IEC-60268-7 Headphone Sequences

Introduction

IEC-60268-7: Sound System Equipment – Part 7: Headphones and Earphones is an international standard intended to characterize the performance of headphones and earphones. The standard itself is a lengthy document, 9 Sections and 3 Annexes covering 46 printed pages. These SoundCheck sequences focus on the electro-acoustic tests which are detailed in Section 8 "*Characteristics to be specified and their method of measurement".*

Five separate sequences are provided, each designed to measure specific characteristics. This approach provides the user with the flexibility to measure all or some of the characteristics of their headphone.

Hardware Requirements

To run these sequences, the following hardware is required.

- Audio Interface, 2 outputs x 4 inputs (minimum 2 out x 2 in if input switching is available*)
- Head and torso simulator (B&K HATS or similar)
- Microphone power supply (Listen SoundConnect 2 or similar)
- Microphone calibrator (B&K 4231 or similar)
- Stereo headphone amplifier (the standard specifies a source impedance of 120Ω. If a different source impedance is used, it should be noted in the test results)
- Reference microphones (pair - Listen SCM-3 or similar)
- Noise playback speakers (pair)
- Stereo power amplifier (if noise speakers are not self-powered)
- Impedance Box (pair)

* The Listen SoundConnect 2 microphone power supply can be used as an input switching device, switching between Line and microphone inputs.

Software Requirements

SoundCheck 18.0

2004 - Post processing

2005 - RTA

2009 – Statistics

Running the Sequences

It is recommended that the sequences be run directly from the IEC-60268-7 folder. The folder contains dependent files required to run the sequences.

Setup System, Hardware and Calibration

Before attempting to run any of the sequences, read the following setup instructions.

System Calibration – Add or Relink Signal Paths

There are several unique Signal Paths used in the sequences which are not a part of the default SoundCheck installation. In order to add these Signal Paths to your System Calibration or relink to existing Signal Paths, you should open each of the sequences individually and, if prompted, add or relink Paths to your System Calibration.

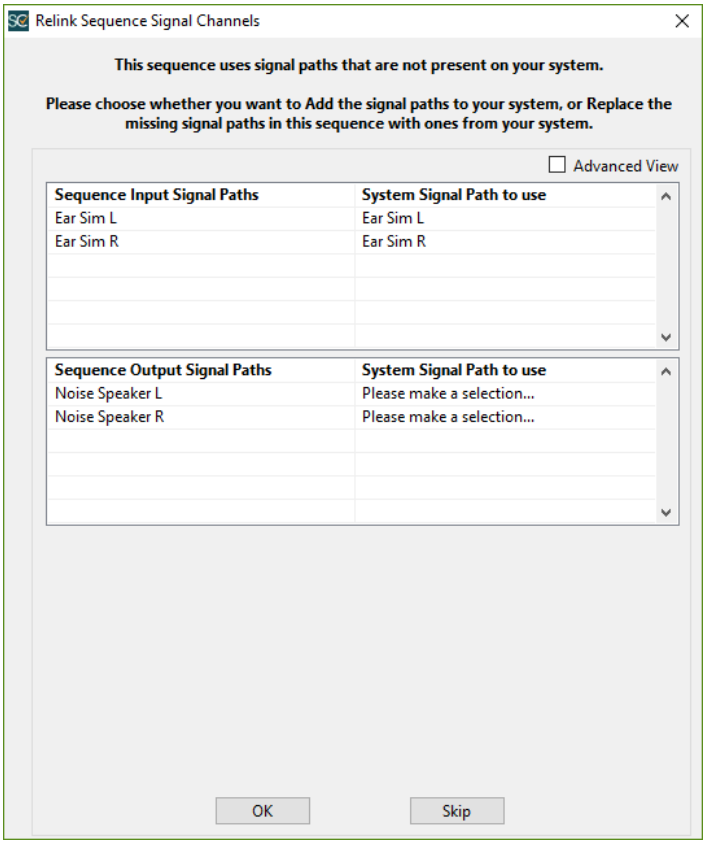

Figure 1 - Relink dialog

Here is a list of sequences and their default signal paths (unique paths are in bold):

Sequence	**Signal Paths**
SPL	Ear Sim L, Ear Sim R, Headphone Amp L, Headphone Amp R
Sensitivity	Ear Sim L, Ear Sim R, Headphone Amp L, Headphone Amp R
Response, Distortion, Impedance	Ear Sim L, Ear Sim R, Headphone Amp L, Headphone Amp R, **Impedance Box L, Impedance Box R**
Radiation and Crosstalk	Ear Sim L, Ear Sim R, Headphone Amp L, Headphone Amp R, **Reference Mic L, Reference Mic R**
Passive & Active Attenuation	Ear sim L, Ear Sim R, **Noise Speaker L, Noise Speaker R**

Figure 2 – Sequences & Signal Paths

1. In some cases, identically named signal paths may prompt a relink.

2. After relinking, you will be prompted to import the calibrated devices associated with the new signal paths. Click Yes to import.

3. You will then likely be asked if you want to overwrite the device “unity cal (Read-only) in.dat”. Click “No to all”.

4. Next, the System Calibration Editor will open, asking you to assign hardware channels to the newly created signal paths. We suggest the following channel assignments:

Inputs		**Outputs**	
Signal Path	**Hardware Channel**	**Signal Path**	**Hardware Channel**
Ear Sim L	Input 1	Headphone Amp L	Output 1
Ear Sim R	Input 2	Headphone Amp R	Output 2
Reference Mic L	Input 3	Noise Speaker L	Output 3
Reference Mic R	Input 4	Noise Speaker R	Output 4
Impedance Box L	Input 3*		
Impedance Box R	Input 4*		

Figure 3 - Suggested Signal Path/Hardware Channel Assignments

* Reference Mic and Impedance Box can share the same hardware inputs as they are not used together in the same sequence. If more than 4 input channels are available, all input signal paths may be assigned to separate hardware channels.

Setup and Calibration

Detailed setup and calibration instructions are included in the following Sequence Notes

Sequence Note Index

1. IEC-60268-7 Headphone SPL Sequence

This sequence satisfies the requirements of Section 8.5 *Sound Pressure (Level).* Using the DUT's rated voltage and impedance values, the sequence measures the left/right 500 Hz SPL at the rated voltage level and at 1 mW. It also uses a Simulated Program Source (SPS) stimulus (pink noise, 20 Hz-20 kHz, shaped according to IEC 60268-1) to measure the 1 mW SPL of the DUT's unfiltered output spectrum and the weighted (A weighting) and corrected (free field correction) output spectrum.

