METHODS FOR MEASURING THE MAIN CHARACTERISTICS OF TELEVISION CAMERAS

Tech 3238 - E

March, 1983

CONTENTS

Technical Centre of the European Broadcasting Union
Avenue Albert Lancaster 32, B-1180 Bruxelles (Belgium)

INTRODUCTION

The present document contains descriptions of methods for measuring the characteristics of 625-line colour television cameras. It has been written by Sub-group G4 of EBU Working Party C which is responsible for studies relating to "video origination equipment". The document is a response to a need that has become apparent for a common language in the exchange of data concerning television cameras among both manufacturers and users. It should be of particular assistance to broadcasters in making valid comparisons between measurements taken in different laboratories.

The methods described here have been devised primarily for use in acceptance tests on studio cameras, although in fact several of them are also suitable for use in the evaluation of the performance of lightweight cameras.

The order in which the measurements are presented here is that which seems most logical and it will generally be found convenient because it avoids the repeated re-adjustment of operational controls. Other measurement sequences may however be equally satisfactory.

A measurement of colour fidelity is also desirable and this question is being studied within the EBU. So far, no EBU recommendation has been established on this subject but detailed descriptions of procedures for implementing existing methods are given in EBU document Tech. 3237.

CHAPTER 1

General conditions

Most of the methods described use test cards, whose reproduction by the camera is evaluated either by measuring the amplitudes of the camera output signals with an oscilloscope, or by measuring the distortion affecting their image on a monitor screen. To guarantee sufficient accuracy and reproducibility in the measurements, the tests must be conducted in certain specified conditions

1.1. Test cards

All the test cards used in the tests ar e rectangular and have the normal television format (4:3); they should exactly fill the area scanned by the camera.

In practice the test cards are often available in two forms: reflective (opacities) or transparent (transparencies). In many cases either type may be used but the transparent type is best when making resolution and streaking measurements because of the greater contrast range possible. The measurement of sensitivity, on the other hand, is described only with use of a reflective test card; it is not impossible with a transparent test card, but it requires very great care if accurate results are to be obtained.

1.2. Illumination

Two types of light box are used for transparent test cards. The first comprises a tungsten source, powered from a stabilised supply, which illuminates a diffusing sphere. The luminous flux and its colour temperature at the output window, where the transparencies are placed. are very uniform and easily adjusted. The second type of light box comprises a set of parallel fluorescent tubes mounted behind a diffusing screen. In this case the colour temperature and the illumination on a test card placed in front of the diffusing screen are usually not sufficiently uniform to permit measurements of sensitivity, signal-to-noise ratio, white shading, flare or gamma correction.

The illumination of reflective test cards is carried out by conventional means. Two spotlights (quartz halogen) with a colour temperature of 3100 ± 100 K are placed at 45* on either side of the perpendicular through the test card centre. By adjusting their distance, or by de-focussing them, uniformity of illumination (of the order of one per cent) is obtained and the luminous intensity can be adjusted without changing the colour temperature. In order to avoid measurement errors, care must be taken to ensure that the supply voltage does not change during the tests.

1.3. Camera

The camera is positioned in such a way that its optical axis coincides with the perpendicular through the centre of the test cards. The lens controls (focal length, iris) are adjusted, unless indicated otherwise, to mean values representative of normal operation. This determines the distance between the camera and test card.

As the test conditions used are those in the studio, the filter wheel in the camera is set to the position "3200 K".

Having adjusted the camera for normal operational conditions in the studio, the following checks are made:

- normal gain (0 dB)
- bias light ON
- black-level correctors ON
- flare corrector ON
- black balanced with lens capped (35 mV)
- white balanced using sensitivity test card (700 mV)
- colour corrector OFF
- contour corrector OFF
- noise reducer OFF
- aperture corrector OFF, if possible
- black and white shading correctors ON and optimised
- gamma corrector optimised and then OFF, or set to "1' if switching is not possible.

The effect of switching these correctors ON or OFF should be negligible on the white and black balance and on the white and black levels; the levels indicated correspond to the normal source levels in 75 O.

The nominal value of signal current (and hence the resulting gain in the signal channel) for the green (or pseudo-luminance) tube will be that recommended by the camera manufacturer (not the tube manufacturer).

When making the measurements, care must be taken to ensure that the general alignment is maintained.

When recording the test results, a note should be made of the types and serial numbers of the camera, the lens and the tubes.

The results obtained will depend to a great extent on the characteristics of the lens and tubes: particulars of these should therefore be indicated as comprehensively as possible.

1.4. Test equipment

In addition to the specific items of equipment described elsewhere, the equipment normally associated with a camera channel will be required:

- video oscilloscope (of adequate and known performance) with facilities for external television synchronisation and clamping of the displayed signal.

By television synchronisation we mean here the ability to trigger the sweep directly from the line or field pulses of a television-waveform or from a composite sync signal, or with an adjustable delay relative to the field interval.

It is useful if the oscilloscope has a marker pulse output which can be used to show on a picture monitor the part of the picture signal displayed on the oscilloscope. This facility is especially useful when carrying out resolution and streaking measurements.

- monochrome monitor capable of resolving at least 600 TV lines, the pulse response of which shows no visible overshoot and which has external sync facilities.

The possibility of displaying an A - B (or A + B) image from two inputs A and B facilitates certain measurements (registration, geometry).

- A sampling video voltmeter, although not essential, can facilitate measurements of sensitivity, shading, streaking, flare and gamma.

The light-meter used to check the illumination and its uniformity must be accurate and, in particular, it must include a "cosine" corrector for the angle of incidence of the illumination.

As will be seen in the descriptions of several methods, the results of measurements on the output signals of a camera will often ' be translated into percentages of the nominal signal amplitude. By this is meant the maximum excursion of the luminance signal, between blanking level (0%) and peak white level (100%).

CHAPTER 2

Measurement methods

2.1. Sensitivity

Measurement principle

There are two equivalent methods of assessing the sensitivity of a camera: either a measurement is made of the amount of light needed to produce a given signal, with a given iris setting, or else the iris setting needed to give this same signal with a given amount of light at the input can be determined.

Both methods are recognised by the EBU which recommends, however, that the results be presented in one single form.

Equipment used

In either method a reflective test-card is used which has at least two neutral matt surfaces of suitable dimensions to allow edge effects (streaking, flare, shading) to be ignored. One surface has a spectral reflection factor equal to 60% over the whole visible spectrum and the other has a spectral reflection factor uniformly equal to zero. The latter surface may be that of black velvet. (A velvet-covered cavity deep enough to prevent any light falling on the bottom, constituting "absolute" black, may also be used).

The step test card used for checking the gamma (see 5 2.10) may be suitable.

Measurement conditions

The video processing system shall be adjusted as follows, regardless of which method is being used:

- the gamma corrector of the camera is turned off or set equal to 1;

- the lift control is set to a value of zero, i.e. black level shall be the same as blanking level.

Measurement procedure

The following procedure is applied:

a) in the first method, a measurement is made of the amount of light needed to produce a signal of nominal amplitude (100%) at the output of the green channel with the iris set to the value shown below;

f/4 for 30-mm tubes

f/2.8 for 25-mm tubes f

f/2 for 18-mm tubes

b) in the second method, one determines the iris setting needed to give a signal of nominal amplitude at the output of the green channel with a given amount of light (1500 lx).

Notes

1. By "amount of light" we mean here the Illumination Incident upon the test card. (The "60% white" sample is regarded an equivalent to a Lambert radiator).

