MASTER **P**ortable **A**mplifier **S**ystem

- MPAS -

Audio and EEG Quality Tests & Specifications

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MASTER Software documentation
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Overview

The Multiple Auditory Steady-State Response (MASTER) technique has been developed over the last 7 years across a series of papers, which can be obtained through www.hearing.cjb.net. MASTER portable amplifier system (MPAS) is a battery-powered portable audiometric assessment system that can be controlled by the MASTER software. Used together, the system can generate and present 2 audio signals (left and right ear), amplify, filter, digitize, and store a subject's EEG, and automatically analyze the data using advanced DSP and statistical techniques.

The MASTER software is for research purposes only.

The MASTER software is for research purposes. The MASTER software requires a sophisticated user who is familiar with the fields of audiology and electrophysiology. Users should download the demonstration software from www.hearing.cjb.net and go through the tutorial fully in order to determine if they will be comfortable using this type of software. Users should have reviewed the articles on our website prior to using the software.

The MASTER software should not be considered a clinically approved software application. We take no responsibility for any use, misuse, or clinical uses of the MPAS system, for any results, for the quality of data, or for ensuring that the users are using the MPAS in a correct manner. We make no claim or assertion that the MASTER software can be used to assess hearing function or hearing impairment. The MASTER software and associated methods have not been approved by the FDA, CSA, AMA or any other regulatory agency. Even if the MASTER software is approved by regulatory agencies for use on other machines, its use with the MPAS system, is still purely for research purposes.

Each MASTER software license that is sold is for use on ONE machine only. The data collection software is shipped with one hardware lock, which is attached to the printer port of the laptop. The software will not run without the hardware lock. The data review modules of the MASTER software can run on multiple computers and do not require the hardlock.

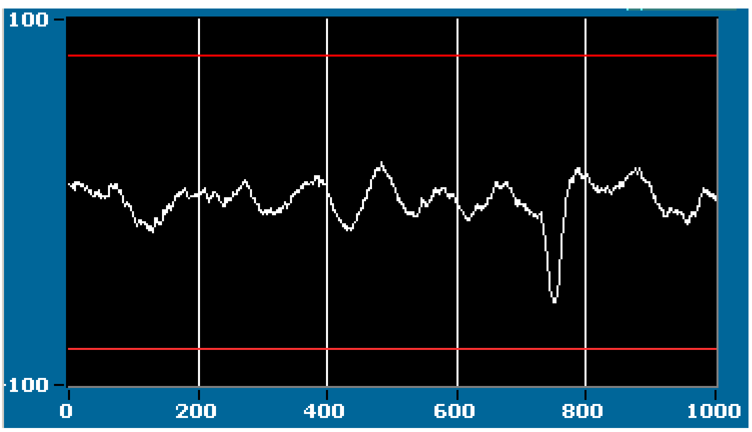
MPAS EEG AMPLIFIER QUALITY ASSESSMENT

We compared our amplifier to a very good quality amplifier that we have used to collect data from hundreds of subjects. Accordingly we used this amplifier as a benchmark for the MPAS system. The two figures below show 1 second of EEG data from a subject whose EEG leads were simultaneously fed to both the commerical amplifier and to the MPAS system. The settings on the two amplifiers were:

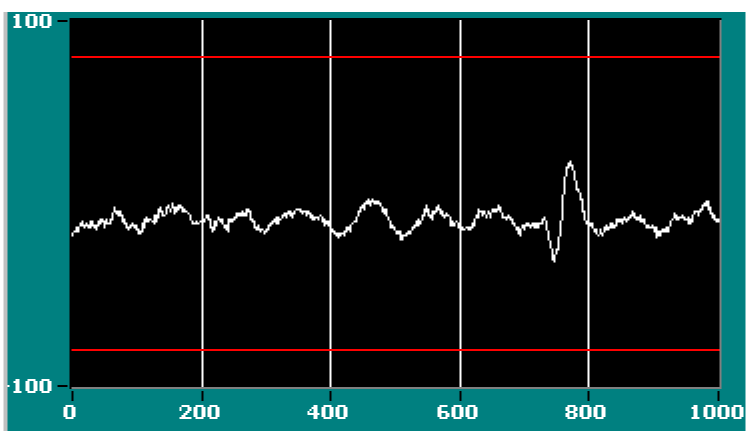
	High-pass	Low-pass	Gain
Commerical	0.1 Hz (-6 dB/Oct)	300 Hz (-6 dB/Oct)	10,000x
MPAS	8 Hz (-12 dB/Oct)	300 Hz (-24 dB/Oct)	10,000x

The two EEGs look similar. The qualitative signal to noise levels are roughly the same, although the EKG heartbeat and alpha waves are smaller and more rounded in the MPAS system due to the higher filter slope and cutoff in the MPAS. The EKG heartbeat appears monophasic in the top graph and biphasic with a phase shift in the MPAS due to the higher filter slope.

