

REPORT 962-2

THE FILTERING, SAMPLING AND MULTIPLEXING FOR DIGITAL ENCODING OF COLOUR TELEVISION SIGNALS

(Question 25/11, Study Programme 25H/11)

(1982-1986-1990)

1. Introduction

Report 629 provides a brief introduction to the subjects of bandwidth and sampling as relevant to the process of encoding component signals into digital form.

In order to ensure that the total bit rate of the digital signal is not excessive, it is clearly necessary to determine the bandwidths of the luminance and colour-difference signals which are adequate to provide high-quality broadcasting signals (which may be in the analogue composite form). Further, when considering the filtering and sampling of component signals, it is also necessary to bear in mind that proposals have been made to use such signals in digital form for purposes which could be more demanding than conventional broadcasting (see § 2.3). In particular, attention must be paid to the constraints imposed by modern programme production techniques, taking into account the quality margin required by the increasing demand for picture-processing operations [Akrich and Zaccarian, 1981].

In choosing the sampling parameters to be used for component signals, the sampling frequencies are, clearly, closely related to the bandwidths of the component signals, but other parameters are concerned with the picture sampling structure or structures (see § 3).

The number of bits necessary to describe each sample is discussed in § 4.

In order to handle a single byte stream in the studio when component coding is used, time-multiplexing of the three byte streams is required. Some possible arrangements are discussed in § 5.

2. Bandwidths

This section is divided in three sub-sections, the two following sub-sections outline the results of subjective tests aimed at establishing the overall luminance and colour-difference signal bandwidths, respectively. The third sub-section discusses the implications with regard to these bandwidths, taking into account the needs of studio signal-processing operations.

2.1 Luminance-signal bandwidth

[CCIR, 1978-82a and b] give the results of tests by members of the EBU, to determine the relationship between subjective quality and the bandwidth of the luminance component, using a 625-line system and monochrome display. The tests were carried out using a method described in Report 405, using the impairment scale and pictures slightly more critical than average, as required by Recommendation 500.

The main conclusion indicates that bandwidth-limiting to 4.5 MHz (at -3 dB) using sharp cut off low-pass filtering introduces an impairment which is imperceptible to 50% of the observers at a viewing distance of four times the picture height (see Fig. 1a). The results indicate that the effects of filtering on electronically-generated captions are less critical than those on the pictures. These studies did not show the expected advantage for the use of a comb filter (with sub-Nyquist-sampling) when compared with a low pass filter cutting off at half the sampling frequency.

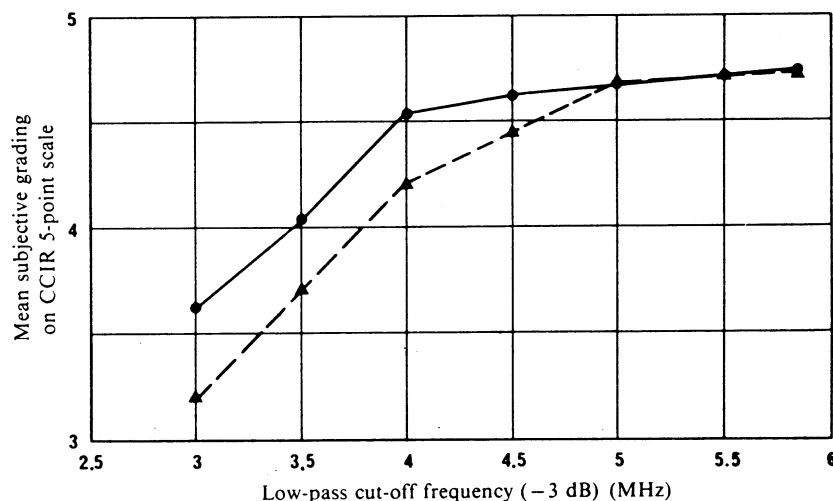


FIGURE 1a — *Low-pass filtering.*
Mean values of the results obtained in seven laboratories,
using 625-line test pictures

- viewers at a distance of six times picture height
- ▲— viewers at a distance of four times picture height

The subjective test results obtained in these EBU tests have been analyzed in accordance with the method described in Annex III of Report 405 and this work is described in [CCIR, 1978-82c]. The result of the analysis is presented in Fig. 1(b). The same document discusses the substantial effect of the choice of picture material and the large spread of the results which can occur when Recommendation 500 is not followed. It also expresses the view that an impairment criterion of $I = 0.05$ (corresponding to grade 4.8 in a five grade scale) is appropriate and that consequently the minimum bandwidth of the luminance signal should be 5.8 MHz.

Tests carried out in Poland, and described in [CCIR, 1978-82d] also indicate that the luminance-signal bandwidth should not be less than 4.5 MHz for 625-line systems.

[CCIR, 1978-82e] describes work by the U.S.S.R. which concludes that the appropriate bandwidth for the luminance signal is 6.0 MHz.

