic EEG System through the Hypertronics multipin receptacle and the Hypertronics multipin plug, respectively. All Nets use the Hypertronics connector.

# Making and Breaking Hypertronics Connections

The Hypertronics connector can be inserted or removed when the lever is in the released position. As shown in the top pictures of Figure 8-3, the lever points downward when the connector to the Net Amps 200 is in its released position and upward when it is locked. For the connector to the GSN, the lever points to the left when it is released and to the right when it is locked (bottom pictures of Figure 8-3). When the lever is locked, the connector cannot be inserted or removed from its connector.

*Note: Before inserting a Hypertronics plug, examine its pins to make sure that none are bent. Inserting a connector with a bent pin can cause the pin to be completely bent over and in need of replacement.*

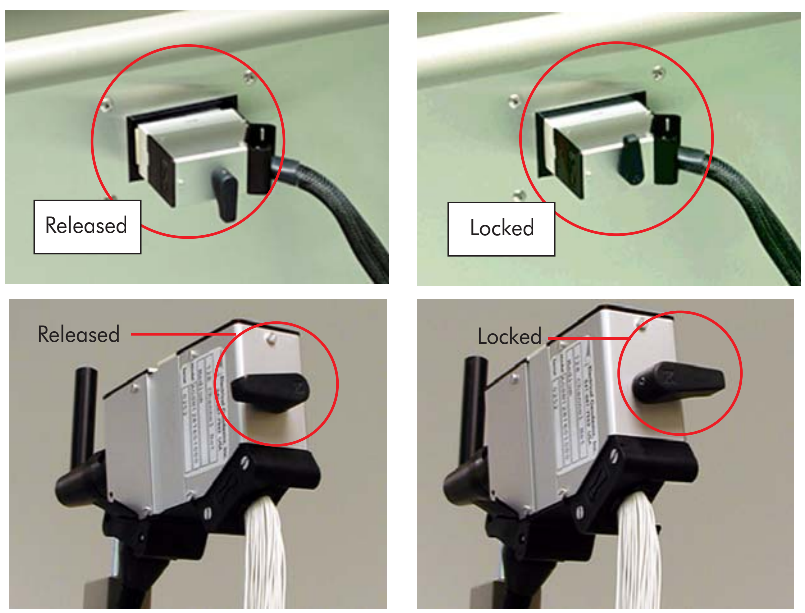



**Figure 8-3.** Hypertronics plug released (left) and locked (right)

## Pinout Reference

A complete reference to the identity and function of Hypertronics connector pins used in the Net is found in Appendix C, "GSN Pinouts."

## The Advantages of Hypertronics Contacts

A Hypertronics Hypertac sleeve (Figure 8-4) is formed by miniature wires strung at an angle to the insertion axis. When a pin is inserted into this sleeve, the wires displace to accommodate it. In so doing, they wrap themselves around the pin, providing a number of linear contact paths. This superior mating principle offers several advantages: low insertion force, long life (over 100,000 cycles), low contact resistance, and excellent electrical continuity.

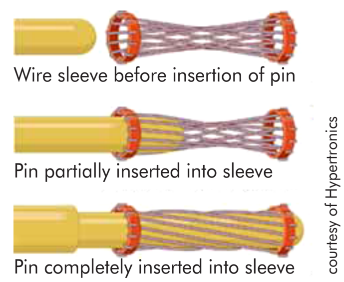



**Figure 8-4.** Magnified view of Hypertac pin and sleeve

# Connecting the Net

Connect the GSN's Hypertronics connector to either the Hypertronics receptacle at the end of an articulated arm (Figure 8-5), or directly to the amplifier front panel. Twist the locking cam to secure the connector in place (see "Making and Breaking Hypertronics Connections" on page 85).

**Figure 8-5.** Plugging GSN into the GSNIC and the articulated arm

# Smart Nets

During manufacturing, factory settings are made at EGI using jumpers on each GSN, such that each Net has a coded channel count and type. EGI's EEG data-acquisition software, Net Station, reads this identity via its interface to the amplifier and can automatically choose a sensor layout that matches the connected Net. EGI calls this technology "Smart Nets." For details of the Smart Net coding, see Appendix C, "GSN Pinouts," and Figure 8-6.

*Note: The 32-channel HCGSNs of the GES 120 and 140 do not use "Smart Net" technology.*

**Geodesic Sensor Net Smart Net Coding**

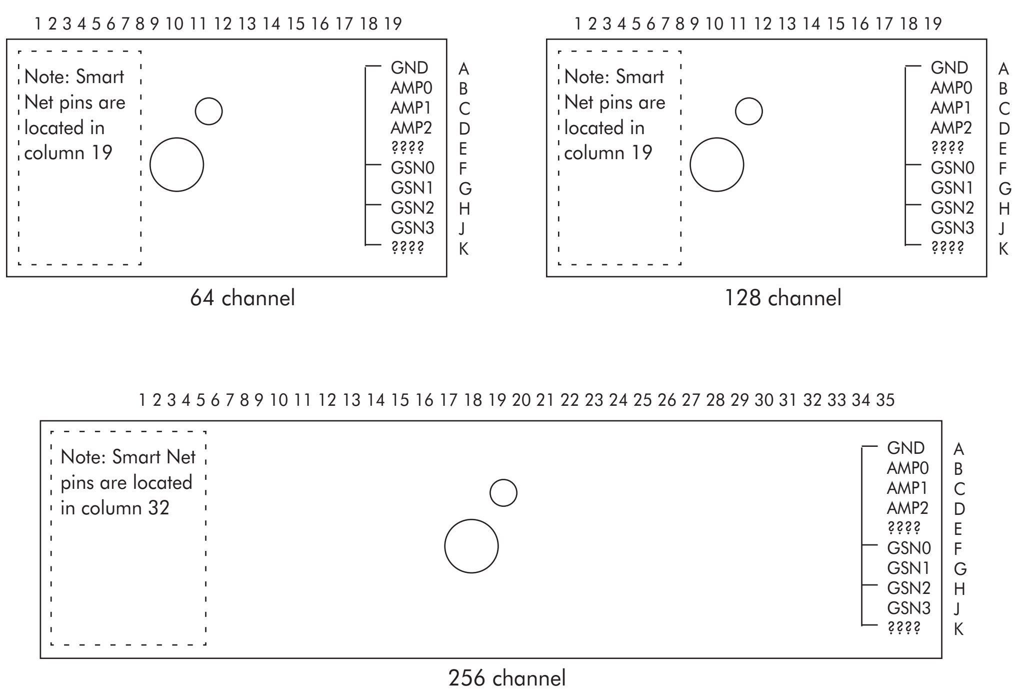



**Figure 8-6.** Schematic view of GSN connectors

## Shared Reference

Because a Geodesic Sensor Net has only a single reference electrode, and because amplifiers measure potentials between an electrode and reference, amplifier arrays must share the reference level. For example, in the GES 250, the reference electrode lead of the GSN is connected to the input side of the reference channel inside the Net Amps 200.

## Shared Common

For the isolated portion of each amplifier's electronics to be at the same potential as the Geodesic Sensor Net common, amplifier arrays must share the common. Hence, the common lead on the GSN is terminated inside the amplifier at the amplifier common.

***WARNING!:*** *Do not confuse the zero potential point of common with that of earth ground. With EGI's Geodesic Sensor Net, common is isolated from earth ground. For further details, read "What is the distinction between "reference" and "common"?" on page 101.*

# Guide to Cabling

In the GES 120 and 140, the GSN connects directly to the Hypertronics connector on the front of the Neurotravel amplifier. This connectivity scheme is shown diagrammatically in Figure 1-5 on page 26.

In the GES 200, 250, and 300, the Geodesic Sensor Net interface cable connects the GSN to the Hypertronics connector on the front of the Net Amps 200 or 300 amplifier. EEG signals travel from the Net to the Net Amps 200 or 300 through this intervening GSNIC. This connectivity scheme is shown diagrammatically in Figure 1-6 on page 26.

For information about the connector, see "Hypertronics Connector" on page 83. For information about the GSNIC, see the *GES Hardware Technical Manual*.

chapter 9

# REPLACING GSN PARTS

Included with each Net are a number of replacement kits. Additional kits are available from EGI.

The GSN 200 comes with five electrode-replacement kits, and the HCGSN is provided with 10 replacement sponges. These are the only parts that can be serviced by the user; all other repairs must be performed by EGI. For instructions on replacing sponges, see page 97.

## Replacing Electrodes (GSN 200)

Each electrode-replacement kit contains a new electrode consisting of a unitized sponge, electrode pellet, lead wire, and integral Hypertronics contact. The kit (Figure 9-1) does not contain a pedestal because the replacement process uses the existing pedestal of the sensor that is receiving the new electrode.


**Figure 9-1.** Electrode-replacement kit

# Tools Needed to Replace Electrodes

Before starting the process of replacing an electrode, gather the tools that will be needed.

Pictured in Figure 9-2, the tools are as follows (top right, clockwise):

- 1.5 mm. Allen wrench
- needle-nose pliers
- pin extraction tool (Hypertronics)
- slot-head screwdriver

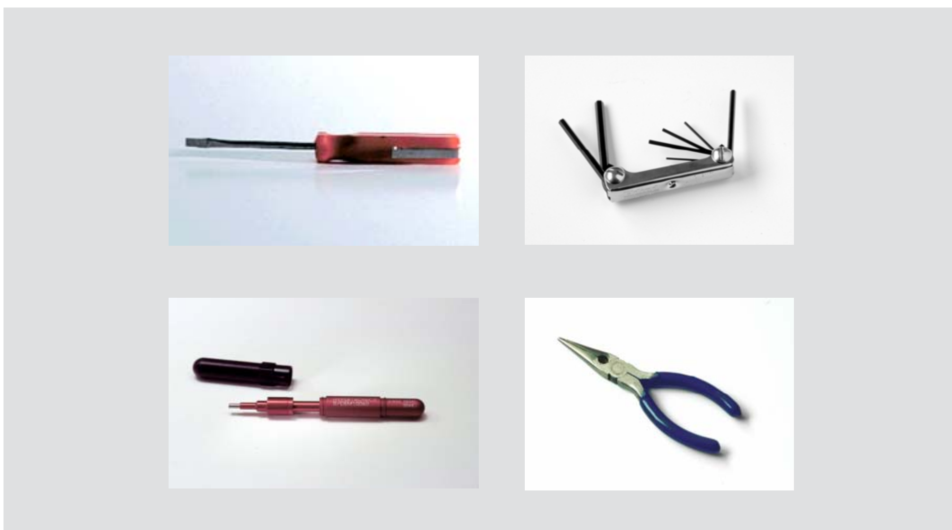


**Figure 9-2.** Tools needed for replacing electrodes

In addition, a roll of electrical tape and scissors for cutting the tape are needed.

# Remove Electrode from Plug

1 Remove the handle on the Hypertronics plug using a 1.5 mm. Allen wrench (Figure 9-3).

**Figure 9-3.** Remove the handle on the Hypertronics plug

2 Remove the six screws that secure the hood. Gently remove the hood (Figure 9-4) and place in a small plastic bag along with the screws and the handle.


**Figure 9-4.** Remove the hood

3 Remove the two long screws that hold the strain relief clamp in place and slide the clamp out of the retainer (Figure 9-5). Save the screws and the clamp in the bag with the other parts.

**Figure 9-5.** Remove the screws and slide the clamp out

**4** Slide the bundled wires out of the strain relief retainer. Remove the electrical tape and clear plastic tubing from around the wires so that the wires all hang loose individually (Figure 9-6). Save the tubing with the other parts. If you are working with an infant Net, work carefully around the soldered wires.

**Figure 9-6.** Let the wires hang loose

**5** Remove the flat black end that is opposite the strain relief by loosening the screw from the bottom. This will allow you more room to work in the connector (Figure 9-7).

**Figure 9-7.** Remove the flat black end

**6** Use the pinout scheme in Appendix C, "GSN Pinouts," to locate the correct contact (Figure 9-8).

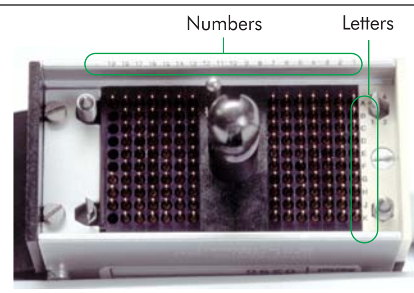



**Figure 9-8.** Note the numbers and letters marked on the connector

**7** It is important to work very slowly and deliberately when removing contacts from the connector. Working too quickly or carelessly will result in contacts becoming stuck in the modules. Do not use force to remove the contacts from the modules. Using force will result in damage to the modules and may necessitate replacing the entire module.

