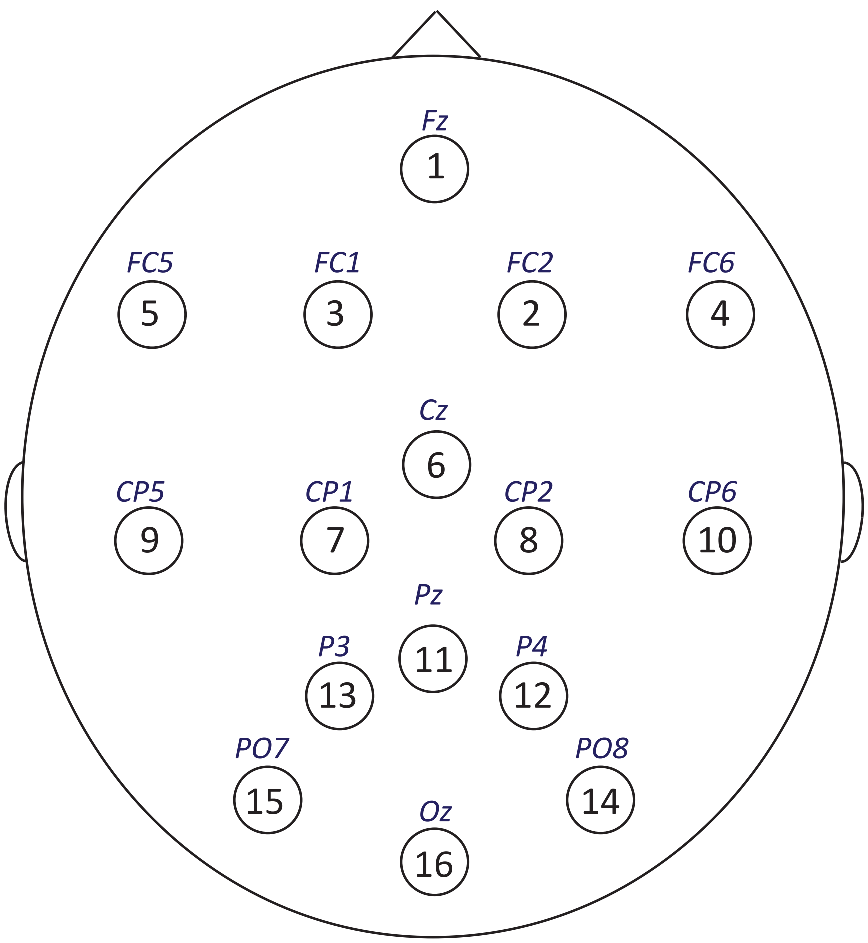
COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Lab Instruction 1
Introduction to EEG

Brain Computer Interface Lab
ECBM 4090



Some materials adapted from g.tec medical engineering (www.gtec.at).

Electrode montage

The international 10-20 electrode system and standardized electrode positions

The international 10-20 electrode system for electrode placement is a method used to describe the location of scalp electrodes. It is called the 10-20 system because the electrodes are placed at sites that are 10% or 20% of a measured length from a known landmark on the skull. Percentages are used because different individuals have different skull sizes. The 10-20 system also makes certain that electrode sites and EEG recordings are comparable across different countries.

The 10-20 system is based on the relationship between the location of an electrode and the underlying area of the cerebral cortex (Figure 1). Each point in Figure 2 indicates a possible electrode position. Each site has a letter (to identify the lobe) and a number or another letter (to identify the hemisphere location).

The letters F, T, C, P, and O stand for Frontal, Temporal, Central, Parietal, and Occipital. Even numbers (2, 4, 6, 8) refer to locations on the right hemisphere, and odd numbers (1, 3, 5, 7) refer to locations on the left hemisphere. The *z* refers to an electrode placed on the midline. The smaller the number, the closer the position is to the midline.

