IEEE Std 208-1995
(Revision of IEEE Std 208-1960)

IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques

Sponsor

Audio and Visual Techniques Committee
of the
IEEE Broadcast Technology Society

Approved March 16, 1995

IEEE Standards Board

Abstract: The methods for measuring the resolution of camera systems are described. The primary application is for users and manufacturers to quantify the limit where fine detail contained in the original image is no longer reproduced by the camera system. The techniques described may also be used for laboratory measurements and for proof-of-performance specifications for a camera.
Keywords: camera systems, video

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Introduction

(This introduction is not a part of IEEE Std 208-1995, IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques.)

IEEE Std 208-1995 replaces IEEE Std 208-1960, which was reaffirmed in 1972, and again in 1978.

The principal purpose of IEEE Std 208-1995 is to define a method of measurement of the image resolving capability of a television camera. The standard defines a method that yields consistent and repeatable quantitative resolution values, and reliably determines the resolution limit at which fine detail contained in the original image is no longer reproduced by the television camera.

The standard has been changed to include new information that permits measurement of greater technical performance and unique picture characteristics resulting from the use of solid state imaging devices in television cameras.

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IEEE Standard on Video Techniques: Measurement of Resolution of Camera Systems, 1993 Techniques

1. Overview

One of the major characteristics of a television system affecting overall picture quality is the ability of the system to reproduce fine detail found in the original image. This ability to resolve detail is determined by a number of factors such as number of scanning lines employed, the scanning method, and the overall response of the electrical circuits, which is usually specified in terms of the frequency response characteristics. Performance of the lens, optical imaging device (camera), and the reproducing device (picture monitor) will also have considerable influence on the ability of the system to resolve detail.

1.1 Scope

The fundamental basis for making a measurement of resolution of a camera system is to reproduce a suitable test chart with the equipment under test. This test chart shall include a pattern that has a sufficient amount of fine detail so that a quantitative observation can be made of the amount of this detail in the reproduced picture. This is usually done by incorporating in the chart a series of lines having graduated widths. The reproduced image of this test chart is then observed on a picture tube or other suitable reproducing device. The point in the picture where the lines are no longer visible as separately defined images gives a measure of the system performance with respect to resolution. A quantitative method of measuring the horizontal resolution response of a camera system is based upon the oscilloscope display of the camera output voltage obtained from any single scan line across the vertical wedges of the resolution chart image. By choosing lines that occur at suitable times, the amplitude of the resulting signal can be plotted as a function of the line number of the chart.

NOTE—The horizontal resolution response characteristic described above is also referred to as the depth of modulation. The term *modulation transfer function* (MTF), or *optical transfer function* (OTF), is strictly defined as sine wave frequency response, and should not be used when referring to the response of the television camera to optical square wave patterns.

2. Reference

This standard shall be used in conjunction with the following publication:

IEEE Std 202-1954, Television: Methods of Measurement of Aspect Ratio and Geometric Distortion.[1]

3. Definitions

3.1 resolution: A measure of the ability to delineate picture detail.

3.2 television lines (TVL): The number of television lines for the measurement of camera resolution is defined as the total number of alternate, equal width, black and white, horizontally oriented lines that can be drawn between the top edge and bottom edge of the picture and that will fill the complete height of the resolution chart. Specification and measurement of the number of television lines always refers to *lines per picture height*.

NOTE—Total Lines per Picture Width = (Picture Width ÷ Picture Height) × (TVL)

For a given value of television lines (TVL), the total number of alternate, equal width, vertically oriented black or white lines that can be drawn between the left edge and right edge of the picture, and that will fill the complete width of the resolution chart, can be determined by multiplying the number of horizontally oriented lines N, by the aspect ratio of the resolution chart, which is the ratio of the chart width to the chart height.

3.3 limiting resolution: In television, a measure of resolution is expressed in terms of the maximum number of lines per picture height discriminated from a test chart.

NOTE—For a number of lines N (number of alternate, equal width black or white lines) the Width of Each Line = (1 ÷ N) × the Picture Height.