**8** Use the Hypertronics extraction tool provided by EGI to remove the target contact. Pull the black top off the extraction tool and snap it onto the opposite end to provide more room to hold the tool. Grip the tool on the small, thick section near the narrow end of the tool (Figure 9-9). Carefully insert the tool **straight** over the contact you wish to remove until you hear a small click and the silver part is no longer visible.

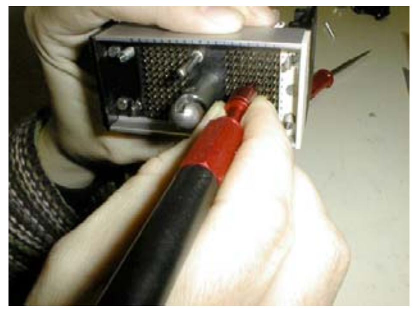


**Figure 9-9.** Remove the contact using the extraction tool

**9** Hold the connector in one hand and firmly grip the thick end of the extraction tool with the other hand. Push the extraction tool **straight** in until the two thick parts of the extraction tool meet (Figure 9-10). This will push the contact most of the way out of the module. If the two thick parts of the tool do not meet, push the contact all the way back into the module and begin again by reinserting the tool over the contact until you hear the click.

**Figure 9-10.** Push the tool until the contact pin slides out

10 Use a pair of needle-nose pliers to grip the contact and pull it the rest of the way out of the module (Figure 9-11). Be sure that you pull the contact **straight** out and not at an angle. If the contact does not pull out easily, it may be necessary to push it all the way back into the module and repeat the entire process again.

**Figure 9-11.** Use a pair of needle-nose pliers to grip the contact and pull it out

11 It is important that you make sure that you always use the extraction tool **perpendicular** to the connector and that when pushing or pulling the contact out of the module that you work **straight** on and not at an angle. Occasionally, it may be necessary to try several times to remove a contact without using force.

12 Double-check to make sure that you have removed the correct contact, then cut the contact from the end of the electrode wire.

13 Gently pull the electrode from the Net sensor housing by pulling on the protruding end of the sponge. Slowly pull until the electrode wire comes free from the sensor housing.

## Replace the Electrode

1 Moisten the sponge of the replacement sensor with water or electrolyte.

2 If the sensor is one that connects to the Hypertronics plug at a perimeter location, see the special perimeter location instructions on page 96. Otherwise, proceed.

3 Gently thread the contact with its trailing lead wire through the flared foot portion of the pedestal and through the cap. While holding the pedestal cap in place, pull the wire until the top of the sponge is just touching the cap of the pedestal.

4 If you have to use too much force to pull the sponge into the housing, trim the sponge slightly for a secure but gentle fit.

**5** Trim the sponge of the new electrode so that it protrudes 0.5 cm. from the sensor housing.

**6** To avoid tangling, it is important to thread the replacement electrode's wire along the same path as the electrode with either the previous number or the following number. Be sure to thread the wire through the correct hole in the sliding wire guide.

**7** Insert the contact into the appropriate location in the connector, making sure that the flat sides of the contact are lined up parallel to the long sides of the connector opening (Figure 9-12 and Figure 9-13). Push the contact into place until you hear a click.

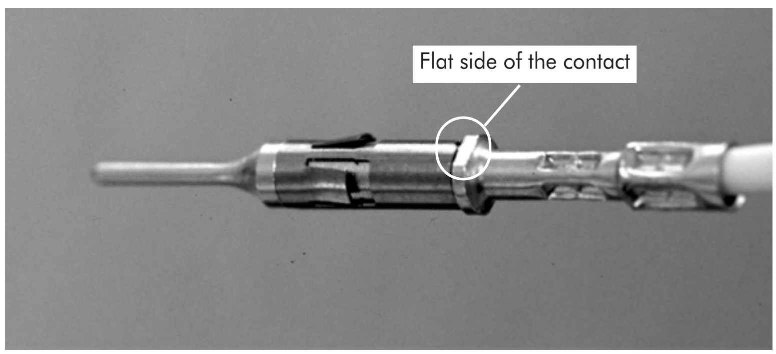



**Figure 9-12.** Enlarged view of Hypertronics contact

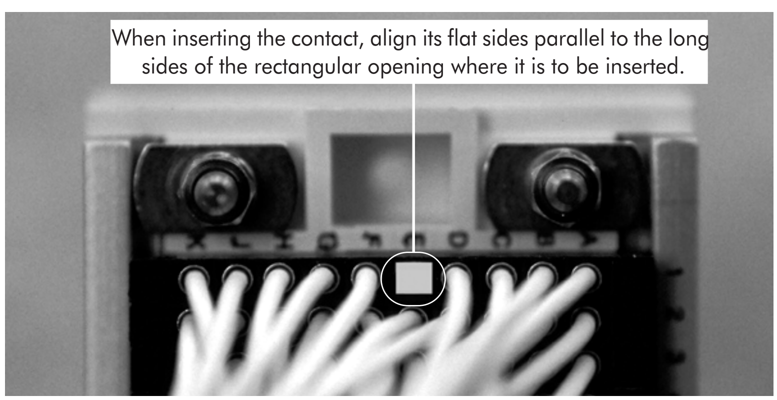



**Figure 9-13.** View of connector before inserting contact

*Note: A condensed version of the replacement instructions are included on the back of the replacement electrode package label (Figure 9-1).*

## Perimeter Locations

Perimeter locations for the 128-channel GSN 200 are sensor numbers 1, 8, 14, 17, 22, 26, 33, 39, 44, 49, 114, 120, 121, 125–128, and common. Use electrodes labeled "perimeter" on any of these locations.

1. Proceed as for a standard electrode, but **do not pull** on the electrode wire to insert the assembly into the sensor housing. Rather, twist or push electrode up from the bottom, holding the cap on top of the pedestal in place, and push the electrode fully into place by gently pressing up with a thumbnail. Trim the sponge to 0.5 cm. and proceed normally.

2. When changing electrodes 44 and 120, go very slowly so you will not dislodge the cap. Ease the contact through the hole. Pull back the chin strap elastic to provide more room, if necessary.

# Reassemble the Equipment

1. Hold the connector in one hand, allowing the Net to hang downward. With the other hand gather the wires together about 1–2 cm. below the connector post. Place the original clear plastic tubing around the gathered area and bind with electrical tape. Place the bundle in the strain relief opening.

2. Slide the strain relief retainer into place and tighten down firmly with the two long screws. Replace the hood, making sure that all the wires are inside the hood and that you do not crimp any of the wires between the hood and the cage (Figure 9-14). Replace the handle.

**Figure 9-14.** Replace the hood without crimping the wires

# Replacing Sponges (HCGSN)

Each HCGSN comes with 10 replacement sponges. Sponges must be specially prepared by the manufacturer; for additional replacement sponges (Figure 9-15), contact EGI.

**Figure 9-15.** Replacement sponges

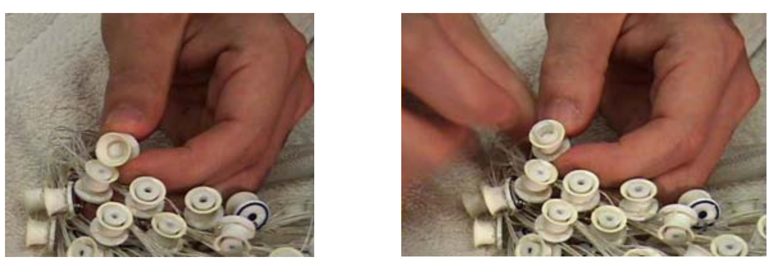
You should replace only sponges that have fallen out of their pedestals. Do not *remove* a sponge from a pedestal and replace it, because you could damage the electrode.

No disassembly and no special tools are required to replace sponges.

## Position Sponge in Pedestal

1. Position the dry sponge in the pedestal so that the electrode sits in the hole in the middle of the sponge.

2. Make sure the sponge is not tilted (Figure 9-16).



Replace only sponges that have fallen out of their pedestals

Position the sponge upright so that the electrode sits in the sponge's center

**Figure 9-16.** In the empty pedestal, place the sponge upright

3 Use your thumb to press the sponge firmly into the pedestal (Figure 9-17).

**Figure 9-17.** Push the sponge in firmly

4 Use a pipette to wet the sponge with water and hold the sponge in place with your thumb while it hydrates.

5 Use your thumb or index finger to press the hydrated sponge farther into the pedestal (Figure 9-18).

Wet the sponge and hold down with your thumb

Push the wet sponge firmly into the pedestal

**Figure 9-18.** Hydrate and again push the sponge in

6 Repeat Steps 4–5, until the sponge is firmly seated in the pedestal.

## Verify Secure Placement of Sponge

1 Gently tug on the sponge. If properly seated in the pedestal, the sponge should not come loose. If it does come loose (Figure 9-19), repeat Steps 1–6 in preceding section, “Position Sponge in Pedestal.

**Figure 9-19.** A poorly seated sponge

# Other Repairs

Repairs other than electrode replacement in a GSN 200 or sponge replacement in an HCGSN must be done by a trained EGI Net technician and will require the return of the Net to EGI for servicing.

In the event that a Net needs servicing or refurbishment, contact EGI Technical Support (Appendix A). Please disinfect the Net (see page 81) before returning it to EGI.

# Disposal of Electrodes or Sponges

See “Component Recycling and Disposal” on page 56.

chapter 10

# Net FAQs

This chapter answers some of the most Frequently Asked Questions about the Geodesic Sensor Net.

## General Issues

### What is the distinction between "reference" and "common"?

Amplifier inputs are differential. The voltage measured at every channel is the difference in voltage between the reference (vertex) sensor and that channel's sensor.

There is no "ground" sensor *per se*. The subject is never connected to earth ground. This would make the subject vulnerable to electrical hazard, just as standing in water makes one vulnerable to electric shock.

The "ground" sensor on the Net is actually an "isolated common," which means it is tied to the zero level or common of the isolated amp circuit's power supply. This supply is isolated, so it is not connected to earth, the computer, or anything else. Thus, an electrical hazard would not make a dangerous circuit with the isolated common.

### Why reference signals to vertex?

Choice of physical reference is somewhat arbitrary. EGI chose reference at the vertex for reasons of symmetry. If you do not like the choice of reference, you can readily reference signals in the software, on the fly, or after the fact to any particular Geodesic Sensor Net sensor or group of sensors, including average reference.

## What should I do with unused channels?

Noise is normal for unconnected channels. Do not worry about it, or short the channels to common. Do not short to reference. Shorting plugs are provided with infant Nets to short eye channels when they are not being used with outrider electrodes (see "Infant Nets" on page 44).

*Note: Because of the lack of common-mode rejection, shorted channels may display 60-Hz noise.*

## Can I return an HCGSN without sponge inserts to EGI to have sponges put in?

Yes. Just contact support@egi.com to arrange for this service. Please disinfect the Net (see page 81) before returning it to EGI.

## And vice versa: Can I remove sponges from my HCGSN for 12-hour recording?

No. Removing all the sponges from an HCGSN may cause damage to the electrodes. This service is not offered by EGI and should not be performed by the customer.

# Application and Comfort

## Are the Geodesic Sensor Nets comfortable?

Yes. In fact, numerous subjects have commented on the snug and comfortable fit of both the GSN 200 and the HCGSN. The geodesic tesselation covers the head evenly and firmly, thus uniformly distributing the tension of the structure and preventing painful pressure points from developing.

The main point to keep in mind is to ***apply the Net properly***, by ensuring that the orbital, vertex, nasion, and mastoid sensors are accurately placed and that the face straps (chin strap, eye electrode bands, and ear electrode bands) are adjusted to maximize subject comfort (see Chapter 6, "Applying the GSN," for step-by-step instructions).

## What should I do with eyeglasses?

Have the subject take glasses off and hold them (better than the technician taking the subject's glasses, which can cause insecurity) during Net application.

After Net application, help the subject thread the glasses past the sponges and over the ears. For the GSN 200, use small, saline-soaked sponge pieces to increase sensor height where gaps exist.

## Are there differences in how to apply the HCGSN and GSN 200?

As described in Chapter 6, "Applying the GSN," the application procedure is almost identical.