The sequence prompts the operator to enter the rated voltage and rated impedance of the DUT. It then calculates the voltage required to produce 1 mW into the rated impedance. Play and Record Acquisition steps then capture the L/R response of a 500 Hz tone played at the rated voltage and at 1 mW. A subsequent Play and Record step captures the L/R response of the 1 mW Simulated Program Source.

The 500 Hz recorded time waveforms are processed using heterodyne analysis to derive their fundamental values. The recorded time waveforms of the SPS response are then processed using RTA Spectrum Analysis (1/3 octave resolution) and the resulting spectra are A weighted and free field corrected. The spectra are then power summed to derive a single SPL value and the 500 Hz fundamentals are post processed to derive their SPL values.

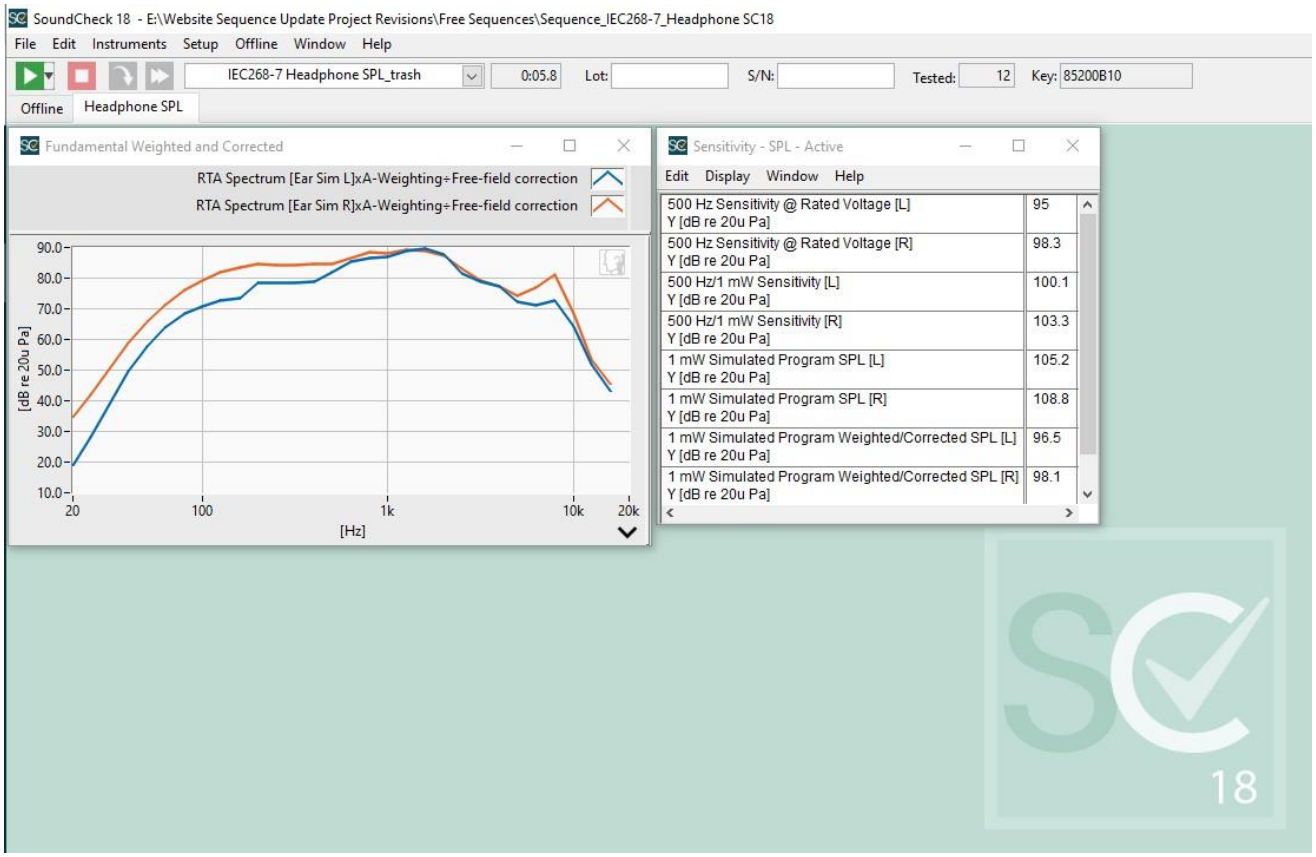

Figure 4 - Headphone SPL Sequence Final Display

Software Requirements

SoundCheck 18.0
2004 – Post processing
2005 – RTA

Hardware Requirements

Audio Interface (2 inputs/2 outputs minimum)
Head and torso simulator
Stereo headphone amplifier
Microphone power supply (2 channels)
B&K 4231 microphone calibrator

Setup & Calibration

1. Connect the HATS Ear left and right outputs to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 1 & 2 on the audio interface.

2. Calibrate the HATS Ears per the instructions in the SoundCheck manual. Use the Ear Sim L and Ear Sim R Signal Paths.

3. Connect the left and right inputs of the headphone amplifier to Hardware Outputs 1 & 2 on the audio interface.

4. Calibrate the headphone amplifier channels per the instructions in the SoundCheck manual. When calibrating, use the Headphone Amp L and Headphone Amp R signal paths.

System Diagram

Your hardware setup should look similar to the following schematic diagram:

