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RESEARCH DEPARTMENT



REPORT

**Equipment for the transfer of
digital video signals to paper tape**

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EQUIPMENT FOR THE TRANSFER OF DIGITAL VIDEO SIGNALS TO PAPER TAPE
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Summary

A digital computer can be used to simulate processing methods for the bit-rate reduction of digital television. To assess such methods, television signals must be converted to a form compatible with computer data-handling systems. This report describes equipment for transferring monochrome pulse-code modulation television signals derived from a slide scanner to punched paper tape. One eight-bit word is extracted from the repeated signal during each picture period and is then punched as a single eight-element character on the tape.

The equipment has been used to produce two paper tapes each containing an area of picture 256 picture elements wide and 256 lines high. The report includes a picture reconstituted from one of the tapes.

Because the phase of the colour subcarrier at a point in the picture is the same only once every four picture periods, the equipment must be modified to take samples at this rate, if it is to be used with coded colour signals. More extensive modification would be needed if subcarrier-locked sampling were to be used.

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Section	Title	Page
	Summary	Title Page
1.	Introduction	1
2.	Principle of operation	1
3.	Method of testing	3
4.	Modifications for colour signals	3
5.	Conclusions	3
6.	Reference	3

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1. Introduction

A general-purpose digital computer may be programmed to perform exactly the same arithmetical and logical operations as a processor for the bit-rate reduction of digital television. However, such computers are not sufficiently fast to accept and process television signals in real-time. So, in order to simulate a bit-rate reduction method by using a digital computer, it is necessary to reduce the input data rate by converting the signal to a form which may be readily accepted by a computer, for example, as characters punched on paper tape. Also, the signals processed by the computer must be stored and subsequently read out at television rate onto a picture monitor.

In this way, many of the degrading effects introduced by the bit-rate reduction process may be seen and assessed without building a specialised processor. However, because it is impracticable to provide sufficient storage to hold several frames of processed signal, it is not possible to assess the effects produced on moving pictures with this simulation method.

To provide suitable input data, equipment has been developed to transfer eight-bit pulse-code modulation television signals to punched paper tape. The equipment transfers a square section of picture consisting of 2^{16} (65536) picture elements, that is approximately one-sixth of the area of a television picture. With a punch operating at 25 characters per second, the transfer takes 44 minutes and uses 170 metres of paper tape.

2. Principle of operation

The rate of signal transfer to the paper-tape punch is reduced by sampling a repeated picture signal. The arrangement used is shown in Fig. 1, where the slide scanner provides stationary monochrome picture signals which are converted to eight-bit digital form by the Analogue-to-Digital Converter,¹ and the sampler selects one word during each picture period and operates the paper-tape punch to produce a corresponding eight-hole character.

The sampler contains two counters which establish a co-ordinate system for the picture. The horizontal counter is advanced at 851 times line-frequency and reset at the beginning of each line, whilst the vertical counter runs at line rate and is reset at the beginning of each field. A picture-rate square wave is used to distinguish the fields and

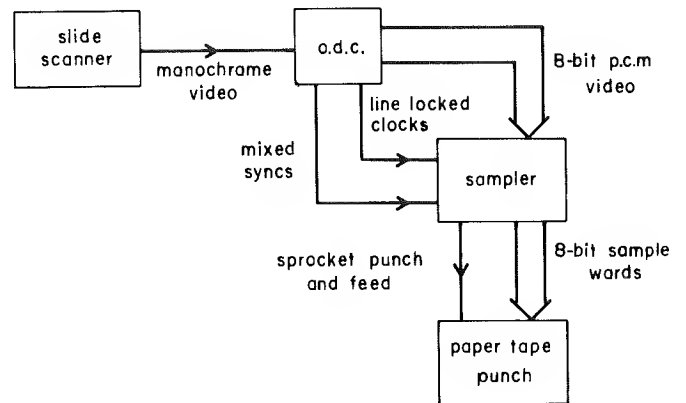


Fig. 1 - Arrangement for transferring digital video signals to paper tape

a further counter, advanced once per picture, is used to register the number of samples taken. The outputs of these counters are compared as shown in Fig. 2 and a sample is taken when the outputs are identical. As a result, the 2^{16}