3.4 resolution response: In television, the ratio of 1) the peak-to-peak signal amplitude, given by a test pattern consisting of alternate black and white bars of equal widths representing a given TV line number on a test chart, to 2) the peak-to-peak signal amplitude, given by large black areas and large white areas having the same luminance as the black and white bars in the test pattern.

[1]IEEE Std 202-1954 has been withdrawn; however, copies can be obtained from the IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

4. Test and measuring equipment requirements

4.1 Test chart

The essential tool for measurement of resolution is a suitable test chart. The *IEEE Resolution Chart, 1993* (figure B.1 in annex B) is recommended for this purpose. This chart may be used directly for measurement of television cameras.

NOTE—If the measured amplitudes at numerous TV line numbers are plotted, the resulting graph is defined as the horizontal resolution response characteristic. Horizontal resolution response is referenced to TV lines (square wave patterns), and is defined as a percentage of the referenced value, 100%.

In addition to being used for the measurement of resolution, the *IEEE Resolution Chart, 1993* may be employed as an aid in checking scanning linearity, aspect ratio, interlacing, shading, streaking, and ringing.

4.2 Picture monitor

When a picture monitor is used to measure the resolution of a camera system, a monochrome monitor is recommended, and it should have a resolution capability exceeding that of the camera system to avoid measurement errors.

4.3 Oscilloscope/wave form monitor

For the measurement of the resolution response of a camera system, an oscilloscope or wave form monitor of sufficiently wide bandwidth is required to avoid measurement errors. Frequency response should be uniform and equal to or greater than that required to accurately measure the system/circuit under test. The highest fundamental electronic signal frequency resulting from the *IEEE Resolution Chart, 1993* (see figure B.1) when used with a television system conforming to system "M" (525 line, 59.94 field—see table A.1), is 12.7 MHz.

The electronic signal frequency may be calculated for any value of TV lines on the resolution chart by the following formula:

$$\text{Frequency} = (1/2) \times (\text{TVL}) \times (\text{Width} \div \text{Height}) \times (1 \div \text{Horizontal Active Line Time})$$

The oscilloscope/wave form monitor should be equipped with a line selector that will permit the selection, display, and identification of any desired horizontal scan interval once each frame time.

5. Measurement procedure

5.1 Conditions

Before a significant measurement of resolution is made, it is essential that the television camera system under test be properly adjusted, and that the *IEEE Resolution Chart, 1993* (see figure B.1) be oriented and aligned perpendicular to the optical axis to permit the camera to accurately reproduce its image. Care should be applied to assuring that the base of the camera and the edge of the chart rest on, or be referenced to, the same level surface. Further, the geometric center of the chart must be aligned, and perpendicular with the optical axis (center line) of the camera lens and optical system. Finally, after adjusting lens focal length (if equipped) and other lens adjustments to their optimum settings (see condition 5.1.7), the distance between the chart and the camera should be adjusted until the entire resolution chart is just completely reproduced by the camera. Two arrowheads located at each edge of the resolution chart are provided to aid in the correct orientation and the complete composition of the chart within the picture raster observed on the monitor. The test pattern on the chart is correctly oriented and composed when the camera is adjusted such that the point of every arrow just touches its corresponding edge of the picture monitor raster.

After the test pattern has been correctly oriented with respect to the camera, the following items are among those that shall be given attention:

5.1.1 Scanning and interlace

For cameras that utilize imaging tubes, care should be taken to check and adjust for proper scanning size, scanning linearity, aspect ratio, and interlace. For measurement and adjustment of scanning size and linearity and aspect ratio, it is suggested that reference be made to IEEE Std 202-1954.[2]

Interlace will affect vertical resolution; hence, any adjustments in the system that influence interlace should be optimized.