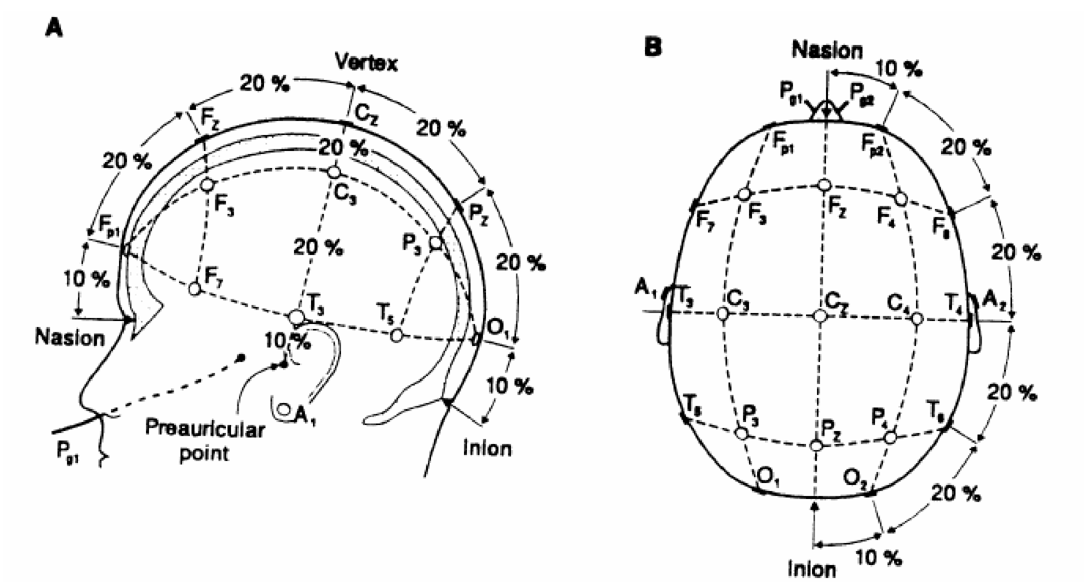


Figure 1: International 10-20 electrode system. The distances between Inion and Nasion and the left and right preauricular are the basis for the location of all electrode positions.

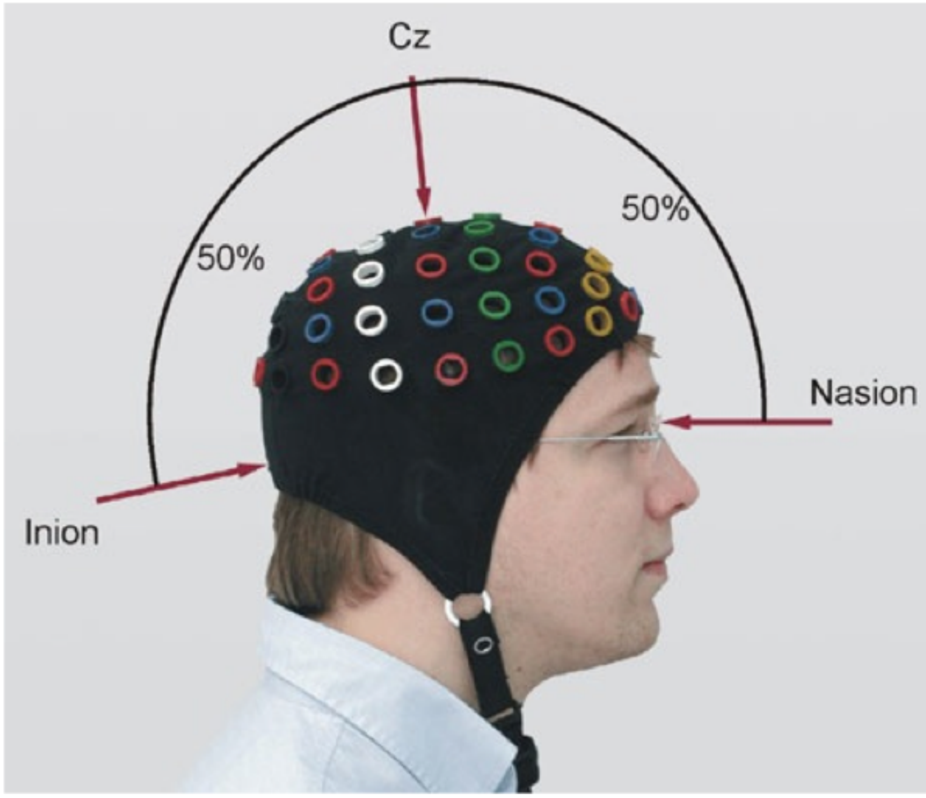


Figure 2. The Nasion and Inion reference points.

