MULTI-CHANNEL AUDIO DATA COMPRESSION

-ABSTRACT ONLY-

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The advantages of digital storage and transmission have become so significant that all new entertainment media under development are based on digitally coded representations of picture and sound. This paper concerns the digital processing of multi-channel audio to lower the bit-rate required for storage or transmission. The coding system is referred to as AC-3.

Multi-channel audio is becoming important. First delivered to the consumer in a limited way in the 1950's by the motion picture industry, multi-channel audio is now the norm in the cinema. This has been made practical by the 4-2-4 surround sound matrix process employed on the stereo 35 mm film print. Using this technique, surround sound can be delivered by any two-channel media such as BTSC stereo television or VHS stereo soundtracks. Since nearly all films are produced with matrix surround sound, source material is prevalent. Surround sound equipment for the home is one of the major growth markets in home electronics.

The film industry is preparing to evolve from analog four-channel matrix sound to five-channel discrete digital sound (left, center, right, left surround, right surround, and subwoofer). The evolution will take place for two reasons: the superiority of digital storage over analog storage; and the superiority of discrete multi-channel sound over matrix multi-channel sound. This evolution is important because consumers will be exposed to discrete five-channel sound in the cinema, and large amounts of program material will be available in this format. As in the case of matrix surround sound, consumers will want this at home and the consumer market will undoubtedly follow the film industry with discrete five-channel sound finding its way into the home. New media which are developed should provide for this new sound format, or they will be at a competitive disadvantage.

The state-of-the-art in high quality low-bit-rate sound coding is the coding of audio into 128 k bits/sec/channel. Conventional thinking would indicate that it would take a 2.5 times increase in data capacity to code five discrete channels of sound compared with two, thus requiring 640 k bits/sec for discrete five-channel sound versus 256 k bits/sec for 4-2-4 matrixed multi-channel sound. However, this is not true. Humans only have two ears, and the addition of more loudspeaker channels do not necessarily increase the amount of information that has to be coded for the human listener (although it would be for the 6 eared Martian!). Using advanced techniques to be described in this paper, AC-3 is able to encode discrete 5 channel audio into a total data rate of only 320 k bits/sec, or 1.25 times the rate required for matrix surround sound. This is very significant, as it allows new media to offer a significantly improved sound experience with only a minor increase in data rate (i.e. an additional 64 k bits/sec over two-channel sound).

Numerous desirable features have been designed into AC-3. Although multi-channel sound is encoded, the decoder can reproduce any number of channels between one and five. The lowest cost monophonic or stereophonic receiver need not fully decode all five channels thus minimizing circuit complexity. Along with the five discrete channels, a low bandwidth subwoofer channel is encoded so that program providers can provide low-frequency sound with the same subjective

loudness as higher frequency sounds without using up the dynamic range of the DACs (higher levels of LF sound are required for the same subjective loudness). Compression control information is included in the bit stream which allows the consumer the option to enjoy either the original wide dynamic range sound or a compressed low dynamic range version (or anything in between) from the same broadcast. Also included in the bit stream is information about the subjective dialog loudness, which allows different program providers to reserve different amounts of headroom for dramatic impact, while the consumer hears uniform dialog loudness for all channels and programs.

This paper will attempt to make clear the significance of multi-channel audio to the cable industry. The AC-3 coding system will be described to show how high quality discrete multi-channel audio can be efficiently encoded for delivery to the subscriber. The paper will also describe how the use of a coding technology such as AC-3 can solve other problems such as channel loudness uniformity and variable dynamic range requirements.