5.1.2 Shading

If the camera equipment employs signals for camera-shading correction, two methods for proper adjustment are suggested:

a) Visual inspection of the picture monitor to determine if the background is an even gray
b) Use of the wave form monitor to determine whether the average picture signal axis is parallel to the black level line, both at line and field frequencies

5.1.3 Nonlinear video signal processing

The influence of nonlinear video signal processing such as gamma correction, white compression (knee), black compression, and expansion (stretch), should be avoided to assure accurate and uniform resolution measurement.

5.1.4 Image enhancement

The influence of image enhancing video signal processing such as aperture correction, contour correction (detail), and others, should be avoided to assure accurate and uniform resolution measurement.

[2]Information on references can be found in clause 2.

5.1.5 Streaking and ringing

Streaking following any one of the horizontal black or white bars is an indication of low-frequency distortion in the video processing circuits.

Ringing, or multiple echoes following any single vertical line, is a function of the high-frequency response of the system. These echoes may be confused with the multiple lines of the resolution wedge and hence lead to an inaccurate determination of resolution.

5.1.6 Focus

All optical and electrical focusing at the camera should be optimized.

5.1.7 Light level

The desired light level value is that which permits all of the elements of the camera system to be adjusted to their optimum performance positions. For instance, lens settings for iris, focus, and focal length, are usually optimum at about the center of their adjustment ranges.

5.1.8 Signal component to be measured

For color cameras, it is recommended that resolution be measured only for the luminance video signal. Color signal components contained in the output signal should be disabled or eliminated. The preferred point for measurement of resolution is the camera output connection that the camera manufacturer directs be connected to a principal program input of a video system.

5.2 Measurement technique

5.2.1 Measurement of limiting resolution

After assuring that the conditions described in 5.1 are satisfied, limiting resolution may be determined by observing the reproduced resolution chart on a picture monitor. The limiting horizontal and vertical resolution of the television camera chain and picture display combination is determined by observing the point at which the individual lines of the graduated wedges are no longer discernible as separately defined images. The resolution readings of both horizontal and vertical wedges will indicate the system performance under the conditions of the test.

Camera systems may have different values of limiting resolution in different areas of the image. This would be observed by comparing the wedges in the center circle with those in the four corner circles of the test chart (see figure B.1). Unless specified with the measurement, the resolution cited applies to the central portion of the picture.

5.2.2 Measurement of horizontal resolution response of camera systems

The oscilloscope/wave form monitor should be connected to the luminance video signal output of the camera system to be measured. A reference reading should be obtained by noting the amplitude of the video signal for the transition between the long horizontal black bars and the white background. The long black bars, located at the bottom of the large center circle, can be used to determine the *reference black to white video level* before measuring horizontal resolution response. Horizontal resolution response at any TV line number is measured as a percentage of the *reference black to white video level* that is defined to be 100%.

As the vertical wedges of the test chart, used to measure horizontal resolution, are selected and displayed, there will be five or nine cycles in the video signal. The duration of the sweep of the oscilloscope/wave form monitor should be adjusted to permit a clear display of the electronic signal wave form corresponding to these bursts. Line numbers should be selected corresponding to the number of TV lines on the chart, from the minimum, to the maximum for which all of the cycles are still discernible. The maximum number of TV lines still discernible corresponds to the limiting resolution. The relative peak-to-peak amplitude of the cycles should be noted for the different TV lines to give a complete measurement of video signal amplitude versus television line number on the chart.

NOTE—This measurement is affected by the fact that the resolution wedges of the chart produce an optical square wave, rather than a sine wave. This means that the reading of horizontal resolution response at a given line number will be influenced by the response of the system being measured to the harmonics of the square wave.

Sampling techniques that may be utilized within the camera system, including the pixel array of CCD image sensors and vertical segmentation by scan lines, and others, will produce aliasing. When the pattern of the test chart exceeds one half the sampling frequency, the camera system may produce a lower frequency alias component that is superimposed on the correct reproduction. All of the measurements previously described can be distorted by alias components.

a) *Limiting resolution*. If the alias component becomes predominant, it can be mistaken as extending the limiting resolution, even though the full number of cycles are not reproduced. The correct quantity of alternating black and white lines should be clearly discernible for valid limiting resolution measurement.
b) *Horizontal resolution response*. The alias component can cause the five or nine cycles of alternating black and white lines to have various peak amplitudes. To minimize the influence of aliasing, the averages of the positive and negative peaks should be used for measurement of relative response (see figure 1).

