BBC Engineering Information Service

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# BBC ELECTRONIC FIELD STORE COLOUR TELEVISION CONVERTER

Today the BBC Engineering Division demonstrates to the press the World's first and only purely electronic standards converter capable of converting colour television pictures instantaneously from the 525-line 60-field NTSC system used in America and other countries, to the 625-line 50-field PAL system used in Europe, including our own country, and in countries in other parts of the World; if required the converter can be arranged to provide pictures on the 625-line 50-field SECAM system used in France and some other countries. The new converter, developed and constructed by the BBC Engineering Division, will enable colour pictures originating at such events as the Olympic Games in Mexico in 1968 on the 525-line NTSC system, to be relayed throughout Europe on the 625-line PAL or SECAM systems.

For the following simple explanation of the method of working of the converter it is helpful to regard the term "field" as equivalent to "picture"; thus a system described as having 50 fields per second may be regarded as presenting 50 pictures per second analagous to the 24 pictures per second of moving photographic film. The task of converting a colour picture originating on the 525-line, 60-field NTSC American system to the 625-line, 50-field PAL or SECAM European systems involves three major problems: changing the number of lines; changing the colour television system; and changing the number of fields per second. Of these, the changing of the number of fields per second is very much the most difficult, particularly in the case of colour pictures.

The process employed in the present converter begins by changing the number of fields per second. Since the American system has 60 fields per second it is clear that each field lasts for a shorter time than a field of the 50 fields per second European system. A field of the American system must therefore be somehow stretched out in time to correspond to the duration of the European field; moreover there are ten more fields in a second of the American system as compared with the European system and these extra fields must contribute in some way to the converted picture if the impression of movement is to be as like that of the original picture as possible. Both these requirements are met by "storing" the incoming American picture for a time, about equal to the duration of a field, and taking the information out of the store in such a way as to assemble the desired outgoing European picture. In this converter the store consists of a number of "glass" blocks capable of storing the information contained in a complete field of the American picture; hence the name, field-store converter. Thus, the input to the store is the 525-line 60-field American colour picture, the output being a 525-line 50-field colour picture.

The next stage may be considered as a process of changing the number of lines by means of a "line-store" converter. The line-store converter developed by the BBC in 1963 was the first all-electronic standards converter, and is capable of changing the number of lines between television pictures on any two line standards provided the

field rates are the same. (For example, line-store converters are in constant use to exchange pictures between the 625-line and 405-line systems). The output of the line-store converter, is, therefore, a 625-line 50-field colour picture as yet not changed to the required PAL colour system.

The last and final stage is to present the pictures on the desired colour system. This is a comparatively conventional process in which any desired colour system can be used. For this demonstration the pictures are being presented on the PAL colour system used in this country.

The area of the converted picture is somewhat smaller than usual and some operational problems are presented to the Broadcasting Authority by the nature of the output signal. These disadvantages are a small price to pay in exchange for the ability to provide viewers with colour pictures of excellent definition directly from American type pictures.

Photographs available

# TECHNICAL DESCRIPTION OF THE PRINCIPLES OF OPERATION OF THE FIELD-STORE CONVERTER

The principle on which the new electronic converter operates is best illustrated by means of the diagram Fig. 1 which shows any 1/10th of a second. In this period 6 fields will have elapsed in the American system whilst 5 fields will have elapsed in the European system. It will also be noted that, if the two systems start scanning simultaneously the first American field will have been completed slightly before the first European field, and thus the information can be transferred directly as regards time.

The second American field will, however, begin slightly before the second European field, 16.6 m.sec after the start as opposed to 20 m.sec. A delay of just over 3.3 m.sec is therefore introduced into the converter circuits between the incoming and outgoing field scan as indicated in the diagram. Thus American field No. 2 is delayed until field No. 2 European is starting, and so on with increasing delays until No. 5 American becomes No. 5 European.

As the line scanning rate has not been altered by the introduction of the delay, the height of the delayed 525-line picture will be reduced and the picture geometry will be wrong at this stage in the conversion; thus as indicated by the dotted lines in Fig. 1, there will be a space at the top and bottom of the screen and any circular object in the picture would appear oval.