2. If possible the signal current recommended by the camera manufacturer will be used; this will determine the gain in the signal channel. in any event, the signal current actually produced by the tube will be noted.

3. As indicated in the general conditions, the lens is adjusted to a mean value of focal length. Otherwise, it should be checked that the result obtained does not depend on the chosen focal length.

4. It will be ensured that, when changes are made to the luminous flux incident on the test card, the colour temperature remains constant.

5. If possible, the camera will be fitted with a test lens calibrated in "T" values. If an ordinary television zoom lens is used, its transmission characteristics will be taken into account. It should be noted that the Iris control calibration should be checked.

Presentation of results

Regardless of which method is used, it is preferable to Indicate the sensitivity in the form of a quantity of illumination (expressed in lux) which is needed to produce a signal of nominal amplitude at the output of the green channel, from the part of the test card with 60% reflectance, using one of the iris settings specified for measurement procedure a).

If method b) is used, this illumination can be deduced from the Iris setting using the following formula:

$$E_s - E_m \times (s/m)^2$$

where E_s is the illumination required to give an output signal of nominal amplitude with the standard iris setting f/s

and E_m is the illumination measured with the iris setting f/m at which the measurement is made.

Table of results

- aperture : F.... or T....

- nominal currents: R .... nA

  G .... nA

  B .... nA

- illumination (60% white) ..... lx (3100 + 100 K)

2.2. Signal-to-noise. ratio

Measurement principle

The continuous random noise which affects the video signal depends on various items of video processing equipment; the measurement must be as representative as possible of the camera performance, depending on the manner in which this processing is done. Furthermore, the subjective effect of the noise is not proportional to its objective measurement and, in order to evaluate the former, a certain weighting factor can be applied. Several measurements of different types are therefore needed to gain an overall representative picture of the noise characteristics of the camera.

Equipment used

A neutral reflective test card or a neutral translucent surface is used (evenly illuminated).

For certain measurements suitable filters (bandwidth limiting, noise weighting) are needed between the camera output and the measuring equipment; these will be described at the appropriate point.

The measuring equipment is a wide-band voltmeter (RMS or peak), the operation of which is inhibited as effectively as possible during the blanking periods. For RMS measurements the time constant or the quadratic integration time is of the order of one second.

Measurement conditions

The signal channel gains are those determined during the measurement of sensitivity for the specified green tube signal current and the white balance.

The main source of noise in a camera is generally the pre-amplifier but the signal-to-noise ratio is also affected by the processing to which the video signal is subjected subsequently, for instance:

1) colour correction (matrixing)

2) aperture correction

3) contour correction

4) gamma correction.

In order to separate the effects of these processes, it in considered essential to take measurements with three acts of conditions:

a) - Colour corrector (matrixing) OFF

- Aperture corrector OFF
- Contour corrector OFF
- Gamma corrector OFF (gamma equal to 1).

b) - Colour corrector (matrixing) ON

- Aperture corrector OFF
- Contour corrector OFF
- Gamma corrector OFF (gamma equal to 1).

c) - Colour corrector (matrixing) ON

- Aperture and contour correctors set to give as flat a frequency response as possible; the effect of noise reducers and other similar controls should be as small as possible; in all cases the level at 4 MHz is made equal to that at low frequencies (0.5 MHz).
- Gamma corrector ON (gamma set to 0.45).

Note

It may be advisable to check the influence of the gamma characteristic by examining the variations of signal-to-noise ratio with lift; the worst value is that which should be recorded.

Measurement procedure

With sets of conditions a) and b), the lens is capped and the black level control is adjusted to give an output signal of 10% or more, thus avoiding clipping of the noise at blanking level.

In set of conditions c), the black level is first set to about 5% greater than blanking level when the lens is capped.

The lens cap is then removed and the camera is directed at the reflective chart or the translucent surface. The lens is then de-focussed.

In conditions c), the (uniform) signal level produced by the camera is adjusted (by modifying either the illumination or the iris) to correspond with the point of unity gain on the gamma characteristic (about 370 mV).

The measurements are made within a band extending from 100 kHz to 5MHz, using a band-pass filter with sharp cut-off (Recommendation 567, Part C, Annex 11, 1 1 for the low-pass response), the characteristics of which are shown in Fig 1.

The measuring set enables the determination of the RMS value of the noise (or the signal-to-noise ratio).

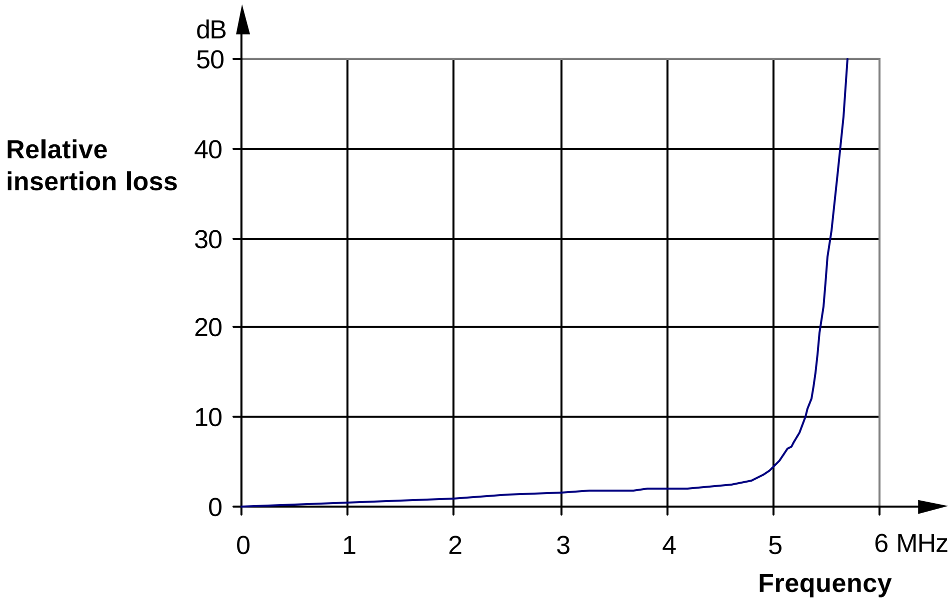


Fig. 1.- Low-pass filter characteristic for noise measurements

This value must be measured, depending on the outputs available from the camera, on several types of signal. In decreasing order of importance, measurements are made on:

1) the luminance signal at the luminance output of the camera

2) the luminance signal at the output of the coder associated with the camera

3) the primary R C B signals at the corresponding camera outputs.

It is to be noted that some of these outputs may not be available on all cameras.

For the luminance signal measurements (whether from the camera or the coder), the noise measuring apparatus Is applied in turn to the corresponding channel:

- first without weighting of the signal;

- then with the luminance weighting defined in CCIR Recommendation 567, Part C, Annex 11, § 3 (the characteristic of the weighting filter to be used is shown in Fig. 2 .

