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## **#AS105b - ABR Testing For Jewett Sequence**

Whenever a sound wave is detected by the ear, it triggers a number of neuro-physiological responses along the auditory pathway. An action potential is conducted along the eighth nerve, the brainstem, and finally to the brain. About a third of a second after initial stimulation, the signal evokes a response in the area of the brain where sounds are interpreted. These response signals are so small that they are frequently masked by the "background noise" of electrical activity in the brain. This interference is random with respect to the initial stimulation. If you find an average of this interference signal, it will approach zero. However, since the evoked response is dependent on the stimulus, it should occur at the same time relative to the stimulus when the process is repeated. Therefore, if you repeat this stimulus-response process many times, the "background noise" will disappear and what will be left is the neuro-physiological response of principal interest.

This is the basis behind Averaged Brainstem Response testing. It can be used for neurodiagnostic purposes to detect lesions on the eighth nerve and brainstem and can also be used for threshold testing. The purpose of averaging is simply to enhance the target response while minimizing background noise.

There are five general response categories based on when they occur relative to the stimuli. This time lag between stimulus and response is referred to as the latency. There are Fast responses which occur anywhere between 2 and 12 msec after stimulation, SWR responses or slow wave components of the brainstem, which occur about 12 msec after stimulation, Middle responses (12 to 50 msec), Slow responses (50 to 300 msec), and Late responses (250 to 600 msec).

We are interested in the Fast responses, named after the man who discovered them, Jewett; hence the name Jewett Sequence. Responses occurring within this latency can be further subdivided into a number of waves which are assigned roman numerals. The most prominent wave (Wave V) occurs about 6 msec after stimulation. The number of waves present, as well as the amplitude and latency of each wave will vary across the life span and from normal to

pathological populations. Generally, the most common waves are peaks I, III, and V. The table below displays the average latencies for each of these waves.

Wave I	Wave II	Wave III	Wave IV	Wave V
1.69	2.81	3.82	4.47	5.62

### **Average latencies for Jewett sequence waves (in msec)**

Also, choice of stimulus can change the latency of some responses. Many different types of stimuli can be used, but they can generally be classed into clicks, tones, and white noise.

In order to detect and record your subject's auditory brainstem response with the MP100 data acquisition system, set all of the hardware and software parameters as stated below. These have proven to be optimal for ABR testing using the MP100, although many of the settings can be customized to account for individual testing preferences.

### **Equipment**

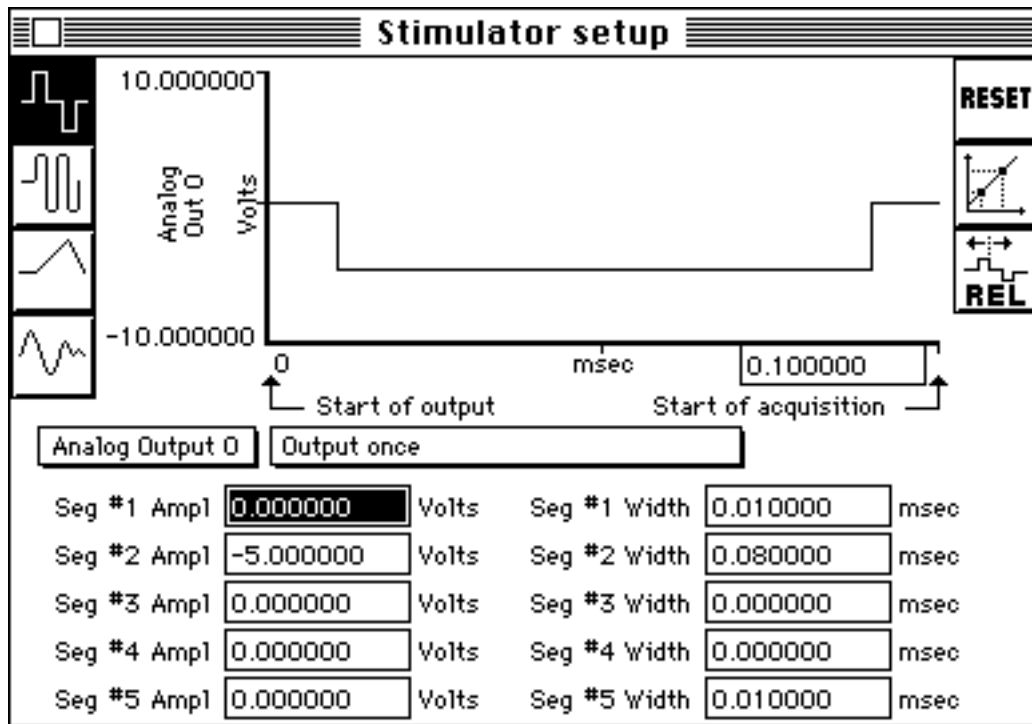
- MP100 data acquisition system
- Evoked response amplifier module (ERS100A)
- Stimulator module (STM100A)
- Tubephone (OUT101)
- Two (2) LEAD100S
- One (1) LEAD100
- Three (3) EL503 electrodes (or equivalent)