Both the GSN 200 and the HCGSN require:

- Stretching the perimeter band with your thumbs and little fingers so that it is slightly larger than the subject's head.
- Standing directly in front of the subject to ensure a straight and even application.
- Aligning the vertex and nasion electrodes with the vertex and nasion of the subject.
- Maximizing the comfort of the subject by moving the eye and ear electrodes as needed, and by adjusting the face straps (chin strap, eye electrode bands, and ear electrode bands) until the desired fit is accomplished.

The few differences related to the HCGSN include:

- *Ear cut-out sections*: Be sure that the ear cut-out sections do not pin down the ears, especially on the bottom edge.
- *Y clip*: Secure the Y clip to the subject's collar to relieve some of the strain on the geodesic structure. *(Exception: 32-channel model has no Y clip.)*

- *Die-cut structure*: The die-cut geodesic structure provides a closer head fit than the GSN 200. This snugger fit makes it even more important that the subject keep his or her eyes closed as instructed.

  The tighter web structure also makes it more challenging to achieve an evenly spaced application. We recommend that you practice applying a "dry" Net (one without electrolyte) to a colleague repeatedly.

# Electrolyte Formulations

## Is NaCl good for mixing HydroCel Saline electrolyte?

In casual testing, EGI did not find any evidence for differences in offset or drift between sodium chloride (NaCl) or potassium chloride (KCl). However, because NaCl electrolyte is not vigorously tested, EGI does not recommend it for use with the Net.

## Is distilled water essential for mixing electrolyte?

EGI has used tap water for making electrolyte without any noticeable problems. However, tap water has a huge range of possible contaminant and ion concentrations, even within a single city's supply. Be aware that you may encounter problems if you do not use distilled water.

## Which HydroCel solution should I use?

The HydroCel formulation you choose depends on your GSN model and desired recording duration.

If you have the following models:

- *GSN 200*: Use only HydroCel Saline, EGI's classic potassium chloride saline solution, for standard 2-hour recordings.
- *HCGSN with sponge inserts*: Use only HydroCel Saline for standard 2-hour recordings.
- *HCGSN without sponge inserts*: Use only HydroCel HS, the hydrogel-based formulation for extended 12-hour recordings.

# Care and Maintenance

## How can I maximize the life span of my GSN?

This topic is discussed in detail in Chapter 5, "Service and Maintenance." In short, you can prolong the life of your GSN by adhering to the following rules:

***Do's***

- *Do* use the correct water type and temperature for mixing the electrolyte.
- *Do* make sure that the subject has clean hair before applying the Net.
- *Do* thoroughly rinse and disinfect your Net after each use.
- *Do* store the Net out of direct sunlight or UV sources.
- *Do* store the Net by hanging it over the drying rack with the connector higher than the sensors.
- *Do* use the wire guide on the GSN 200 to prevent tangles.

***Don'ts***

- Do *not* overstretch the Net.
- Do *not* leave the Net in disinfectant for more than 10 minutes.

How long your Net lasts also depends on frequency of use. In general, a GSN has a life span of two years.

chapter 11

# TROUBLESHOOTING

Described in this chapter are a number of possible problems that may arise in connection with using Geodesic Sensor Nets. For each problem, one or more remedies are proposed.

In cases where none of the remedies corrects the problem, do not use the GSN to collect EEG. Disconnect the Net and contact EGI Technical Support (Appendix A).

## General Problems

### Smart Net Not Detected

If the Smart Net is not detected or is incorrectly detected, contact EGI Technical Support (Appendix A).

*Note: Nets that shipped before the GSN 200 may not feature Smart Nets technology, although Nets returned to EGI for refurbishing are ordinarily upgraded to Smart Nets technology. Consult Appendix C, "GSN Pinouts," or Figure 8-6 on page 87 to determine if your Net is a Smart Net.*

# EEG Contains Excessive Noise

The noise components of an EEG recording have a number of sources. Some noise originates in the electronics of the amplifier. Problematic noise originates in the environment in the form of electric and magnetic fields that are picked up by system components, such as cables, and contaminate EEG signals by being acquired along with the EEG.

EEG data are susceptible to noise only during recording. After the EEG has been recorded to disk, it is no longer susceptible to noise contamination.

One way to manage noise is to identify noise generators that may exist in the EEG recording environment. Another is to be aware that certain ways of positioning system components can affect the level of noise that is picked up during recording. By changing the location and orientation of system components, and monitoring the effect on the amount of noise that the EEG waveforms exhibit, you can reduce or eliminate the deleterious effects of noise on your EEG recordings.

## Noise Generators

Take note of possible noise generators and change the environment accordingly to reduce noise, per the following sections.

### Power Sources

Power cables carry relatively large-amplitude, 50- or 60-Hz electric and magnetic fields. These transmit noise to nearby cabling.

- Check that there are no power cables near the subject or the interface cable connecting the GSN to the amplifier.

### Other Large Electric Fields

Anything that generates a large electric or magnetic field (for example, ceiling fans, freezers, centrifuges, or transformers) can be a source of environmental noise. Such sources can sometimes be elusive, especially if hidden in a wall, ceiling, or floor, or in a different room.

- Check that all obvious sources (fans, copiers, fluorescent lights) are eliminated, disabled, or placed at a greater distance from the vicinity of the subject, all data cables, and the amplifier. The contribution of electric fields to noise decreases as the square of the distance between the devices increases.
- Avoid subject contact with antenna sources (metal desks or chairs).

## Configuration Issues

Channels with floating inputs affect the amplifier's ability to perform common mode rejection (CMR) and, hence, increase susceptibility to environmental noise.

- To improve CMR, short unused channels to isolated common. Do not short unused channels to reference.
- Check for sensors close to, or touching, common. Sensors near common will normally exhibit increased noise.

# EEG of Poor Quality

The previous section discussed electrical and magnetic noise as a source of degraded EEG signals. This section discusses the issue of poor EEG more generally and provides guidelines for remedying it.

Disregarding noise for the moment, poor EEG can be characterized by one of more of the following phenomena:

- flatline or relatively low-amplitude waveforms at a single channel, a group of neighboring channels, a set of non-neighboring channels, or the entire sensor array
- certain channels being steadily or intermittently stuck at maximum amplitude, also called *railing*

- certain channels exhibiting wide, high-amplitude oscillations that greatly exceed the levels of neighboring channels (*flailing*)
- waveform drift

Such phenomena can be due to user inexperience in the area of Net application, a plug-type electrical connector being incompletely inserted in its matching receptacle, or a hardware problem involving the GSN or the amplifier. When troubleshooting poor EEG, you should study the following remedies offered and implement the ones that seem most likely to correct the problematic EEG.

If Net application remedies do not solve the problem, and loose Hypertronics connectors are not to blame, you should suspect a hardware problem involving the GSN or the amplifier. Where such hardware problems have user-implementable remedies (the replacement of faulty sensors in a GSN 200 or the replacement of sponges in an HCGSN), a description of the remedy or where to find it in the manual will be given (see the *GES Hardware Technical Manual* for amplifier remedies). Otherwise, you should contact EGI Technical Support (Appendix A).

# Improper Net Preparation and/or Application

The following guidelines will help to diagnose Net application issues. See Chapter 6, "Applying the GSN," for expanded coverage of this topic.

- Check that the sensor sponges of the GSN 200 or HCGSN are properly wetted with electrolyte. Start with dry sensor sponges for best absorption, or alternately squeeze and release the sponges to improve the uptake of electrolyte by the sponges.
- When preparing for application of the GSN 200, do not pat the sensors too vigorously in an attempt to prevent dripping. It is possible to cause the sponges to lose too much electrolyte this way. ***(For the HCGSN, do not pat the sensors at all because the sponges are smaller and absorb less electrolyte.)***
- Check for cold electrolyte. Sensors are thermally sensitive, and movement from cold electrolyte to a warm head will induce sensor drift. As the temperature stabilizes, so does temperature-induced drift.
- Check that the electrolyte was properly prepared. Weak electrolyte degrades data quality. If uncertain, use fresh electrolyte.

- If an individual sensor is providing poor EEG, try using a pipette (see page 117) to add more electrolyte.
- Try gently removing the sponge from its pedestal to inspect it more carefully, checking for dry spots caused by overcompression. Trim away a little sponge if needed, rewet with electrolyte, reinsert into pedestal, and retest.
- Note the result of placing a piece of sponge (moistened with electrolyte) between the sensor's sponge and the scalp.
- Check that sensors are properly seated. Use the foot of the pedestal to part the hair as you seat the sensor. Use a pipette to part the hair in difficult areas during seating. Right after applying the Net, try seating the sensors at the back of the head first or where the subject's hair is thick. Thick hair tends to absorb electrolyte.
- If some sensors are not making sound contact, the Net may be the wrong size or may have been overstretched. Try a different (smaller) Net.
- If some sensors ride up or flip, try a larger Net; adjust the eye channels using the cord locks.

## Loose, Improper, or Faulty GSN Connectivity

- Check that connections are sound. Unplug and replug the connectors, checking for bent or missing pins, corrosion, or buildup.
- On infant Nets, check to make sure that the shorting jack is plugged into the connector if outrider sensors are not being used (see "Infant Nets" on page 44).
- Consider the possibility of a lead wire being internally faulty, resulting in an open circuit existing somewhere between an electrode's connection to the lead wire (inside the sensor) and the GSN Hypertronics plug. This can happen when a lead is hyperextended, causing the wire inside the lead to lose its connection to either the Hypertronics pin or to its associated electrode. For instructions on how to diagnose a faulty sensor and/or lead, see the next section, "Faulty Sensors."

# Faulty Sensors

The following guidelines are useful to determine whether an individual sensor is faulty.

## Unacceptably High Impedance

- Check for contaminating substances on the subject's scalp or hair. Natural oils, dirt, and hair-styling products can all affect contact quality.
- Immerse the sensor end of a Net in a bucket of electrolyte, and use your acquisition software to measure sensor impedances. If a sensor's impedance is above 10 kΩ while immersed in the bucket of electrolyte, it is likely to be faulty. (All sensors are certified below 3 kΩ in new Nets, but may increase slightly in impedance over time.)
- See "EEG Contains Excessive Noise" on page 108.

## Sensor Consistently Faulty in Some Way

It is always a good idea to wait for a sensor to fail for more than one recording session before replacing it.

*Note: It is also a good idea to keep a logbook in the data-acquisition area of your facility, for keeping track of which sensors on which Nets appear to be out of order.*

## Faulty Sensor Tied to a Specific Net

Check whether a different Net apparently has the same faulty sensors. If it does, then the problem is actually not related to the GSN sensor array but resides in the GSNIC, the amplifier, or elsewhere.

If a different Net does not exhibit the same faulty sensors, then the problem likely is local to the Net with the faulty sensors.

# Before Replacing a Sensor

Before you rush to replace a sensor, consider the possibility that the real problem might be with the single reference sensor or the single common sensor of the GSN.

If you experience multiple and inconsistent sensor problems with a Net, the problem might be due to faulty reference and/or common sensors.

Try replacing both of these before replacing large numbers of other sensors.

# Miscellaneous

## GSN 200 Lead Tangles

To prevent or remedy tangled GSN 200 leads, subscribe to the following protocol.

- When removing the GSN 200 from the subject, peel back the Net and allow it to turn inside out, then allow sensors to drop flat. This prevents tangling.
- Do not allow the connector or sensor array to pass through the lead bundle during handling or storage of the GSN 200.
- Immediately solve any tangles. Do not let problems accumulate.
- Use a wire with the previous number or the following number as a guide during electrode replacement in the GSN 200.
- Use the sliding wire guide (see Figure 3-2 on page 40) properly. Slide the guide toward the sensor end of the Net any time the GSN 200 is *not* being applied to a subject. When applying the GSN 200 to a subject, slide the wire guide toward the connector end of the Net.

## Dried HydroCel HS

Dried-on HydroCel HS may permanently damage the appearance and/or function of the HCGSN. This damage is ***not*** covered under warranty. For instructions on how to remove residual HydroCel HS from an HCGSN, see "Rinsing (HydroCel HS)" on page 80.

chapter 12

# ACCESSORIES AND SUPPLIES

Every complete Geodesic EEG System ships with a Net Support Kit. Some of the items in the Net Support Kit are also available for separate purchase from EGI. In this chapter, we provide a reference list of all the items that are part of the Net Support Kit and indicate which are available for separate purchase.