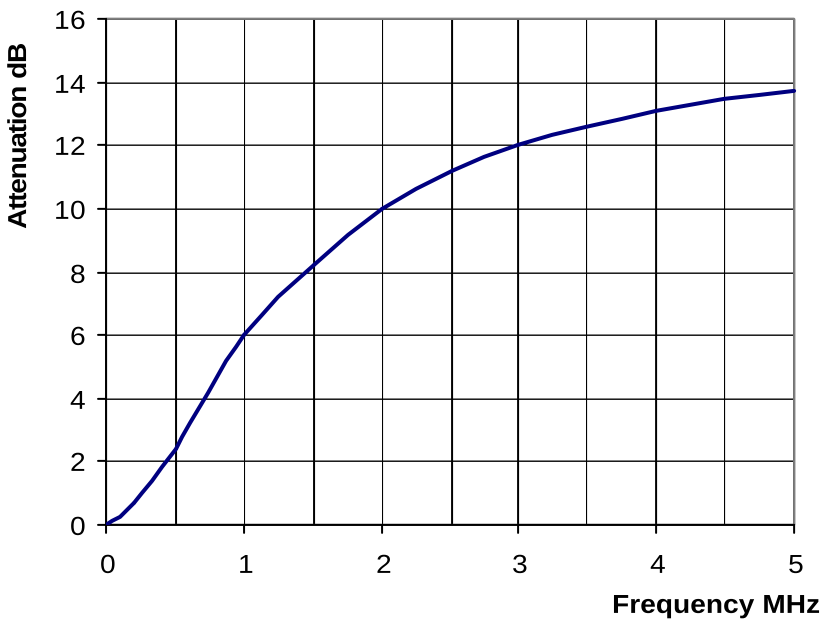


Fig. 2. - Unified weighting characteristic for random noise on the luminance signal

When measurements are made on the signals at the coder output, any effects of the colour subcarrier must be minimised by reducing as much as possible the level of this subcarrier or by the use of a notch filter. The characteristic of an appropriate notch filter, for the PAL system, is shown in Fig. 3.

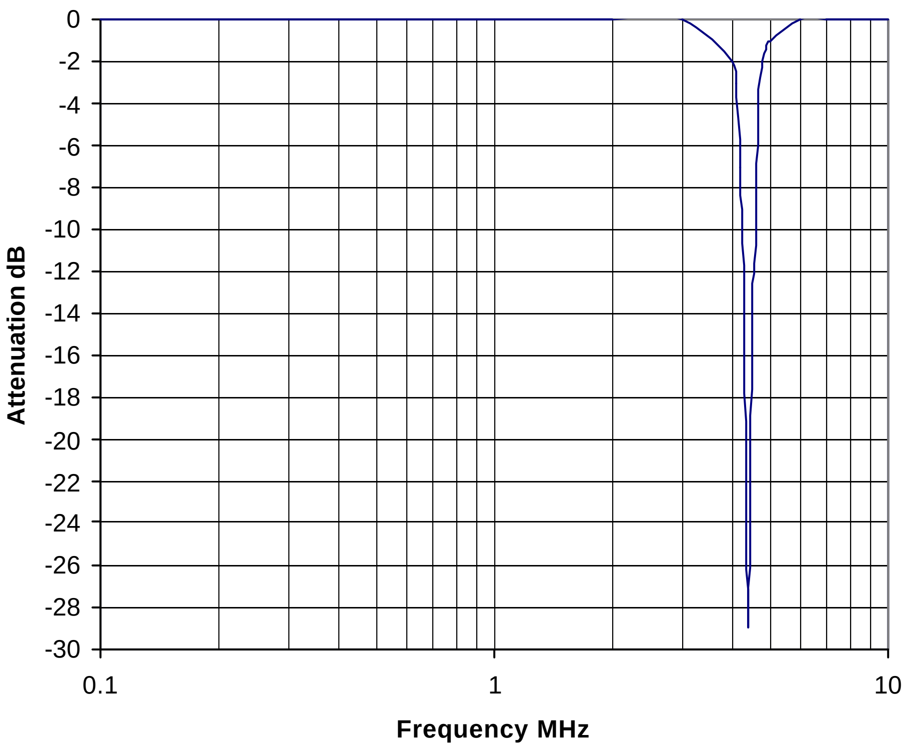


Fig. 3. - Example of notch filter characteristic to suppress the chrominance subcarrier

For each measurement the value of signal-to-noise ratio is noted, expressed in dB with reference to the nominal signal amplitude. Therefore :

S/N - 20 log V_n /V_N

where

V_n - nominal signal level (700 mV in 75 2) V_N - RMS noise voltage

In addition to these measurements which allow an evaluation to be made of the severity of the noise in the luminance band, it may be worthwhile making further measurements with a view to determining other details.

It is difficult to specify a measurement of chrominance noise owing to the variety of output signals provided by the different makes of camera. It is nonetheless possible to make a measurement of chrominance noise in PAL cameras, by measuring the RMS value by means of a chrominance weighting filter, such as that defined in CCIR Report 637 for system I, inserted in place of the luminance weighting filter. The characteristic of such a filter is shown in Fig. 4.

It may also be desirable to measure the low-frequency noise between 40 Hz and 10 kHz. The CCIR recommends (Rec. 567 B.3.2.2) the use for this purpose of a peak-to-peak measurement and a filter is helpful (Rec. 567 C.3.2.2) to separate the periodic noise (hum) from the random noise. Fig. 5 shows a suitable filter characteristic.

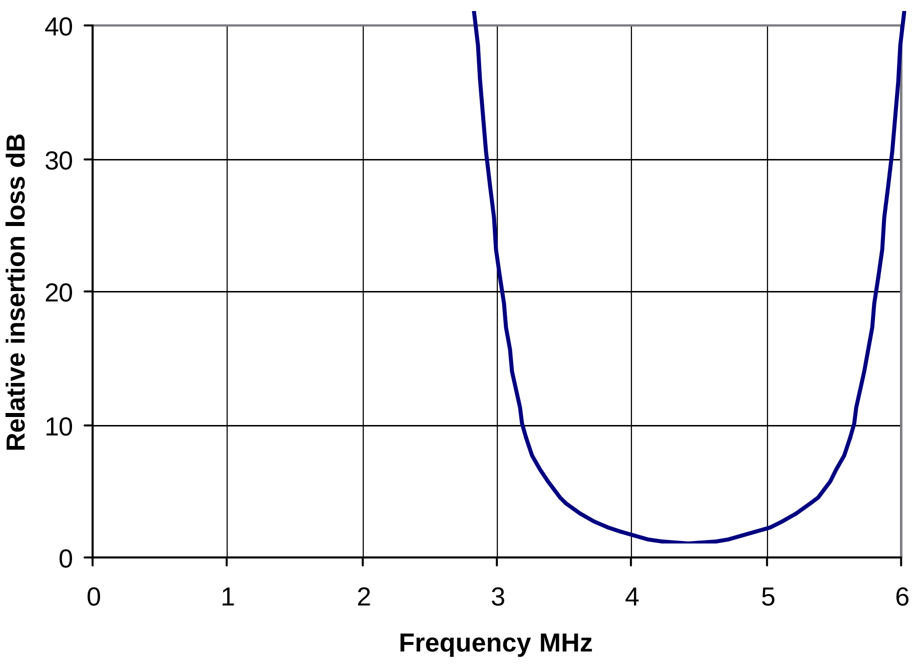


Fig. 4.- Characteristic of the weighting network for random noise on the Cbrominance signal (attenuation >35 dB above 6 MHz)