### **Hardware Setup**

- Select ERS100A module for channel 1
- ERS100A amplifier sensitivity to 5,000
- Filter OFF
- HI PASS filter set to 1Hz
- STM100 Set to OUT 0, OUT101 connected to EXT STIM on STM100
- AC/DC switch set to DC
- POS/NEG switch set to POS
- Level set to 100%

### **Software Setup**

- Under Setup Channels select channel 1 and scale it to read in "mVolts"
- Under Setup Acquisition set storage to Averaging; sample rate to 45,000 samples/second; acquisition length to 15 msec.
- In the Averaging setup dialog box, set the number of averages to 1000 and the latency to 90 msec.
- Under Setup Stimulator, set parameters as shown in the diagram below.



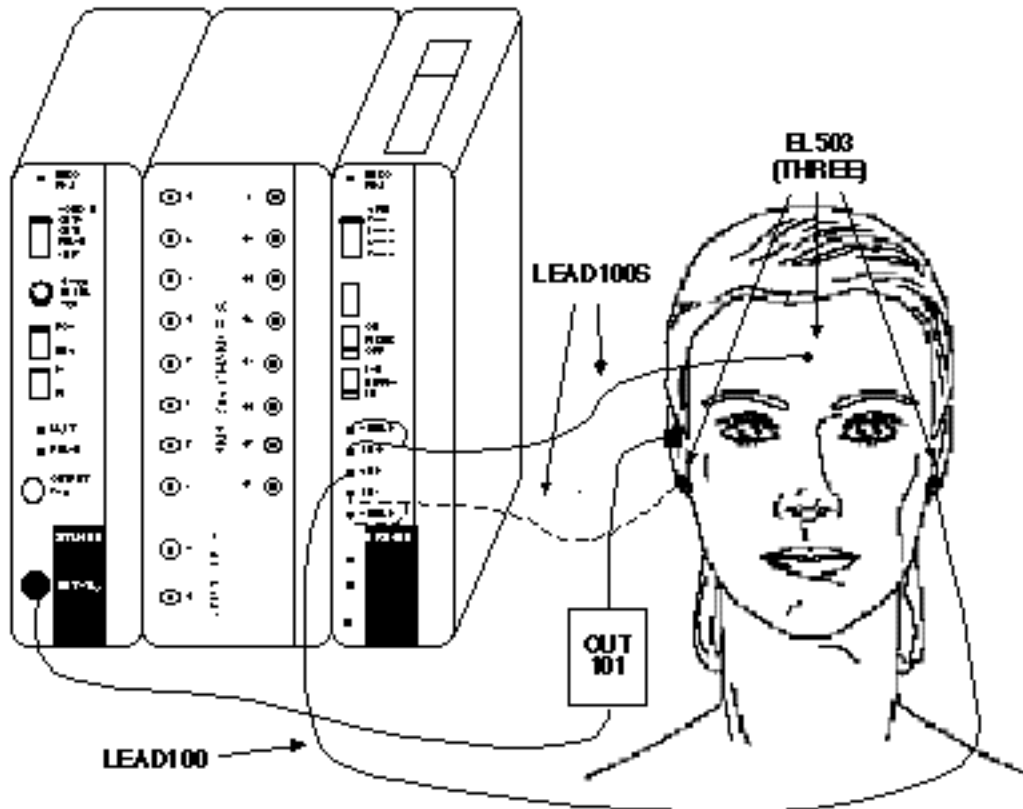
### Stimulus output set to output a 0.080 msec pulse prior to acquiring data

Connect the MP100 to the Macintosh or PC and connect the STM100 module to the UIM100. The STM100 is connected between the MP100 and the UIM100, whereas the ERS100A attaches to the free side of the UIM100 (see attached diagram). Power up the MP100 and start AcqKnowledge.