Individual GSNs ship with a set of pipettes, syringes (for spongeless HCGSNs), and replacement parts (see "Replacement Parts and Supplies," below).

## Net Support Kit

The Net Support Kit (page 116) includes consumable items such as potassium chloride and baby shampoo, a surfactant. See the following section "Replacement Parts and Supplies" for instructions on replenishing consumable items.

## Replacement Parts and Supplies

Each GSN 200 ships with five replacement electrodes, and each HCGSN (with sponge inserts) ships with 10 replacement sponges. Additional replacement electrodes and sponges are available from EGI. Instructions for electrode and sponge replacement are given in Chapter 9, "Replacing GSN Parts." Tools required for electrode replacement are included in the Net Support Kit (page 116); no special tools are needed to replace sponges.

A HydroCel Saline kit is available for sale from EGI. It includes potassium chloride and baby shampoo for making electrolyte. Order EGI part number A-ACC-KIT-3000-000. For the HydroCel HS electrolyte formulation, contact EGI.

## Obtaining Replacement Parts and Supplies

Contact EGI (see Appendix A, "Technical Support”) to order replacement parts and supplies.

# Items in the Net Support Kit

**Table 12-1. Net Support Kit items**

| Item | **Description (Qty)**<br>***EGI part no.*** | Item | **Description (Qty)**<br>***EGI part no.*** |
|---|---|---|---|
|  | Electrolyte/Rinse Bucket with Lid (1)<br>*N-PRT-BUC-1000-001* |  | Disinfectant Bucket with Lid (1)<br>*N-PRT-BUC-1000-002* |
|  | Drying Rack (1)<br>*N-PRT-DRY-1000-000* |  | Baby Shampoo (Johnson’s 15 oz.) (1)<br>*N-PRT-SHA-1000-000*<br>*also sold separately |
|  | Towels (1 pk of 6)<br>*N-PRT-TOW-1000-000* |  | Timer (1)<br>*N-PRT-TIM-1000-000* |
|  | Measuring Tape (1)<br>*N-PRT-MET-1000-000* |  | Measuring Spoon Set (1)<br>*N-PRT-MES-1000-000* |
|  | China Marker (1)<br>*N-PRT-CHM-1000-000;*<br>*N-PRT-CHM-2000-000* |  | 1/8-in. Slot-Head Screwdriver (1)<br>*N-PRT-SCR-1000-000* |

**Table 12-1. Net Support Kit items**

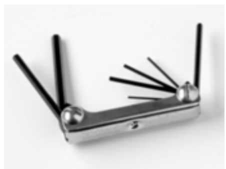
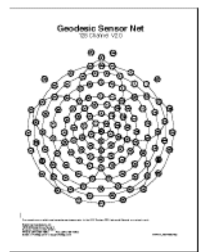
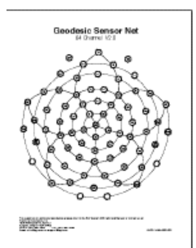
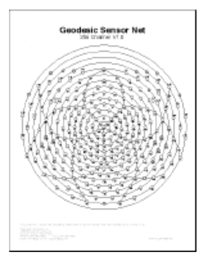
| Item | Description (Qty)<br>***EGI part no.*** | Item | Description (Qty)<br>***EGI part no.*** |
|---|---|---|---|
|  | Allen (Hex) Wrench Set with 1.5 mm. Allen Wrench (1)<br>*N-PRT-HXW-1000-000* |  | Long-Nosed Pliers (1)<br>*N-PRT-PLY-1000-000* |
|  | Electrical Tape (1)<br>*N-PRT-ELT-1000-000* |  | Strain Relief Tubing (128-channel) (2)<br>*N-PRT-SRT-1000-000* |
|  | Pipettes (5)<br>*N-ACC-PIP-1000-000* |  | Control III Disinfectant (2 oz.) (1)<br>*N-ACC-DIS-1000-000* |
|  | Potassium Chloride (1 lb.)<br>*N-PRT-KCL-1000-000*<br>*also sold separately |  | Connector Module Net End (Hypertronics) (2)<br>*N-PRT-CON-2000-001*<br>*also sold separately |
|  | Pin Extraction Tool (Hypertronics) (1)<br>*N-ACC-CON-2000-003*<br>*also sold separately |  | Styrofoam Head (1)<br>*N-ACC-STH-1000-000* |
|  | Laminated GSN Application Placard (1)<br>*N-PRT-LAM-1000-001* |  | Laminated Rinsing/ Disinfecting Placard (1)<br>*N-PRT-LAM-2000-001* |

**Table 12-1. Net Support Kit items**

| Item | Description (Qty)<br>*EGI part no.* | Item | Description (Qty)<br>*EGI part no.* |
|---|---|---|---|
|  | Laminated GSN Sizing Placard (1)<br>*N-PRT-LAM-3000-001* |  | Laminated Sensor Map (128 v2.0) (1)<br>*N-PRT-LAM-4000-002* |
|  | Laminated Sensor Map (64 v2.0) (1)<br>*N-PRT-LAM-6000-002* |  | Laminated Sensor Map (256 v 1.0) (1)<br>*N-PRT-LAM-6000-002* |
|  | Laminated Control III Instructions (1)<br>*N-PRT-LAM-7000-001* | | |

appendix A

# Technical Support

## Before Contacting EGI

Please check the Contents on page v and the Index on page 145 for coverage of your issue or question. You can also perform an electronic search using Find or Search in the PDF version of this manual posted on the Documents page of the EGI website (www.egi.com/documentation.html).

In addition, the Support page of the EGI website (www.egi.com/support.html) may have the information you need.

If you need more help, EGI recommends the following:

• ***Try to isolate the problem***. Is your problem well defined and repeatable?

• ***Document the problem.*** Carefully record and organize the details gleaned from the above step and report the problem to EGI.

## Contacting EGI

| | |
|---|---|
| **EGI Support web page** | www.egi.com/support.html |
| **Email support** | support@egi.com |
| **Sales information** | info@egi.com |
| **Telephone** | +541-687-7962 |
| **Fax** | +541-687-7963 |
| **Address** | Electrical Geodesics, Inc.<br>1600 Millrace Drive<br>Suite 307<br>Eugene, OR 97403<br>USA |

# NET SIZING AND SENSOR LAYOUTS

Table B-1 and Table B-2 provide estimates of the GSN size ranges that EGI currently makes and sells. Note that infant Nets made for subjects under the age of 3 do not have built-in eye channels but are equipped for use with outrider electrodes.

Table B-1 lists all the sizes for the GSN 200.

**Table B-1. GSN 200 sizing chart**

| Age | Head circumference | Category | Available channels |
|---|---|---|---|
| Neonate | 31–33 cm. | Infant | 32, 64, and 128 |
| Birth–2 weeks | 33.5–35.5 cm. | Infant | 32, 64, and 128 |
| 2–7 weeks | 36–38 cm. | Infant | 32, 64, and 128 |
| 7–16 weeks | 38.5–41 cm. | Infant | 32, 64, and 128 |
| 4–7 months | 41.5–43 cm. | Infant | 32, 64, and 128 |
| 7–10 months | 43.5–45 cm. | Infant | 32, 64, and 128 |
| 10–12 months | 45.5–46.5 cm. | Infant | 32, 64, and 128 |
| 1–2 years | 47–48 cm. | Infant | 32, 64, and 128 |
| 2–3 years | 48.5–50 cm. | Infant | 32, 64, and 128 |
| 3–6 years | 50–51.5 cm. | Pediatric | 32, 64, and 128 |
| 6–11 years | 52–53 cm. | Pediatric | 32, 64, 128, and 256 |
| 11 years–adult | 53.5–55 cm. | Adult Small | 32, 64, 128, and 256 |
| 11 years–adult | 55.5–58 cm. | Adult Medium | 32, 64, 128, and 256 |
| 11 years–adult | 58.5 cm. and above | Adult Large | 32, 64, 128, and 256 |

The HCGSN features a snugger fit than the GSN 200 and has a different sizing chart. This chart is ordered by head circumference, rather than age, and differentiates between gender. If you are unsure of the range of head circumference you will be testing, we recommend selecting at least one Net above and below the age range of interest.

The approximate age ranges for U.S. infants are taken from the 50th Percentile on The Centers for Disease Control and Prevention (CDC) Growth Charts, published in May 2000 ("50th Percentile" means that half of the children will have a larger head circumference and half will have a smaller head circumference). The charts are available for download at http://www.cdc.gov/nchs/data/nhanes/growthcharts/set1/chart09.pdf and at http://www.cdc.gov/nchs/data/nhanes/growthcharts/set1/chart10.pdf.

EGI recommends that customers consult infant growth charts for their own country as growth statistics may vary.

Table B-2 lists all the sizes for the HCGSN.

**Table B-2. HCGSN sizing chart**

| | Head circumference | Male | Female |
|---|---|---|---|
| ***Infant*** | 36–37 cm. | Birth–2 weeks | Birth–1 month |
| | 37–38 cm. | 2 weeks–1 month | 1–2 months |
| | 38–40 cm. | 1–2 months | 2–3 months |
| | 40–42 cm. | 2–3 months | 3–6 months |
| | 42–43 cm. | 3–5 months | 6–7 months |
| | 43–44 cm. | 5–7 months | 7–9 months |
| | 44–47 cm. | 7–15 months | 9–21 months |
| ***Pediatric*** | 47–51 cm. | Pediatric Small | Pediatric Small |
| | 51–54 cm. | Pediatric Large | Pediatric Large |
| ***Adult*** | 54–56 cm. | Adult Small | Adult Small |
| | 56–58 cm. | Adult Medium | Adult Medium |
| | 58 cm. and above | Adult Large | Adult Large |

Table B-3 is a guide to the sensor layouts contained in this appendix. The thick blue lines in each layout indicate proper thumb placement for the initial application (see Table 6-1 on page 65).

**Table B-3. Sensor layouts**

| Page number | Sensor layout |
|---|---|
| page 123 | 32-channel HCGSN v.1.0 |
| page 124 | 64-channel HCGSN v.1.0 |
| page 125 | 128-channel HCGSN v.1.0 |
| page 126 | 256-channel HCGSN v.1.0 |
| page 127 | 64-channel GSN 200 v.2.0 |
| page 128 | 128-channel GSN 200 v.2.1 |
| page 129 | 256-channel GSN 200 v.2.1 |