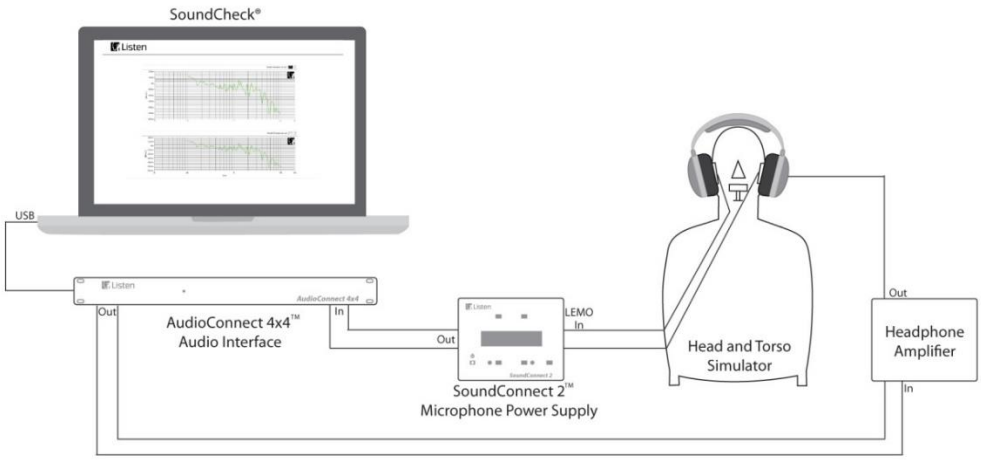

Figure 5 - Hardware setup for Headphone SPL Sequence

Sequence Logic

Type	Step Name	#	Out	In	
	(Overall sequence)				
Rec	Recall curves	1			// Recall free field correction curve
Rec	Recall curves	2			// Recall A weighting curve
Mes	Enter Test Level	3			
Mes	Enter Impedance	4			
Pos	Conversion	5			// ohm > milliohm conversion
Pos	Sq Root	6			// Calculates voltage for 1 mW stimulus level
Sti	500 Hz (V)	7	Headphone Amp L		// 500 Hz stimulus using test level
Sti	500 Hz (mW)	8	Headphone Amp L		// 500 Hz stimulus @ 1 mW
Sti	WAV	9	Headphone Amp L		// Simulated Program stimulus
Acq	Play & Record (V)	10	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	
Acq	Play & Record (mW)	11	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	
Acq	Play & Record Simulated Program Sig	12	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	
Ana	Fundamental (V)	13			
Ana	Fundamental (mW)	14			
Ana	RTA Spectrum	15			
Pos	A Weight RTA	16			// Applies A weighting to the Simulated Program spectra
Pos	FF Correct RTA	17			// Applies Free Field correction to the A weighted curves
Pos	Power sum	18			// Power sums weighted/corrected spectrum [L]
Pos	Power sum	19			// Power sums weighted/corrected spectrum [R]
Pos	Power sum	20			// Power sums Spectrum [L]
Pos	Power sum	21			// Power sums Spectrum [R]
Pos	Curve Average	22			// 500 Hz sensitivity (V) [L]
Pos	Curve Average	23			// 500 Hz sensitivity (V) [R]
Pos	Curve Average	24			// 500 Hz sensitivity (mW) [L]
Pos	Curve Average	25			// 500 Hz sensitivity (mW) [R]
Dis	Headphone SPL	26			

2. IEC-60268-7 Headphone Voltage Sensitivity Sequence

This sequence satisfies the requirements of Section 8.3 *Input Voltage.* The sequence uses a Simulated Program Source (SPS) stimulus (pink noise, 20 Hz-20 kHz, shaped according to IEC 60268-1) and a 500 Hz sine to determine the DUT's voltage sensitivity. The sequence calculates the SPCV (Simulated Program Characteristic Voltage, e.g. voltage required to produce 94 dBSPL) for the unfiltered SPS response and the A weighted/free-field corrected response as well as the 500 Hz 94 dB voltage sensitivity.

The sequence first recalls the SPS WAV file, free field correction and A weighting curves into the memory list. It then enters a loop which will run 5 times. First, two signal generators and two multimeters open and the user is prompted to adjust the DUT position on the HATS to produce maximum level on the L & R HATS Ears. The sequence then plays and records the DUT's response to a 500 Hz 50 mV stimulus. Next, two Signal Generators and two RTA virtual instruments will open. The signal generators play the SPS and the RTA spectrum of the response is saved to the Memory List. A series of post-processing steps follow to apply the weighting and correction curves, calculate the LAEQ and then the Simulated Program Characteristic Voltage is calculated along with the 500 Hz voltage sensitivity. Finally, a Statistics step calculates the running mean of the SPCV and 500 Hz values. The data from each loop iteration is displayed as it is acquired. After 5 loop iterations, the mean values for SPCV, SPCV weighted/corrected and 500 Hz sensitivity are displayed in a table.