5.3 Presentation of data

The following data should be recorded.

5.3.1 Quantitative data presentation

5.3.1.1 Test chart illumination

For reference purposes, light level and lens settings (f numbers) should be recorded.

5.3.1.2 Using the picture monitor

At the points of interest, the limiting horizontal resolution and limiting vertical resolution should be measured and recorded.

5.3.1.3 Using the oscilloscope/wave form monitor

The peak-to-peak amplitude of each burst relative to the appropriate television line number for each burst that is of interest should be measured and recorded. Measurements, as instructed in 5.2.2, should be taken. Where aliasing is present, special note should be taken.

5.3.2 Graphical data presentation

The measured values may be plotted to display the horizontal resolution response characteristic. Such a curve defines the horizontal resolution response of the camera system. From this characteristic, the video signal amplitude response is measured as a percentage of the reference amplitude for any number of television lines that the camera system can reproduce.

A reading may be taken of one or more of the following significant points, as appropriate:

a) The chart line number for which the horizontal resolution response is half its reference value (half amplitude response)
b) The chart line number at which the horizontal resolution-response characteristic approaches zero (corresponds roughly to the limiting resolution)

c) The value of the horizontal resolution response corresponding to a chart line number of 350 lines (corresponds to the approximate maximum video frequency that may be transmitted under United States broadcasting standards for monochrome television)

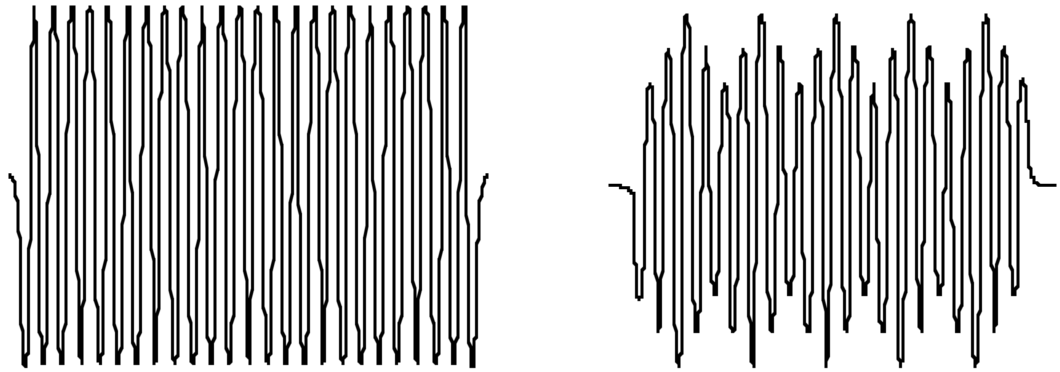

Figure 1—Effect of aliasing on the horizontal resolution response wave form

NOTE—An extensive discussion of the subject of resolution, especially in terms of the oscilloscope method of measurement, is given by O. H. Shade, “Image Gradation, graininess and sharpness in television and motion picture systems,” J. SMPTE, vol. 56, pp. 131-171, February, 1952; vol. 58, pp. 181-222, March, 1952; vol. 61, pp. 97-164, August, 1953; vol. 64, pp. 593-617, November, 1955.

Annex A
Instructions for the use of the IEEE Resolution Chart, 1993

(informative)

A.1 Purpose

The *IEEE Resolution Chart, 1993* was designed to provide a standard reference for the measurement of the resolution response of television cameras and other video devices. In addition, the chart serves as an aid in the observation of other performance characteristics such as streaking; ringing; aliasing; and geometry, linearity, and aspect ratio of the picture. The chart may be used to observe some optical system performance characteristics as well.