To rectify the geometry, to change the number of lines, and also to deal with the colour content of the picture, further stages are necessary to complete the conversion and these are illustrated in Fig. 2. The output from the delay section of the converter is fed to an American type, (NTSC) decoder which separates the luminance and chrominance components of the delayed incoming signal. An extra unit in the decoder breaks down the chrominance signal into the I and Q signals which together form the coded NTSC colour signal. The luminance component is fed through a line-store converter which reconstitutes the delayed black and white picture to 625-line standards and, in doing so, corrects the picture geometry. The I & Q signals are also passed through a second line-store converter and emerge as I & Q signals on 625-line standards. The luminance and chrominance components, all three now at 625-line standards, are fed into a PAL colour coder the output of which is a European 625-line 50-field per sec PAL colour signal. The same three signals could, alternatively, be coded to provide a 625-line SECAM picture for distribution to those countries requiring it.

If only black and white signals are incoming the output of the luminance line-store converter alone provides the 625-line picture as no colour information is present. In correcting the picture geometry the line-store converters compress the picture in a horizontal direction and the fully converted picture therefore has a small space on the right and left hand edges as well as at the top and bottom.

It will be noted that in the diagram Fig. 1 field No. 6 of the incoming 525-line picture appears to be discarded. If this were really the case, movement in the picture, particularly of fast-moving objects, would appear to be jerky as every 6th field would be completely missing in the

converted picture.

To overcome this disadvantage, a further delay of 3.3 m.sec making a total of 16.6 m.sec or one complete field, is introduced between field No. 6 of one series and field No. 1 of the following series so that these two are superimposed as far as the delay section output is concerned. The result of this technique is to mitigate the jerky effect to an extent at which it is barely noticeable except when the movement being portrayed is extremely rapid.

The new field-store converter, the first electronic device in the world to convert directly between two colour, or black and white, pictures on systems having a different field repetition rate, provides excellent colour and definition at the expense of a few sq. ins. of picture area in the converted picture.

Photographs available

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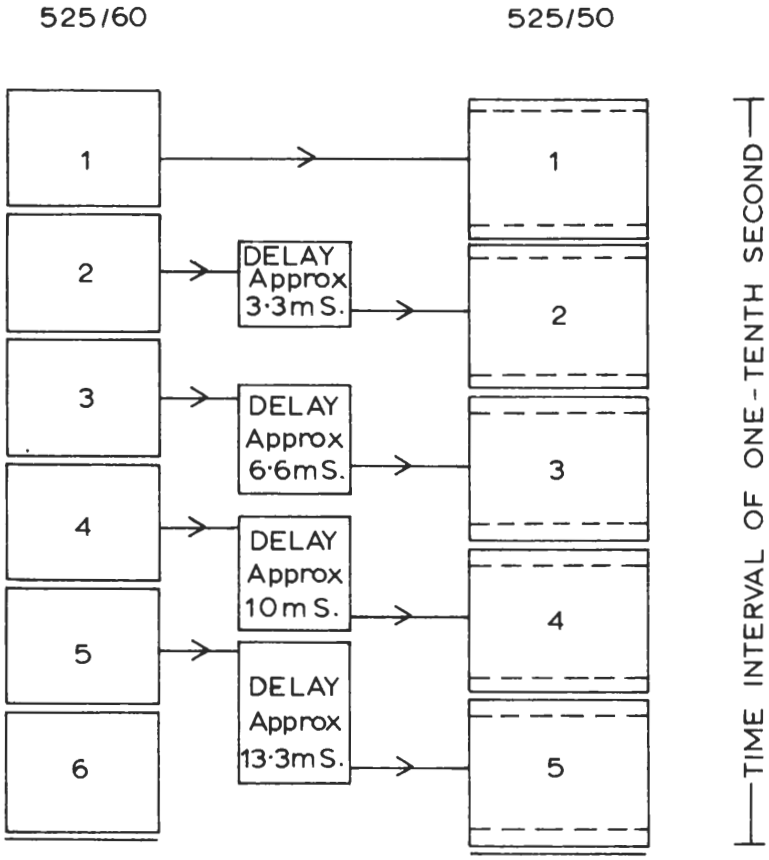