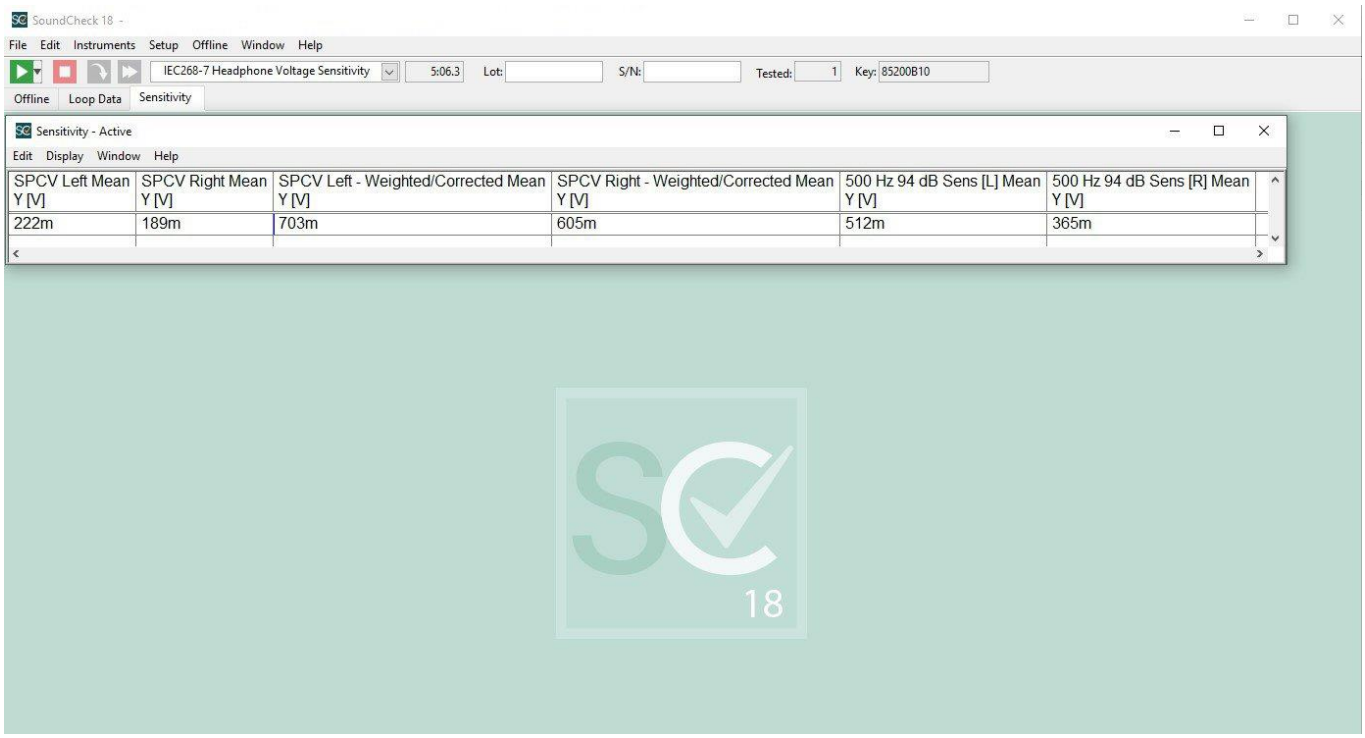

Figure 6 - Headphone Voltage Sensitivity Final Display

Software Requirements

SoundCheck 18.0
2004 – Post processing
2005 – RTA
2009 - Statistics

Hardware Requirements

- Audio Interface (2 inputs/2 outputs minimum)
- Head and torso simulator
- Stereo headphone amplifier
- Microphone power supply (2 channels)
- B&K 4231 microphone calibrator

Setup & Calibration

1. Connect the HATS Ear left and right outputs to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 1 & 2 on the audio interface.

2. Calibrate the HATS Ears per the instructions in the SoundCheck manual. Use the Ear Sim L and Ear Sim R Signal Paths.

3. Connect the left and right inputs of the headphone amplifier to Hardware Outputs 1 & 2 on the audio interface.

4. Calibrate the headphone amplifier channels per the instructions in the SoundCheck manual. When calibrating, use the Headphone Amp L and Headphone Amp R signal paths.

System Diagram

Your hardware setup should look like the following schematic diagram:

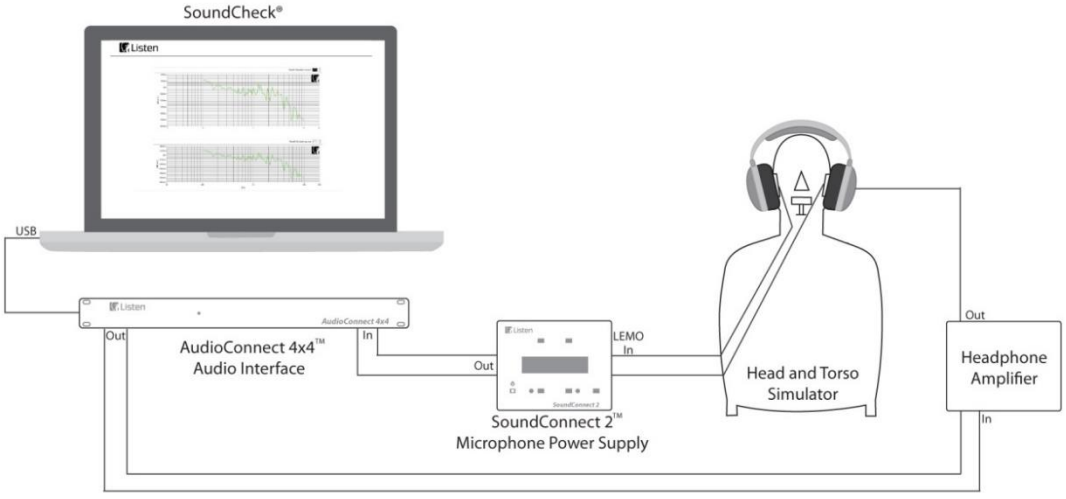

Figure 7 - Hardware setup for Headphone Voltage Sensitivity Sequence

Sequence Logic

Type	Step Name	#	Out	In	
	(Overall sequence)				
Rec	Recall Simulated Program File	1			
Rec	Recall Free Field Correction Curve	2			
Rec	Recall A Weighting Curve	3			
Mes	Initialize Stim Level	4			
Mes	94 dBSPL	5			
Sti	500 Hz	6	Headphone Amp L		
Mes	Position the DUT	7			
Mes	Re-position DUT	8			
Mes	Pause	9			
Acq	For adjusting headphones	10	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	// Position headphones for max level
Mes	Pause	11			
Acq	500 Hz	12	Headphone Amp L Headphone Amp R	Ear Sim L	Ear Sim R
Mes	Pause	13			
Acq	Measure SPL	14	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	// Virtual Instrument Acquisition
Pos	A Weighting	15			// Applies A weighting
Pos	A Weighting	16			
Pos	Free field correction	17			// Applies free field correction
Pos	Free field correction	18			
Pos	Rename	19			
Pos	Rename	20			
Pos	LAEQ	21			// Calculates the LAEQ of the spectra
Pos	Divide Values	22			// Calculates SPCV (corrected) [L]
Pos	Divide Values	23			// Calculates SPCV (corrected) [R]
Pos	Divide Values	24			// Calculates SPCV [L]
Pos	Divide Values	25			// Calculates SPCV [L]
Ana	Fundamental	26			// 500 Hz analysis
Pos	Curve Average	27			// 500 Hz sensitivity [L]
Pos	Curve Average	28			// 500 Hz sensitivity [R]
Pos	Curve minus constant	29			// 500 Hz 94 dB Sens [L]
Pos	Curve minus constant	30			// 500 Hz 94 dB Sens [R]
Sta	Sensitivity	31			// Statistics on SPCV and 500 Hz sensitivity
Dis	Loop Data	32			
Dis	Sensitivity	33			

3. IEC-60268-7 Headphone Response Distortion Impedance Sequence

This sequence satisfies the requirements of Section 8.2 *Electrical Impedance*, Section 8.6 *Frequency Response* and Section 8.7 *Amplitude Non-linearity*. The sequence uses a stepped sine stimulus to measure frequency response, THD and impedance, a composite signal of 70 Hz and 600 Hz with an amplitude ratio of 4:1 to measure intermodulation (IM) distortion and two sinusoidal signals, separated in frequency by 80 Hz to measure difference frequency distortion.

The user is first prompted to enter the rated voltage. This value is converted to dBV and used to calculate the IM and difference frequency stimulus levels. The sequence then runs through a series of Play and Record and Analysis steps to calculate the Frequency Response, Impedance, IM distortion and Difference Frequency Distortion of the DUT which are then shown on the final display.