The horizontal resolution response of a television camera is usually limited by the resolving capability of the imaging device, not by the bandwidth of the video amplifiers. Useful information and measurements of the percentage of resolution response at numerous TV line numbers, and the limiting resolution response of a television camera, may be obtained by utilizing the *IEEE Resolution Chart, 1993*. For this purpose, horizontal and vertical wedges of TV line patterns, and other groups of TV line patterns have been arranged on the chart to permit resolution response measurement extending from 100 to 1000 TV lines.

A.2 Description

The 100 to 600 TV line number horizontal and vertical line pattern wedges in the center of the chart are composed of five black lines separated by four white lines. The 500 to 1000 TV line number wedges are composed of nine black lines, separated by eight white lines. All lines are of equal width at any TV line number point on each wedge. The numbers printed alongside the wedges correspond to the total number of lines (black and white) of the indicated thickness that may be placed adjacent to one another in the height of the chart. For example, if black and white lines having the thickness of those indicated at the 300 position were placed adjacent to one another, a total of 300 (black and white) lines can be fitted into the height of the chart. Since the aspect ratio of the chart is 4 to 3, a total of 400 lines of this same thickness can be fitted into the width of the chart. The fundamental frequency generated by scanning through any TV line number on the vertical wedge may be calculated. Fundamental frequencies for various TV line numbers are listed in table A.1 (see also 4.3).

Table A.1—Fundamental video frequencies at various TV line numbers on the vertical wedges, for the NTSC—M system (525 line, 59.94 field)

TV line number on vertical wedge	Fundamental video frequency
100	1.3 MHz
200	2.5 MHz
300	3.8 MHz
400	5.0 MHz
500	6.3 MHz
600	7.6 MHz
700	8.8 MHz
800	10.1 MHz
900	11.3 MHz
1000	12.6 MHz

A.3 Resolution

TV line wedge patterns are provided for the observation and measurement of resolution response. In addition to the principal wedge patterns located within the large center circle, wedges are provided within small circles located at each corner of the chart. These permit observation and measurement of resolution response at the edges of the picture, as well as in its center.

A.4 Reference level

The long black bars, located at the bottom of the large center circle, can be used to determine the *reference black to white video level* before measuring horizontal resolution response. Horizontal resolution response at any TV line number is measured as a percentage of the *reference black to white video level*, which is defined to be 100% (see 3.4, for the definition of resolution response, and 5.2.2).

A.5 Streaking

The long black bars, located at the bottom of the large center circle, can be used to observe streaking in the picture. Streaking may indicate poor phase response, especially in the low frequencies, or, poor clamping, resulting in unsatisfactory DC restoration. The black bars can also be useful for the observation or adjustment of high frequency compensation. Poor high frequency compensation is indicated by short peaks or streaks that occur at the edges of the transitions between the white background of the chart and the black bars.

A.6 Bandwidth

In addition to the horizontal resolution response that can be measured at any individual TV line number point along the vertical TV line number wedges, a single complete display of the horizontal resolution response for all TV line numbers between 100 and 1000 may be observed from the rows of TV line number patterns located below the center point of the chart.

The top row is composed of individual patterns of TV line numbers from 100 to 1000 TV lines. The patterns with the highest TV line numbers are located in the center of the row. The odd TV line number patterns descend from the center to the left side of the row. The even TV line number patterns descend from the center to the right side of the row. These patterns are separated by wide black areas to permit their easy identification during measurement. The bottom row is a single pattern, increasing continuously from 100 TV lines at its left, to 1000 TV lines at its right. Thick black markers are included at incremental points of 100 TV line numbers to permit their easy location during measurement.

The middle row is composed of individual patterns of TV lines from 100 to 1000 TV lines, arranged exactly as they are in the top row. The lines, however, are oriented at a slight diagonal from true vertical and, therefore, facilitate observation of alias interference effects resulting from image sampling, such as in television cameras that utilize CCD imagers.

