

ASSR - How to use

An auditory steady-state response (ASSR) is an electrophysiological response that follows the envelope of a periodically repeated narrow band stimulus. The stimuli may consist of pure tones modulated in amplitude and/or frequency, repeated filtered clicks or repeated band-limited chirp signals.

The portion of the basilar membrane being stimulated is restricted to the stimulus frequency range, thus a frequency specific assessment of hearing is possible.

ASSR can be recorded over a wide range of stimulus rates. Different stimulus rates result in stimulation at different levels of the auditory pathway. At fast stimulus rates (> 70 Hz, so called 80-Hz-response) the response is dominated by early evoked activity from the brain stem and is therefore not affected by subject state (sleep, sedation, attention, level of arousal). So, the 80-Hz-response is mainly utilized in sedated or lightly anesthetized children/babies. At stimulus rates around 40 Hz, named as 40-Hz-response, components of the Middle Latency Response (MLR) contribute to the ASSR. Therefore the response includes activity from the higher auditory pathways in the Thalamus and the Cortex. They are mainly used in awake adults.

The narrow band stimuli allow either single frequency or multiple frequency stimulation to one or both ears simultaneously. When multiple frequencies are tested, different stimulus rates are used so that the ASSR to each frequency can be detected separately .

Recordings of ASSR are obtained differentially from electrodes placed on the scalp at locations typically used for the recording of other auditory evoked potentials (vertex, mastoid). The ASSR consists of neural activity that follows the rate of the narrow band stimulus. So the frequency of interest in the brainwaves is that corresponding to the stimulus rate.

Averaging is commonly used to extract the ASSR from other electrical activity (e.g. EEG) to increase the signal-to-noise ratio and with that enabling response detection. Unlike ABR, ASSR analysis occurs in the frequency domain rather than the time domain. Objective response detection algorithms use amplitude and/or phase of the response and its variability to determine whether a response is present or not.

Clinical Use:

The ASSR is mainly used in the audiological diagnosis. It is a powerful method to provide frequency specific estimation of the behavioural pure-tone thresholds in the entire audiometric frequency and level range.

In the following, the use of ASSR test is described in detail.

Preparation of the patient to be tested

- Advise the subject to lay as comfortable as possible to avoid muscle activity.
- Clean the skin where the electrodes will be placed.
- Place electrodes.

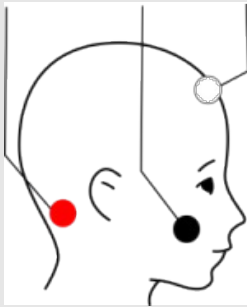


Fig. 1a: Screen pictogram

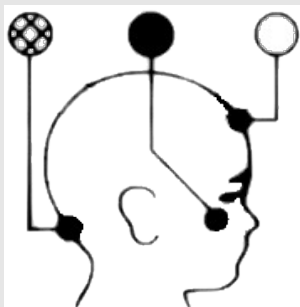


Fig. 1b: Cable pictogram

There are several possibilities to place the electrodes. The position of the electrodes affects response amplitude and phase. Best electrode position for yielding maximum wave amplitudes is vertex and ipsilateral mastoid (vertical montage). Alternatively to the vertex position, forehead position for placing the vertex electrode is possible (see Fig. 1a). However, in this case ASSR amplitude is slightly decreased. Despite this fact forehead is preferred in practice, especially in patients where vertex electrode placement is inconvenient because of hairs.

Reference electrode (black) is usually placed on the cheek.

Since Sentiero provides 1-channel recordings, optimized responses are obtained for the ipsilateral ear only. ASSR is decreased in amplitude at the ear where mastoid electrode cable is connected to the contralateral ear.

Common placement of the electrodes for audiological testing:

Red(⊗): Mastoid, **Black** (●): Cheek, **White** (○): Forehead

Alternatively, the red electrode can be placed on the nape of the neck for binaural recording (see Fig 1b).

