inter.noise 2014
MELBOURNE AUSTRALIA
16-19 NOVEMBER

Stereo or binaural headphones for sound location

Graeme J. COHEN[1];

Valve Research, Adelaide, Australia

ABSTRACT

Stereo sound is reproduced over two spaced apart loudspeakers. When headphones are used in place of loudspeakers the stereophonic space is incorrectly reproduced. Stereo headphones could arguably be called binaural headphones, that is the left sound source being heard in the left earphone only. In a live situation of sound the human head hears the sound with both ears. When using headphones and two microphones the sound is different and may not have accurate location in space.
By using a cross feed of sound, left to right and right to left, and using suitable compensation and delay, it can be shown that a natural and accurate location of sound source, music, noise etc. may be accomplished.

A cross feed system has been developed using previous work, with references. A sound source and delay system has been developed to give a measure of the source using headphones. This technique can be used for use with microphones and recording media, using headphones as a human interface.
This is used, with two sound level meters, and computers, for accurate sound source position by using controlled cross feed, amplitude, delay etc. within the frequency band measured. Headphones being used as a live check of the recording.

1. INTRODUCTION

Stereo headphones could arguably be called binaural headphones, i.e. the left sound source being heard in the left earphone only. In a live situation of sound, the human head hears the sound with both ears. When using headphones and two microphones the sound is different and may not be accurately located in space. By using a cross feed of sound, left to right and vice-versa, it is shown that a natural and accurate location of the sound source, music, and noise etc may be accomplished.

An addition to this is a delay system to relieve the center of head artifact when using headphones. The delay system has a delay in both stereo channels with a third delay in a summed centre channel.

Each delay has a un-delay bypass of suitable level. By setting the delay times and levels and by setting the bypass levels of the three channels a system has been developed to help remove the centre of head aural experience.

Subjective listening using an audience and difference headphones has shown an acceptance of the concept described.

[1] graemejohncohen@gmail.com

2. STEREOPHONIC AND BINAURAL SOUND

The original concept of Stereophonic sound has been credited to Blumlein.[1] In Fig 1 It is showing the difference between what can be, stereo into two loudspeakers, but binaural into headphones.

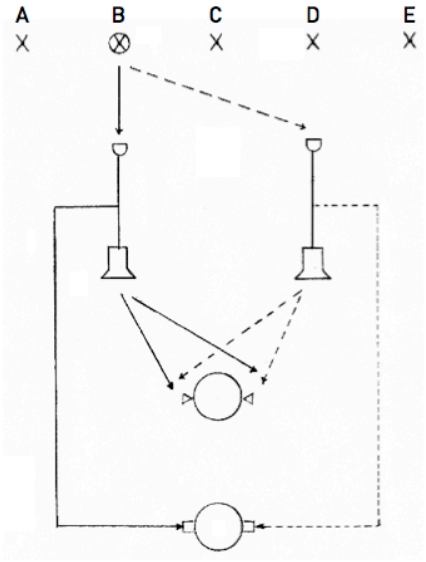

Fig. 1 Listening to Loudspeakers Vs Headphones

Sound from the source as shown in Fig 1, is mainly heard in both ears using loudspeakers, but not as well defined using headphones.

Original work by Bauer[2] uses a cross feed system that takes sound information from either channel and presents some sound to the opposite earphone with suitable amplitude, delay and modified frequency response. The modified frequency response is to allow for the shape of the head and nose etc.

In the figure shown, a sound source that is midway between centre stage and the left stage shows the difference between the loudspeakers and using headphones. By using the cross feed, this area is filled in, when using headphones.

The cross feed circuits described by Bauer, one for low impedance headphones and one for high impedance headphones were built and evaluated.

The result in both cases was good and filled in the area of sound stage B and D as shown in Fig 1. A simplified circuit by Linkwitz[3] has not as yet been tried.

Standard headphones have the center of the head presence, which can be noticed as uncomfortable. A concept has been developed to move the centre head sound to another apparent position, slightly forward of centre, with an apparent openness of the centre image i.e. not dominating the sound experience at center of the head.

Headphones used, were Sennheiser HD 280-Pro low impedance and HD 800 high impedance. Also used was Grado RS-1 low impedance and several other types. The HD 280 is a closed ear type used for live sound recording. The other two are open ear types, used for HIFI listening. All three headphones sound different in the low to medium frequencies with the closed ear type having more apparent level around 200Hz and Grado RS-1 having a more apparent low frequency level. The Sennheisr HD 800 has a smooth extended response.

3. CENTRE OF THE HEAD AURAL PROBLEM

Work by Schroeder[4] on artificial reverberation and by Basha et al[5] on stereo widening of the headphones using delay methods. Schroeder's work to match the reverberation in real rooms and Basha et al, to widen the stereo image in headphones. Both these concepts use delay and bypass systems. Delay and a bypass system using different amplitude levels and suitable delay can cause the head to relocate the sound stage within the head.