The 10-20 system uses the Nasion and the Inion as reference points. The Nasion is at top of the nose; the Inion is the bony lump at the base of the skull on the midline at the back of the head (see Figure 2). From these points, the skull perimeters are measured in the transverse and median planes. Electrode locations are determined by dividing these perimeters into 10% and 20% intervals. Instead of measuring each electrode position separately EEG caps with predefined electrode positions can be used. EEG caps are available according to the 10-20 system.

Experiment 1: Capping the subject

1. Select one subject for the EEG recordings and place the person in a comfortable chair with arm and back rests. Ask the subject to put on the cap.

2. Adjust the cap along the sagittal (front to back) plane.
   a. Measure the distance between the nasion and the inion (DNI):
      DNI = ___ cm
   b. Calculate 50% of the DNI:
      DNI50% = ___ cm
   c. Measure DNI50% beginning at the nasion along the midsagittal plane. Adjust the cap so that Cz falls at DNI50%.

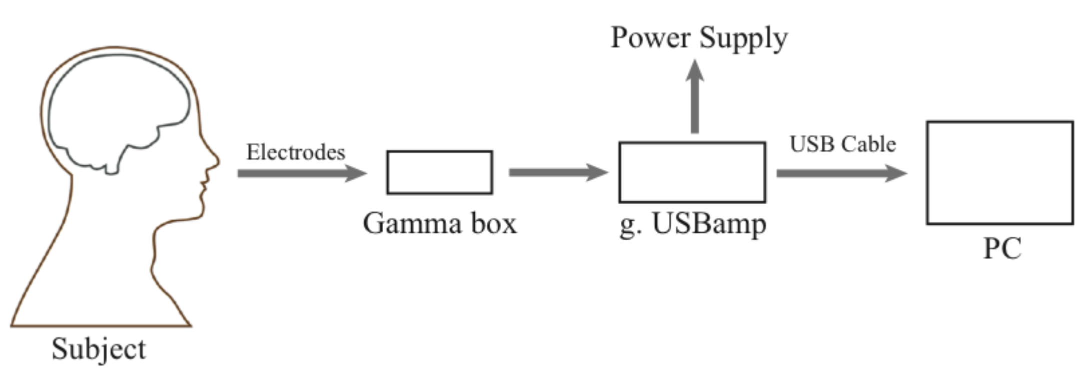
3. Adjust the cap along the axial (side to side) plane.
   a. First identify the tragus (the little triangular shaped tissue) in front of each ear. Then place your fingers in front of this tissue and ask the subject to open and close the mouth. This allows you to feel an indentation between the jawbone and the skull. Measure the ear-to-ear distance:
      EAR-EAR = ___ cm
   b. Calculate 50% of the ear-to-ear distance:
      EAR-EAR50% = ___ cm
   c. Measure EAR-EAR50% from one indentation. Adjust the cap so that Cz falls at EAR-EAR50%, without moving the cap from from DNI50%.

Report: Record your measurements and calculations. (1 pt)

Experiment 2: Build up the biosignal recording system and test the configuration

1. Set up the equipment.

   a. g.USBamp is the biosignal amplifier. Place it behind the subject so that the EEG electrodes can be easily connected to the equipment.
   b. Place the PC close to the amplifier unit. Connect g.USBamp to the PC with the USB cable.
   c. Plug both the amplifier and the PC into a power source.



d. Turn on the PC and open MATLAB.
e. Turn on g.USBamp with the switch at the back of the device. Check the power lights on the front of the amp and the power supply unit.
f. Turn on the Gammabox unit and make sure the Battery OK light is green.