Have the subject insert a foam eartip in his/her ear and connect the OUT101 to the foam plug. The OUT101 is then connected to the EXT STIM jack on the STM100. Whichever ear the OUT101 is connected to is referred to as the ipsilateral ear, and the other ear is referred to as the contralateral ear.

The ipsilateral earlobe electrode is connected to the VIN- input on the ERS100A. The ground electrode is attached to the contralateral earlobe and is connected to the input on the ERS100A labeled GND. The VIN+ input should technically be connected to an electrode at the vertex in the top center of the

subject's head, however forehead placement is generally accepted as a more convenient alternative (see figure below). Forehead placement slightly reduces the signal of Waves IV and V. However, since wave V is already large, it is not noticeably affected. The only drawback to forehead placement of an electrode is the weak signal from Wave IV (see graph on page 4).



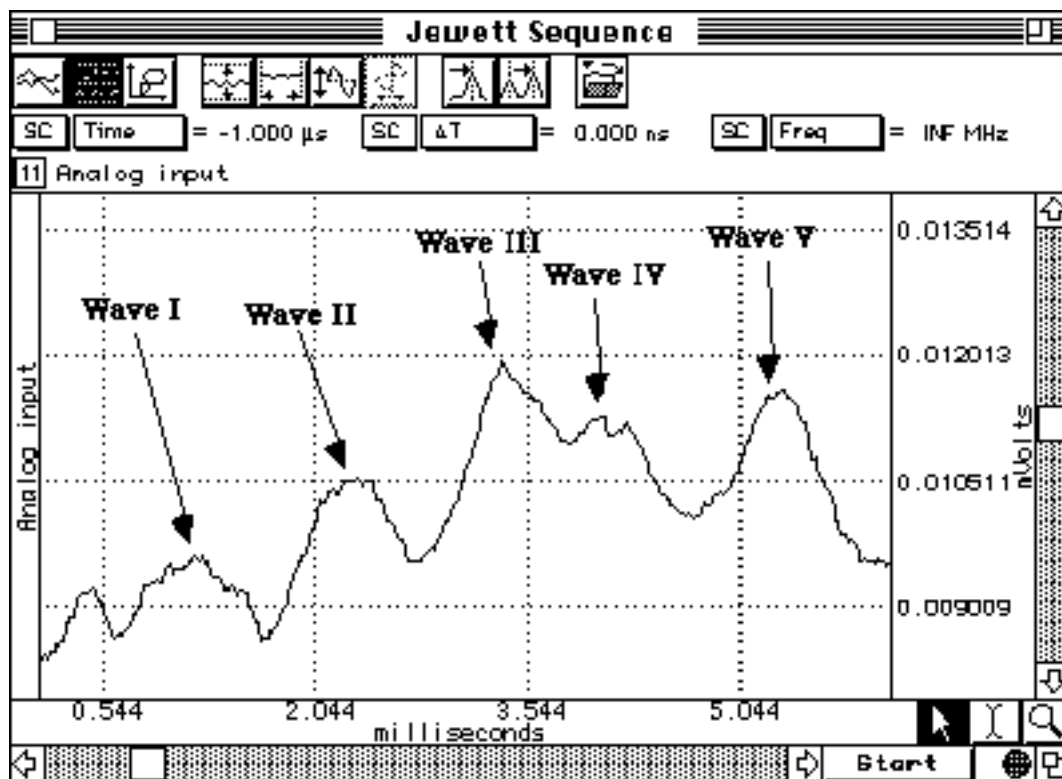
### **Detail of electrode configuration and connections to UIM100 Electrode Impedance**