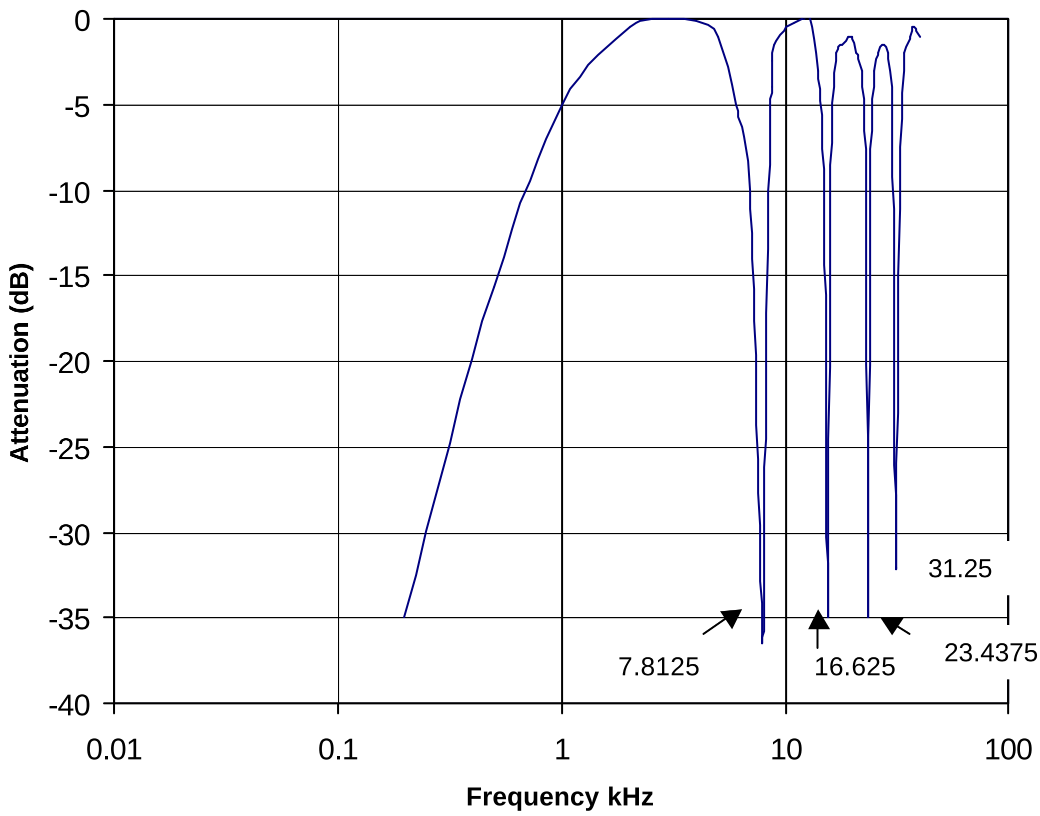


Fig. 5. - Low frequency weighting characteristic

Presentation of results

For the low-frequency noise measurement, the result is expressed, in dB, as a ratio of the nominal amplitude of the luminance signal to the peak-to-peak amplitude of the noise.

For all the other measurements the result is expressed, in dB, as a ratio of the nominal amplitude of the luminance signal to the RMS noise value.

2.3. Resolution

Measurement principle

The measurement of resolution is designed to assess the overall response of the camera to fine details.

Equipment used

A transparency is presented before the camera having groups of vertical bars with sharp transitions: the spatial variation of the density gives a periodic square wave. Two sets of such groups are evenly and alternatively distributed across the picture area; they correspond, through the spatio-temporal transformation due to the television scanning process, to signals with fundamental frequencies of 0.5 (40 TV lines) and 5 MHz (400 TV lines).

17

Centred, as a minimum, on the nine positions situated in the centre of the picture and at points 10% within the extremities of the diagonals and central horizontal and vertical axes, there are triplets of adjacent groups which, in terms of signal frequencies, give 1 cycle at 0.5 MHz, 10 cycles at 5 MHz and 1 cycle at 0.5 MHz. The overall average picture level (APL) is less than 50%.

A test card of the type shown in Fig. 6 is suitable.

A video oscilloscope (with a known frequency response) offering an auxiliary output, as described in § 1.4, helps to identify the points of interest in the picture.

Measurement conditions

The video processing functions in the camera are set as follows:

- aperture corrector OFF
- contour corrector OFF
- gamma set to 1 (gamma corrector OFF)
- colour correction (matrixing) OFF.

The test card is illuminated so that, with the iris at f/5.6 for 30 or 25-mm tubes and at f/4 for 18-mm tubes, the gratings corresponding to 0.5 MHz at the centre of the image are reproduced with an output level of 100% for the white bars and 0% for the black bars.

Care must be taken to avoid effects due to clipping of the signal at black or white level.

Measurement procedure

The measurements are taken, according to the requirements, on as many outputs as possible from the camera but, as a minimum, on the luminance signal at the coder output (taking account of any attenuation that may be introduced by the coder).

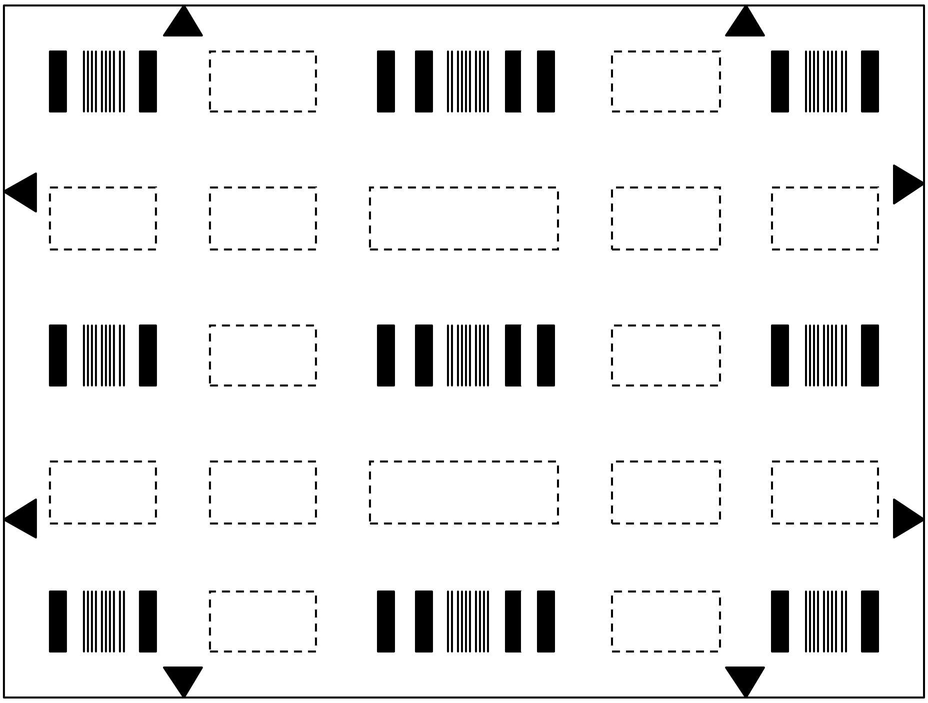


Fig. 6 - Test card for resolution measurements

A comparison in made, at the points referred to above and, to a minimum, at the centre of the image and at each of the four corners, between the peak-to-peak levels of the 5 Mz bursts and those of the adjacent 0.5 MHz bursts (in the case of the 0.5 MHz bursts, the overshoot Is neglected).

Presentation of results

The signal amplitude for the 5 MHz bars is recorded in the form of a 3 x 3 matrix for each of the positions where measurements are taken, as a percentage of that for the 0.5 MHz bars.

Note

The test card used does not allow all aspects of the resolution characteristic to be determined and other measurements may prove helpful In particular, measurements with sinusoidal signals allow a better correlation to be made with measurements of the modulation transfer function (MTF) of lenses.

The measurements that are made correspond to measurements of the contrast transfer function (CTF).

Table of results

CTF at 400/40 TV lines

... %	... %	... %
... %	... %	... %
... %	... %	... %

2.4. Registmtion

Measurement principle

By means of a test card having a grille of sufficiently thin grey lines, an examination is made of the relative offset, at the output of the camera, between the primary colour signals in various areas of the picture.

