S14 Insert Earphones

Instructions

The S14 insert earphones are designed for use in research that required delivery of auditory stimuli to subjects while undergoing fMRI scans. They provide both high-quality acoustic stimulation and substantial attenuation of background noise, while causing very little or no disruption of the scanner image.

I. SETTING UP
The three main components of the S14 earphone system are:

1) an audio transformer,
2) a long (~9 m) cable, and
3) a short (~0.5 m) cable with the insert earphones at one end.

The schematic figure below shows these components connected in a typical configuration in which a PC delivers left (blue) and right (red) audio signals. These signals must be amplified by an audio amplifier (not included in the S14 system) before delivery to the transformer. The amplifier must be capable of delivering a few watts.
The preferred setup is to keep the transformer outside of the scanner room with connection to the long cable made via a penetration panel or an intermediate cable. The outer conductor of the BNC connectors may be grounded or floating. Be careful to maintain consistent signal polarity between left and right channels.

NOTE THAT THE BNC CONNECTORS AT THE END OF THE LONG CABLE CONTAIN MAGNETICALLY ATTRACTIVE METAL. THEY SHOULD BE KEPT A SAFE DISTANCE FROM THE SCANNER.

THE TRANSFORMER IS ALSO MAGNETICALLY ATTRACTIVE. IF IT IS TAKEN INTO THE SCANNER ROOM IT SHOULD BE KEPT A SAFE DISTANCE FROM THE SCANNER.

The short cable enables the subject to insert the earphones, and to don an additional hearing-protector muff if desired, prior to entering the scanner room where connection to the long cable can then be made. To insert each earphone, first attach a clean foam tip to the earphone. Then compress the foam tip by rolling it between thumb and forefinger and insert it into the ear canal. Hold it in the ear for about 10 sec while the foam expands.

II. SAFE PRACTICES

Please read the enclosed Guidelines for Safest Use of the S14 Earphones.

In addition to the recommendations listed in the Guidelines, you should adopt the following as routine practices when using the S14 earphones.

> Inspect all components for damage. If any signs of damage are noticed, please contact Sensimetrics before using the system (contact information given below).

> Manage cables carefully in the scanner:
  - Route the earphone cables as close as possible to the center axis of the scanner bore
  - Makes sure that the earphone cables are kept at least 10cm apart
  - Avoid loops in the cables
  - Advise subjects not to hold the cables in their hands
  - Do not disconnect the earphone cables from the long assembly

> Be familiar with the sound levels that will be delivered to subjects to ensure that they are comfortable.

> Establish a procedure by which subjects can indicate if they feel sounds are too loud.
III. ACOUSTIC PERFORMANCE
The acoustic response of the earphones has been measured on a KEMAR manikin equipped with Zwislocki couplers. In order to ensure repeatable measurements, KEMAR's pinnae were removed and the earphones with foam tips were inserted directly into the circular steel ear canals, resulting in a good acoustic seal.

A. Frequency Response and Output Level
The frequency response of the transducer used in these earphones typically has strong resonances. In addition, these responses differ slightly from earphone to earphone, resulting in undesirable phase and amplitude variations between left and right earphones. The frequency responses of the left and right S14 earphones supplied to you are shown in the upper panels on the accompanying documentation page (S14_xxxy_yyyy.pdf). The dashed lines show the responses of the transducers to a white noise stimulus. The ordinate values are given in terms of the sound pressure level in the ear canal for a 0 dBV narrowband signal measured at the input to the transformer. The inter-channel phase difference is plotted as the dashed line in the middle panel.

B. Equalization Filters
Digital equalization (EQ) filters have been custom designed to smooth the amplitude responses and to set the inter-channel phase difference to zero. The solid bold lines (red and blue lines in the upper plots and black in the phase plot) show the responses after EQ filtering. These correction filters are supplied on the product CD-ROM and can be used for pre-filtering stimuli by the EQ Filtering program provided with the S14 system.

C. Distortion
Measurements of harmonic distortion at three signal frequencies are shown in the bottom panels. Max distortion is defined as the level of the largest of the components at integer multiples of the fundamental stimulus frequency.

IV. CLEANING AND MAINTENANCE
• Use clean foam tips with each subject. Replacement tips can be ordered from http://www.complyfoampro.com/products/canal-tips-original/
• Check that there is no ear wax or other debris blocking the adapter tip of the earphone.
• Establish a quick but repeatable check for gross changes in acoustic performance.