Perform measurements



After placing the electrodes electro-acoustic transducers (headphones or insert phones) have to be fitted. Important: Please make sure that the red transducer is placed at the right ear and the blue transducer is placed at the left ear.

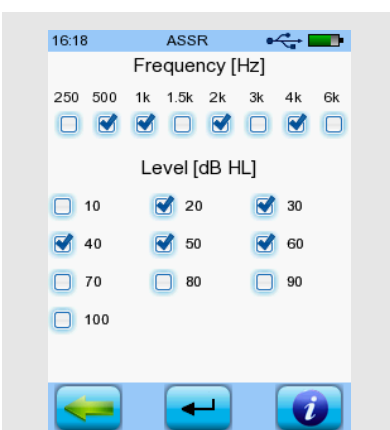
Plug the ABR cable connector in the white jack. Then connect the electrodes with the colored clips as described above (red: mastoid, white: vertex or forehead, black: cheek).



Start the measurement module by pressing “AEP” and select „ASSR“

By pressing “Right” or “Left” or „Binaural“ the test ear(s) is/are selected and the test starts.

The stimulus and recoding parameters can be edited by pressing the “settings” button. There are two settings pages. Each has to be confirmed with “enter” in order to store the settings.



Select test frequencies and stimulus levels

ASSR stimuli are constructed as the sum of cosines having fixed frequencies corresponding to whole number multiples of the stimulus repetition rate. As an example, an ASSR chirp centred at 1000 Hz with a bandwidth of one octave covers the frequency range from 750 Hz to 1250 Hz. It can be designed as the sum of seven cosines with frequencies 760, 840, 920, 1000, 1080, 1160, and 1240 Hz (see Fig 2a and 2b).

The user can select up to eight test frequencies, the bandwidth is set by the system automatically (bandwidth: 1 octave).

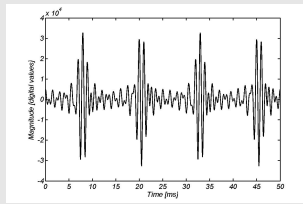


Fig. 2a Time domain

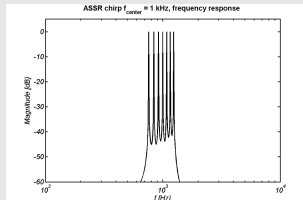
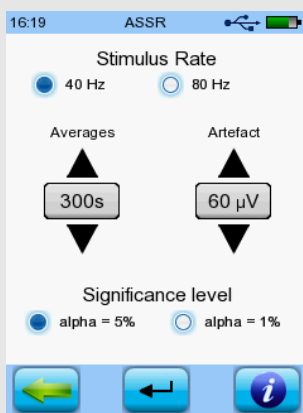


Fig. 2a Frequency domain



Stimulus levels from 10 to 100 dB can be selected. Measurement will be started at the highest stimulus level. All stimulus levels are tested. The Algorithm will proceed the measurement at the next stimulus level when significance is reached for the current measurement

Select stimulus rate, averaging time per response, artefact threshold, significance level of the detection algorithm.

Two types of ASSR are available, the 40-Hz-response and the 80-Hz-response.

In case the 40-Hz is selected the following stimulus rates are assigned to a test frequency: 38.99, 39.57, 40.23, 40.99, 41.63, 42.59, 43.28, 44.15 Hz.

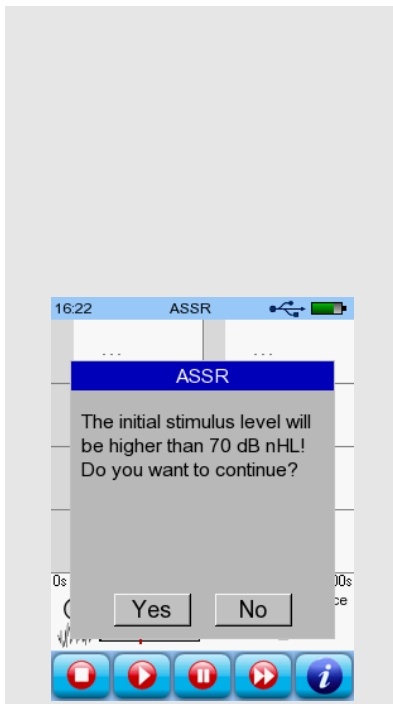
In case the 80-Hz is selected the following stimulus rates are assigned to a test frequency: 80.13, 80.94, 82.05, 83.18, 84.06, 85.25, 86.17, 87.75 Hz.