EEG using Grass P55



EEG Using MASTER Portable Amplifier System

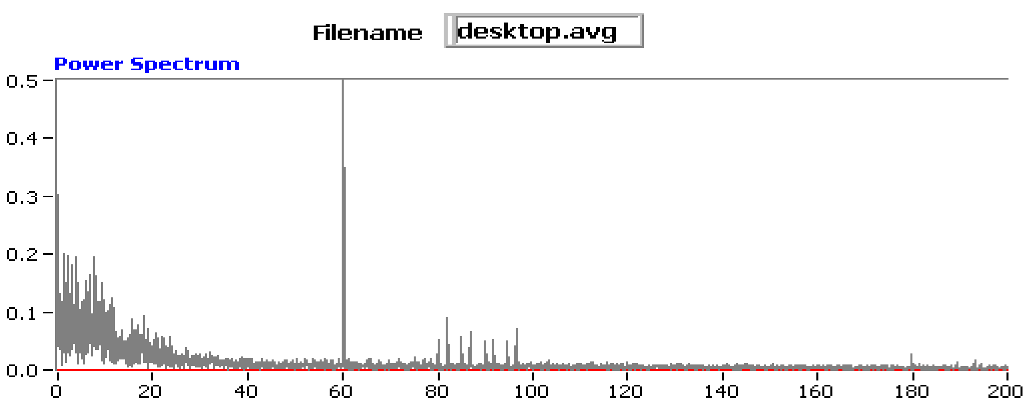


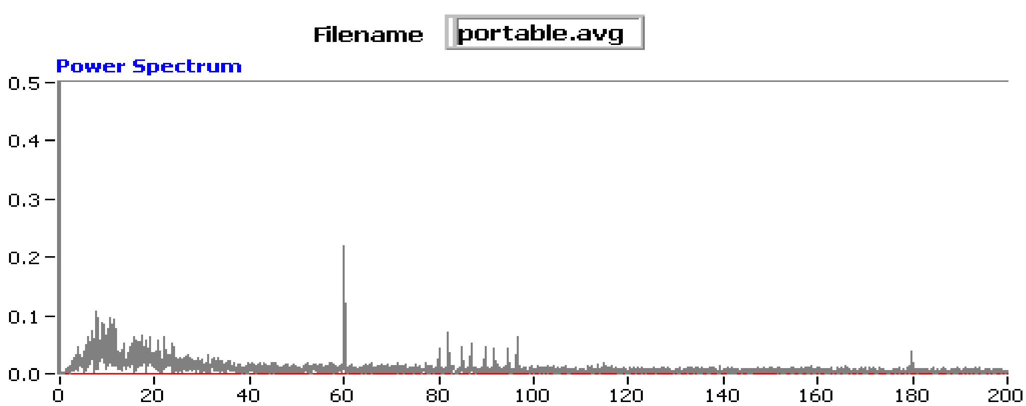
COMPARING AMPLITUDE SPECTRA OVER 5 SUBJECTS:

The two figures below show the average spectra for 5 subjects, each of which underwent a 192 second recording. Stimuli were 4 amplitude modulated carrier frequencies in each ear. Each subject's EEG leads were simultaneously fed to both a commercial amplifier and the MPAS system. The settings on the two amplifiers were:

	High-pass	Low-pass	Gain
Grass	0.1 Hz (-6 dB/Oct)	300 Hz (-6 dB/Oct)	10,000x
MPAS	1 Hz (-12 dB/Oct)	300 Hz (-24 dB/Oct)	10,000x

The two spectra look similar. The signal to noise levels are roughly the same. The portable system using the MPAS hardware shows a smaller amount of energy at the low frequencies(see text below). All eight stimuli were significant in both the MPAS and Grass data. The number of false positives and negatives in the individual subject results were comparable for the two systems. The large amount of 60 Hz noise, which is not usually present in average data recordings at this level was likely due to our setup for this experiment, which required several feet of wire to be used for the simultaneous recording using 2 amplifier systems and data collection systems. Due to the MPAS's EEG amplifer design, a single-pole high-pass characteristic exists at 8 Hz (-6-dB/Oct) in addition to the 1 Hz (-12 dB/Oct). The user would normally set the digital filter at 10 Hz or above, however we used a 1 Hz digital filter, in order to show the 8 Hz hardware filter.





MPAS AUDIO AMPLIFIER QUALITY ASSESSMENT

MAXIMUM SPL & THD LEVELS IN THE MPAS:

The performance of the MPAS audio amplifiers was examined as per ANSI S3.6-1989 Total Harmonic Distortion (THD) standards. The MPAS audio amplifier THD exceeded the ANSI specification and was comparable to a commercial audiometer used in our laboratory. The MPAS amplifier was unable to amplify frequencies of 125, 250, 6000, and 8000 to the same degree as our commercial clinical audiometer. Users who are concerned with testing frequencies from 500 to 4000 do not need to worry about this limitation, however, users who want to test in these low and high ranges should review the following tables to ensure that the MPAS system can provide them with adequate volume at these frequencies.