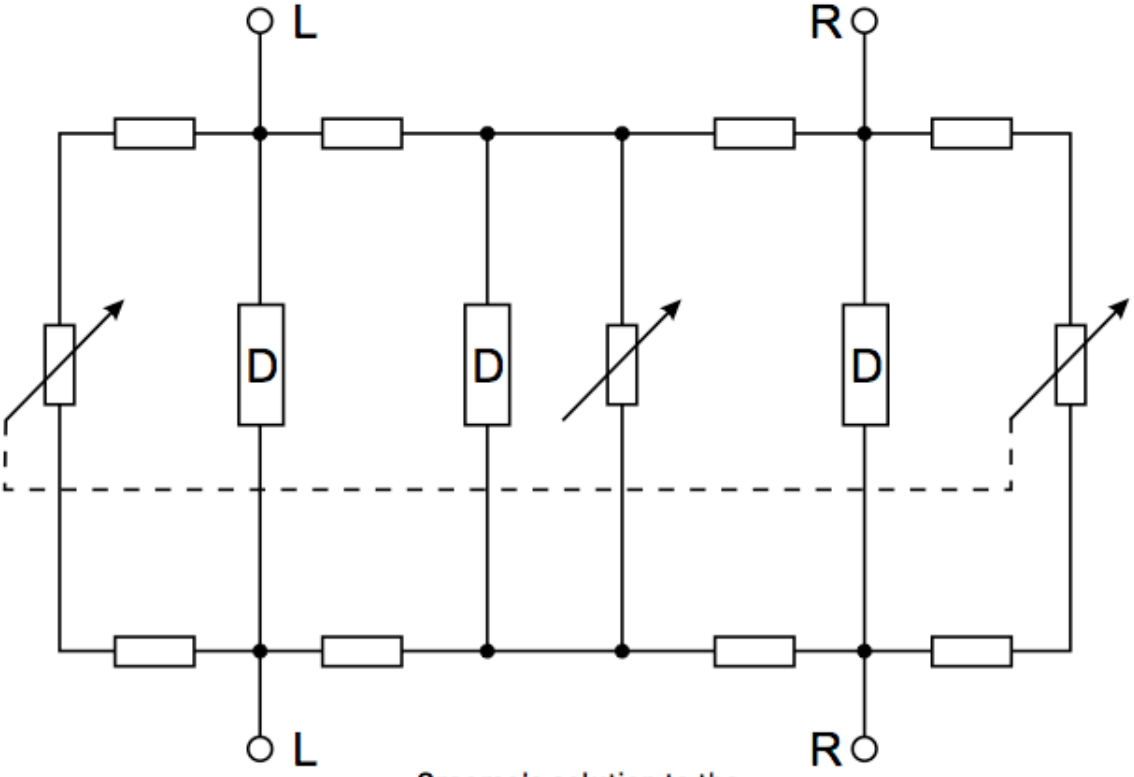

Fig. 2 Graeme's solution to the middle-of-head problem

The author's concept as shown in Fig 2 has two paths L and R for each ear.

L and R is then split into 6 paths, essentially M (centre), being 2 paths, one un-delayed and one delayed by 28 milliseconds. S path left, split into un-delayed and delayed by 14 milliseconds. S path right, un-delayed and delayed by 14 milliseconds.

S and M are combined back to L and R

The concept being, to pre-condition the centre of the head, with a low level common signal. Combining this M signal, the equal delay left and right information arrives at both ears. By using short delays at high levels, in stereo, the S information dominates the M information, even though the delayed M information arrives slightly later. If the delay S signals are kept short in time, the reverberation is not apparent.

Fig 2. Shows additional low level bypass signals around the delay systems in each channel.
The two side bypass signals have a ganged level control to track left and right signals S. The

centre M channel has a level control. The S and M delay bypass paths can be independently switched out, so independent evaluation can be made.

The centre path has a bypass shown as a variable level control around the delay. The stereo channels are also shown with the matched delays and ganged bypass level control. These two signals are the high level main stereo paths.

The delay times used were possible at the acceptable limits, but were set for demonstrations. Shorter delays may be preferable. The system described has an approximate 2:1 delay ratio between the main stereo paths S and the centre paths M. The system described has a subjective enhancement when the center channel has a longer delay as described.

4. FUTURE WORK

A dummy head with microphone inserts in the ear canals is being developed. The object is to mount reference headphones on to the head to calibrate the microphones in the dummy head.

A closed loop system can be utilized to do equivalent objective measurements at the ear canal. Frequency shaping can then be measured for both loud speakers and headphones.

5. CONCLUSION

The results, particularly for the centre of the head sound, are noticeable when the authors system is applied to the L and R sound (Fig 2). Even more noticeable when switched back to the unprocessed sound.

When combining L and R sound with previously discussed Bauer's crossfeed techniques (see reference 1), the over all affect increases the change in location of the sound in the head.

A demonstration of the discussed sound processing system in Fig 2 was presented to the South Australian section of the Audio Engineering Society (AES) on June 17th 2014. The author's sound processing systems was demonstrated with different headphones and applied to different styles of music. With approximately 25 attendee's present, the overall comments were recognising the noticeable change in the sound location inside the head.

REFERENCES

[1] Blumlein The Life and Works of Allen Dower Blumlein ISBN 0 24051628 1. p.64.
[2] B B Bauer, Journal of the Audio Engineering Society, April 1961. p. 148
[3] S Linkwitz, Audio, Dec 1971.
[4] M R Schroeder, Journal of the Audio Engineering Society, July 1962.
[5] SMA Basha, Abhinav Gupta, Anshul Sharma, Stereo widening system using binaural cues for headphones. http://users.cecs.anu.edu.au, July 1962.