The algorithm always runs a multiple frequency protocol. Up to eight frequencies (four per ear) are tested simultaneously in case of the 80-Hz-response and up to four frequencies (two per ear) in case of the 40-Hz-response.

With increasing averaging time the probability of detecting an ASSR is increased. In quiet subjects and at good measuring conditions 300 seconds may be sufficient. If there is high muscle activity, high electrode impedance, ambient acoustical and electrical noise the averaging time has to be increased considerably, especially, at close-to-threshold stimulus levels. Please note, ASSR recording stops if a response is detected. The set averaging time is only needed if no response is present.

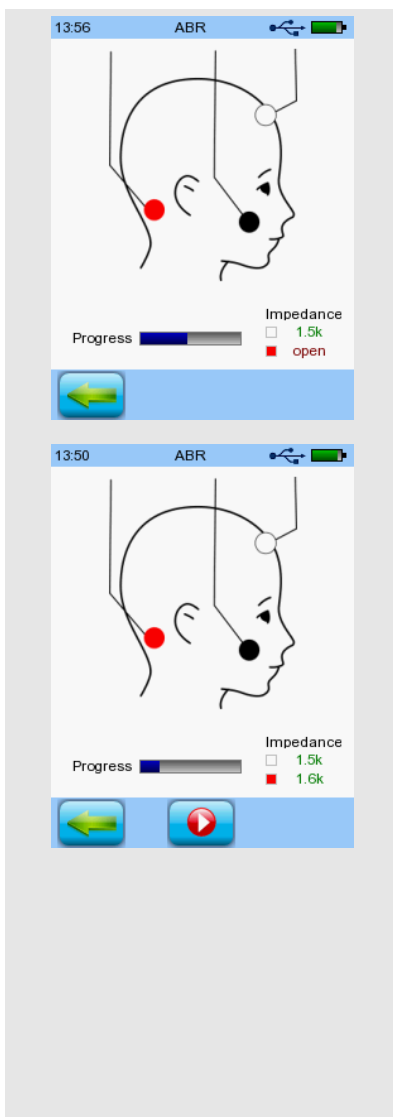
The artefact level can be selected in the range between 40 and 250 μV . Recorded signal frames with amplitudes exceeding the artefact level will be rejected. Manufacturer default value is 60 μV . Increase the artefact level if more than 5% of the collected frames are rejected. A high percentage of artefacts increase the overall recording time and degrades the performance of the response detection algorithm. If only artefact is being collected increase the artefact level and check the electrode connections.

The significance level (alpha) of the detection algorithm can be set to 5% or 1%. The criterion is used to stop the ASSR recording if the probability that the response is significant by chance is 5% or 1%, respectively. Manufacturer default value is 5%. If a more strict criterion is desired, choose the 1% significance level.



Initial stimulus levels higher than 70 dB nHL have to be confirmed prior to measurement!

