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Television broadcast receivers and associated equipment — Immunity characteristics — Methods of objective picture assessment

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Television broadcast receivers and associated equipment – Immunity characteristics – Methods of objective picture assessment

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CONTENTS

TELEVISION BROADCAST RECEIVERS AND ASSOCIATED EQUIPMENT – IMMUNITY CHARACTERISTICS – METHODS OF OBJECTIVE PICTURE ASSESSMENT

1 Scope

This Technical Report describes the algorithms used for objective picture assessment in immunity tests of analogue and digital TV broadcast receivers and associated equipment.

The algorithms used were developed on the basis of the specifications included in Annex K[1] of CISPR 20. The method of objective picture assessment described in that annex employs the same interference mechanism and is based on the same wanted signal definition as specified in CISPR 20. Objective picture assessment, therefore, constitutes an alternative to the subjective method and offers the advantage of direct correlation to the subjective method.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 20:2002, *Sound and television broadcast receivers and associated equipment – Immunity characteristics – Limits and methods of measurement*
Amendment 1 (2002)

ITU-R BT.500-10, *Methodology for the subjective assessment of the quality of television pictures*

ITU-R BT.801-1, *Test signals for digitally encoded colour television signals conforming with Recommendations ITU-R BT.601 (Part A) and ITU.R BT.656*

3 Abbreviations

For the purposes of this document, the following abbreviations apply.

CCVS	composite colour video signal (chrominance, video, blanking and sync signal)
DCT	discrete cosine transform
EUT	equipment under test
HSL	hue, saturation, luminance (colour space model)
SSCQE	(single stimulus continuous quality evaluation)

4 Test method for objective picture assessment

Objective picture assessment is based on comparison with a reference picture or a reduced reference picture.

Both the reference picture and the test picture can be recorded from the EUT monitor by means of a video camera or at the EUT's video output (CCVS) direct.

[1] See Amendment 2 to CISPR 20:2002, to be published.

The recorded test picture is digitised, and deviations from a stored reference picture are determined by means of the picture assessment algorithms described below. An alternative methodology computes the deviation from specific features determined on both the reference picture and the picture to assess.

5 Methodology for detection of analogue picture degradations

Analogue picture degradations are defined as:

- superimposed patterns, moiré patterns;
- loss of luminance and contrast;
- loss of colour;
- loss of synchronization.

5.1 Algorithm for superimposed patterns, moiré patterns

To assess picture degradation showing as a set of lines, an average signal value is formed for a defined area in the simplest case. The deviation of the average signal value of this area from a reference value determined from an undisturbed picture serves as a criterion of whether or not picture degradation is present.

For picture assessment according to this method, the colour bar pattern according to ITU-R BT.801-1 is first converted to a suitable colour space, preferably grey. From each colour bar, a rectangular section is taken into which a rectangular test window is positioned. The test window is divided into column segments (see Figure 1).

To reliably detect picture degradation, the test window is rotated by a constant angular increment of 2° until 180° is attained. For picture degradation in the form of lines, the test window segments will, in the case of one of the angles measured, be aligned approximately parallel to the interference lines, thus producing a significant deviation from average signal values.

As already mentioned, an average value or column sum is determined for each segment, and the deviation from a reference value is calculated. In addition, a regression line over all column sums is formed, and the square offset of each column sum from the regression line is calculated. If the sum of the square offsets of the column sums exceeds the corresponding value determined for a reference picture, a superimposed pattern or moiré pattern is detected.

The position and size of the test window, or the test window diagonal, should be selected such that, for any angular position of the test window, all pixels of the test window are located within the same colour bar of the test pattern, i.e. within the homogeneous area of the colour bar. This excludes impairment of results by influences from the cross-colour region.

After a 180° rotation, the test window is shifted vertically, i.e. parallel to the borders of the colour bar section, by a length increment of half the test window height. In its new position, the test window is again rotated by 180°, and a measurement is performed for each angular increment. By repeatedly shifting the test window within the colour bar section, virtually the complete colour bar is covered.