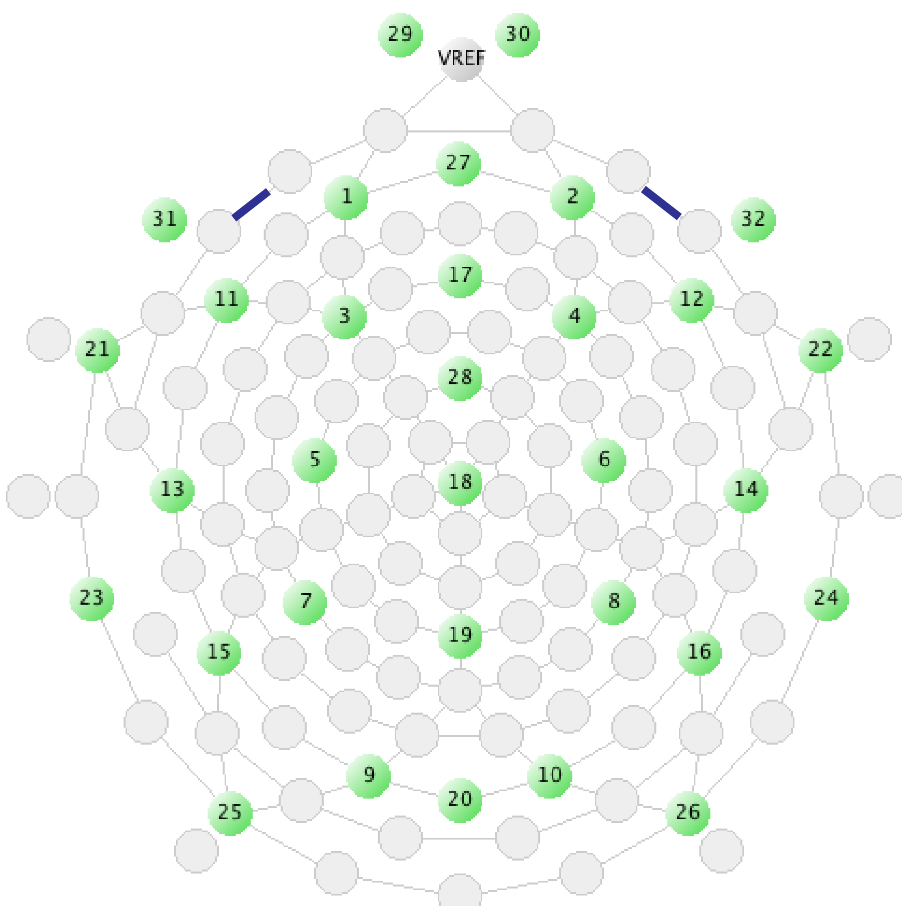



**Figure B-1.** 32-channel HCGSN v.1.0

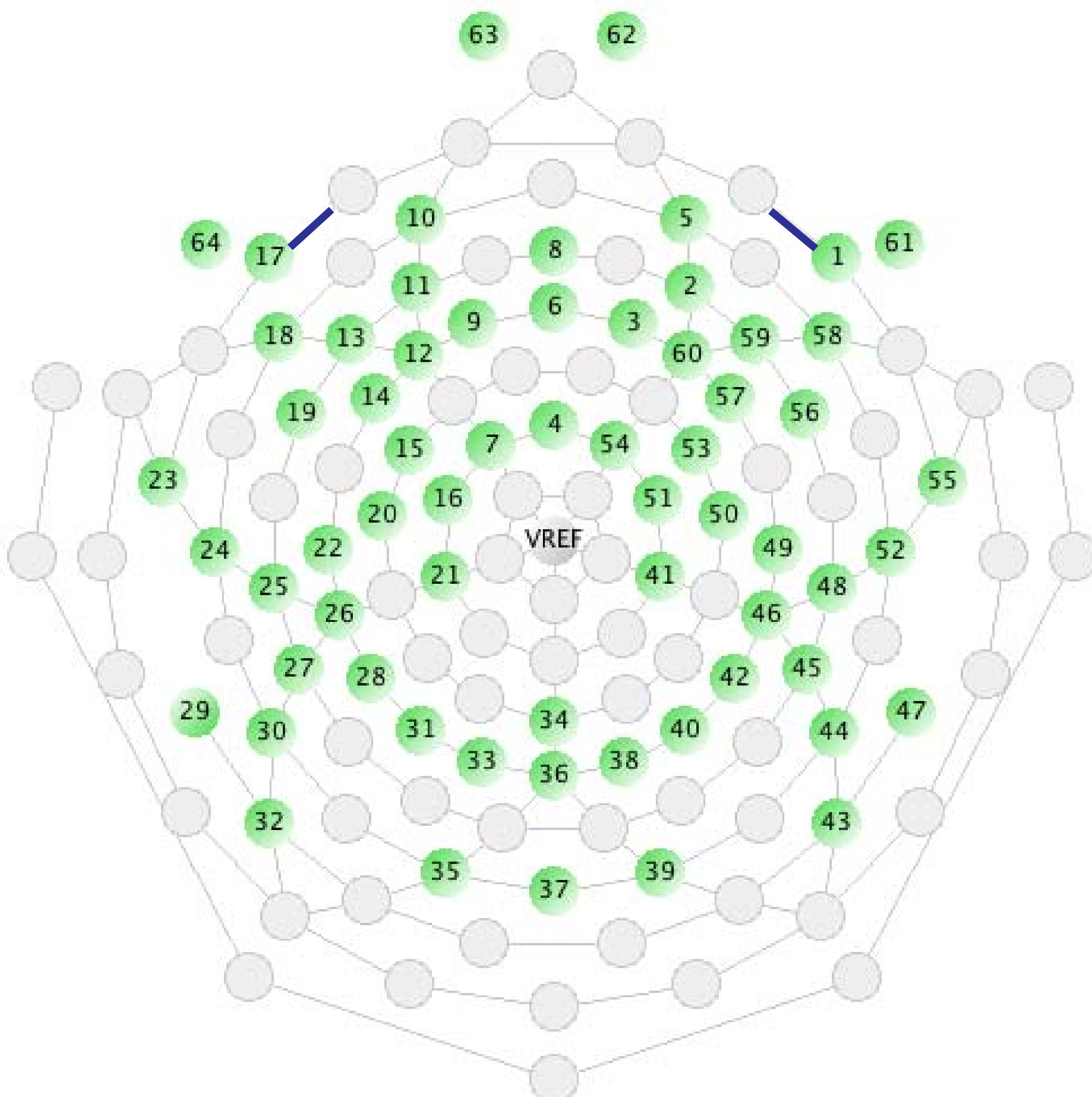



**Figure B-2.** 64-channel HCGSN v.1.0

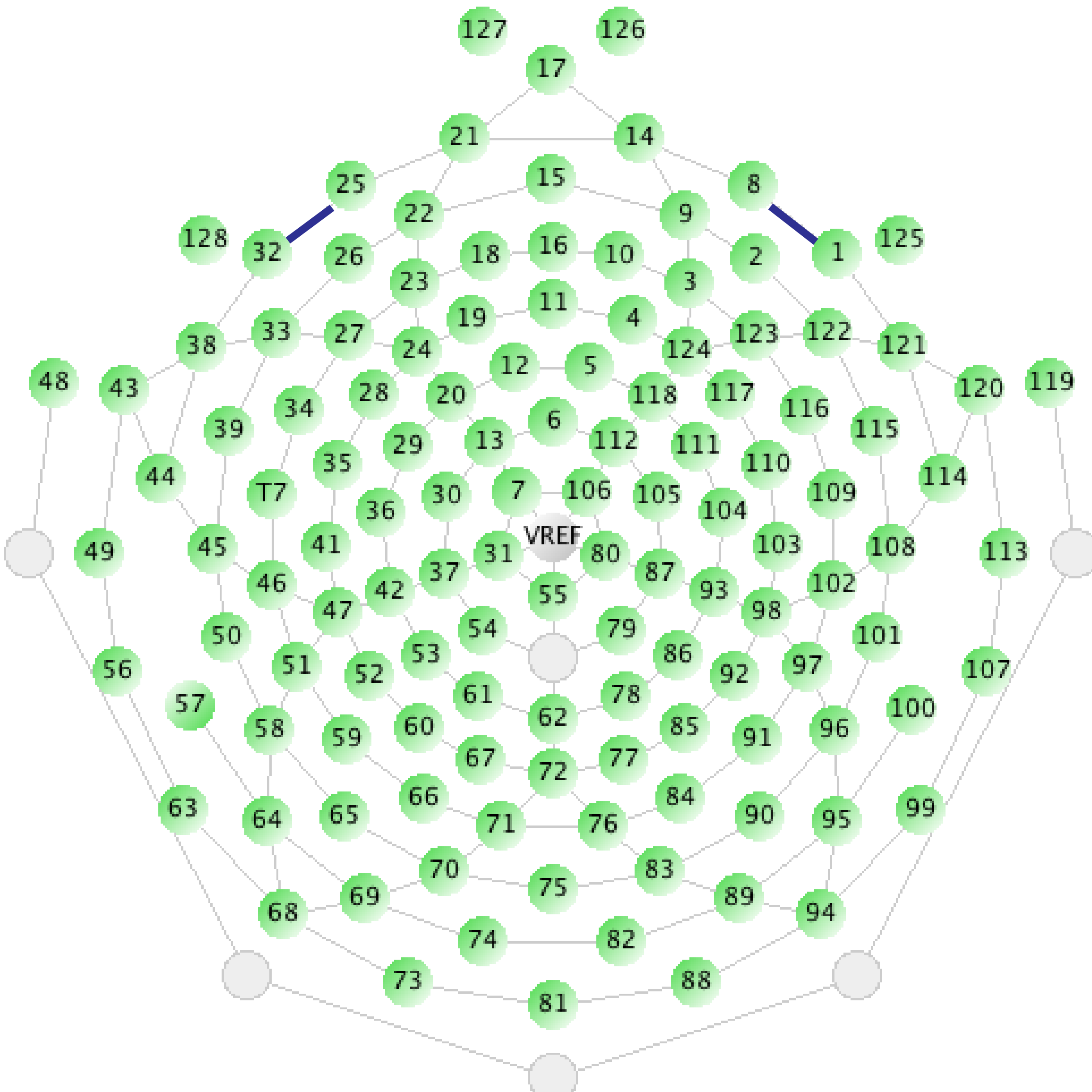



**Figure B-3.** 128-channel HCGSN v.1.0

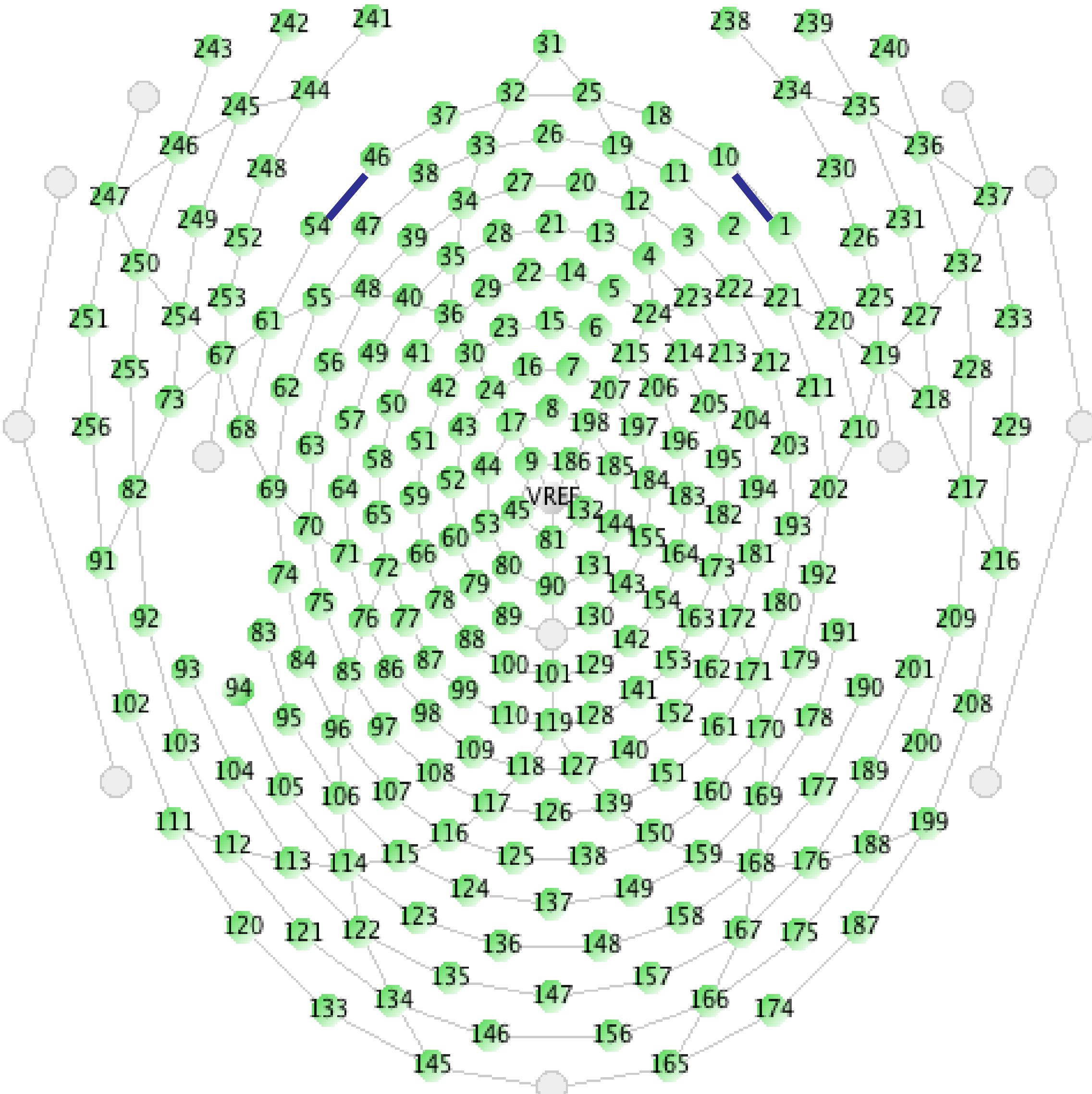



**Figure B-4.** 256-channel HCGSN v.1.0

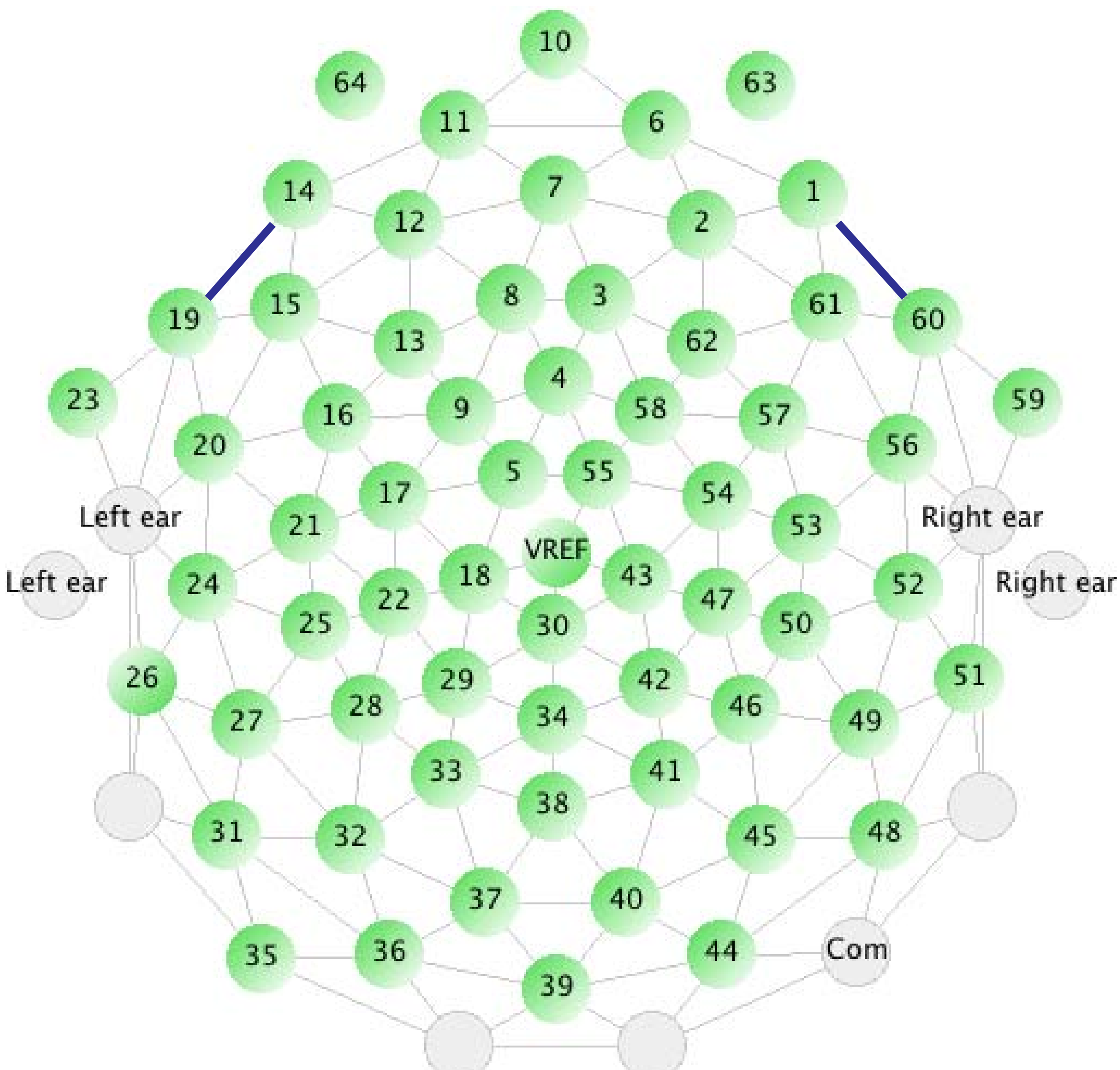



**Figure B-5.** 64-channel GSN 200 v.2.0

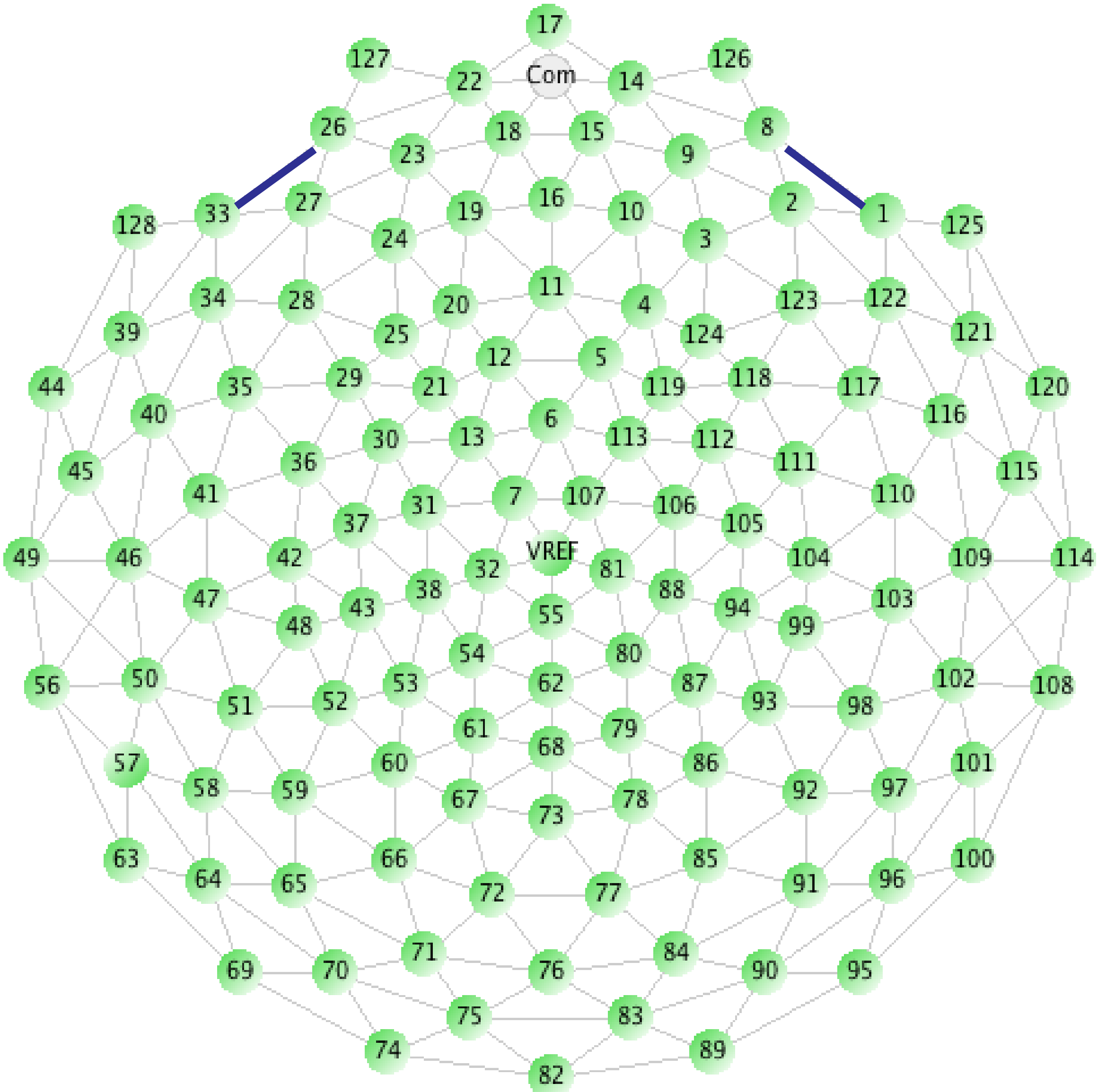



**Figure B-6.** 128-channel GSN 200 v.2.1

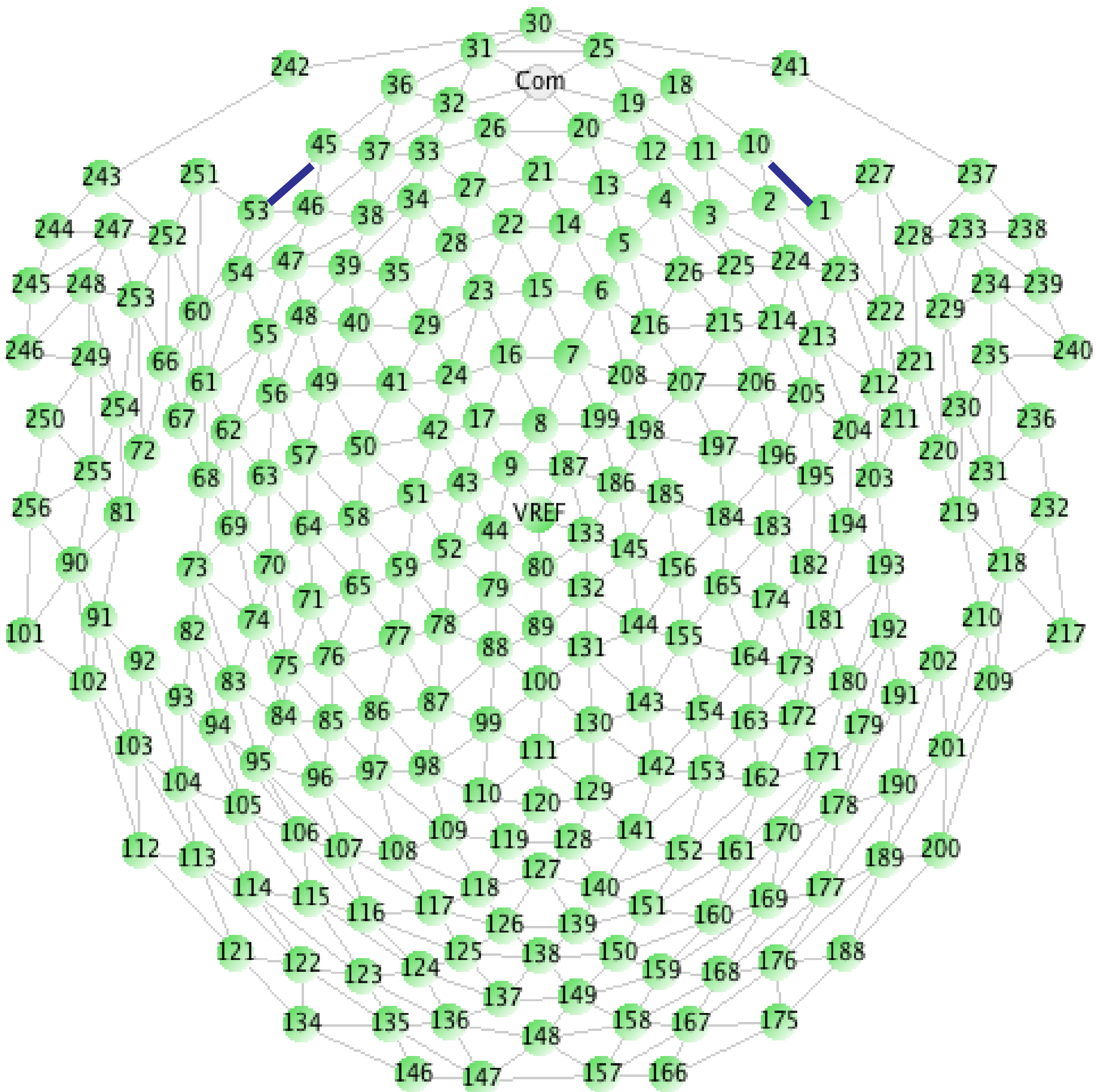



**Figure B-7.** 256-channel GSN 200 v.2.1

appendix C

# GSN PINOUTS

Electrical connections between system components are achieved with cables and connectors. This appendix is a technical reference containing the pinouts for the system connectors.

## Terminology

When one *connector* is plugged into another, the metal parts that establish electrical continuity between the connectors are called *contacts*. A connector that has only male contacts is called a *plug*; one with only female contacts is a *socket* or *receptacle*. Strictly speaking, a *pin* is a male contact, but for ease of communication the term *pinout* is used to denote a scheme for naming the contacts of a connector, whether it is a plug or a receptacle.

