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DEVELOPMENTS IN HIGH*FIDELITY SYSTEMS

A multiplex 4-channel disc system

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The problems of information storage and transmission have been with engineers for a long time and many of the difficulties have been associated with bandwidth limitations. With information in parallel/serial form it is easy to double the information capacity by doubling the number of parallel channels, keeping each channel of the same bandwidth. Alternatively an increase in the bandwidth of the original channels can give the same effect.

The increase from monophonic recording and reproduction to stereophonic systems led to the development of quarter track reel to reel tape recorders, the Westrex 45/45 disc system and later 4-track cassette machines. The latest development in consumer sound reproduction is described most popularly as Quadraphonics though the philologists have written much expressing their dislike of this Latin-Greek hybrid word and putting forward alternatives. This further doubling of the number of information input channels to be stored on tape and disc has naturally led to reduced playing time on the former and severe bandwidth limitations on the latter.

For hi-fi recording and reproducing it has been accepted that ¼" domestic tape machines should have four tracks each running in the same direction thus halving the playing time. Similarly 8-track cartridge systems have utilised the same number of recorded tracks to give two 4-channel programmes instead of four 2- channel stereo programmes, thus again halving the playing time. For the consumer market of the future JVC have developed their quadraphonic cassette machine which has eight tracks, four in each direction, on tape which is only 3.81mm wide, thus retaining the same playing-time as mono and stereo cassettes and maintaining compatibility.

Because of the high cost of reel to reel tape systems and the enormous world-wide investments in disc production and replay machines it has been felt necessary for the record companies to develop quadraphonic disc systems. These fall into two basic types - the so-called "matrix" and "discrete" types.

The matrix methods of encoding four information channels in a 2-channel storage medium so that the four

channels can be separately identified on decoding are inherently faced with the problems of crosstalk. It is basically not possible to compress four channels of bandwidth x into two storage or transmission channels of the same bandwidth x. The advocates of the two matrix systems available in this country at present have tackled this matrixing or mixing in different ways.

CBS have used a method of deliberate stereo compatibility for their (SQ) encoding method which has led to an asymmetrical encoding matrix and problems of image location. Their aim of left to right separation at the front and the back has been achieved though crosstalk in other directions is still present. Sansui's QS matrix system relies on diagonal separation and has an encoding matrix which is regular and symmetrical. The stylus vectors for this system are a horizontal movement if the recorded sound is at the centre in the front and angles varying from 0 to $+90^0$ to the horizontal as the sound moves to left and then to centre back. Similarly for movement from centre front through right to centre back the stylus vectors vary from 0 to -90^0 to the horizontal.

Both systems are compatible with existing stereo equipment and use the normally recorded bandwidth. However mono compatibility is not always satisfied and rear channel signals can be lost completely or severely attenuated.

The crosstalk problem has been dealt with in different ways by the developers of the SQ and QS systems. The former relies on the sensing of phase and amplitude signals in adjacent channels to give information for the adjustment of the gain of the four amplifiers. These gain-riding logic circuits work well to give directionality information but are evident as switching sounds to the critical listener. The vario-matrix system of QS again relies on sensing unwanted crosstalk and creating a directionality effect by a time delay signal on the unwanted sounds. The subjective effects of this are said to greatly increase the separation although the author cannot attest to this personally at this time.

JVC have tackled the problem of 4-channel recording on disc by developing a multiplex system. In the single disc groove one wall contains the sum of the left front (Lf) and left back (Lb) signals in the bandwidth 0 to 15 kHz. In addition to this directly recorded signal there is the difference signal (Lf-Lb) phase and frequency modulated about a 30kHz carrier giving a further band from 20 kHz to 45 kHz. Provision to increase this total bandwidth to 50 kHz has already been made giving an increased channel bandwidth, facilitated also by decreasing the inter-band gap. Similarly the other groove wall contains the sum signal (Rf+Rb) and the modulated carrier (Rf-Rb) signals. Because the signals are summed in the normal bandwidth 0-15 kHz the CD-4 disc system, as it is called, is fully compatible for stereo or mono reproduction with any cartridge and stylus.

For full 4-channel reproduction however a 45 kHz bandwidth cartridge is needed and preferably a high

quality stylus. Since the high frequency band is recorded 19dB lower than the directly recorded band the suspected problem of wear of these discs is not as great as was expected. New materials have been developed for the disc which has assured the life and a new shape of stylus, Shibata, has been formed to give better contact with CD-4 and all other discs. This system when correctly engineered and set up can give a 4-channel output signal almost indistinguishable from the original 4-track master tape.

Sophistications in the production of CD-4 records include JVC's own noise reduction system and groove waveform compensation to minimise tracking errors in playback. The cutting of these discs, previously at a reduction of 1 : 2 · 7 is now at half speed.

The claim of JVC that there is no significant loss of information if a CD-4 disc is played 100 times with a conical stylus tracking at 5g has been substantiated by listening tests but there is some noise present after this treatment. However it is expected that this is no more serious than the effects of a 2-channel stereo record given the same treatment.

The JVC CD-4 system is potentially capable of reproducing sounds anywhere in the 360^{0} sound field and of giving the listener complete identification of the four separate sound signals. It must also be said that some recordings will benefit from a certain degree of crosstalk between channels and there is, of course, the possibility of also including this on a CD-4 disc.