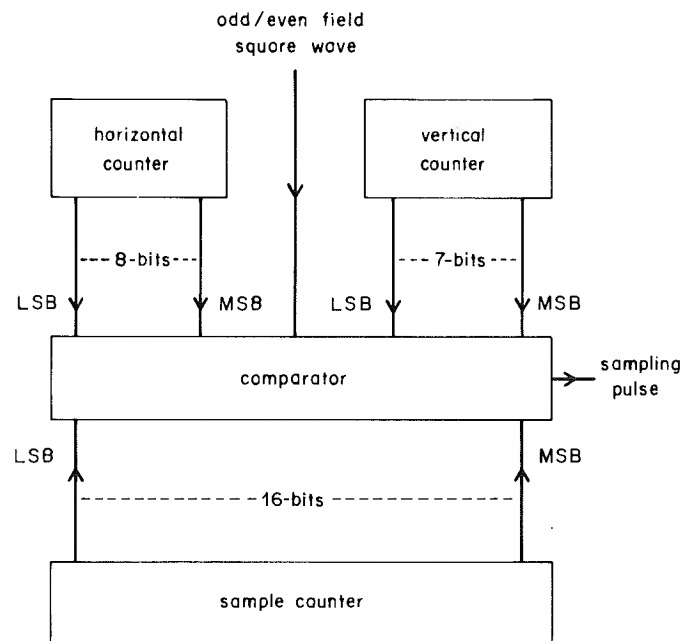


Fig. 2 - Generation of sample position

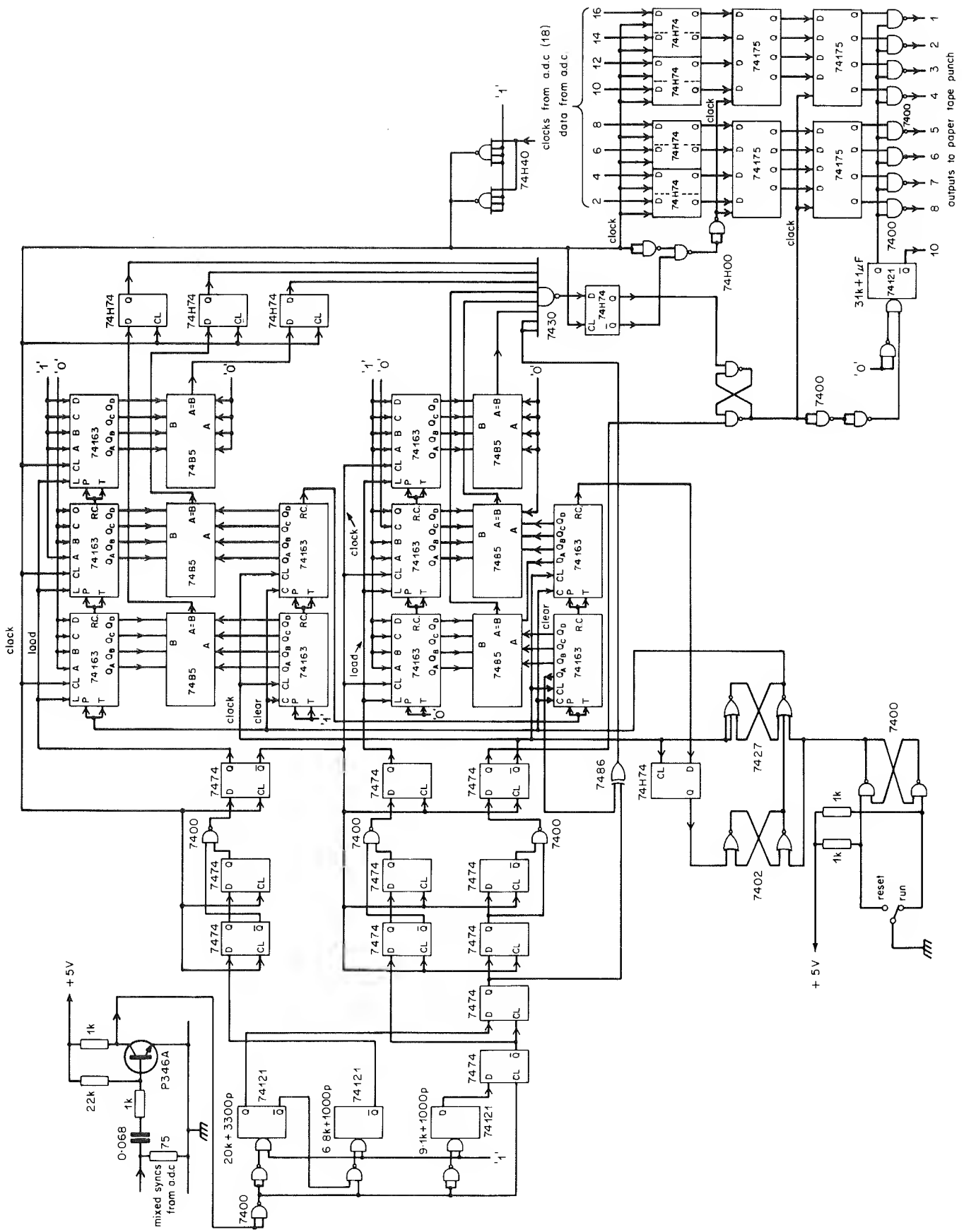


Fig. 3 - Logic diagram of the sampler

states of the sample counter correspond to 65536 different positions on the picture. By comparing bits 1 to 8 of the sample counter with the horizontal counter, bit 9 with the Odd/Even-field square wave and bits 10 to 16 with the vertical counter, an area 256 picture elements wide and 256 lines high is scanned sequentially. A sequential scan was chosen in preference to an interlaced scan to minimise the effect of drift in the analogue circuits of the slide scanner and analogue-to-digital converter during the scanning period. The full logic diagram of the sampler is shown in Fig. 3.

Whilst scanning along any line, the interval between sampling pulses is two field periods. However, because a sequential scanning order has been chosen, the interval between the last sample of a line and the first sample of the next line varies from just over one field period to just over three field periods. In order to provide a regular flow of data to the punch, the eight-bit words must be stored in a second register at the end of each picture and read from this to the punch.

Although the horizontal counter takes up 851 different states in a line period, samples are only taken over the 256 lowest states. By resetting the counter to an appropriate state at the beginning of each line, the sampled area can be positioned anywhere along a line. A similar method is used to determine the vertical position of the sampled area.

Operation of the sampler is controlled by a switch having two positions: Run and Reset. The switch is latched to ensure correct starting and the latching circuits automatically stop the sampler after 2^{16} samples have been taken.

The system produces paper tapes on which the data appears as a continuous block of 2^{16} characters. Since samples are only taken during the active line, there is no possibility of null characters (no holes punched) being produced as data and the section of lead-in tape can be recognised.

3. Method of testing

Although it was not possible to check the picture information stored on the tapes directly, tests were made to establish that the correct samples were punched. The sampling order was checked by observing the traverse of the sampling pulse on a picture monitor. Paper tapes made from analogue waveforms of known amplitude and timing were examined visually to check that the correct sample values were transferred; further, an electronic counter was used to count the number of characters punched on full-length tapes. No errors were detected.

Two paper tapes of picture signals have been produced, one corresponding to a portrait and the other to a section of test card. The portrait comprises both plain areas and areas of fine detail, whilst the test card includes