Fig. 1
DIAGRAM OF DELAY SEQUENCE

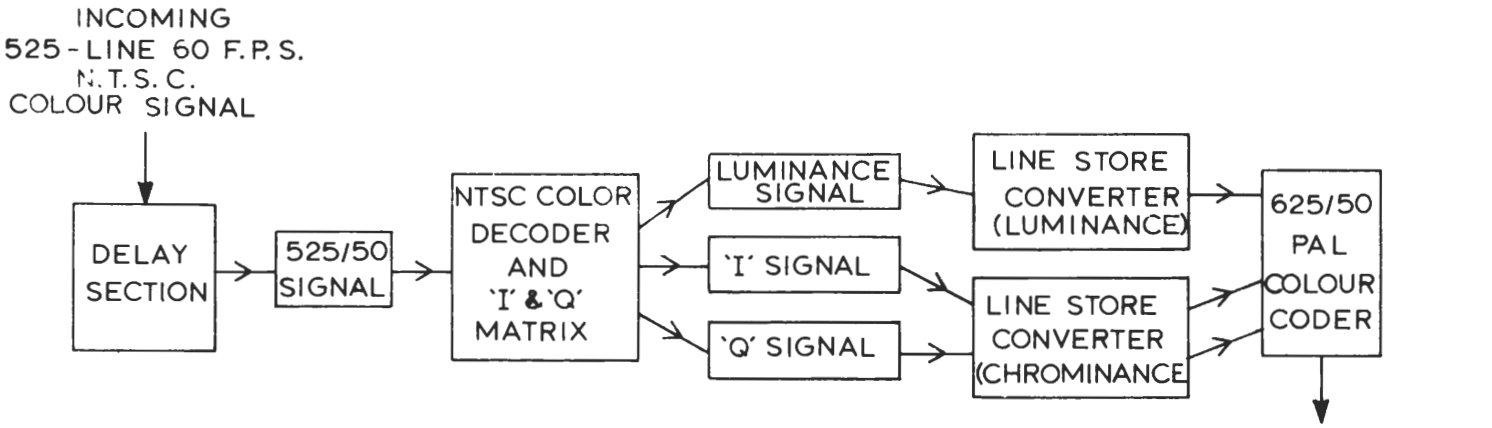


Fig. 2
BLOCK SCHEMATIC OF ELECTRONIC FIELD STORE STANDARDS CONVERTER

## Statement on Transcoding

Recent work on transcoding between different colour systems nominally having the same scanning standards has shown that transcoded pictures of broadcast quality can be obtained by using the relatively simple technique of separating the luminance and chrominance components of the incoming signal by means of a phase-corrected low-pass filter, demodulating the chrominance signal to obtain colour primary or difference signals and then using them to remodulate a subcarrier in a manner appropriate to the outgoing system. The separated luminance signal is processed to improve the subjective picture quality (i.e. waveform correction, crispening, vertical aperture correction etc.) and this luminance signal is then combined with the new chrominance signal to form the transcoder output.

An inherent difficulty arises with SECAM to PAL transcoding because the tolerance on line frequency for the SECAM system ($2.10^{-4}$) is much wider than the tolerance for PAL ($2.10^{-7}$ in the U.K.). Thus, the relationship between the SECAM (and transcoded PAL) line frequency and the standard PAL subcarrier can depart from that specified for the PAL system and this will produce some loss of compatability and will lead to difficulty with videotape recording.

To overcome this difficulty the present practice is to produce two outputs from the transcoder:

1) The Transmission output is used for transmission to domestic receivers and has the standard PAL subcarrier but a line frequency which may be incorrect and result in a loss of compatability.

2) The Recording output is used for videotape purposes and has a special subcarrier with the correct arithmetic relationship to the incorrect line frequency such that it can be recorded and when replayed (with a slightly different tape velocity) will produce a standard PAL signal.

The fact that the transcoded signal exists in two forms is operationally very inconvenient and there is a requirement for further equipment which can process the "Transmission" output from the ~~decoder~~ transcoder at a remote point such that it is in a form suitable for videotape recording. One simple but rather inelegant method is to use a PAL to PAL transcoder; there are few technical problems involved but there may be a loss of picture quality. The apparatus could be available within about four months and would probably cost in the region of £500. A more satisfactory solution may be forthcoming in which the "Transmission" signal is processed directly (without decoding and recoding) to provide the recording signal. As several methods for doing this are still under consideration it is difficult to give any accurate forecast but the apparatus should not cost more than about £600 and could probably be available within six months.

Equipment of this type would also be suitable to deal with the similar problems which arise in standards conversion.