Equipment used

A test card is required which has a test pattern of 19 vertical and 14 horizontal black lines on a white background, these lines having a width approximately equal to 0..2% of the picture height; it will generally be of the reflective type. A test card of the type shown in Fig. 7 is suitable.

A monochrome monitor of the type described in § 1.4 and two video delay lines, switchable in 10 ns steps and with a total delay greater than 200 ns, facilitate this measurement if R G B signals are available at 75 O source impedance.

Measurement conditions

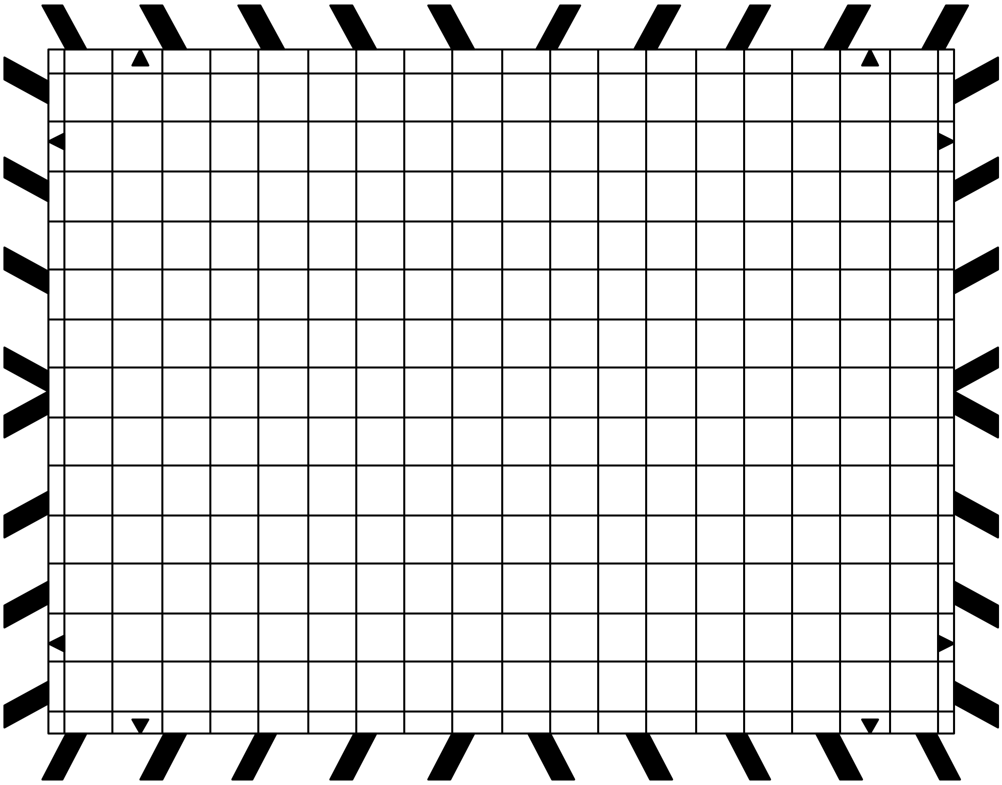
The measurements are made with the following test conditions:

- zoom lens set to average focal length and aperture, or use of a test lens
- maximum R G B signal level between 50 and 100%
- colour corrector (matrixing) OFF
- aperture corrector OFF
- contour corrector OFF
- gamma corrector - unimportant.

The registration controls are adjusted to give zero error at the centre of the image.

Measurement procedure

With the monochrome monitor, and the switchable delay lines inserted in the A and B inputs, two vertical lines of the R - G (or B - G) image are superimposed at a given point in the picture area. The horizontal convergence error is then directly read off at this point. By comparison with a horizontal distortion of the same amplitude, the vertical convergence error is measured (by forming a small square).



The measurements are made in three areas of the picture:

a) within a circle of diameter equal to 80% of the picture height (Zone 1);

b) outside Zone 1 and within a circle of diameter equal to 100% of the picture width (Zone 2);

c) over the remainder of the picture area (Zone 3).

These three areas are shown in Fig. 8.

Note

It should be borne in mind that the results may be influenced by the following factors:

1) the focal length of a zoom lens, because of differential magnification effects (chromatic aberrations);

2) the level of illumination of the front surface of the tube (beam pulling);

3) the amount of beam current used to stabilise the picture signal.

The most representative results will be obtained by adopting typical operational values for these three factors.

Presentation of results

The positions where the maxImum registration errors are observed in each zone will be noted.

The results are given in the form of percentages of picture height (as a reference, 0.1% of picture height is equal to 39 ns in the 625-line systems).

Table of results

Zone 1	... % H
Zone 2	... % H
Zone 3	... % H

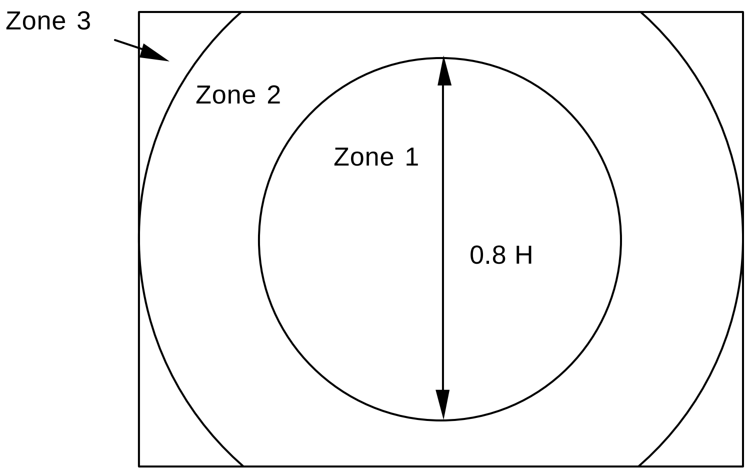


Fig. 8. - Measurement zones

2.5. Geometry and scan linearity

Measurement principle

Geometric errors in the reproduced picture are evaluated by superimposing the image of a suitable test card on a matching image generated electronically.

Equipment used

An electronic pattern generator is used to display on a monochrome monitor (of the type described in § 1.4) a grille with a predetermined structure. The camera is directed at a test card having a pattern of rings arranged so that their centres will coincide with the cross-points of the grille (assuming that the latter is scanned and displayed in an ideal fashion). The pattern generator and the camera are synchronised.

The test card shown in Fig. 9 is suitable for this measurement.

To facilitate the measurements, the internal and external diameters of the rings are calibrated as percentages of picture height.

Measurement procedure

The signal from the test pattern generator is superimposed on the signal from the green channel of the camera and the superposition is carefully adjusted so that, in the central area of the monitor screen, the centres of the rings coincide with the cross-points of the grille (note that the monitor is used here to <u>compare</u> two Images; its geometry characteristics are therefore unimportant).

An examination is made, across the entire picture area, of the positional differences between the cross-points of the grille and the centres of the rings with which they should coincide. With the above mentioned test card, the known dimensions of the rings assist in the immediate determination of the offsets.

Presentation of results

The worst results are recorded in the form of percentages of the picture height. The positions of the errors are also noted.