The quality assessment was done using a Brüel & Kjær model 2230 sound level meter using an “A” weighting and either a DB 0138 2-cm^2 coupler (for testing the ER-3A ear inserts) or a artificial ear type 4152 (for testing the TDH-50P headphones.) The signal recorded from the microphone was sent to a Tektronics digital oscilloscope and was analyzed using Wavestar Software in order to obtain THD levels.

The MASTER portable system software generated the carrier frequencies, using 100% of the output level and 100% of the stimulus buffer. If one was presenting 4 stimuli at one time, then each stimulus would be defined as 25% of the full buffer and the maximum SPL level would be down by –6 dB for each frequency. The frequencies from the MASTER system were routed to the audio system of the MPAS unit.

SPL and THD Measurement Notes:

The HL levels are those required by ANSI S3.6-1989. THD should be measured at these levels or at the maximum levels of the amplifier. The Correction factors are the ANSI standards for the TDH-39 in order to convert from HL to SPL (these were used since the ER-3A's are modeled after then TDH-39s.) Using the correction factors, the required SPL for calculating THD was obtained.

Table 1: Evaluation of MPAS audio amplifier using ER-3A transducers.

F	HL	Corr. factor	SPL recommend	Setting	SPL act.	THD	Harmonics
125	75	45	120	Max	93	2.52	50
250	90	25.5	115.5	Max	100.4	1.274	39
500	110	11.5	121.5	Max	104.5	1.482	18
1000	110	7	117	Max	111.2	0.842	9
2000	110	9.0	119	Max	113	0.943	4
4000	110	9.5	119.5	Max	111.1	0.401	2
6000	90	15.5	105.5	Max	86.2	0.206	2
8000	90	13	103.5	Max	74.4	0.476	2

Conclusion: Using the MPAS audio amplifier and ER-3A insert earphones the system was able to meet the ANSI standards for TDH above for all frequencies. However, some maximum SPL levels were below those recommended by ANSI for general-purpose audiometers. This may be a concern for users who wish to test outside of the 500-4000 Hz range.

Table 2: Evaluation of MPAS audio amplifier using TDH-50P transducers.

F	HL	Corr. factor	SPL recommend	Setting	SPL act.	THD	Harmonics
125	75	45	120	Max	93.3	0.658	50
250	90	25.5	115.5	Max	101	0.550	39
500	110	11.5	121.5	Max	106.8	0.451	18
1000	110	7	117	Max	111.2	0.253	9
2000	110	9.0	119	Max	111.9	0.159	4
4000	110	9.5	119.5	Max	110	0.193	2
6000	90	15.5	105.5	Max	108.4	0.146	2
8000	90	13	103.5	Max	97	0.343	2

Conclusion: Using the MPAS audio amplifier and TDH-50P headphones the system greatly exceeds the ANSI THD standards for all frequencies. However, all but the 6 kHz maximum SPL levels were below those recommended by ANSI for general-purpose audiometers. This may be a concern for users who wish to test outside of the 500-4000 Hz range.

Crosstalk Measurement Notes: In this test, both channels were set to maximum gain, but only one was fed a signal by the software. The signal resulting in the other channel was measured as crosstalk. Sound pressure levels were measured with "A" weighting.

Table 4: Evaluation of MPAS audio amplifier using EAR-3A transducers.

F	SPL R	SPL L, "A" wgt	SPL L ambient	Difference
125	93.4	23.8	11.8	69.6
250	100.9	23.8	11.8	77.1
500	104.9	13.8	11.8	91.1
1000	111.8	14.6	11.7	97.2
2000	113.3	26.8	11.6	86.5
4000	111.5	30.2	11.8	81.3
6000	87.5	23.6	11.8	63.9
8000	73.4	23.6	11.8	49.8

In this test, the Left channel SPL was the same whether the driven channel was switched on or off.

Conclusion: Since the absence of a signal on the right channel did not change the recorded SPL on the left channel, the crosstalk signal was likely only white noise at the amplifier output. The crosstalk figures above are therefore minimum values.

Table 5: Evaluation of MPAS audio amplifier using TDH-50P transducers.

F	SPL R	SPL L	SPL L ambient	Difference
125	83.4	36.2	36.2	47.2
250	92	25.2	25.2	66.8
500	106.2	36	36	70.2
1000	110.8	38	38	72.8
2000	112.5	38	38	74.5
4000	109.9	32	32	77.9
6000	107.5	31.5	31.5	76
8000	96.6	36	36	60.6

Conclusion: Since the ambient noise levels (transducer disconnected from the amplifier) produced no change in the measured left channel SPL, the crosstalk figures above are minimum values. Testing the equipment in a lower noise setting would likely act to improve these results.

Warranty

The MPAS can be returned for a refund within the first 60 days of shipping (10% restocking charge). After 60 days, all sales are final.

The MPAS comes with a two year warranty on parts and labor. We will perform any required maintenance for free and pay for shipping to the customer. The warranty does not cover battery performance and battery life, which may vary, based upon usage and charging routines chosen by the user. The warranty covers normal usage and does not cover damage that results from physical negligence (e.g., accidentally dropping the MPAS on the ground.)