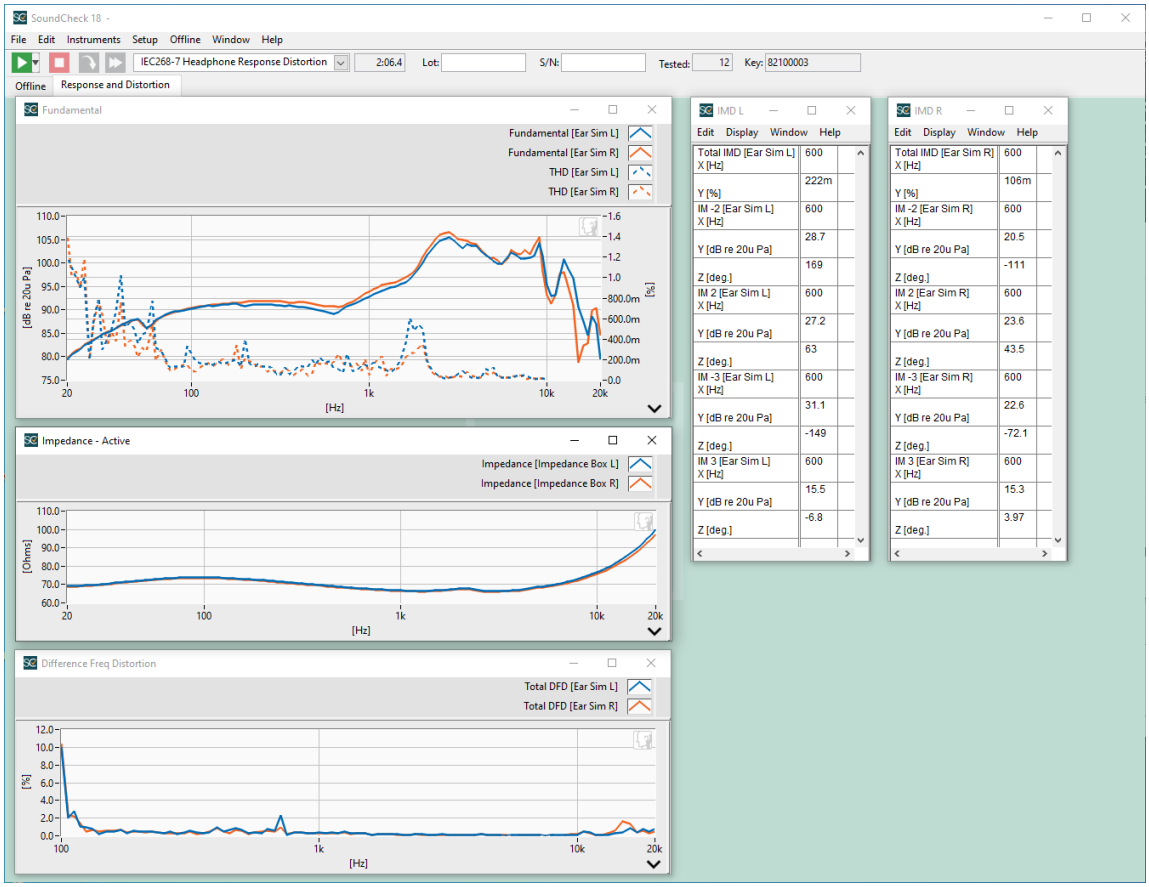

Figure 8 - Headphone Response Distortion Impedance Sequence Final Display

Software Requirements

SoundCheck 18.0
2004 – Post processing
2019 – IM Distortion

Hardware Requirements

- Audio Interface (4 inputs/2 outputs minimum)
- Head and torso simulator
- Stereo headphone amplifier
- Microphone power supply (2 channels)
- B&K 4231 microphone calibrator
- Impedance box (2 pc.)

Setup & Calibration

1. Connect the HATS Ear left and right outputs to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 1 & 2 on the audio interface.

2. Calibrate the HATS Ears per the instructions in the SoundCheck manual. Use the Ear Sim L and Ear Sim R Signal Paths.

3. Connect the left and right inputs of the headphone amplifier to Hardware Outputs 1 & 2 of the audio interface.

4. Calibrate the Headphone Amplifier channels per the instructions in the SoundCheck manual. Use the Headphone Amp L and Headphone Amp R signal paths.

5. Connect the impedance boxes between the headphone amp out and headphone input. Connect the impedance box outputs to Inputs 3 & 4 on the audio interface.

System Diagram

Your hardware setup should look like the following schematic diagram:

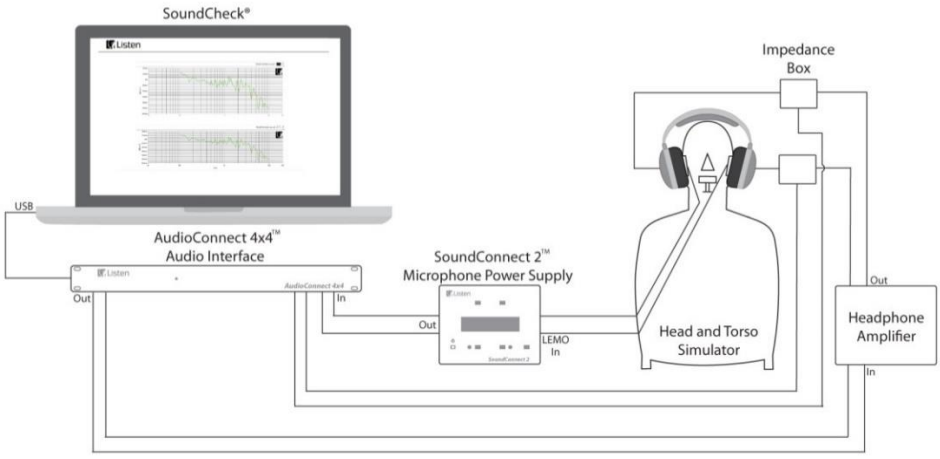

Figure 9 - Hardware setup for Headphone Response Distortion Impedance Sequence

Sequence Logic

Type	Step Name	#	Out	In	
	(Overall sequence)				
Mes	Enter Rated Test Voltage	1			// Prompt operator for test level
Pos	Change Units	2			// V to dbV conversion
Pos	IM Slave Level	3			// Calculate IM slave level
Pos	IM Master Level	4			// Calculate IM master level
Pos	Curve divided by constant	5			// Calculate diff freq. level
Sti	Stweep - 20k - 20Hz (R40)	6	Headphone Amp L		
Sti	Intermodulation Difference	7	Headphone Amp L		
Sti	Frequency	8	Headphone Amp L		
Acq	Play & Record	9	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R Impedance Box L Impedance Box R	
Ana	THD	10			// Fundamental & THD analysis
Ana	Impedance	11			// Impedance analysis
Acq	IM	12	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	
Ana	IM Distortion	13			// IM distortion analysis
Acq	Diff	14	Headphone Amp L Headphone Amp R	Ear Sim L Ear Sim R	
Ana	Diff Distortion	15			// Difference frequency analysis
Dis	Response and Distortion	16			