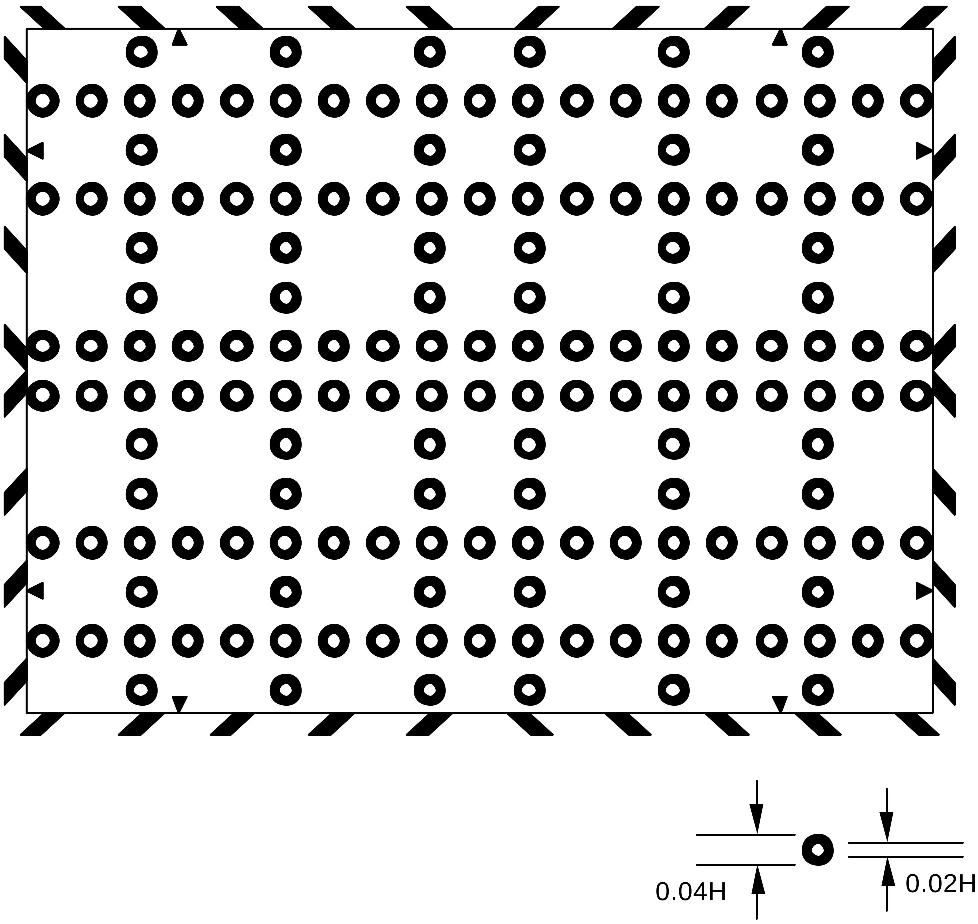


Fig. 9. - Test card for geometry measurements

2.6. White shading

Measurement principle

Deviations from a uniform luminous field are evaluated by measuring the maximum signal variations across this field in various areas of the picture.

Equipment used

The camera is directed towards a uniformly reflective neutral surface which is illuminated evenly.

Measurement conditions

The camera is white balanced. The intensity of the illumination is adjusted so that, with an iris setting of f/5.6 for 30 and 25-mm tubes and f/4 for 18-mm tubes, an output signal of nominal amplitude is obtained from all channels.

The gamma is set to 0.45.

The lens, which is initially focussed on the uniform neutral surface, is then de-focussed, the shading correctors being optimised.

Measurement procedure

The output signals from the R, G and B channels are measured, together with the difference signals between channels R-G, R-B and B-G.

The measurements are made in two areas:

a) within a rectangular zone of which the height and width equal 90% of the height and width of the picture (see Fig. 10);

b) outside this rectangle.

The greatest peak-to-peak variation in level in each zone is recorded.

Presentation of results

The results are expressed as percentages of the nominal signal amplitude.

The form of the shading can be noted, if necessary, by means of oscillograms.

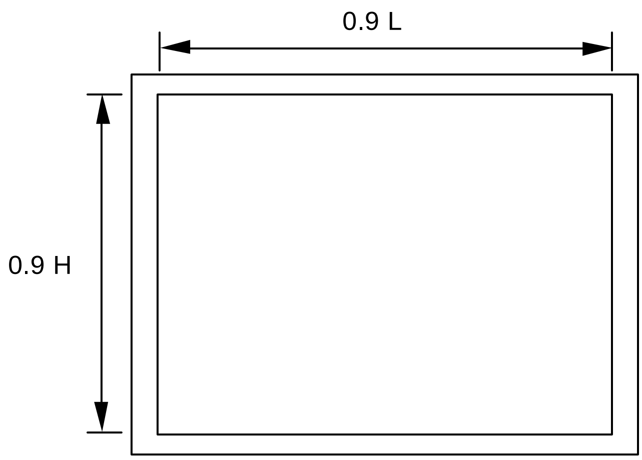


Fig. 10. - Measurement zones

2.7. Black shading

Measurement principle

The camera performance Is evaluated whilst it is receiving no luminous stimulus, a measurement of the maximum signal variation being made in suitable areas of the picture.

Equipment used

No special equipment is needed for this measurement.

Measurement conditions

The camera is set up for nominal operation. It is checked, in particular, that the bias light is on.

The lens cap is fitted.

The gamma is set to 0.45.

The black level is set to give an output of 5%, or to a higher value, which is just sufficient to prevent any clipping.

Measurement procedure

The measurements are made on the outputs of each channel and on the difference signals between pairs of channels.

The measurements are made in two areas:

a) within a rectangular zone of which the height and width equal 90% the height and width of the picture (see fig. 10);

b) outside this rectangle.

The greatest peak-to-peak variation in level in each zone is recorded.

Note

A low-pass filter, cutting off at approximately 0.5 MHz, inserted in each output, may facilitate the measurement.

Presentation of results

The results are expressed as percentages of the nominal signal amplitude.

The form of the shading can be noted by means of oscillograms.

2.8. Streaking

Measurement principle

An evaluation is made, using a suitable test card, of the disturbance caused to the level of the video signal in a black area to the right of, or below, a white area; a measurement is made of the duration of the delay before re-establishment of the normal signal level for the black area, and of the signal waveform during this transition.

Equipment used

A test card (preferably transparent) is used showing, on a black background, a series of horizontal white bars of differing lengths. An example of a suitable test card is shown in fig. 11.

Measurement conditions

The illumination must be adjusted so that the white bars give a signal of about 100% with an average iris setting.

The gamma is set to 0.45.

The lift control is adjusted to give a level of 5% for the black back-ground.

Measurement procedure

Lines which traverse the white bars are displayed on the oscilloscope and a measurement is made of the outputs of the R, G and B channels and of the difference signals between pairs of channels R-G, B-G and R-B.

The measurements are made at various points, the number of which will depend on the nature of the streaking (short, medium, long).

(The total streak duration may be evaluated on the monochrome monitor.)

Note

Care must be taken to distinguish between the effects of streaking, those of flare, and those of contour and aperture corrections. For this purpose it may be helpful, first, to take measurements without any contour or aperture correction.

Account will be taken of flare by making differential measurements of streaking, taking as the reference adjacent lines which do not traverse any white bars and which, therefore, are free of streaking.

Presentation of results

The worst result will be recorded together with its form.

The signal amplitude is expressed as a percentage of the nominal amplitude, the delay being expressed in microseconds.