A.7 Shading

White level shading may be checked by visual observation of the picture monitor to determine if the background of the chart is consistently white over its entire area. A wave form monitor may be used to measure horizontal white level shading in TV line frequency display time, and vertical white level shading in TV field frequency display time.

A.8 Ringing

Two groups of TV line patterns, located to the left and right of the large center circle, contain only one black line for each TV line number between 100 and 1000 TV lines. The width of each of these single lines is the same as the width of all of the lines, located at the same TV line number, in the multiline wedge patterns. Single lines between 100 and 500 TV lines, in 100 TV line increments, are located to the left of the circle. Single lines between 600 and 1000 TV lines, in 100 TV line increments, are located to the right of the circle. These single line patterns are provided to facilitate observation of ringing, and other effects, more difficult to observe from the multiline wedge patterns.

A.9 Aliasing

Interference patterns, referred to as aliasing, can sometimes be observed in television pictures. These can occur when video frequencies in the picture approach the frequency at which the picture is sampled (sampling frequency). Aliasing can occur in CCD television cameras and in television devices that employ digital video processing. The following several patterns are provided to permit observation of aliasing:

a) Diagonal lines located to the right of the vertical line pattern wedges
b) Slanted black rectangle located to the left of the vertical line pattern wedges
c) Circular line pattern located exactly at the center of the chart
d) The middle row of TV line patterns, located in the lower half of the large circle. The lines of these patterns are oriented at a slight diagonal from true vertical.

A.10 Miscellaneous

Arrowheads, and vertical and horizontal line patterns located at all edges of the chart, are provided to facilitate its alignment with respect to the television camera or imaging device under test. Alignment marks also are provided along the edge, at the vertical and horizontal axes, of the large center circle.

A.11 Care and handling

Television test charts must be stored, handled, and used carefully to achieve accurate and dependable results from their use. Charts that are soiled with dirt, and that possess handling marks and fingerprints, cannot yield accurate measurement results. Charts exposed to intense light and/or heat for prolonged periods, will fade and become undependable for use as measurement tools.

Annex B
The IEEE Resolution Chart, 1993

(informative)