V. CONTACT INFORMATION
Please visit the S14 website (http://www.sens.com/s14/index.htm) for updated product information and frequently-asked questions. If your question is not answered there and you need technical support, contact Sensimetrics by:

Email: tech-support@sens.com

or

Phone: (781) 399-0858 Ext. 235
Installation of EQ Filtering
Verify whether you have a 32bit or 64bit version of Windows installed on your machine. Insert the product CD into your computer's CD/DVD drive. Double-click the appropriate setup file for your version of Windows, either SetupEQF32bit.exe or SetupEQF64bit.exe and then follow the onscreen instructions.

The installation will create an EQ Filtering shortcut on your desktop and in the Windows Start menu. To run the program, double-click either of these shortcuts. Instructions for using EQ Filtering are found in the Instructions menu item of the program.

Note: If you do not already have Microsoft .net Framework 3.0 (or higher) installed on your system, the EQ Filtering installer will automatically begin the .net Framework 3.0 installer. This Microsoft installation may take a while on older systems. Please be patient and wait for it to complete. The EQ Filtering installer will resume after the .net Framework installer completes.

S14 Instructions and Custom Filters
Instructions for the use of the S14 earphones are in the file S14 Instructions.pdf on the product CD-ROM. The custom EQ filters for the earphones are in files with names of the form EQF_xxxx.mat, where xxxx is the four-character serial number found on the earphone cable. The file S14_xxxx_yyyy.pdf documents the electroacoustic responses of the earphones.

Reading PDF Files
For your convenience, Adobe Reader 9.4 (for displaying .pdf files) has been included on the CD-ROM. To install it, double-click 'setup adobe reader 9.4.exe' on the product CD-ROM.
## Guidelines for Safest Use of the S14 Earphones

Non-clinical testing has demonstrated that the Sensimetrics S14 earphones are MR Conditional. They can be used safely while scanning under the following conditions:

- Static magnetic field of 1.5 or 3 Tesla
- Normal operating mode
- Maximum whole body averaged specific absorption rate (SAR) of 0.4W/kg for 10 minutes of scanning

In non-clinical testing, the S14 earphones produced a temperature rise of less than 0.57°C at a maximum whole-body-averaged specific absorption rate (SAR) of 0.4 W/kg, as assessed by calorimetry for 10 minutes of MR scanning in a 3T Siemens Tim Trio (software version VB 15A) MR scanner.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions for safest use</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>MRI field strength</td>
<td>1.5T and 3T only</td>
<td>Field strengths above 3T use a higher transmit frequency, which may increase the coupling of RF currents on the earphone cables.</td>
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<tr>
<td>RF transmit coil</td>
<td>Body volume transmit coil</td>
<td></td>
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<tr>
<td></td>
<td>Head-only volume transmit coil</td>
<td></td>
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<tr>
<td>RF receive coil</td>
<td>Any receive coil can be used.</td>
<td></td>
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<tr>
<td>Cable positioning</td>
<td>• Cabling must be routed as close to the center axis of the scanner bore as is possible.</td>
<td>Loops in cables can increase RF coupling.</td>
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<tr>
<td></td>
<td>• Cables must not be crossed and should be kept at least 10cm apart.</td>
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<tr>
<td></td>
<td>• Avoid loops of any kind.</td>
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<tr>
<td>SAR</td>
<td>Sequence power must be restricted to less than 0.4W/kg (20% of the allowed whole body SAR under the IEC’s regulations) and 20W time-averaged power.</td>
<td>Lower sequence powers reduce the risk of heating. Therefore it is recommended that sequences should be adapted to use less power if possible. Additionally high and low power sequences can be interleaved, or pauses in scanning can be introduced, to reduce the time-averaged power.</td>
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<tr>
<td>Sequence type</td>
<td>Any sequence with power less than 20W time-averaged power and 0.4W/kg whole-body SAR may be used.</td>
<td>This limit should facilitate standard GE-EPI fMRI scans, localizer, and T₁-weighted structural scans (e.g. MDEFT or MP-RAGE). Spin echo scans are not advised as sequence power is much higher; for these scans the earphones must be removed.</td>
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