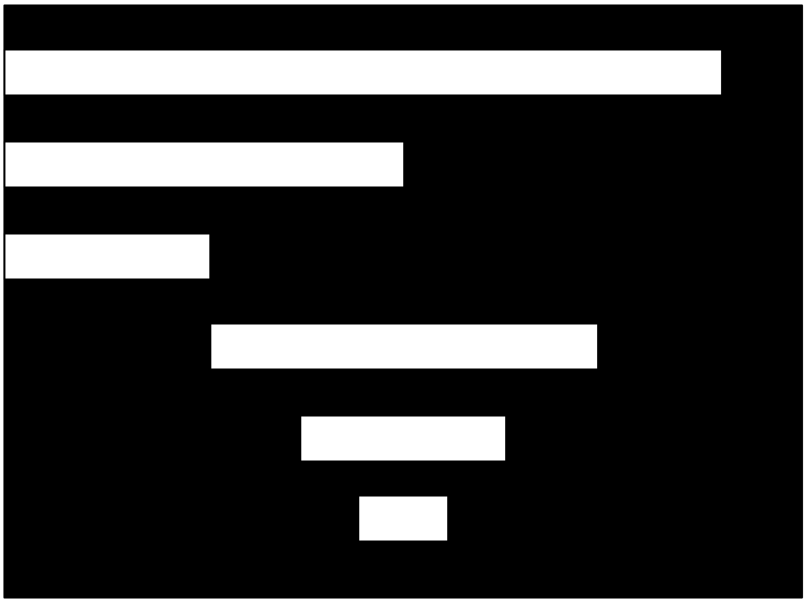


Fig. 11. - Test card for streaking measurements

2.9. Flare

Measurement principle

Flare caused by diffusion in the optical path (in the lens, the beam splitter, at the front face of the tube or at the target) impairs the picture either by throwing a uniform white veil over the picture or by blurring high-contrast transitions. The recommended method of measurement distinguishes between these two effects. It involves the determination of the variation of the black level, as compared to its theoretical level, when the average picture level (APL) changed from 0 to 50% and from 0 to 99%.

An example of the characteristic is shown in Fig. 12.

Equipment used

Two test cards must be used, these being provided with suitable illumination.

For the measurement of overall flare (linear), the card has in the centre a black rectangle of proportions 4:3; this surface is surrounded by a white surface of equal area, thus giving an APL of 50%. A test card of this type is shown in Fig. 13.

For the measurement of localised flare (non-linear), the card has a central black rectangle of proportions 4:3 surrounded by a white surface of dimensions that result in an APL of 99%. This test card is shown in Fig. 14.

Measurement conditions

The illumination is adjusted to give an output of 100% from the white areas when the iris is set to f/5.6 for 30 and 25-mm tubes and to f/4 for 18-mm tubes.

The measurements are taken with two sets of conditions:

a) Gamma set to 1; flare corrector OFF.

b) Gamma set to 0.45. Flare corrector operative and optimised to give the best possible results with the 50% test card.

Before taking the measurements, the black level is set to 10% at the centre of the image of a black screen with a similar surface to that of the black rectangle of the test cards (totally black image of the same format as the test cards).

Measurement procedure

The focal length and aperture of the lens are not changed during the measurements.

The card with the API of 50% is placed in front of the camera and the change in level at the centre point of the black area is measured in each channel.

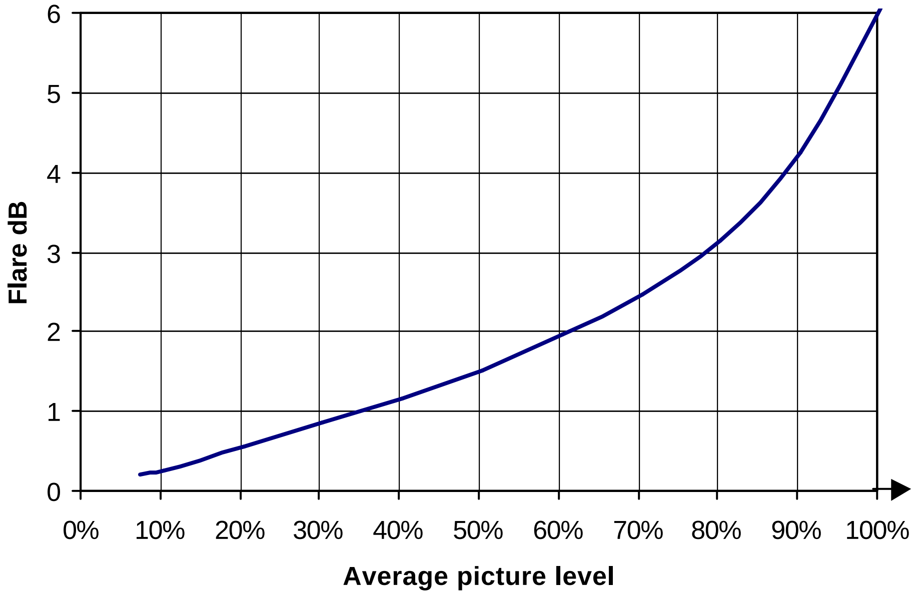


Fig. 12. - Example of the variation of flare factor as a function of the average picture level