DA
15/9/67

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# SIGNALS FROM FIELD STORE STANDARDS CONVERTERS

## (A note by Chairman Conversion Sub-Group Working Party M.)

The BBC is developing two types of field store standards converters, which for purposes of differentiation may be called "simple" and "advanced" types.

The simple converter is approaching completion; its performance was recently demonstrated to the Conversion Sub-group of Working party M. There is no doubt that this converter will be available for the conversion of American colour signals to the European 625-line PAL standard from December 1967, and will of course also be available if required for the Olympic Games from Mexico City. Good progress is also being made with the development of the advanced type of convertor, but at the present time it is not possible to give a categorical guarantee that it will be available for use on the Olympic Games, although there is every expectation that this will be the case. The two converters produce different types of signals and it is the purpose of this note to state what these are and to suggest how they ought to be handled on the Eurovision Network.

### The Simple Converter

As is well known the simple converter produces a 625-line signal whose field frequency is exactly 5/6ths of that of the incoming 60-field American pictures. Unfortunately, the line and field scanning frequencies of the 60-field and 50-field systems do not have this exact 6 to 5 relationship when both systems are producing their specified colour sub-carrier frequencies and the correct relationship of colour sub-carrier frequencies to line and field scanning rates. Thus the PAL signal produced by the converter can have one of two forms, viz:

(a) The colour sub-carrier has a frequency according to the specification of the PAL system, but has not the specified relationship between the frequency of the colour sub-carrier and the line and field scanning frequencies. This signal is suitable for direct broadcasting purposes but cannot be recorded or mixed with the standard PAL signals normally available.

(b) The signal has the specified relationship between the frequency of the colour sub-carrier and the line and field scanning frequencies, but all three are incorrect; in fact they are of the order of 0.1% low in frequency by comparison with the specification. This signal is suitable for recording and on reproduction will produce a standard PAL signal. Monitoring of this signal prior to recording requires that the decoder employs a burst-locked oscillator with a crystal having a nominal frequency which is that of the colour sub-carrier, the value of which is given at the end of this note.

### Advanced Convertor

The advanced converter produces a perfectly standard PAL signal and has, in addition, the unusual feature of being capable of producing this signal completely synchronous with reference to a local source of pictures.

It is clear that no problem exists in the distribution of signals from the advanced type of converter, but for the simple type it is necessary to make a decision as to the form in which the signals should be distributed and arrangements made for using these signals in the desired fashion.

It is technically possible, at points remote from the converter, to change either of the two types of signals produced by the simple converter into the alternative

form. In particular it is relatively simple to convert the recording type of signal to the direct broadcasting type by a process of decoding and re-coding. However, this requires the development of special equipment and in view of the expectation that the simple type of converter will have only a short period of use for international exchanges, it is not thought worthwhile to undertake this development work, particularly as a number of countries would have to provide themselves with such equipment. It is suggested therefore, that the signal should be sent on any one occasion in the form in which it is required.

It is thought that on the majority of occasions the signal will be wanted in its recording form for subsequent broadcasting. There will, however, be occasions on which the signal will be required for both recording and broadcasting purposes; it is suggested that for these occasions two circuits should be provided from the site of the field store standards converter to the various destinations. It is thought that the occasions on which the signal for direct broadcasting purposes will be required alone will be so infrequent that to make provision for sending this type of signal alone would only add confusion to an already complicated situation. Should this type of signal be sent alone, it would be impossible, for example, for a Broadcasting Organisation to change its mind at the last moment that it required the signal for recording as well as for direct broadcasting.

The values of the frequencies of the colour sub-carrier, $f_{sc}$, line scanning, $f_{line}$, and field scanning, $f_{field}$, will be:

Signal suitable for recording:

$f_{sc}$ = 4,429,189.6Hz $\pm$10Hz

$f_{line}$ = 15,609Hz

$f_{field}$ = 49.95Hz

Relationship of line frequency to colour sub-carrier : $f_{line} = \frac{4f_{sc} - 2f_{field}}{1135}$

Signal suitable for direct transmission:

$f_{sc}$ = 4,433,618.75Hz $\pm$1Hz

$f_{line}$ = 15,609Hz

$f_{field}$ = 49.95Hz

Relationship of line frequency to colour sub-carrier : none specified

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