4. IEC-60268-7 Headphone Passive & Active Attenuation Sequence

Section 8.11 *Sound Attenuation* references the ISO 4869-1 standard which uses human listeners and subjective "threshold of hearing" metrics to determine attenuation values. We encourage interested users to obtain a copy of ISO 4869 but in its place we offer an updated version of Listen's ANC Headphone Test Sequence. This sequence uses a pink noise stimulus to characterize the passive, active and total attenuation of noise cancelling headphones. It can also be used to characterize the passive attenuation only of a standard (non-ANC) headphone.

Noise speakers are set up adjacent to the HATS left and right ears. First, a pink noise stimulus is played from the noise speakers and recorded by the unoccluded ears. An RTA spectrum of the response is calculated and named Unoccluded Spectrum. Next, the user is prompted to place the DUT on the HATS. If it is an ANC headphone, the ANC circuit should be turned off. A pink noise stimulus is played from the noise speakers and recorded by the occluded ears. An RTA spectrum of the response is calculated and named Occluded Spectrum. The play and record acquisition takes place 3 times and the user is prompted to reposition the DUT on the HATS in between acquisitions. A statistics step calculates the mean of the 3 unoccluded measurements. The user is then asked if the DUT has an ANC circuit. If the answer is No, the sequence jumps to post-processing steps which calculate passive attenuation and the final display step. If the answer is Yes, the user is prompted to turn the ANC on and the sequence repeats the passive measurements. A series of post processing steps calculates the attenuation curves, their average values and shows them on the final display.

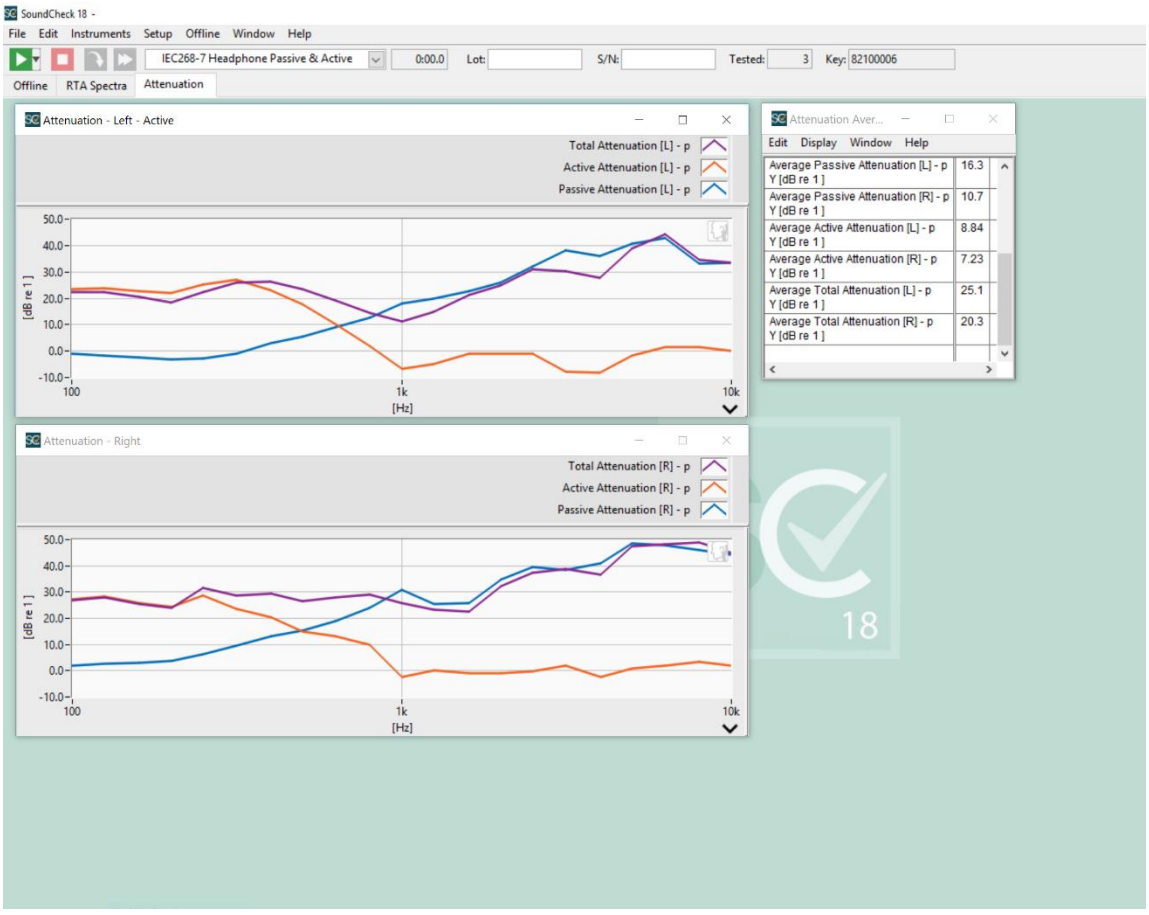

Figure 10 - Headphone Active & Passive Attenuation Sequence Final Display

Software Requirements

SoundCheck 18.0
2004 – Post processing
2005 – RTA
2009 - Statistics

Hardware Requirements

- Audio Interface (4 inputs/2 outputs minimum)
- Head and torso simulator
- Stereo headphone amplifier
- Microphone power supply (2 channels)
- B&K 4231 microphone calibrator
- Noise speakers (pair – if passive, amplification required)

Setup & Calibration

1. Connect the HATS Ear left and right outputs to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 1 & 2 on the audio interface.