Start Measurement



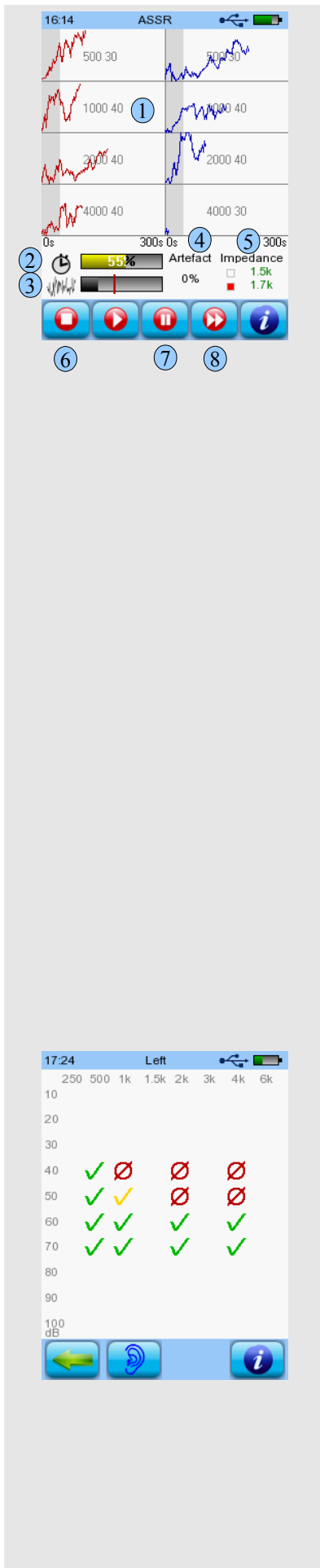
Before ASSR measurement starts electrode impedance is checked. When the impedance is within an acceptable range (below 12 k Ω) a “play” button appears in the footer. To indicate good impedances the colour of the impedance value will turn green if it is below 6 k Ω .

Please note: In neonates impedance may be higher than 6 k Ω because of tenderness of the skin. Also, unbalanced impedance affects the quality of ASSR measurements.

By pressing the “play” button ASSR measurement at the highest selected level is started.

If the “play” button is not pressed or the impedance remains too high the device stops measuring after some seconds. In this case place the electrodes again and restart the test.

The ongoing status of the ASSR recording is shown.



The red plots indicate ASSR recordings of the right ear, the blue plots of the left ear. Eight ASSR recordings are running simultaneously.

- 1) Status of an ASSR recording (at $f=1000$ Hz and $L = 40$ dB HL) Time elapsed of the detection algorithm is shown (x-axis: recording time, y-axis = response criteria). The upper boundary line indicates the significance level. The recording is stopped after
 - i. the response criterion reaches significance level for four consecutive signal frames.
 - ii. the maximum averaging time is elapsed and the response criterion did not reach significance level

The grey area indicates the minimum recording time. Recording is not stopped in case the significance level is reached within that time interval.

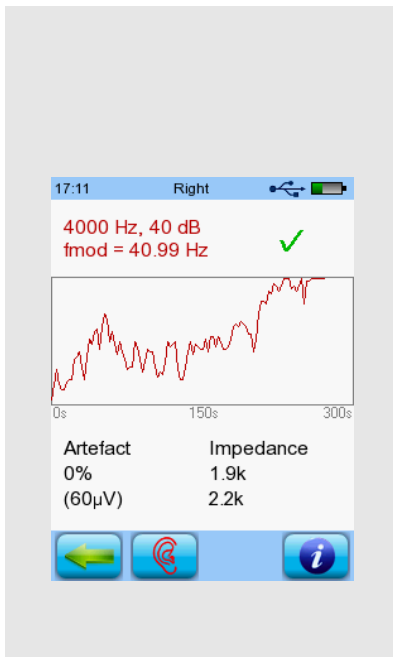
- 2) Progress bar of overall recording time
- 3) EEG background noise indication. The vertical line indicates the artefact threshold set in the settings menu.
- 4) Displays a calculation of the percentage of artefacts that have occurred since recording was initiated.
- 5) Current electrode impedances. During the measurement the electrode impedance is measured periodically.
- 6) By pressing the “stop” button the recording is stopped
- 7) By pressing the “pause” button the recording is paused. To continue press “play”.
- 8) By pressing the “skip” button single ASSR recordings can be skipped. To skip an ASSR recording press the skip button that appears in the corresponding plot.