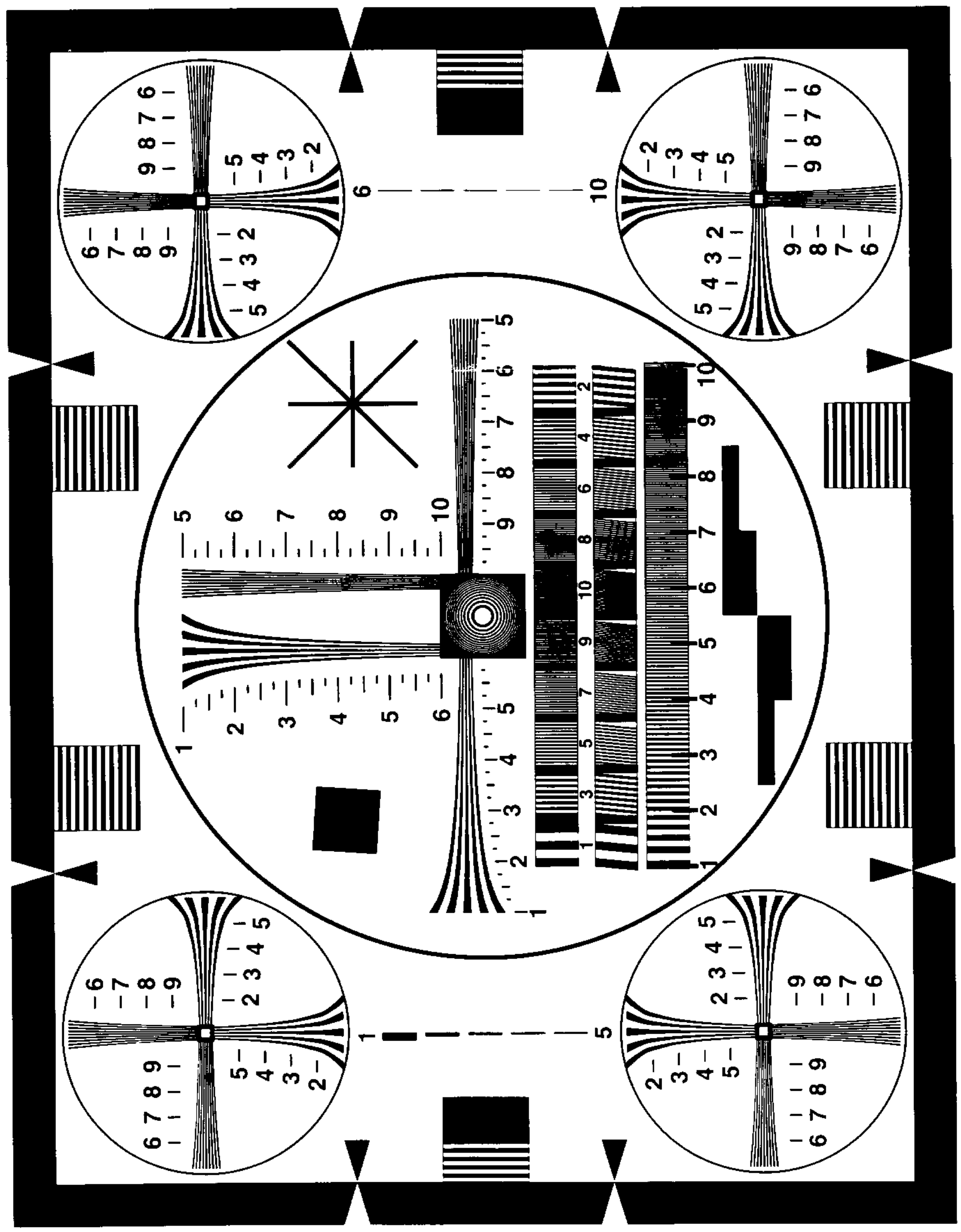

Figure B.1—IEEE Resolution Chart, 1993

B.1 Description of IEEE Resolution Chart, 1993

B.1.1 Size

The size of the chart is not specified in this standard. A chart manufacturer may use any appropriate chart height. All chart dimensions are specified either as percentages of the chart height (vertical active chart area), or as TV line thickness values.

B.1.2 Tolerances

Test chart locations have a tolerance of ±1% of the active chart height. Test chart line widths have a tolerance of ±5% of the specified nominal TV line values. Test chart angles have a tolerance of ±0.5 degrees from the specified nominal angles.

B.1.3 Contrast ratio

The minimum contrast ratio between the black and white features shall be 50:1. The chart may be either a reflectance chart or a transparency.

B.1.4 Text

The thickness of all features shall be denoted using numbers that indicate the value in TV lines × 100. For example, *5* denotes lines whose thickness equals 500 TV lines.

B.1.5 Vertical framing arrows

The chart shall include sets of vertical framing arrows at the top and bottom of the active area of the chart, also referred to as the chart height.

B.1.6 Horizontal framing arrows

The chart active area shall include sets of horizontal framing arrows at the left and right of the active area, which indicate a 4:3 image aspect ratio.

B.1.7 Center circle

The inner radius of the large center circle shall be 80% of the chart height. Circle thickness shall be 200 TV lines. Short marks having a thickness equal to 100 TV lines and a length equal to 4% of the target height shall be centered at 0, 90, 180, and 270 degree points on the circle.

B.1.8 Center zone plate

The center of the chart shall include a zone plate (set of concentric circles) having a line width that linearly decreases from 100 to 1000 TV lines. The zone plate shall be located within a black square having sides equal to 10% of the chart height.

B.1.9 Horizontal measurement hyperbolic wedges

Two horizontal measurement hyperbolic wedges shall be positioned above the center black square. The wedges shall include a five-cycle horizontal measurement wedge with a thickness varying linearly from 100 to 600 TV lines positioned nearer the left of the target, and a nine-cycle horizontal measurement wedge with a thickness varying linearly from 500 to 1000 TV lines positioned nearer the right edge of the target. The wedges shall have a length equal to 30% of the chart height. Fiducial marks shall be spaced at 25 line increments. Text shall indicate the line thickness values at 100 line increments.