## Abbreviations

- GND = earth ground
- COM = isolated common
- REF = reference
- AMP = amplifier
- GSN = Geodesic Sensor Net

*Note: The 32-channel HCGSN for the GES 120 and 140 contains no separate reference sensor because it is designed to interface with the Neurotravel amplifier. In this Net model, the average signal on channels 1 and 2 (also known as Fp1 and Fp2) form the reference.*

# Pinout Schematics

Figure C-1 provides a schematic view of the connectors in 32-, 64-, 128-, and 256-channel Geodesic Sensor Nets. Note that the large pin in the middle occupies much space, causing the pinout-numbering scheme to skip rows 8–12 in the 128-channel GSN and rows 16–20 in the 256-channel GSN.

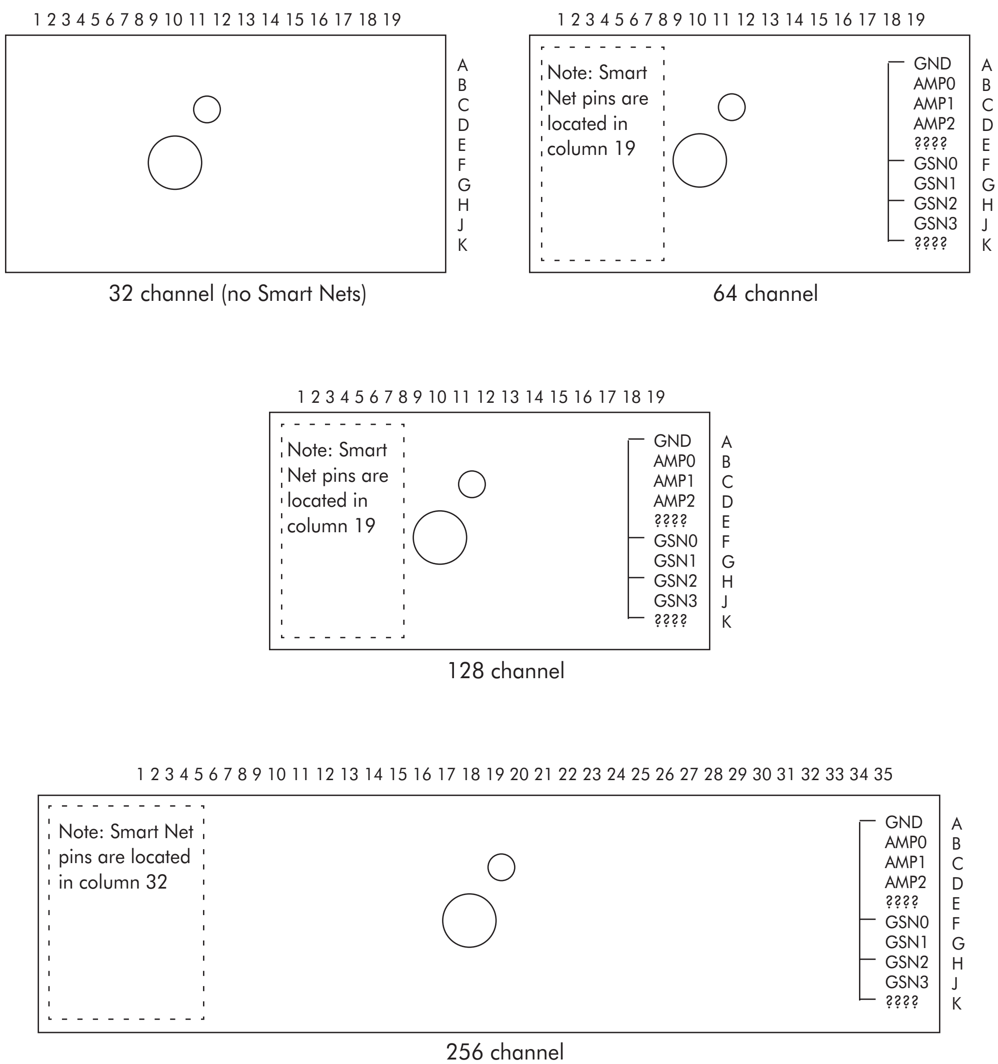



**Figure C-1.** Schematic view of GSN connectors

# Pinout Tables

Listed in Table C-1 are the pinout schemes contained in this appendix.

**Table C-1. Pinout tables**

| Table | Pinout | Comment |
|---|---|---|
| Table C-2 | Sensor to 32-, 64-, and 128-pin plug | Sensor number to Hypertronics pin number |
| Table C-3 | Sensor to 256-pin plug | Sensor number to Hypertronics pin number |

**Table C-2. Sensor to 32-, 64-, and 128-pin plug**


*Note: In the following table, sensors 65–128 and their corresponding pin numbers apply **only** to the 128-channel Net. These sensors/pins are absent in the case of the 64-channel Net. For the 32-channel Net, sensors 33–128 and their corresponding pin numbers are absent.*

| Sensors 1–10 | Pin | Sensors 11–20 | Pin | Sensors 21–30 | Pin | Sensors 31–40 | Pin |
|---|---|---|---|---|---|---|---|
| 1 | 1A | 11 | 2A | 21 | 3A | 31 | 4A |
| 2 | 1B | 12 | 2B | 22 | 3B | 32 | 4B |
| 3 | 1C | 13 | 2C | 23 | 3C | 33 | 4C |
| 4 | 1D | 14 | 2D | 24 | 3D | 34 | 4D |
| 5 | 1E | 15 | 2E | 25 | 3E | 35 | 4E |
| 6 | 1F | 16 | 2F | 26 | 3F | 36 | 4F |
| 7 | 1G | 17 | 2G | 27 | 3G | 37 | 4G |
| 8 | 1H | 18 | 2H | 28 | 3H | 38 | 4H |
| 9 | 1I | 19 | 2J | 29 | 3J | 39 | 4J |
| 10 | 1J | 20 | 2K | 30 | 3K | 40 | 4K |

**Table C-2. Sensor to 32-, 64-, and 128-pin plug**

| Sensors 41–50 | Pin | Sensors 51–60 | Pin | Sensors 61–70 | Pin | Sensors 71–80 | Pin |
|---|---|---|---|---|---|---|---|
| 41 | 5A | 51 | 6A | 61 | 7A | 71 | 13A |
| 42 | 5B | 52 | 6B | 62 | 7B | 72 | 13B |
| 43 | 5C | 53 | 6C | 63 | 7C | 73 | 13C |
| 44 | 5D | 54 | 6D | 64 | 7D | 74 | 13D |
| 45 | 5E | 55 | 6E | 65 | 7E | 75 | 13E |
| 46 | 5F | 56 | 6F | 66 | 7F | 76 | 13F |
| 47 | 5G | 57 | 6G | 67 | 7G | 77 | 13G |
| 48 | 5H | 58 | 6H | 68 | 7H | 78 | 13H |
| 49 | 5J | 59 | 6J | 69 | 7J | 79 | 13J |
| 50 | 5K | 60 | 6K | 70 | 7K | 80 | 13K |

| Sensors 81–90 | Pin | Sensors 91–100 | Pin | Sensors 101–110 | Pin | Sensors 111–120 | Pin |
|---|---|---|---|---|---|---|---|
| 81 | 14A | 91 | 15A | 101 | 16A | 111 | 17A |
| 82 | 14B | 92 | 15B | 102 | 16B | 112 | 17B |
| 83 | 14C | 93 | 15C | 103 | 16C | 113 | 17C |
| 84 | 14D | 94 | 15D | 104 | 16D | 114 | 17D |
| 85 | 14E | 95 | 15E | 105 | 16E | 115 | 17E |
| 86 | 14F | 96 | 15F | 106 | 16F | 116 | 17F |
| 87 | 14G | 97 | 15G | 107 | 16G | 117 | 17G |
| 88 | 14H | 98 | 15H | 108 | 16H | 118 | 17H |
| 89 | 14J | 99 | 15J | 109 | 16J | 119 | 17J |
| 90 | 14K | 100 | 15K | 110 | 16K | 120 | 17K |

| Sensors 121–COM | Pin | Sensors GND–???? | Pin |
|---|---|---|---|
| 121 | 18A | GND | 19A |
| 122 | 18B | AMP0 | 19B |
| 123 | 18C | AMP1 | 19C |
| 124 | 18D | AMP2 | 19D |
| 125 | 18E | ???? | 19E |
| 126 | 18F | GSN0 | 19F |
| 127 | 18G | GSN1 | 19G |
| 128 | 18H | GSN2 | 19H |
| REF | 18J | GSN3 | 19J |
| COM | 18K | ???? | 19K |

*Note: The pin-numbering scheme jumps from 7 to 13 because rows 8–12 are occupied by the pin (see Figure C-1). Also, 32-channel Nets do not contain row 19.*

**Table C-3. Sensor to 256-pin plug**

256-channel GSN

| Sensors 1–10 | Pin | Sensors 11–20 | Pin | Sensors 21–30 | Pin | Sensors 31–40 | Pin |
|---|---|---|---|---|---|---|---|
| 1 | 1A | 11 | 2A | 21 | 3A | 31 | 4A |
| 2 | 1B | 12 | 2B | 22 | 3B | 32 | 4B |
| 3 | 1C | 13 | 2C | 23 | 3C | 33 | 4C |
| 4 | 1D | 14 | 2D | 24 | 3D | 34 | 4D |
| 5 | 1E | 15 | 2E | 25 | 3E | 35 | 4E |
| 6 | 1F | 16 | 2F | 26 | 3F | 36 | 4F |
| 7 | 1G | 17 | 2G | 27 | 3G | 37 | 4G |
| 8 | 1H | 18 | 2H | 28 | 3H | 38 | 4H |
| 9 | 1J | 19 | 2J | 29 | 3J | 39 | 4J |
| 10 | 1K | 20 | 2K | 30 | 3K | 40 | 4K |

| Sensors 41–50 | Pin | Sensors 51–60 | Pin | Sensors 61–70 | Pin | Sensors 71–80 | Pin |
|---|---|---|---|---|---|---|---|
| 41 | 5A | 51 | 6A | 61 | 7A | 71 | 8A |
| 42 | 5B | 52 | 6B | 62 | 7B | 72 | 8B |
| 43 | 5C | 53 | 6C | 63 | 7C | 73 | 8C |
| 44 | 5D | 54 | 6D | 64 | 7D | 74 | 8D |
| 45 | 5E | 55 | 6E | 65 | 7E | 75 | 8E |
| 46 | 5F | 56 | 6F | 66 | 7F | 76 | 8F |
| 47 | 5G | 57 | 6G | 67 | 7G | 77 | 8G |
| 48 | 5H | 58 | 6H | 68 | 7H | 78 | 8H |
| 49 | 5J | 59 | 6J | 69 | 7J | 79 | 8J |
| 50 | 5K | 60 | 6K | 70 | 7K | 80 | 8K |

**Table D-3. Sensor to 256-pin plug**

| Sensors 81–90 | Pin | Sensors 91–100 | Pin | Sensors 101–110 | Pin | Sensors 111–120 | Pin |
|---|---|---|---|---|---|---|---|
| 81 | 9A | 91 | 10A | 101 | 11A | 111 | 12A |
| 82 | 9B | 92 | 10B | 102 | 11B | 112 | 12B |
| 83 | 9C | 93 | 10C | 103 | 11C | 113 | 12C |
| 84 | 9D | 94 | 10D | 104 | 11D | 114 | 12D |
| 85 | 9E | 95 | 10E | 105 | 11E | 115 | 12E |
| 86 | 9F | 96 | 10F | 106 | 11F | 116 | 12F |
| 87 | 9G | 97 | 10G | 107 | 11G | 117 | 12G |
| 88 | 9H | 98 | 10H | 108 | 11H | 118 | 12H |
| 89 | 9J | 99 | 10J | 109 | 11J | 119 | 12J |
| 90 | 9K | 100 | 10K | 110 | 11K | 120 | 12K |

| Sensors 121–130 | Pin | Sensors 131–140 | Pin | Sensors 141–150 | Pin | Sensors 151–160 | Pin |
|---|---|---|---|---|---|---|---|
| 121 | 13A | 131 | 14A | 141 | 15A | 151 | 21A |
| 122 | 13B | 132 | 14B | 142 | 15B | 152 | 21B |
| 123 | 13C | 133 | 14C | 143 | 15C | 153 | 21C |
| 124 | 13D | 134 | 14D | 144 | 15D | 154 | 21D |
| 125 | 13E | 135 | 14E | 145 | 15E | 155 | 21E |
| 126 | 13F | 136 | 14F | 146 | 15F | 156 | 21F |
| 127 | 13G | 137 | 14G | 147 | 15G | 157 | 21G |
| 128 | 13H | 138 | 14H | 148 | 15H | 158 | 21H |
| 129 | 13J | 139 | 14J | 149 | 15J | 159 | 21J |
| 130 | 13K | 140 | 14K | 150 | 15K | 160 | 21K |

| Sensors 161–170 | Pin | Sensors 171–180 | Pin | Sensors 181–190 | Pin | Sensors 191–200 | Pin |
|---|---|---|---|---|---|---|---|
| 161 | 22A | 171 | 23A | 181 | 24A | 191 | 25A |
| 162 | 22B | 172 | 23B | 182 | 24B | 192 | 25B |
| 163 | 22C | 173 | 23C | 183 | 24C | 193 | 25C |
| 164 | 22D | 174 | 23D | 184 | 24D | 194 | 25D |
| 165 | 22E | 175 | 23E | 185 | 24E | 195 | 25E |
| 166 | 22F | 176 | 23F | 186 | 24F | 196 | 25F |
| 167 | 22G | 177 | 23G | 187 | 24G | 197 | 25G |
| 168 | 22H | 178 | 23H | 188 | 24H | 198 | 25H |
| 169 | 22J | 179 | 23J | 189 | 24J | 199 | 25J |
| 170 | 22K | 180 | 23K | 190 | 24K | 200 | 25K |