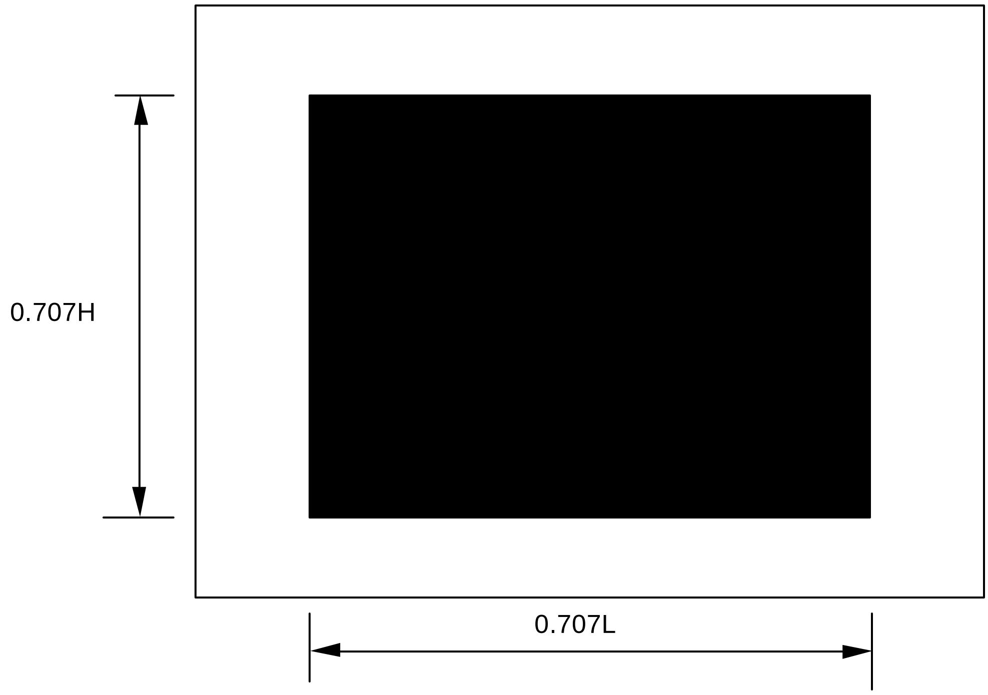


Fig. 13. - Test card for overall flare measurements

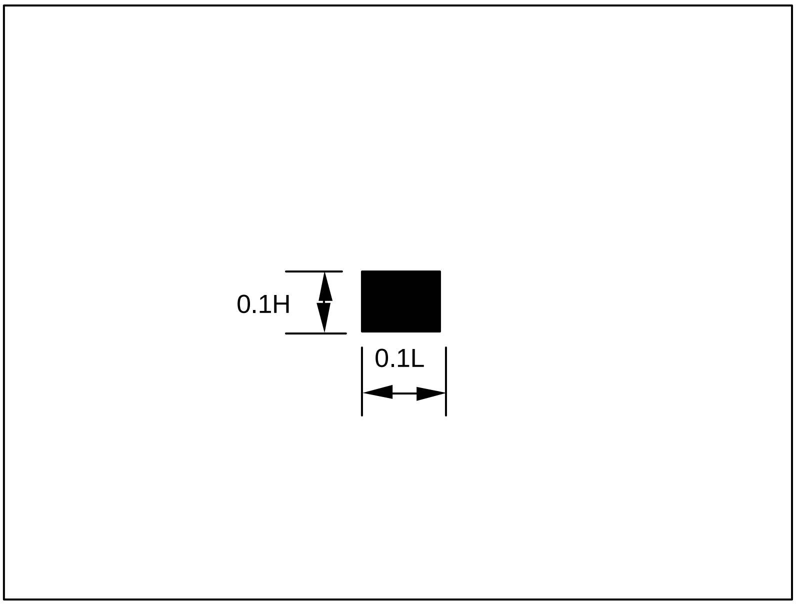


Fig. 14. - Test card for localised flare measurements

The card is replaced with the 99% APL card and the difference between the level at this central point and that obtained under the line-up condition is measured for each channel.

Note

Care should be taken to ensure that there are no high reflectance surfaces near to the test card.

Further useful information can be obtained by making differential measurements between the camera output signals.

Presentation of results

The results are expressed as percentages of the nominal signal amplitude

The focal length of the zoom lens should be noted. If necessary this can be changed and a new series of measurements can be made after modifying the illumination to give the correct signal amplitudes with the iris settings indicated above.

Note

The flare characteristic is strongly dependent on the lens and beam splitter; the above test procedure does not enable the respective contributions of these various elements to be determined. Despite the complexity of this problem, it is hoped that further work will lead to a clarification of this subject.

Table of results

	? = 1			? =- 0.45		
	R	G	B	R	G	B
Overall effect	....	......	......	......	......	......
Localised effect	......	......	......	......	......	......

2.10. Gamma correction

2. 10.1. Electronic transfer characteristics

Measurement principle

The purpose of this measurement is to determine the transfer characteristic of the electronic system in the camera.

Equipment used

A test signal generator is required which permits the injection, before the gamma corrector, of a signal having a linear amplitude variation, either in steps or continuous (stair-case or saw-tooth), to cover the range from 0 to 100% of the nominal level available in the camera.

Measurement conditions

The pick-up tubes, and the correctors for shading and flare, are all non-operative.

The black level is adjusted to its normal value (see § 1.3).

The gamma corrector is, of course, operative.

The switching on or off of the aperture, contour and colour correctors should have no effect.

Measurement procedure

A stair-case or saw-tooth signal is injected into the camera (at the tubes a video signal with negative polarity is needed).

The signal produced at the reference output (green or luminance channel) is measured with sufficient accuracy to allow the transfer characteristic to be determined over the entire output range from 0 to 100% amplitude.

Presentation of results

The results are presented in graphical form using linear co-ordinates.

2.10.2. Overall transfer characteristic

Measurement principle

This measurement serves to determine the complete opto-electronic transfer characteristics of the camera.

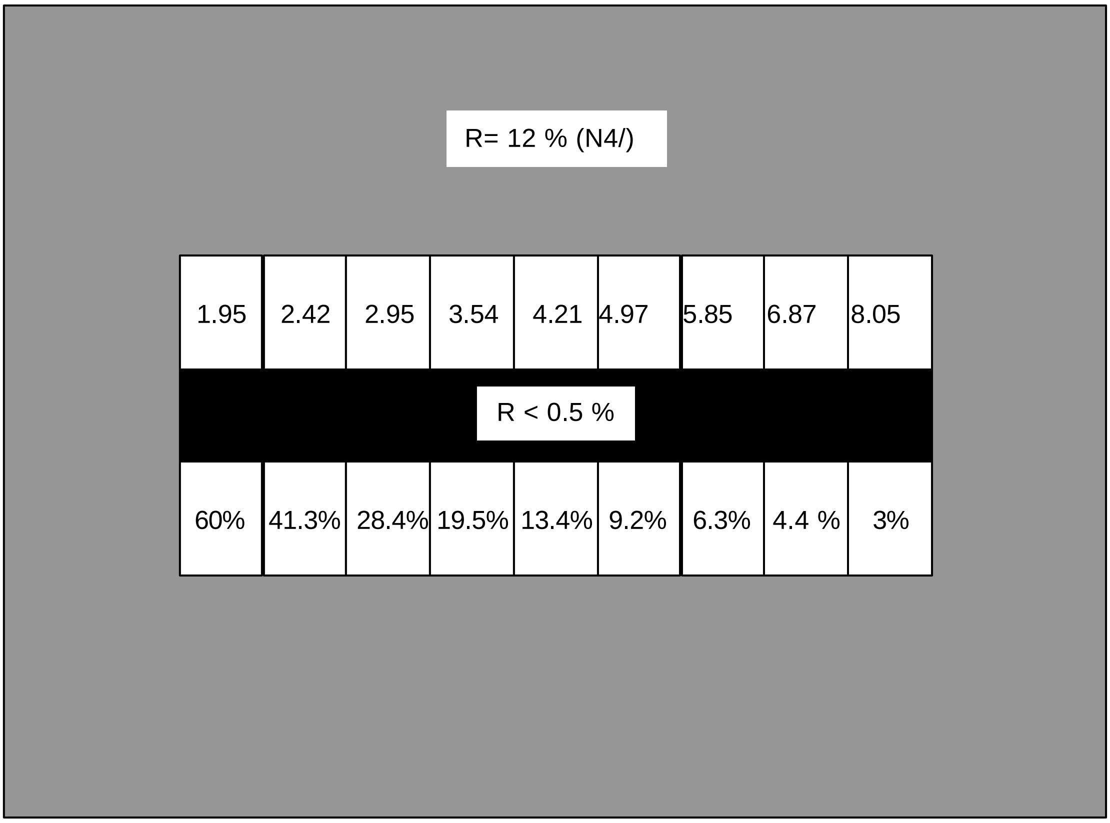


Fig. 15. - Test card measuring the overall transfer characteristic

The figures in the upper row indicate Munsell values,
those in the lower row indicate the reflectance values

Equipment used

A suitably illuminated reflective or transparent tent card is scanned by the camera. This card must have a number of steps of known neutral density or reflectance, there being enough such steps to enable a curve to be plotted through the corresponding measurement points. The greyscale shown in Fig. 15 is one suitable example.

Measurement conditions

The pick-up tubes and the shading, black level and flare correctors are all in service.

The lens is capped and the black level of each channel is set to correspond with blanking level.

Measurement procedure

The transparency or the card is shown to the camera and the output level is accurately adjusted (using lens aperture and white balance) to 100% in each channel for the step having the highest reflectance or the lowest density.

The output signal is measured for each step in the reference channel (green channel).

The accuracy of the greyscale tracking can be determined by making differential measurements between pairs of signals.

Presentation of results

The gamma curve(s) is(are) plotted from these results.

The maximum differentiel values (R'-G', B'-G') are also noted, as percentages of the nominal amplitude.

Note

Owing to non-linearities in the tube response, suitable care will be taken in interpreting the characteristics obtained from these measurements.

D/198310299/205

Editeur responsable : Rudolf Gressmann, avenue Albert Lancaster 32, 1180 Bruxelles (Belgique)