

Development of Multichannel Surround Technology for Cars

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Abstract

Generally with the assembly of multichannel surround systems in an in-car environment, the addition of center speakers and woofers are necessary, which present a burden from the perspective of mounting and cost. Thus in order to solve these problems, technology was developed to achieve multichannel surround at a reasonable cost.

This technology is a fusion of new surround technology at SRS Labs, Inc: Circle Surround II, and Rear Mix processing, our company's original technology for application in the in-car environment.

With Rear Mix processing, it is possible to solve playback sound field bias due to the seat occupied, a problem with the in-car environment, as well as acoustic oscillation in the forward/back direction during FM broadcast reception with a weak electric field while in driving.

It becomes possible to enjoy multichannel surround simply and at low costs by building this technology into AV systems.

In this paper, we will describe issues related to the realization of an in-car multichannel surround system, the solution of these issues, and the technological investigations and process of commercialization.

1 Introduction - Background to development

In recent years, with the digitization of media, high-quality sound information has become obtainable in cars; together with improvements in the quietness of the car compartment this has established the car as an audio listening room.

However, problems with the in-car environment include the fact that unlike the home, the in-car space is cramped, and the stereo image of sound is rarely felt. On the other hand, with car audio products, there has been a general propagation of sound field control, adding reverberations simulating conventional sound field such as places with live music and concert halls, as well as development and creation of products providing so-called surround functions.

From another perspective, with the deployment of media digitization, for which hardware has seen even further price reductions, DVD5.1 channel surround systems have become pervasive, particularly for home use. In the same way, with the diffusion of DVD navigation, DVD players are also starting to become pervasive in car -fitted systems as well. However, while DVD5.1 channel is a richly entertaining product, center speakers and woofers are needed. With car -fitted systems, the burden is prohibitive from a mounting and cost perspective, and system adoption has been limited to premium units.

Thus, this report details the development of systems capable of playing multichannel surround sound, like the DVD5.1 channel, in affordable systems for the enjoyment of more users.

2 Structure of car -fitted multichannel surround system

2.1 What is The multichannel surround system?

The term multichannel surround system refers to a multichannel system epitomized by the DVD5.1 channel surround. The 5.1 channel surround is reproduced by a speaker system, which comprises a combination of 5 speakers - 2 front channels, a center channel and 2 rear channels, as well as a sub woofer (expressed as 0.1 channel) with a band of 120Hz or less. This speaker set-up, as shown in Fig. 1, is highly recommended.

Further, as the sound recording method is not merely the conventional 2 channel stereo, but rather Dolby digital and DTS (Digital Theater Systems), capable of playback with an even greater sense of authenticity, the multichannel surround system epitomized by 5.1 channel has been adopted.



Fig.1 Location of 5.1 channel speakers

In terms of the in-car environment, there are generally 4 speakers installed even in standard grade cars, and thus a multichannel surround playback environment has been prepared from the start. In the typical household, in many cases, DVD playback is with television speakers and the 2 speakers for audio components, and compared to this it is possible to think of the in-car environment as superior in terms of multichannel surround playback.

Based on this, we would like to consider here the in-car mounting of a reasonably priced multichannel surround system.

2.2 Issues arising from differences between the home environment and the in-car environment

As outlined earlier, generally 4 speakers are generally mounted in car, at the front and rear. However, this arrangement ends up as shown in Fig. 2, leading to the problems shown below.

- The sound field is biased back and forth and around depending on the where one is seated
- Installation of a center speaker and woofer is difficult
- The speaker position is low



Fig.2 Location of car speakers

Regarding problem a, the issue has been solved by the "HAAS Effect" (our company's patented technology (*1)), function based on psychoacoustic techniques, built-in to digital sound processors for 5.1 channel systems sold by our company for the North American FY 2000 market.

Countermeasures have been taken for the other problems as well, the history of which is outlined below, focusing on psychoacoustic techniques.

2.3 Selection of a car -fitted multichannel surround system

Recent trends in the newest digital audio technology for home use indicate that various companies have begun releasing methods that do not playback as is the multichannel signals offered by media such as the DVD5.1 channel; rather, playback as multichannel surround like the 5.1 channel is implemented using conventional 2 channel. This technology provides multichannel playback through decode processing of sound signals down mixed (*2) to 2-channel from other conventional stereo sound sources like CD and DVD 5.1 channel sound sources.

With the notion of successfully adapting this technology to in- car use, comparative investigations were implemented with respect to multichannel surround playback using 4 speakers.

The results of the comparison of surround technology from various companies are shown in the table below.