The relationship between picture quality and luminance-signal bandwidth, for 525-line systems, has been investigated in Japan [CCIR, 1978-82f]. Separate tests were carried out, using colour pictures, for two different values of colour-difference signals bandwidth; the filters used in the luminance and colour-difference channels were of the Thomson type (i.e. relatively slow cut-off). The results of the tests indicate that a luminance-signal bandwidth of 5.6 MHz is suitable.

2.2 Colour-difference signal bandwidth

Tests in Poland [CCIR, 1978-82d] indicate that, for 625-line systems, the bandwidth of each colour-difference signal should be not less than 1.5 MHz, a result which agrees with that given in [CCIR, 1978-82e] from the U.S.S.R.

The work described in [CCIR, 1978-82f] also included tests to determine the colour-difference signal bandwidth appropriate to 525-line systems. The relationship between picture quality and colour-difference signal bandwidth was determined by separate tests, using colour pictures, in which two different values of luminance-signal bandwidth were involved. From the results it is concluded that the colour-difference signal bandwidth should have a value of approximately 2.8 MHz (Fig. 2).

Experiments conducted in France [Sabatier and Sallio, 1981; Sabatier and Chatel, 1981] show very similar results for 625-line systems.

Investigations to establish the optimum characteristic for limiting the bandwidth of colour-difference signals are outlined in [CCIR, 1978-82g]. These studies, carried out in the Federal Republic of Germany, were made assuming that the maximum bandwidth available (the Nyquist limit) was 2.0 MHz.

Studies involving subjective tests have been made to determine the optimum characteristics for a filter, also with a bandwidth of 2.0 MHz; these studies are described in [CCIR, 1978-82h].

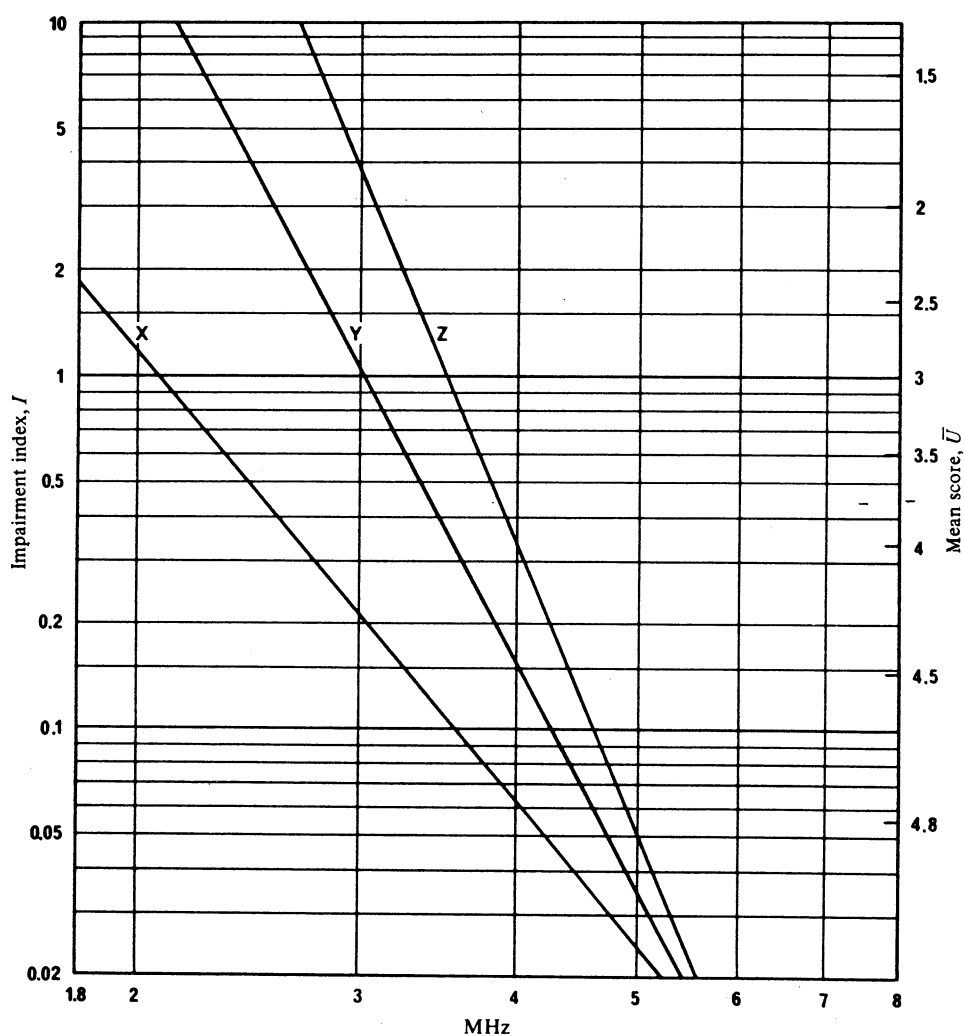


FIGURE 1b – Impairment characteristics for bandwidth restriction, from EBU experiments: spread of results from different laboratories. Viewing distance is 4 times picture height

Curves X: laboratory A (the least critical)
 Y: average of results from 7 laboratories
 Z: laboratory B (the most critical)