**Table D-3. Sensor to 256-pin plug**

| Sensors 201–210 | Pin | Sensors 211–220 | Pin | Sensors 221–230 | Pin | Sensors 231–240 | Pin |
|---|---|---|---|---|---|---|---|
| 201 | 26A | 211 | 27A | 221 | 28A | 231 | 29A |
| 202 | 26B | 212 | 27B | 222 | 28B | 232 | 29B |
| 203 | 26C | 213 | 27C | 223 | 28C | 233 | 29C |
| 204 | 26D | 214 | 27D | 224 | 28D | 234 | 29D |
| 205 | 26E | 215 | 27E | 225 | 28E | 235 | 29E |
| 206 | 26F | 216 | 27F | 226 | 28F | 236 | 29F |
| 207 | 26G | 217 | 27G | 227 | 28G | 237 | 29G |
| 208 | 26H | 218 | 27H | 228 | 28H | 238 | 29H |
| 209 | 26J | 219 | 27J | 229 | 28J | 239 | 29J |
| 210 | 26K | 220 | 27K | 230 | 28K | 240 | 29K |

| Sensors 241–250 | Pin | Sensors 251–COM | Pin | Sensors GND–???? | Pin |
|---|---|---|---|---|---|
| 241 | 30A | 251 | 31A | GND | 32A |
| 242 | 30B | 252 | 31B | AMP0 | |
| 243 | 30C | 253 | 31C | AMP1 | |
| 244 | 30D | 254 | 31D | AMP2 | |
| 245 | 30E | 255 | 31E | ???? | |
| 246 | 30F | 256 | 31F | GSN0 | 32F |
| 247 | 30G | | | GSN1 | 32G |
| 248 | 30H | | | GSN2 | 32H |
| 249 | 30J | REF | 31J | GSN3 | 32J |
| 250 | 30K | COM | 31K | ???? | 32K |

*Note: The pin-numbering scheme jumps from 15 to 21 because rows 16–20 are occupied by the pin (see Figure C-1).*

# GLOSSARY

## A

***Ag/AgCl*** See *silver/silver chloride*.

***amp/amperage*** A measure of the amount of current, or number of electrons, moving across a point.

***amplifier*** A circuit that increases the voltage, current, or power of a signal.

***artifact*** An inaccurate observation, effect, or result, especially one resulting from the technology used in scientific investigation or from experimental error.

## C

***cable*** A group of two or more insulated wires.

***channel*** Each sensor of the Geodesic Sensor Net is cabled into the amplifier where its signal is converted into a stream of digital values. Each of these streams is the data of a channel.

***CMR*** See *common mode rejection*.

***common*** An electrical point that functions in much the same way that an earth ground does, but is separated from earth ground by an isolation barrier (typically thousands of volts of isolation) in the interest of safety.

***common mode rejection*** A measure of the attenuation of noise induced in the signal or reference lines relative to common. The ratio is typically expressed in *decibels*.

***conductivity*** A measure of the tendency of a material to transmit electrons; the reciprocal of *impedance*.

***connector*** Any plug and socket that links two devices together.

***contact*** Current carrying part of a switch, relay or connector.

***current*** Measured in amperes, this is the flow of electrons through a conductor. Also know as electron flow.

## D

***dB*** See *decibel*.

***decibel*** A logarithmic measure of the ratio between two values. For electrical signals, the measure is $-20 \log_{10}(A_0/A_1)$. A ratio of 1/1,000, for example, corresponds to –60 dB.

***dense (sensor) array*** Any (sensor) system that supports a sufficient number of sensors to spatially sample a phenomenon adequately. For EEG recording, this generally means 64 channels or more.

***disinfection*** The process of removing most microbes from a material (compare with *sterilization*). The actual effectiveness of disinfection varies with the disinfection materials, thoroughness of the procedure, and susceptibility of the microbes to the disinfection protocol.

***drift*** The change in a signal's offset over time, or the amount by which a signal's offset changes with time.

## E

***EEG*** See *electroencephalography*.

***elastomer*** Any of various polymers having the elastic properties of natural rubber.

***electrical field*** A field or force that exists in the space between two different potentials or voltages. Also known as an ***electrostatic field.***

***electroencephalography*** science of recording and analyzing the electrical activity of the brain.

***electrolyte*** Electrically conducting liquid (wet) or paste (dry).

***electrostatic discharge*** The transfer of an electrostatic charge between bodies at different electrostatic potentials (voltages), caused by direct contact or induced by an electrostatic field.

***ERP*** See *event-related potential*.

***ESD*** See *electrostatic discharge*.

***event-related potential*** An EEG waveform elicited by a stimulus such as an auditory or visual event.

***extraorbital*** To the side of the eye socket.

## F

***Faraday cage*** A grounded enclosure made of conductive material. Instrumentation positioned inside such a cage will acquire some immunity to signals such as line noise that originates outside the cage.

***Finder*** On Macintosh computers, the Finder is the program that keeps track of files and folders and displays the desktop (the working area on the screen with disk icons, a Trash icon, and so on).

***foramen*** An aperture or perforation through a bone or a membranous structure.

## G

***geodesic*** The shortest distance between two points on the surface of a sphere. The Geodesic Sensor Net is a structure of elastomer lines in the approximation of a geodesic.

***Geodesic Sensor Net*** Electrical Geodesics Inc.'s dense sensor array.

***glabella*** The part of the frontal bone between the eyebrows.

***ground*** A large conducting body (e.g., as the earth) used as a common return for an electric circuit and as an arbitrary zero of potential.

***GSN*** See *Geodesic Sensor Net*.

***GSNIC*** Geodesic Sensor Net interface cable. See *interface cable*.

# H

***HydroCel CleanLeads®*** The HCGSN electrode leads, which feature a Teflon-core coaxial design to minimize noise.

***HydroCel Electrolyte Delivery Systems®*** EGI's family of electrolyte solutions, which include HydroCel Saline, HydroCel ES, and HydroCel HS.

***HydroCel ES*** EGI's glycerol-based electrolyte solution for 8-hour recordings with an HCGSN with sponge inserts.

***HydroCel Geodesic Sensor Net®*** EGI's third-generation of Geodesic Sensor Net, featuring die-cut geodesic structure, carbon-fiber electrodes with HydroCel CleanLeads® technology to minimize noise, low-profile design, and HydroCel Hydrating Skin Interface Chamber®. Often referred to as *HCGSN*.

***HydroCel HS*** EGI's hydrogel-based electrolyte solution for 12-hour recordings with an HCGSN without sponge inserts.

***HydroCel Hydrating Skin Interface Chamber®*** Proprietary pedestal design featuring a chamber with a soft, flexible plastic foot. This creates a sealed micro-environment for hydrating the skin and interfacing it with the electrode surface.

***HydroCel Saline*** EGI's classic potassium chloride saline electrolyte solution for 2-hour recordings with a GSN or an HCGSN with sponge inserts.

# I

***icosahedra*** A polyhedron having 20 faces.

***impedance*** The alternating current equivalent of resistance, impedance is the measurement of the resistance to the flow of electricity for a particular substance. Electrode/scalp impedances affect waveform susceptibility to environmental noise.

***infraorbital*** Below or beneath the eye socket.

***inion*** Protuberance on the midline of the occipital bone at the base of the skull, below which the skull curves inward to the *foramen magnum* (the opening through which the spinal cord enters the brain).

***interface cable*** The cable connecting the Geodesic Sensor Net to the amplifier. The interface cable connectors are Hypertronics connectors. This cable is also known as the *Geodesic Sensor Net interface cable (GSNIC*).

***isolated common*** See *common*.

***isolation mode rejection*** A measure of the attenuation of ambient electrical noise common to all electrodes and common in relation to mains supply ground.

## J

***jack*** Socket or connector into which a plug may be inserted.

## M

***mastoid*** A bony outcropping of the skull located behind each ear.

***montage*** One of several methods of combining, selecting, or arranging data from multiple sensor locations, or the result of defining one of such methods. On a given montage, a combined waveform is a derivative of the waveforms at the sensors chosen to be combined. A selection of sensors results in the display of a subset of all the sensors originally used to make a recording.

***MRI*** Magnetic resonance imaging uses computer imaging of atomic response to radio waves in a magnetic field to generate imagery of tissue.

## N

***nasion*** The point where the bridge of the nose meets the skull.

***Net Amps 200 and 300*** Electrical Geodesics Inc.'s dense-array amplifiers.

***Net Station*** Electrical Geodesics Inc.'s Mac-based data-acquisition software.

***Neurotravel amplifier*** Electrical Geodesics' 32-channel amplifier.

***Neurotravel Win*** Electrical Geodesics' PC-only clinical EEG data-acquisition software.

***noise*** Unwanted electromagnetic radiation within an electrical or mechanical system.

## O

***occipital protuberance*** The prominence on the outer surface of the occipital bone.

***offset*** With reference to waveforms, offset is a DC deviation or the amount of DC deviation from zero.

***orbital*** Relating to orbits. In the case of *orbital sensors*, this refers to sensors near the eye sockets.

## P

***plug*** A fitting used to make electrical connections.

***preauricular point*** The indentation just in front of the ear flap (pinna) where the jaw meets the skull.

## R

***receptacle*** A fitting connected to a power supply and equipped to receive a plug.

***reference*** An electrical point that is treated as zero for purposes of amplifying electrical signals. The Geodesic Sensor Net has a reference electrode located at the vertex.

## S

***sample*** When a continuous signal is measured by examining it at discrete moments in time, each measurement corresponds to a sample.

***sensor*** A device that picks up a signal being generated by something in the real world.

***sensor layout*** Descriptive information for a particular quantity and arrangement of sensors. Includes 2D and / or 3D coordinates specifying the locations of sensors, labels (names) of sensors, and connectivity. Such information is stored in a sensor layout file.

***short*** To cause a short circuit in.

***short circuit*** A low-resistance connection between two points in an electric current.

***signal*** A detectable, measurable quantity that can be expected to display periodicity or other forms of variation in time.

***silver/silver chloride*** An electrode material known for superior noise and drift characteristics.

***sintering*** The process of bonding either a metal or powder by cold pressing it into a desired shape and then heating to form a strong cohesive body.

***socket*** An opening or cavity into which something fits.

***sterilization*** The process of killing all microbes in a material. Compare with *disinfection*.

## T

***tessellate*** To cover a surface with interlocking patterns.

## V

***vertex*** The point on an EEG subject's scalp that is closest to the top of the head. In the International 10-20 system, Cz is the vertex electrode. In the Adult 128 GSN, electrode #129 is the vertex. The point on the scalp or skull located midway between the nasion and inion and centered between the periauricular points. Also the name of the Geodesic Sensor Net sensor that corresponds to this location and that contains the reference electrode.

***volt/voltage*** A measure of electrical force, or the tendency for electrons to move from one location to another. Voltages are measured with respect to a reference.

## W

***waveform*** Any graphical representation of a signal.

## Z

***zygomatic bone*** The bridging bone from the cheekbone to the skull at the ear, with the jaw hinge and the big temporalis muscle below it. Also called the *zygomatic arch*.

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