Table 1 Comparison of surround technology from various companies

	Sound field	Additional functions	Characteristics
SRS company	Natural sound field	Present • Low sound correction • Position improvement	4 ch playback (Center speaker and woofer can be omitted)
D company	Sound field with clear directionality	Not present	Basically 6 ch playback (Center speaker necessary)
W company	Sound field with indoor reverberations	Not present	Sound field with directionality differing from DVD 5.1 ch

As shown in Table 1, each company has its own sound field features. Of these, the SRS company technology (Circle Surround : hereinafter referred to as CS) offers in addition to a natural sound field relationship between each speaker, a great deal of flexibility in speaker arrangement. This technology was thus deemed applicable to a variety of systems.

Further, The SRS company technology included additional function, the effectiveness of which in solving prob-

lems described earlier inherent to car -fitted audio, was evident.

Here, the features of CS technology and the results of listening tests with CS in actual car are outlined.

3 CSII technology and issues with car installation

3.1 Features of CSII

CS is a new surround technology developed by SRS Labs, Inc. (Head office: California, USA, hereinafter referred to as SRS company). It provides the following 3 functions.

(1) SRS Circle Surround decoder

- This technology provides multichannel surround playback of all types of 2 channel stereo materials, creating a very authentic sound field.
- The function also has the ability to convert mono-aural signals to stereo, providing multichannel playback.

(2) Additional function 1: SRS TruBass

Utilizing pipe organ low-sound playback techniques, the technology provides reasonable playback of deep bass, below the fundamental frequency (f0) of the speakers used. It is psychoacoustic technology, enabling playback of deep bass on par with a sub woofer, without relying on amp speakers.

(3) Additional function 2: SRS FOCUS

Psychoacoustic technology that can move the stereo image vertically, and at the same time clarify the contour of the sound, offering music that sounds as if it were created before ones eyes, even with speakers installed at the low position found in doors.

Listening tests were performed on this CS technology in audio systems mounted in actual cars, and it was evident that the technology in (2) and (3) was effective with respect to the abovementioned issues b and c. However, new issues were evident with the technology in (1).

The details are explained below.

3.2 Issues with car installation of CSII

It was evident that the sound appears to oscillate back and forth in the rear seats when FM broadcasts with weak electric field were received while traveling by car. In terms of the basic principle of (1), as shown in Fig. 3, as the rear surround signal is generated from the L/R sound difference, when a mono-aural signal is subjected to the abovementioned (1) surround processing, sound from the rear is not output. This is the cause of the problem noted.

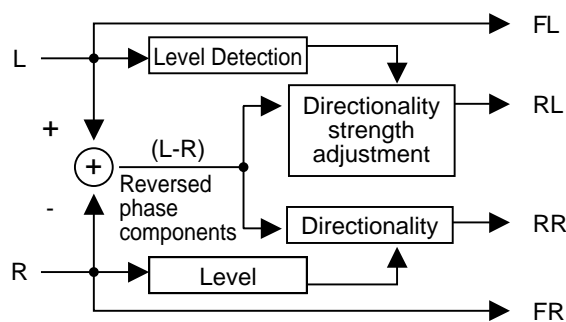


Fig.3 Basic principle of surround processing

Most FM broadcasts are in stereo. However, generally with car radios, to reduce reception signal noise when there is weak electric field, sound separation is changed from stereo to mono-aural using what is referred to as an ASC (Automatic Separation Control) function. In this way, when the abovementioned (1) surround processing is implemented, the phenomenon of no sound output from the rear channels.

Thus, it was surmised that countermeasures for this issue could be taken through adjustment of the parameters of the above mentioned HAAS Effect process. When this was confirmed in actual cars, as shown in Fig. 4, rear volume fluctuation was reduced, and its effectiveness was verified. The HAAS Effect is technology that can improve articulation while maintaining as is the sense of surround sound. It can reduce rear volume fluctuation while at the same time maintaining the sense of surround sound. For this reason, by using this technology, it was evident that CS could be applied as a car-fitted multi-channel surround system.

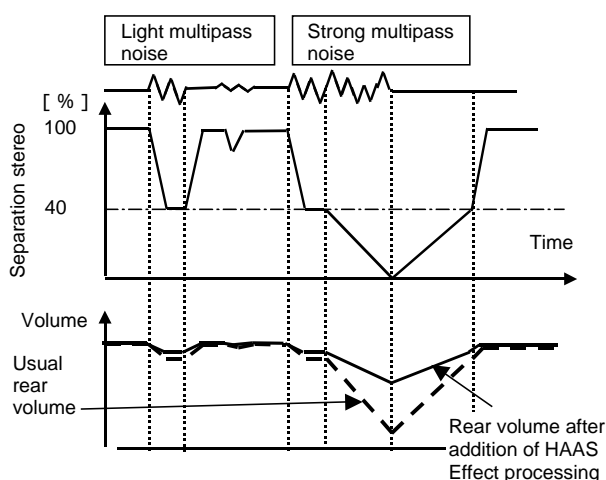


Fig.4 Rear volume fluctuation with stereo separation fluctuation

4

Realization of car-fitted CSII

In the creation of a CS product, optimization was implemented of hardware configuration and algorithms, with the goal of speedy commercialization through the addition of CS function while maintaining the conventional audio functions of DSP built-in devices as is.

