DIGITAL AUDIO

Collected Papers from the AES Premiere Conference,
Rye, New York 1982 June 3–6

AES

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INTRODUCTION

The audio community began its romance with digital technology in the early 1970s, with the introduction of the digital delay line. At this time the technology was becoming inexpensive enough to be commercially applicable to the professional audio environment. Looking back we notice that the technology was first introduced by people who were members of other technological communities. Because of this it was easy for the technology to be misapplied, misunderstood, and misdesigned.

Several years were required for the simple digital audio delay system to be fully debugged in the audio sense. By the mid-1970s the second digital system was introduced: the digital reverberation system. The level of sophistication of this device was several orders of magnitude more complex than the delay line. Both the delay and reverberation systems were, however, standard audio black boxes which could be used as analog replacements without considering their digital nature. Only the designers had to understand the technology.

Toward the end of the 1970s large numbers of technologists were beginning to understand that digital audio held even greater promise. This promise would require a major transformation of the profession in order to be realized. Extensive research and development efforts were begun on a large scale. Thus, in less than one decade, the professional and consumer audio industries could see the long-term pattern. Because of the speed at which the new technology had been introduced, many members of the audio community were being shut out of this revolution.

In late 1981 the organizers of the Rye Conference realized that the Audio Engineering Society could perform a major service to the AES family by holding an intensive three-day conference on this new technology. Unlike many conferences held by other societies, this one would be made up of the senior contributors who were leading the technology. Papers were by invitation only. The organizers hoped to put together a collection of experts who could cover the entire field. The goal of this group was to teach in a tutorial fashion as well as to summarize the state of the art. To some extent these are conflicting goals. The conference started with the most elementary point of view in order to allow beginners to become acquainted with the new technology. Other papers were meant to summarize the advanced concepts. Because digital audio covers so many topics, experts in one area learned the issues of other technologies with which they were not familiar.

In a survey at the end of the conference many of the experts indicated that they were actually more ignorant of issues outside of their specialties than they had expected. These comments are a warning to the reader: the technology is not simple and covers many areas. To be fully expert in digital audio one would have to know the following topics: information theory, data conversion, analog filter design, signal processing, error correction, optical physics, modulation techniques, digital filter design, hardware processor design, perception, testing techniques, industrial processes, rate conversion, studio applications, and broadcast issues, to name just a few.

The papers listed in the table of contents have been organized somewhat differently than at the actual conference in order to give the reader a clear sense of the categories.

Part one, on BASICS, provides the most elementary instruction for those readers who do not have any training or experience in this field. Experts may skip this section.

Part two, on CONVERTERS, presents papers which discuss some of the issues in the design of high-quality analog-to-digital and digital-to-analog converters. Any degradation which may be produced by these elements is irremovable by later processing. Moreover, since a feature of digital audio is quality, one would wish the converters to be of the highest quality. These two papers illustrate, if nothing else, that

data conversion at these quality levels is extremely difficult and requires consideration of many issues before it can be understood.

Part three, MEASUREMENTS, presents the notion of a scientific method for evaluating quality. It is not always easy to determine how good the system must be. Since digital audio attempts to make a "perfect" signal, we need to understand a methodology for confirming the degree of perfection. Moreover, some of the degradations in a digital audio system are unique to digital audio and have no counterpart in analog audio.

Part four, on RATE CONVERSION, covers a very specific topic which is the result of having several sampling rates in use. The requirement to convert from one sampling frequency to another puts an exacting demand on state-of-the-art digital signal processing. The area of signal processing is very general and only some aspects of it are relevant to digital audio. Sampling rate conversion happens to be one of them.

Part five, RECORDING FORMATS, presents many of the format issues in the recording of digital bits. Because digital audio has uniform and high bit rates, in comparison to computers, special burdens are placed on the recording system. The intellectual basis for recording may be straightforward but the secondary aspects such as errors, editing, tape speed, etc., put unique questions to the designer. As a result the design of a digital audio recorder is not a trivial task.

Part six is devoted entirely to ERROR CORRECTION. The need for error correction in both storage and transmission comes from several factors. A re-read of bad data, which is possible in a computer environment, is not possible in audio because it is always a real-time event, except for special cases. Also the tolerance to errors is actually much smaller in an audio application. Finally, the desire to get the highest bit density on a recording medium means that one always operates in the region where there will be significant errors. Unfortunately, the topic of error correction is one which requires very specialized training in mathematics. These papers provide an introduction, but the reader should expect to spend many long nights of study in order to actually understand this topic.

Part seven introduces us to the issues of MANUFACTURING a very high-technology product for the consumer marketplace. Although this would appear to be a commercial issue, the technology required to manufacture the equipment is actually more difficult than that required to design it. The choice of system design is controlled almost completely by the consequences of manufacture. With low technology this is not true. The Compact Disc thus represents a very interesting case study of the question of mass distribution of high technology. Historically, an industry attempts to do mass distribution only after there has been a learning phase during which the technology is used exclusively in a professional environment. This is not true for the digital audio disk.

Part eight is a collection of papers describing the ways in which digital technology has been used in special APPLICATIONS. Each of these applications has defined the design of certain types of equipment. A signal processor which is used for generating music for motion pictures will be very different from the equipment which is used for editing. Historically, the applications have always driven the technology, and this is certainly the case with digital audio. This section contains papers describing various applications for which digital audio has provided possible solutions.

One of the defects of these proceedings and the related conference is that the organizers were faced with the restriction of having only five months between the initial start of the idea and the actual meeting. Nevertheless, it is hoped that the reader will find this volume to be of assistance in understanding the digital revolution which is currently taking place. We, the organizers, have enjoyed the opportunity to serve the AES in this capacity and are grateful to those who made it possible: the AES headquarters staff; the *JAES* editors, in particular G. Franklin Montgomery, who edited most of the manuscripts; and the conference speakers who shared their knowledge and experience with us.

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