Result view:

- ✓: ASSR test criterion significance level reached
- ✓: ASSR test criterion significance level ($\alpha = 7.5\%$) reached at the end of the maximum averaging time
- ✗: ASSR test criterion significance level not reached
- ✗: ASSR recording was skipped

By pressing the “ear” button the results of the other ear are displayed.

By pressing any of the result symbols detailed information on the corresponding ASSR recording is displayed.



Detailed result view of a single ASSR recording

The following items are shown:

- test frequency
- stimulus level
- stimulus rate
- time elapsed of the detection criterion
- percentage of artefacts with artefact threshold
- electrode impedance at the end of the recording

By pressing the “ear” button the result view of the other ear is displayed.

ASSR-case example

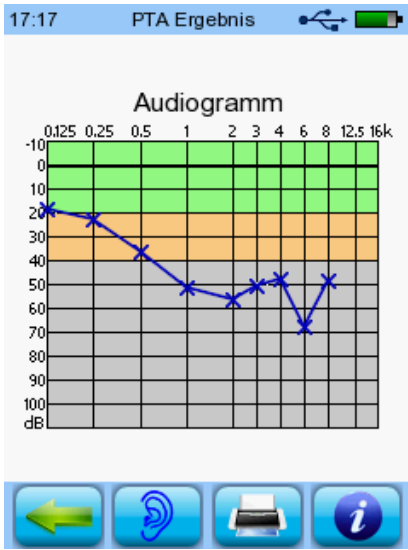
Subject with cochlear hearing loss

The pure tone audiograms of the left and right ear show a moderate pantonal hearing loss with slightly increasing hearing loss with increasing frequency.

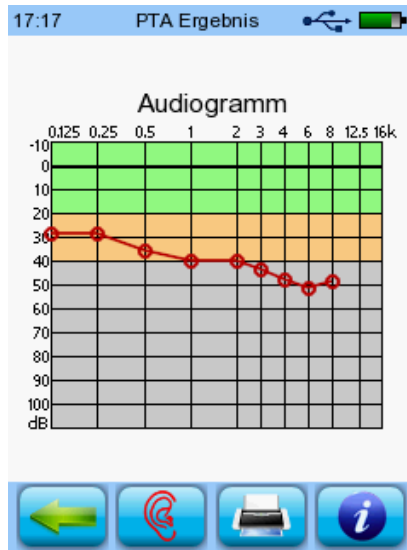
The 40-Hz-response thresholds on the left ear were 40 dB HL at 500 Hz, 60 dB HL at 1000 Hz, 50 dB HL at 2000 Hz, and 60 dB HL at 4000 Hz. Pure-tone thresholds and ASSR thresholds were closely related on both ears.

The detailed result view of the left ear at 4 kHz show increasing recording time with decreasing stimulus level. Above threshold stimulation recording time was below 120 seconds. At close-to-threshold stimulation recording time was 240 seconds. No significant response was detected after 300 seconds at stimulus level of 30 dB HL.

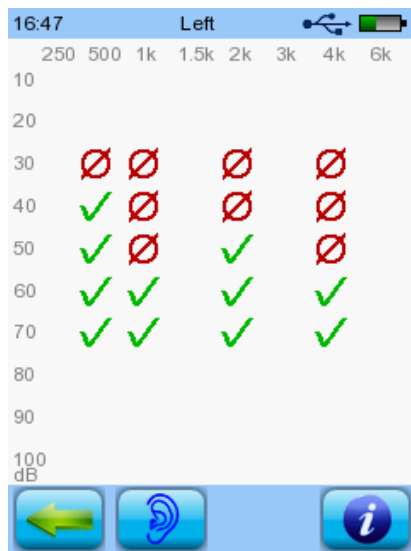
pure-tone audiogram left ear



pure tone audiogram right ear



Result view 40-Hz ASSR



Detailed result view: right ear, 4 kHz



