Foreword

21st Century Audio Technology — DSP

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I am honored to offer those introductory comments to you, in this third volume of the *FUJITSU TEN TECHNICAL JOURNAL*. The articles contained in this volume are devoted to an area with particularly intriguing potential, DSP sound field control technology. The applications of DSP technology are so extensive that its introduction by FUJITSU TEN constitutes a revolution in car audio.

The most exciting application for new DSP technology in car audio will lie in sound field control, it is in this field that FUJITSU TEN has chosen to debut its DSP technology. In fact, FUJITSU TEN was the first company to introduce digital sound field processing in the automotive environment. It is virtually impossible to overstate the importance of this introduction. With DSP sound field control, it is possible to create an ambient condition in the car interior which simulates the ambient condition in a concert hall or other acoustical space. The result for the driver and passengers is the experience of hearing music in its proper, large acoustical space, while driving in the car.

With DSP sound field control in the car, the listening characteristics can be completely redefined. For example, I recently auditioned an ECLIPSE EQS-1000 sound processor in three cars. In each case, the small, enclosed sound was transformed into a large, three-dimensional field, with sound arriving correctly both in terms of space and time. The psychoacoustical effect is remarkable, the music takes on new realism as all the important elements of acoustical space are added. Moreover, with the EQS-1000, it is possible to adjust processing parameters to define a particular space that best suits certain music. The result truly is a revolution of car audio; surely, in the near future, every quality car audio system will use DSP for processing such as sound field control.

The secret to DSP sound field processing lies in the understanding of a room's influence on sound, and the successful duplication of those sonic cues. In an open space, sound radiates from a source, never returning. However, in most environments, some sound returns toward the source, reflected from boundaries. For example, in a stadium, some sound from the field strikes the seating area, and reflects back to the field, creating an echo. The effect is even more pronounced in a room, where significant energy is reflected from the walls, floor, and ceiling.

This contained energy can be considered as several components. The direct sound is that emanating from the source, early reflections are those returning after a single reflection, and late reflections are those returning after multiple reflections. The latter form a dense pattern, creating reverberation. In addition, the frequency response of sound is altered as reflections occur. Overall, this ambient energy defines the enclosed space. In general, short time intervals between early reflections define a small space, and long delay times define a large space. The amount of reverberant energy defines a room as "live" or "dead." In this way, every room imposes its sonic fingerprint on sound within it.

Most music is performed within spaces. Whether it be medium-size and reverberant concert halls, small and less reverberant jazz clubs, large and highly reverberant churches, or large and almost anechoic (with echoes) stadiums, we identify certain music with certain spaces, for example, symphonic works demand the reverberation time of a concert hall of about 2 sec. Although a recording captures some of this sense of ambience, it cannot be accurately reproduced through two front speakers because the ambience, unlike the music source, must come from all directions at different times.

With sophisticated DSP processing, we can simulate room acoustics. Audio data is passed through delay lines to create early reflections, and delay lines with feedback loops to create reverberation. In addition, the signal is properly equalized. Finally, correct spatial information is applied, for example, the first early reflections are directed to front speakers, whereas later reflections are directed to rear speakers. The parameters used to control the processing determine the type of recreated acoustic space.

In the car, the potential of ambience processing is considerable. The car listening environment is highly artificial, for example, one essentially sits within the loudspeaker enclosure itself. Ambience processing is vital in overcoming the characteristic "upfront" car sound. By the same token, fortunately, a car interior has little acoustical character of its own, for example, despite large reflective glass areas, the interior has very short reverberation times. Thus the car interior's own acoustics will not overly interfere with the recreated acoustic. Finally, we know precisely where the listeners will be sitting, hence relative delays between channels can be precisely adjusted for best effect. The car is thus a perfect environment for sound field processing.

With the advent of digital audio, it was inevitable that DSP would be applied to audio products. However, compared to A/D and D/A conversion, or storage of audio data on disc or tape, digital signal processing of the audio signal is even more challenging. The speed of computation required to handle the tremendous throughput of audio data, for example, 1 machine cycle of 75n sec, as well as the wordlength required for precise computation demanded DSP hardware which, until recently, simply was not available.

FUJITSU TEN, drawing on its parent company's expertise in LSI design and manufacture, has developed new DSP chips specifically intended to process digital audio data. Moreover, these chips are able to perform under the adverse conditions of car audio installations, i.e., small space and wide temperature range of −30°C to 85°C. With chips such as these, many audio applications are possible in the automotive environment, such as filtering, equalization, compression, expansion, and acoustical noise reduction, to name a few. Other possible DSP applications beyond audio range from soil analysis to image processing, from pattern recognition to antiskid braking.

The FUJITSU TEN engineers who developed this DSP technology deserve the highest congratulations. They are truly leading the way in audio reproduction. As you read their words in the following articles, you will glimpse into audio technology of the 21st century, here today.

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