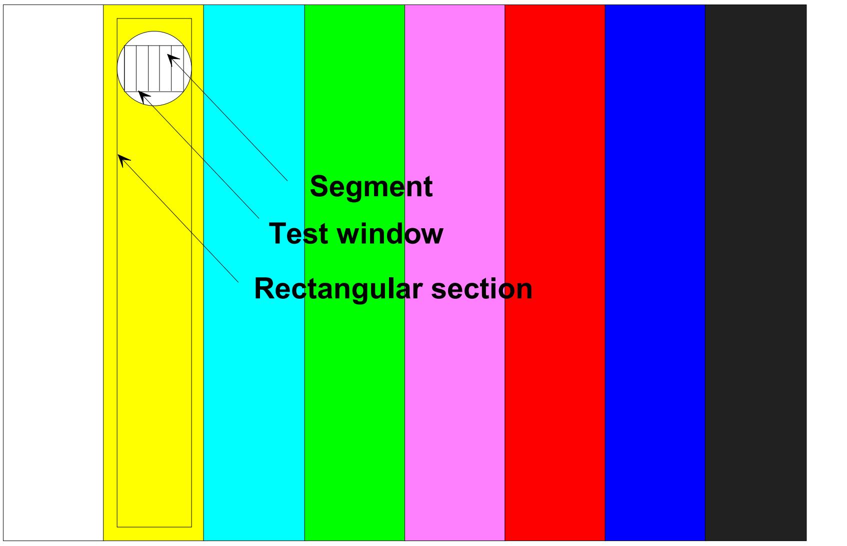


Figure 1 – Colour bar pattern with test elements for detection of analog picture degradation

The above procedure is repeated for each colour bar of the test pattern.

To cover the complete colour bar pattern, the cross-colour regions between the bars also have to be analysed. For this purpose, the cross-colour regions are divided into vertical segments of seven pixels in height. For each segment, the position of the colour transition edge and its deviation are determined. Evaluation is performed on the assumption of a Gaussian distribution of the colour transition edge in each segment over a defined number of reference pictures, preferably 20 and based on a confidence interval of five times the standard deviation σ. Picture degradation is present if the position of colour transition in a segment is found to be outside the confidence interval of the corresponding reference segment.

5.2 Algorithm for loss of luminance and contrast

As described under 5.1, the colour bar pattern is converted to a suitable colour space, preferably grey. Any change in luminance or contrast directly affects the grey level, so this type of degradation can be reliably identified. The algorithm detects grey-level errors if the grey level deviates by a minimum of ± 5 grey tones from the grey level of the stored reference picture based on a quantisation of 8 Bit (256 grey tones).

5.3 Algorithm for loss of colour

Colour errors are identified by checking the hue of each colour contained in the colour bar pattern. To this effect, the test window is additionally converted to another colour space, preferably HSL. The algorithm detects colour errors if the hue deviates by a minimum of $\pm 10°$ from the value of the stored reference picture.

5.4 Algorithm for loss of synchronisation

Synchronisation errors or total sync loss manifest themselves by the loss of one or more colour components. The algorithm detects loss of colour components if the hue deviates by a minimum of $\pm 10°$ from the value of the stored reference picture. Total loss of sync is present if the grey level drops below 30 in all colour bars (black screen).

6 Methodology for detection of digital picture degradations

Digital picture degradations are defined as:

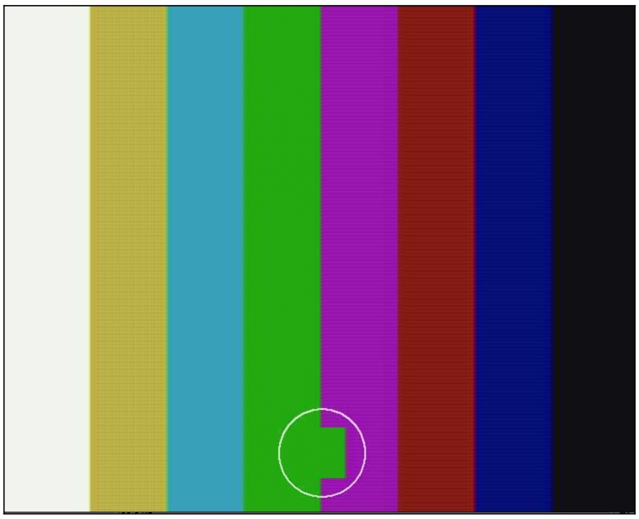
- blocking;
- frozen patterns, stop of moving element, blocking in moving element;
- total loss of picture, irrecoverable data stream error.

6.1 Algorithm for blocking

Blocking is characterised by the loss of macroblocks (e.g. 8 × 8 pixels). The edges of lost macroblocks show as interfering lines that can be detected using the method described under 5.1. Rotating the test window is not necessary here as the loss of a macroblock always produces interfering lines at 0° and 90°. The test window size can therefore be expanded to extend over the full colour bar width so that lost macroblocks will be reliably detected also in the cross-colour regions.

6.2 Algorithm for frozen patterns, stop of moving element

Frozen patterns are characterised by a stop of the moving element. To detect this type of picture degradation, a colour bar pattern according to ITU-R BT.801-1 is used that includes a rectangular moving element (see Figure 2). The movement of this element is effected by partially shifting the green-to-magenta colour transition by one pixel per frame, the maximum shift being 40 pixels in either direction. The movement of the colour transition (edge) is monitored by means of an edge filter. A stop of the edge movement is detected if there is no change in the position of the colour transition while the picture is continuously being captured.



IEC 1179/04

Figure 2 – Colour bar pattern with moving element for detection of digital picture degradation

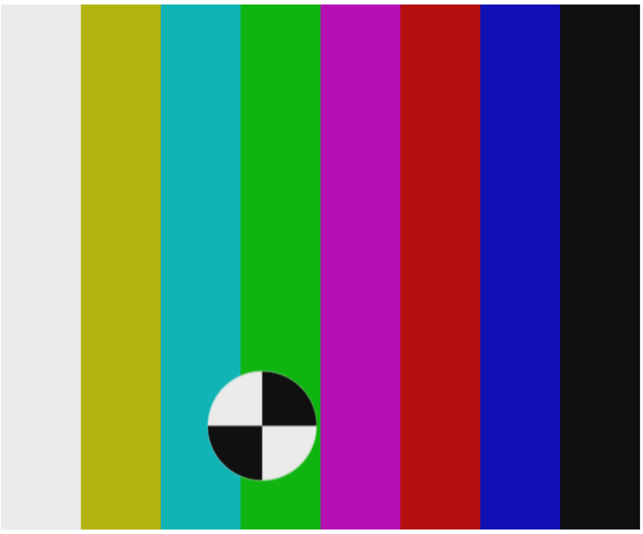
6.3 Algorithm for total loss of picture, irrecoverable data stream error

Total loss of picture means a drastic change in the grey-level characteristics. This type of picture degradation can also be interpreted as extreme blocking and therefore be detected by means of the algorithm described under 6.1.

7 Alternative methodology for detection of digital picture degradations

7.1 Test pattern

To be able to detect frozen pictures due to digital degradations, CISPR 20 recommends the use of a colour bar test pattern including a moving element. The following described quality assessment method uses the test pattern represented in Figure 3.



IEC 1180/04

Figure 3 – Alternative colour bar pattern with moving element for detection of digital picture degradation

The test pattern is composed of the common colour bar in compliance with ITU-R BT.801-1, with a moving black and white disk. The disk describes a horizontal translation with a period of 30 pictures.

7.2 Analysis

The methodology is a reduced reference approach. This is based on computation of specific features that are sensitive to perceived video impairments. Features are first computed on pictures from the equipment without stress, and then compared with the same features computed on pictures from the equipment under stress. The feature comparison provides perceived video quality. The video quality is then converted in binary evaluation to raise alarms.