2. Calibrate the HATS Ears per the instructions in the SoundCheck manual. Use the Ear Sim L and Ear Sim R Signal Paths.

3. Connect the left and right inputs of the headphone amplifier to Hardware Outputs 1 & 2 of the audio interface.

4. Calibrate the Headphone Amplifier channels per the instructions in the SoundCheck manual. Use the Headphone Amp L and Headphone Amp R Signal Paths.

5. Connect the Noise Speakers to the appropriate output source (If powered, connect directly to Hardware Outputs 3 & 4 of the audio interface. If passive, connect to the headphone amp or separate audio power amplifier)

System Diagram

Your hardware setup should look like the following schematic diagram:

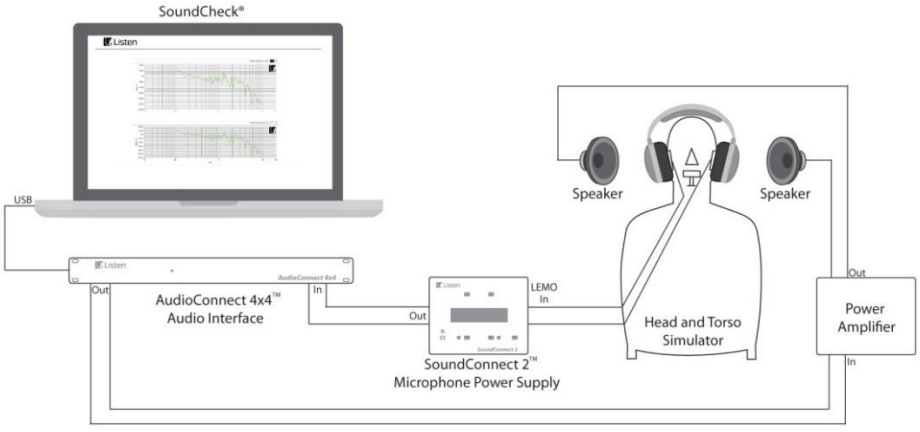

Figure 11 - Hardware setup for Headphone Passive & Active Attenuation Sequence

Sequence Logic

Type	Step Name	#	Out	In	
	(Overall sequence)				
	Setup Hardware -				
Mes	Reset Statistics	1			
Sti	Noise	2	Noise Speaker L		
	Unoccluded				
Mes	Measurement	3			
			Noise Speaker L	Ear Sim L	
Acq	Play & Record	4	Noise Speaker R	Ear Sim R	// Unoccluded ear measurement
Ana	RTA Spectrum	5			
	Occluded				// Loop for occluded ear
Mes	Measurement	6			measurement
Mes	Reposition DUT	7			
			Noise Speaker L		
Acq	Play & Record	8	Noise Speaker R	Ear Sim L	Ear Sim R
Ana	RTA Spectrum	9			
Sta	Curves and Results	10			
Mes	ANC Measurement	11			// Loop for ANC measurement
Mes	Reposition DUT	12			
			Noise Speaker L		
Acq	Play & Record	13	Noise Speaker R	Ear Sim L	Ear Sim R
Ana	RTA Spectrum	14			
Sta	Curves and Results	15			
Pos	Curve division	16			// Passive attenuation curve [L]
Pos	Curve division	17			// Passive attenuation curve [R]
Pos	Curve division	18			// Active attenaution curve [L]
Pos	Curve division	19			// Active attenuation curve [R]
Pos	Curve division	20			// Total attenuation curve [L]
Pos	Curve division	21			// Total attenuation curve [R]
Pos	Curve Average	22			// Average Passive Attenuation [L]
Pos	Curve Average	23			// Average Passive Attenuation [R]
Pos	Curve Average	24			// Average Active Attenuation [L]
Pos	Curve Average	25			// Average Active Attenuation [R]
Pos	Curve Average	26			// Average Total Attenuation [L]
Pos	Curve Average	27			// Average Total Attenuation [R]
Dis	RTA Spectra	28			
Dis	Attenuation	29			

5. IEC-60268-7 Headphone Radiation & Crosstalk Sequence

This sequence satisfies the requirements of Section 8.10 *Unwanted Sound Radiation.* The sequence uses a stepped sine stimulus to measure the sound radiation from the DUT as well as the DUT's crosstalk (e.g. signal level at the HATS R ear of a stimulus played from the DUT's L output.

The sequence first plays a stepped sine through both channels of the DUT and captures the sound radiation from the DUT using 2 reference mics. Heterodyne analysis is used to calculate the fundamental of the L & R radiation. The sequence then goes through a series of acquisition steps to generate four fundamental curves which are then post-processed to calculate crosstalk. Crosstalk and radiation curves are then shown on the final display.