2. Use g.Recorder to test the signal quality

a. Open g.Recorder on the PC.
b. Change Mode to Administrator. No password is required.
c. Go to Setting → Select Hardware → select g.USBamp.

d. Go to Setting → g.USBamp.
   i. Set the sampling rate to 256.
   ii. Select the following channels (find the corresponding numbers from the electrode map): **Fz, Cz, Pz, Oz, P3, P4, PO7, PO8**
   iii. Add Notch filter at 60Hz and bandpass 0.5-60Hz.

e. Use autoscale and zoom in until you are able to see the details of the signal.

f. Observe **and take a screenshot** of the signal during the following conditions, before applying the gel:
   i. Blinking eyes
   ii. Rolling eyes
   iii. Tensing neck muscles
   iv. Clenching jaw
   v. Closing eyes

g. Apply gel.
   i. Apply a dot of gel to the reference electrode, and clip it to the left earlobe.
   ii. On the cap, apply gel to the electrodes, beginning with the ground electrode (yellow, in the middle of the forehead).
   iii. Apply gel to selected electrodes (listed in 2d.ii).

h. Confirm the quality of your signal with the TA.

i. Observe **and take a screenshot** of the signal during the conditions in 2f after applying the gel.

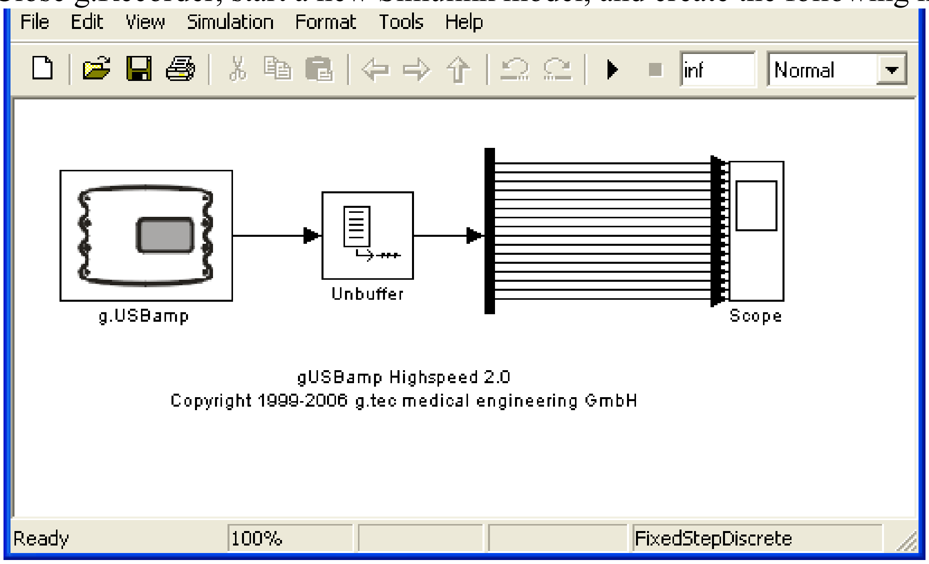
j. Observe **and take a screenshot** of the signal during the conditions in 2f with the notch filter and bandpass filter removed.

Report: Include the screenshots of the EEG signal during each of the conditions listed in 2f before and after applying gel. Describe in your lab report what you observe under each of these conditions. Also include the screenshots of each condition without the notch and the bandpass filters. Can you observe the same effects when you remove the notch and bandpass filters? (7 pts)

Experiment 3: Recording EEG signals in Simulink

1. Build the Simulink module

   a. Close g.Recorder, start a new Simulink model, and create the following module:



   You can find these blocks by searching "g.USBamp"," Unbuffer"," Demux", and "Scope" in Library Browser of Simulink.