One of the most important factors in ABR testing is reducing the amount of impedance between the electrode and the skin's surface. Impedance, also called resistance, is the measure of opposition to the current in a circuit. High impedance can be caused by excess dry skin, long hair, or the presence of scar tissue and has the detrimental effect of hiding or altering the acquired data. Proper skin preparation must take place so that the least amount of impedance is present and optimal skin contact is obtained. Abrasive skin prepping gel and/or Biopac's ELPAD can be rubbed on the electrode placement area to lightly abraid the skin in order to increase electrode conductivity. This gently removes dry, non-conductive skin cells which might impede the efficiency of the electrode signal. Electrode gel can then be applied to the electrode in order to further increase the conductivity. Once an acceptable electrode set-up is achieved, a check can be made to determine the resistance by hooking up pairs

of electrodes to an electrode tester. This will directly determine the resistance between the two selected electrodes. Impedance levels as low as 1 or 2 K ohm can be maintained with proper skin preparation, however 5 or 10 K ohm is acceptable.

The MP100 Stimulator will output a 0.080 msec pulse through the STM100. When the pulse is output through the OUT101, it will sound like a click.

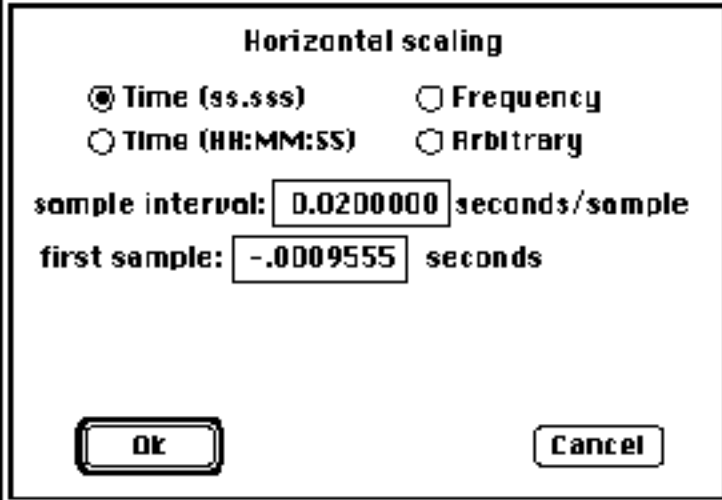
The first waveform plotted may appear somewhat random, and as each trial is acquired, the waveform will reflect the average of all previous trials. The level of background noise decreases with each trial, making the response waveforms more pronounced. Increasing the number of averages will result in a more robust pattern of responses, although it will take longer to complete the acquisition. After all of the averages are finished, you should end up with a waveform similar to the one below.



### AcqKnowledge graph with Jewett waves identified

In order to insure accurate representation of your graphical data, you will need to alter your waveform to account for several discrepancies. First of all, AcqKnowledge software has a built in feature that ignores the first two samples, which are occasionally corrupted. This is done so that remnants of the stimulus signal and its echo are not recorded in the acquisition. The time

elapsed during these two samples must be added back onto the beginning of the acquisition. In addition, there may be external hardware delays which require adjusting. Depending on the type of earphone used, a minor modification may need to be made. Some earphones, such as Biopac's OUT101, delay the stimulus signal by 1 msec and others may not delay the signal at all. This will cause the first millisecond of each acquisition to be "lost". In order to counter both of these circumstances, you will need to change the horizontal axis. Under **Display : Horizontal Axis** you will see the horizontal scaling dialog box (see diagram below).



The image shows a dialog box titled "Horizontal scaling". It contains four radio button options: "Time (ss.sss)" (selected), "Time (HH:MM:SS)", "Frequency", and "Arbitrary". Below the options are two input fields: "sample interval:" with the value "0.020000" and "seconds/sample", and "first sample:" with the value "-.0009555" and "seconds". At the bottom are "Ok" and "Cancel" buttons.