4.1 Hardware configuration

In terms of the hardware configuration, as a result of investigations in order to utilize past resources and minimize changes, it was decided to adopt a structure (Fig. 5) in which CS DSP is added to conventional audio DSP.

With respect to the DSP added, as there was conformity with our company's structures, a low-cost CS DSP was adopted.

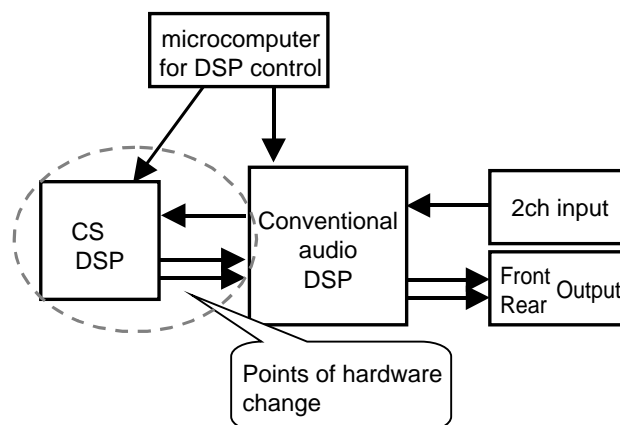


Fig.5 Hardware configuration diagram

4.2 Optimization of algorithms

With the abovementioned hardware configuration, the addition of HAAS Effect processing is necessary to conventional audio DSP. However, as DSP processing quantity is insufficient, Rear Mix processing, specific to car-fitted CS, was developed and built-in as a new method of processing.

Rear Mix processing implements Fig. 6, and aspects of HAAS Effect processing. (2 patents pending)

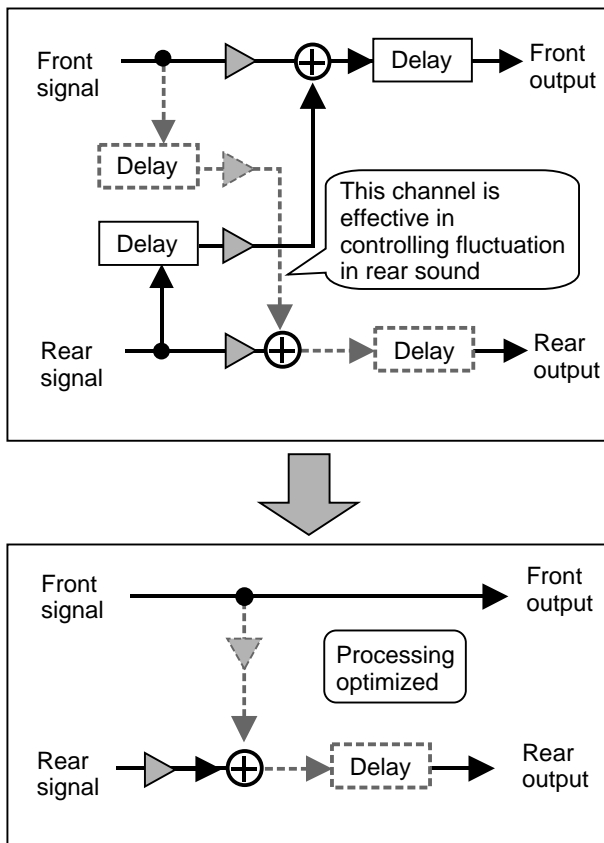


Fig.6 HAAS Effect processing and Rear Mix processing

Processing in which front sound supplements the rear sound

Delay between front sound supplemented to the rear and the rear sound

With implementation of this Rear Mix processes, the following effects are obtained at each seat:

At the front seats:

- The sense of sound diffusion is increased via rear output delay (process)

At the rear seats:

- Reduction of rear volume fluctuation due to weak electric field at the time of FM broadcast reception (process)
- The supplemented front signal delay produces precedence effect, improving the articulation of the front sound (process)

In this way, CS was achieved in a car-fitted product, while satisfying hardware constraint.

5

The commercialization of a car-fitted CSII built-in device, and evaluation of the product

Enjoyment of multichannel surround playback has become possible even in an in-car environment, with the

4-speaker systems in standard grade cars, through the addition of our company's original Rear Mix process technology to CS. Further, development was implemented for early commercialization, with the mass production period 1 year ahead of initial schedule, leading to the release of the car first" vehicle-fitted product with built-in Circle Surround.