B.1.10 Vertical measurement hyperbolic wedges

Vertical measurement hyperbolic wedges shall be positioned at the left and right of the center black square. The wedges shall include a five-cycle vertical measurement wedge with a thickness varying linearly from 100 to 600 TV lines positioned nearer the left of the target, and a nine-cycle vertical measurement wedge with a thickness varying linearly from 500 to 1000 TV lines positioned nearer the right edge of the target. The wedges shall have a length equal to 30% of the chart height. Fiducial marks shall be spaced at 25 line increments. Text shall indicate the line thickness values at 100 line increments.

B.1.11 Burst patterns

Two burst patterns shall be positioned below the center black square. The patterns shall include bursts of lines having line widths equal to 100, 300, 500, 700, 900, 1000, 800, 600, 400, and 200 TV lines, in order from left to right. The upper pattern shall have lines that are vertically oriented, and the lower pattern shall have lines that are tilted off the vertical axis in the clockwise direction by 6 degrees. Text shall indicate the line thickness values of each of the 10 bursts.

B.1.12 Sweep pattern

A continuous sweep pattern shall be positioned below the lower 10 burst pattern. The line thickness values shall decrease linearly from left to right, starting at a thickness value equal to 100 TV lines, and ending at a thickness value equal to 1000 TV lines. Text shall indicate the line thickness values at 100 line increments.

B.1.13 Tilted black square

The target shall include a tilted black square positioned in the upper left quadrant of the center circle. The square shall have sides whose length equals 7.5% of the chart height, and shall be tilted off the vertical axis in the clockwise direction by 4 degrees.

B.1.14 Cross and X

The target shall include a group of four intersecting lines, forming a cross and an *X*, positioned in the upper right quadrant of the center circle. The length of the lines forming the cross shall be equal to 15% of the chart height. All four lines shall have a thickness equal to 200 TV lines.

B.1.15 Long black bar patterns

The target shall include two long black bar patterns located inside the bottom of the large center circle. The lower bar shall have a length equal to 10% of the chart height. The right edge of the lower bar shall be located at the horizontal center of the chart. The upper black bar shall have a length equal to 40% of the chart height, and shall be centered horizontally. The white bar inside the upper black bar shall have a length equal to 19% of the chart height. The right edge of the white bar shall be located at the horizontal center of the chart.

B.1.16 Corner circles

The inner radius of the corner circles shall be nominally 33% of the chart height. The corner circles shall surround four hyperbolic wedges. The wedges shall include five-cycle vertical and horizontal measurement wedges with a thickness varying linearly from 100 to 600 TV lines positioned nearer the center of the target, and nine-cycle vertical and horizontal measurement wedges with a thickness varying linearly from 500 to 1000 TV lines positioned nearer the outer edge of the target. Text shall indicate the line thickness values at 100 line increments.

B.1.17 Single pulse pattern

Two groups of individual lines shall be positioned to the left and right of the large center circle, between the corner circles. The left group shall contain single lines of width equal to 100, 200, 300, 400, and 500 TV lines. The right group shall contain single lines of width equal to 600, 700, 800, 900, and 1000 TV lines. Text shall indicate the position of the 100, 500, 600, and 1000 TV line marks.

B.1.18 Horizontally striped squares

The target shall include two squares of horizontal stripes located at both the extreme top and bottom of the chart, inside the framing arrows. The width of the stripes shall be 200 TV lines. The square shall have sides equal to 10% of the chart height.

B.1.19 Vertically striped squares

The target shall include squares filled with vertical stripes and a black rectangle, located at both the extreme left and right of the chart, vertically centered inside the framing arrows. The width of the stripes shall be 200 TV lines. The width of the black rectangle shall equal 5.5% of the chart height. The square shall have sides equal to 10% of the chart height.