In the first step, impairment features are extracted. They seek to represent typical encoding and transmission error impairments. Usual impairments include blocking effects, false edges, and empty or misplaced macroblocks, to black or frozen areas. Each of these impairments affects picture contents in a specific way. Based on this assumption, a set of four parameters that seek to track these impairments has been defined, with computationally efficient algorithms: the process analyses all pictures in real time to track all transmission errors.

These parameters are based on a DCT blocks-based transform. Such an analysis in the transformed domain has the advantage of being close to the principle that MPEG uses for the compression, and to integrate other features like the human eye sensibility to spatial frequencies. Each feature is computed on the DCT luma component blocks of the picture.

7.2.1 Automatic spatial synchronisation

A preliminary algorithm of spatial synchronisation is performed, in order to compute features at the same position for the reference picture and for the current signal. This algorithm is based on the computation of several horizontal gradients all over the picture and merged in a mean gradient sequence for each horizontal studied position. The gradients sequence is then converted into a frequency domain. The frequency sequence is used to match the region of interest with the picture, excluding 16 pixels borders bottom, top, left and right. The same synchronisation algorithm is processed for both the reference signal and the signal under test, which guarantee a successful synchronisation between the reference computation and the computation of the signal under test. This procedure is particularly efficient because it prevents the user from performing long and difficult alignment of signals.

7.2.2 Spatial activity parameter

The first and the second features represent the spatial activity of the picture. The first one is dedicated to the global content of the picture, calculated as the mean of the picture. This allows easy detection of black pictures.

7.2.3 Temporal activity parameter

The third feature deals with temporal activity. It is based on the integration of the spatial activity for several pictures. The spatial activity sequence is transformed into frequency and then summarised into a squared sum to obtain one value for the length of the sequence. This feature is really efficient to detect frozen pictures, for example, or jerky motion.

7.2.4 Blocking effect parameter

The last feature is the blocking effect indicator. It is sensitive to DCT patterns and perceptually annoying block edges. The blocking effect parameter is the ratio of the spatial activity computed for the picture to the spatial activity computed for the picture shifted in a translation equivalent to half of the block diagonal. Thus, the ratio of shifted spatial activities is particularly relevant for enhancing the increase or loss of the block’s edge.

Once these reference parameters are computed for the source test pattern, they are recorded on the hard disk of the measurement equipment. The reference has to be recorded for twice the length of the sequence. The dedicated test pattern is 30 pictures long, so the reference-recording step takes only 60 pictures, i.e. for less than 3 s. Parameters are also computed on the current video signal, and then compared.

7.3 Comparison

In the second step, the equipment realises the synchronisation of the incoming signal (delivered by the receiver under test), with the recorded reference data. This procedure is automatic, it does not require any other information than the incoming signal and is realised in a very short time.

Finally, comparative impairment features are computed based on the changes of a parameter between the reference measure and the current measure. These features are designed to be representative of the perceptual video quality. In order to be correlated to subjective data, the impairment feature is first computed using a comparison, and then time-collapsed with a specific norm.

The features are individually well correlated with the operator evaluation for small degradation levels, but a single feature is more difficult to correlate with a subjective evaluation for strong impairments. One major reason is that several types of impairments occur simultaneously with the impairment for which each feature is designed, requiring other specific parameters. This optimising approach has been used to set up several features.

A video quality assessment method should provide a single quality evaluation value, but for application in EMC tests, it is even more relevant to only raise alarms. So, the assessment method is specifically tuned to detect visible degradation. To achieve this, we merge the defined features into a single alarm prediction value, since several impairment types can occur simultaneously to influence the subjective judgement. The model combines in a non-linear process the relevance of the video impairment features to predict an alarm.

To this end, an optimisation procedure carried out with subjective data obtained by the single stimulus continuous quality evaluation (SSCQE) standard is used to set up the model (see ITU-R BT.500-10). Thus, the equipment computes a binary quality score for each frame, and displays the score to the operator.

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