The car-fitted product with built-in CS was widely adopted not only in car AV and navigational systems for our company's brand "ECLIPSE", but also in options (MOP, DOP) from a variety of automotive manufacturers.

In terms of product evaluation, it was presented at the FY 04 mobile electronics show, and was favorably received, providing "good sound at low cost" and "excellent authenticity of sound and dynamism".

Further, information related to this product has appeared in a variety of publications: It was featured at the end of April, 2004 in the magazine AutoSound #50, and in Option Wagon, October 2004 issue.



Fig.7 CSII installed model: ECLIPSE 6604HD

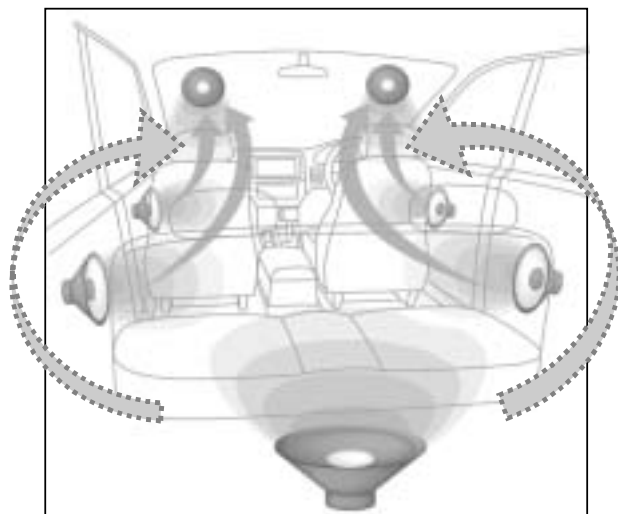


Fig.8 Image of the effect of car-fitted CSII

6 Summary and future outlook

This paper has described the development of the new surround technology, the car -fitted CS . Through a fusion of psychoacoustic research results and new digital signal processing techniques, this technology achieves a rich authentic surround sound field at a low cost, even in the narrow confines of a car compartment space. In this way, it becomes possible to build in multichannel surround function even for reasonably priced car audio systems, allowing even more users to easily enjoy wonderful surround sound.

Further, with FM Tokyo as the key station, Circle Surround -encoded transmissions started as of April 2004 across a 38-station network nationwide, utilizing the features of Circle Surround technology to allow transmission of 5.1 channel surround information using conventional 2 channel as is. When these broadcasts are heard with a car -fitted audio system with built-in CS , one can enjoy 5.1 channel surround even with FM radio. Broadcast has started not only of talk shows, in which the personalities engage in discussion separated not only to the left and right but also forward and backward, but also of live soccer broadcasts, replete with authenticity of sound. Currently, the only car -fitted product that can enjoy this broadcast with multichannel surround is our company's AV system with built-in CS . However, in future, a strong increase in car -fitted products with built-in CS is to be anticipated, in conjunction with the development of surround-encoded broadcasts.

In future we plan to continue development of this sort of sound function for the enjoyment of many users based on the DSP technology cultivated by our company over a period of many years.

(* 1) HAAS Effect

The HAAS Effect is a psychoacoustic technique, also referred to as the precedence effect. It is a phenomenon in which, if the same sound arising from multiple sound sources, the audio image is linked to the direction of the sound source first arriving at the listener's ears.

In Fig. 9, one sees that in terms of audio image, if the quantity of delay is set such that sound arrives from the closer speaker (B) after sound arrives at the listener from the distant speaker (A), the articulation of speaker A's sound will be improved, while retaining the direction of the forward speaker (A).

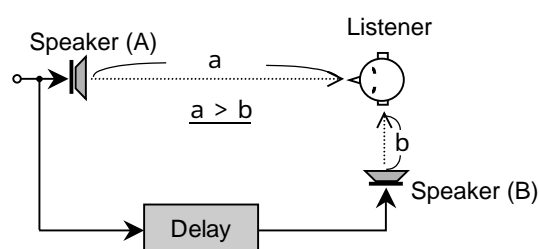


Fig.9 HAAS Effect processing

(* 2) Down Mix

Down Mix is the implementation of playback with 2-channel, reflecting the intentions of the creator as is, when for example DVD 5.1ch sound cannot be played back with 5.1 channel. This is normally used when playing back the music source created in multichannel signals with 2 channel player.



is a trademark of SRS Labs, Inc.

Profiles of Writers



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Entered the company in 1997. Since then, has engaged in the development of in-car audio systems. Currently in the Acoustic System Department, Audio Business Division, Business Division Group.



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