You will need to change the "first sample" so that it reflects these two variations. By default, AcqKnowledge will automatically correct for the first two samples, however for the sake of simplicity, use the following formula:

$$\text{first sample} = -(\text{delay by external earphone apparatus in msec}) + (2 / \text{sampling rate})$$

Enter this number in the "first sample" box. For example, if you are using a Biopac OUT101 and sampling at a rate of 45,000, you would enter "-.000955" seconds. By readjusting the horizontal axis, you will counter the effects of both internal and external differences in timing so that responses to the stimuli are correctly measured.

### Option #1

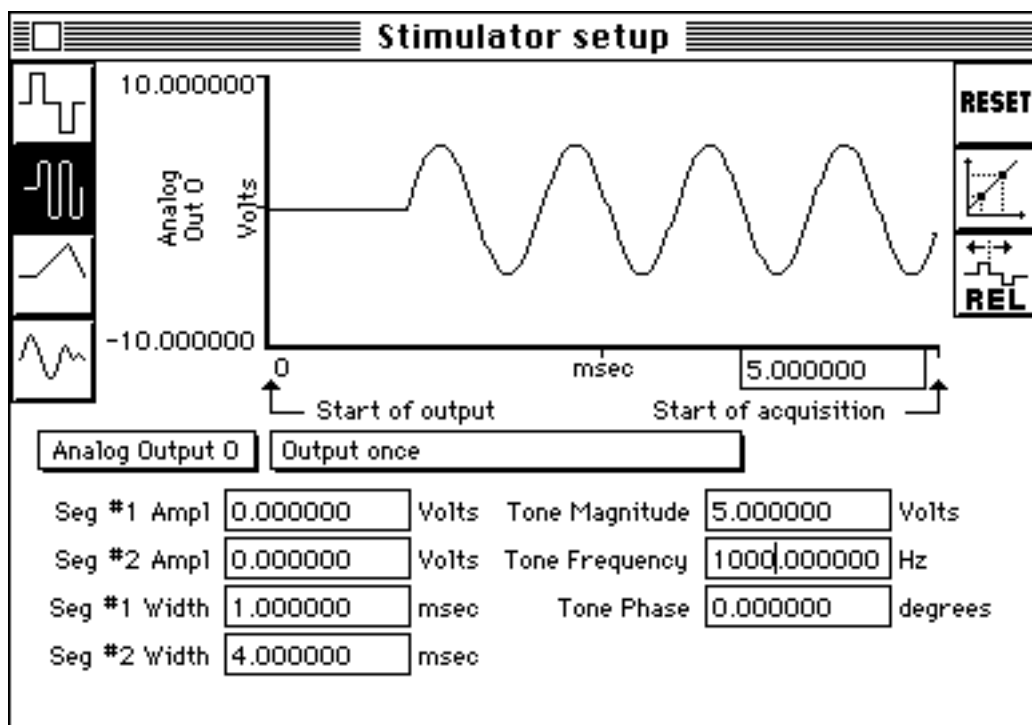
In some cases, the results of the ABR test can be dependent on the amplitude (volume) of the signal. You can control the amplitude of the stimulus signal through the Manual control dialog box (found under the MP100 menu). The

manual control option attenuates the signal output through the STM100. To attenuate the signal to a given dB value, turn the level setting on the STM100 to 100%, and choose Show manual control from the MP100 menu item. Since the signal is being output through the STM100, check the STM100 box in the upper left corner of the dialog box. This will cause a scroll box and text field to appear, allowing you to change the extent to which the signal from the STM100 is attenuated.

Since the stimulator module will limit the output signal to 128 dB, attenuating a full scale signal (one scaled to +/- 10 Volts in the scaling window) by 40 dB will result in a 88 dB signal. You can adjust the attenuation level either by moving the scroll bar or entering a value in the STM100 attenuation text box.

## Option #2

In addition to pulse signals, the stimulator setup window also allows you to output pure tones, "tone pips" and other types of waveforms through the analog output channels (out 0 or out 1). The setup stimulator dialog box changes somewhat when averaging mode is selected, and the sample dialog below illustrates how a 5 msec tone (at 1000 Hz) would be output. When averaging mode is selected, the time base of the stimulator setup window changes so that you can edit the total duration of the stimulus signal. In the example below, the total stimulus signal is 15 msec, even though the actual tone is only 5 msec.



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