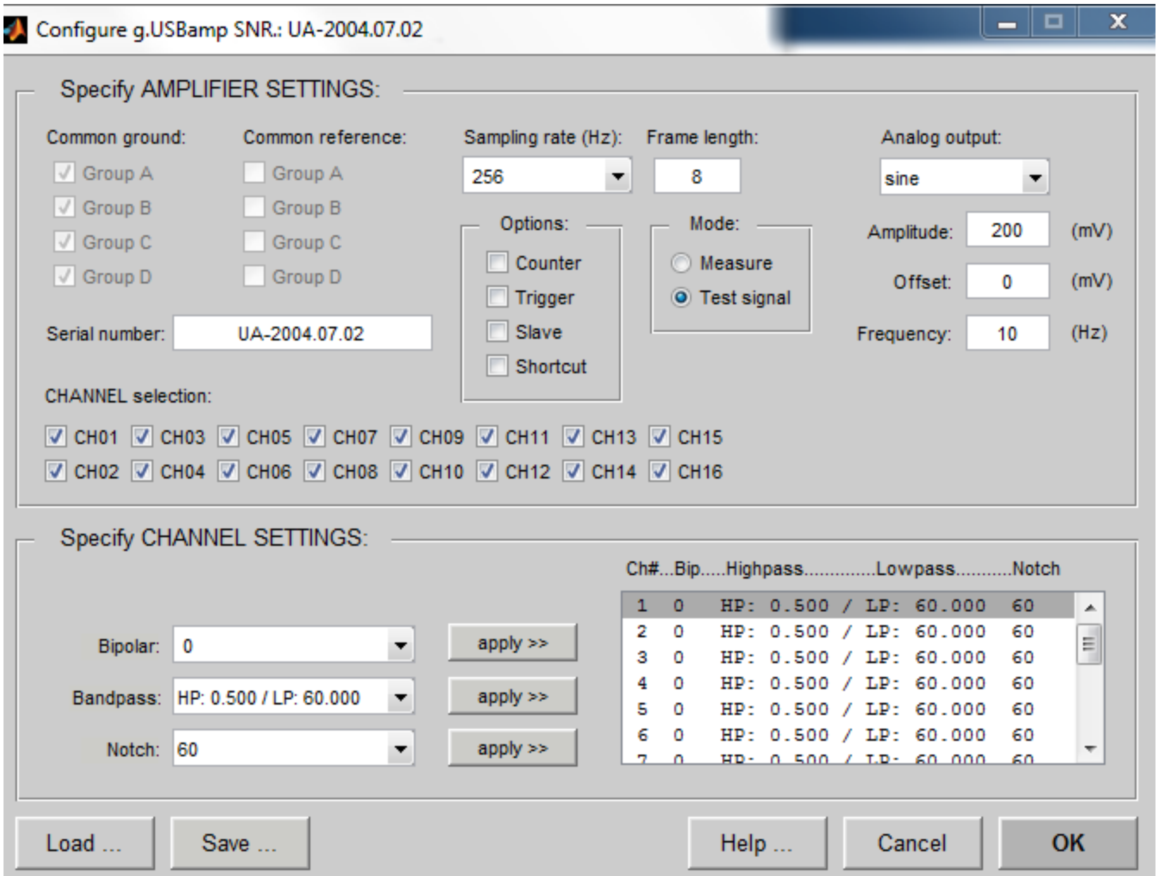
   b. Double-click on g.USBamp module to adjust settings.
      i. Select the appropriate channels (FZ, CZ, PZ, OZ, P3, P4, PO7, PO8).
      ii. Make sure the serial number matches your hardware.
      iii. Set sampling rate to 256.
      iv. For all channels, apply a Notch filter at 60Hz and Bandpass at 0.5Hz to 60Hz (select the filter and 'apply' to all channels).

2. Test your biosignal acquisition system with a sine wave (see figure on next page).

   a. In the g.USBamp module, switch **Mode** to Test signal.
   b. Under **Analog output**, select sine with an amplitude of 200 mV and a frequency of 10 Hz.
   c. Press **OK** to confirm the configuration and close the window.
   d. In the Simulink module, double-click the **Scope** block to open the visualization and press the **Start simulation** button to acquire data.
   e. Press Autoscale to show the full amplitude of the sine wave on each channel.
   f. Take a screenshot of the scope

If this example is working successfully, then the installation of the system was performed correctly.

Report: Include a screenshot of the scope in your lab report. (1 pt)



3. Use your Simulink module to record EEG data.

   a. Double click on the g.USBamp and change **Mode** to "Measure."
   b. Run the module and double click on Scope.

Report: Take a screenshot of the brain signals during the same conditions tested before (blinking eyes, rolling eyes, tensing neck muscles, clenching jaw, closing eyes--after gel and with filters only) and include in your report. (1 pt)

Troubleshooting:

Make sure that:

1. The Gammabox is on and the light is green.
2. g.USBamp is on and the light is green.
3. You didn't forget to gel the ground (yellow electrode on the forehead) and the reference (clipped to ear).
4. You do not run g.Recorder and Simulink simultaneously.