horizontal, vertical and diagonal bars. Fig. 4 shows the portrait* reproduced on a computer line-printer using a sixteen level grey-scale of variable character density.

4. Modifications for colour signals

The equipment as described cannot satisfactorily be used with coded colour signals because the phase of the colour subcarrier at a point in the picture is the same only once every four pictures. Thus, to reproduce a portion of a coded colour signal, the samples must be taken from every fourth picture. To prevent the transfer taking four times as long, a store could be used to hold four consecutive samples from one picture which would then be punched at the rate of one per picture (the maximum rate at which the paper-tape punch can operate).

If it were intended to decode the colour signals as part of the computer processing, it would be much more convenient to use samples phase-locked to the subcarrier than the line-locked samples used for monochrome transfers. However, subcarrier-locked sampling would require a considerably more complicated horizontal counter because line pulses could no longer be used for resetting the count. Furthermore, extra samples, conveying the subcarrier reference phase on each line, would be required.

5. Conclusions

The monochrome transfer equipment establishes a system of positional co-ordinates for a television picture 851 picture elements wide and 625 lines high. Any area of the picture 256 picture elements wide and 256 lines high can be scanned sequentially and this section of the picture signal transferred in digital form onto punched paper tape. Each picture element, represented digitally as an eight-bit word, is punched as a single eight-digit character on the tape. Two paper tapes of picture signals suitable for testing bit-rate reduction techniques have been made, one describing a portrait and the other a section of test card.

The design of the equipment could be easily modified to accommodate coded colour signals provided that sampling were still locked to a multiple of line frequency. However, to transfer coded colour signals in a convenient form for subsequent decoding, it would be necessary to use sampling locked to the colour subcarrier; this would entail extensive changes to the counter determining the horizontal co-ordinate.

6. Reference

1. Pulse code modulation of video signals: 8-bit coder and decoder. BBC Research Department Report No. 1970/25.

* Reproduced by kind permission of Professor P.S. Brandon, Cambridge University.



Fig. 4 - Portrait reproduced from paper tape on a computer line printer using a grey-scale of variable character density
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