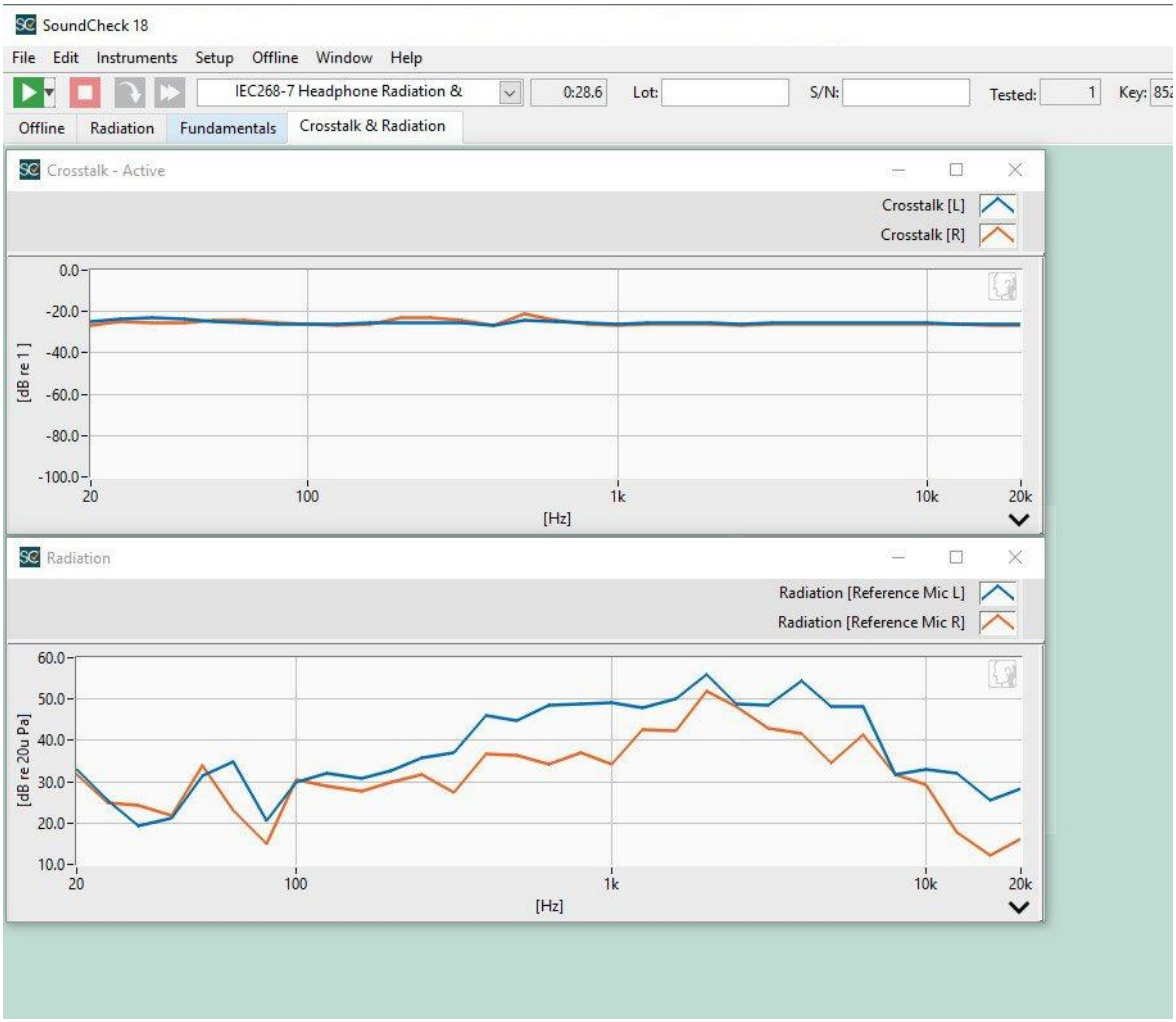

Figure 12 - Radiation & Crosstalk Sequence Final Display

Software Requirements

SoundCheck 18.0
2004 – Post processing

Hardware Requirements

- Audio Interface (4 inputs/2 outputs minimum – or two inputs with switching, e.g. SoundConnect 2)
- Head and torso simulator
- Stereo headphone amplifier
- Microphone power supply (4 channels – or two channels with input switching)
- B&K 4231 microphone calibrator
- Reference microphones (2 pc.)

Setup & Calibration

1. Connect the HATS Ear left and right outputs to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 1 & 2 on the audio interface.

2. Calibrate the HATS Ears per the instructions in the SoundCheck manual. Use the Ear Sim L and Ear Sim R Signal Paths.

3. Connect the Reference microphones L&R to the microphone power supply and connect the outputs of the power supply to Hardware Inputs 3 & 4 of the audio interface (or Inputs 1 & 2 if switching is available).

4. Calibrate the microphones per the instructions in the SoundCheck manual. Use the Reference Mic L and Reference Mic R signal paths. Once calibrated, position the microphones 0.1 meter from the DUT's L & R exterior shells.

5. Connect the left and right inputs of the headphone amplifier to Hardware Outputs 1 & 2 of the audio interface.

6. Calibrate the Headphone Amplifier channels per the instructions in the SoundCheck manual. Use the Headphone Amp L and Headphone Amp R signal paths.

System Diagram

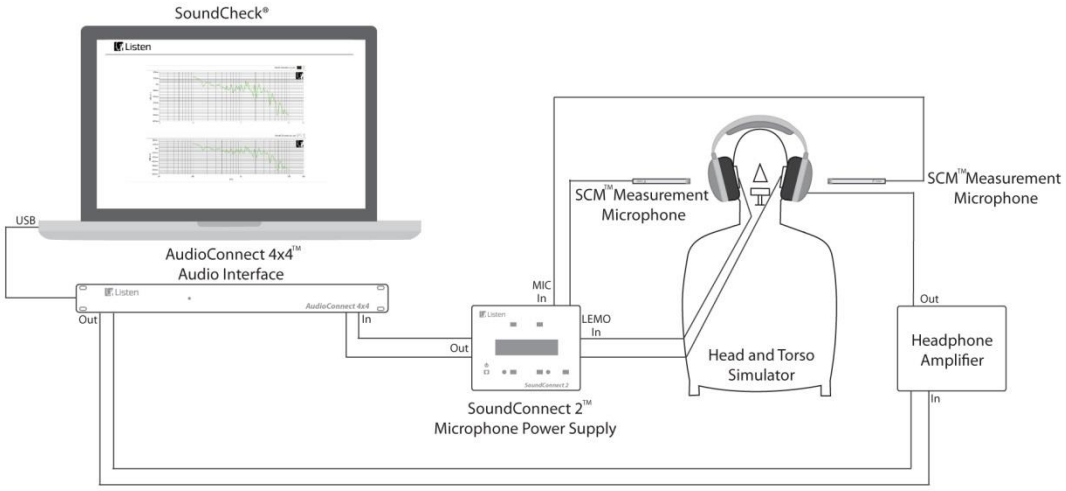

Figure 13 - Hardware setup for Headphone Radiation & Crosstalk Sequence

Sequence Logic

Type	Step Name	#	Out	In	
	(Overall sequence)				
Mes	Setup Hardware	1			
Mes	*Rated Input* *Voltage* Stweep - 20k - 20Hz	2			
Sti	(R10)	3	Headphone Amp L Headphone Amp R		
Acq	Play & Record	4	Headphone Amp L	Reference Mic L	Reference Mic R
Ana	Fundamental	5			
Dis	Radiation	6			
Acq	Play & Record	7	Headphone Amp R	Ear Sim L	// Play R, record L
Acq	Play & Record	8	Headphone Amp L	Ear Sim L	// Play L, record L
Acq	Play & Record	9	Headphone Amp L	Ear Sim R	// Play L, record R
Acq	Play & Record	10	Headphone Amp R	Ear Sim R	// Play R, record R
Ana	Fundamental	11			
Dis	Fundamentals	12			
Pos	Curve division	13			// Calcualtes Crosstalk [L]
Pos	Curve division	14			// Calcualtes Crosstalk [R]
Dis	Crosstalk & Radiation	15			