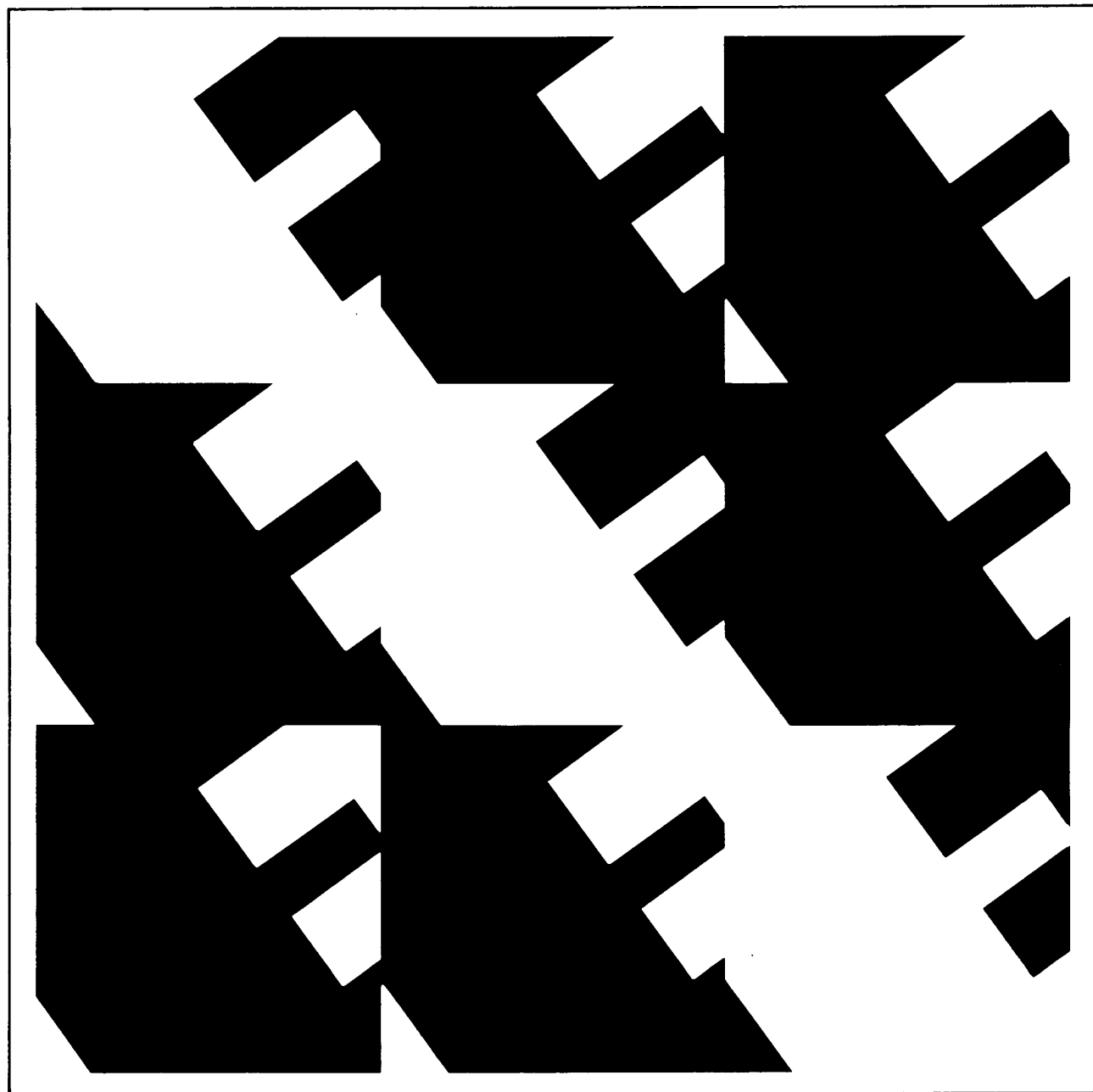


IEEE Standard on Video Signal Transmission Measurement of Linear Waveform Distortion

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**IEEE Standard on
Video Signal Transmission
Measurement of Linear Waveform Distortion**

Sponsor
Audio-Video Techniques Committee of the
IEEE Broadcasting Group

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Foreword

(This Foreword is not a part of IEEE Std 511-1979, IEEE Standard on Video Signal Transmission Measurement of Linear Waveform Distortion.)

The Audio-Video Techniques Committee voted on May 1, 1973 to approve IEEE Std 511 on Trial-Use basis. The document was then reviewed, modified, and approved for trial use by the IEEE Standards Board on September 6, 1973.

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An American National Standard

IEEE Standard on Video Signal Transmission Measurement of Linear Waveform Distortion

1. Scope

This standard describes methods for measuring the linear waveform distortions of TV video signals, that is, distortions which are caused by amplitude-independent (linear) transmission characteristics of television equipment and facilities.¹

The primary application of this standard is for routine operational and maintenance tests, where rapid interpretation of test results is desirable. The techniques described here may also be applicable to laboratory measurements, proof-of-performance measurements, and detailed maintenance procedures.

2. Definitions

For tutorial purposes the definitions are presented in a logical sequence so that terms defined in the beginning of the section can be used in definitions toward the end of the section.

2.1 General Terms

linear distortion. That distortion of an electrical signal which is independent of the signal amplitude.

NOTE: A small-signal nonuniform frequency response is an example of linear distortion. By contrast, non-linear distortions of an electrical signal are those distortions that are dependent on the signal amplitude, for example, compression, expansion, and harmonic distortion, etc.

¹ This standard applies specifically to equipment and facilities operating as a CCIR System M (525 lines/60 fields, monochrome or NTSC color).

TV waveform signal. An electrical signal whose amplitude varies with time in a generally non-sinusoidal manner and whose shape (that is, duration and amplitude) carries the TV signal information.

linear TV waveform distortion. The distortion of the shape of a waveform signal where this distortion is independent of the amplitude of the signal.

NOTES:

(1) A TV video signal may contain time components with durations from as long as a TV field to as short as a picture element. The shapes of all these time components are subject to distortions. For ease of measurement it is convenient to group these distortions in three separate time domains: short-time waveform distortion, line-time waveform distortion, and field-time waveform distortion.

(2) The waveform distortions for times from one field to tens of seconds is not within the scope of this standard.

short-time waveform distortion (SD). The linear TV waveform distortion of time components from 125 ns to 1 μ s, that is, time components of the short-time domain.

line-time waveform distortion (LD). The linear TV waveform distortion of time components from 1 μ s to 64 μ s, that is, time components of the line-time domain.

field-time waveform distortion (FD). The linear TV waveform distortion of time components from 64 μ s to 16 ms, that is, time components of the field-time domain.

$\sin^2$ pulse. One cycle of a sine wave, starting and finishing at its negative peaks with an added

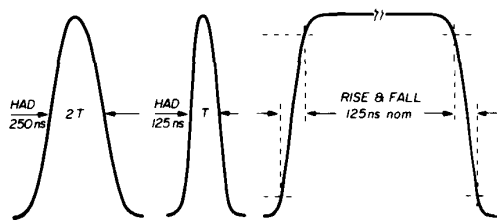


Fig 1
2T Pulse, T Pulse, and T Step

constant amplitude component of half the peak-to-peak value, thus raising the negative peaks to zero.

NOTE: As shown in detail in Appendix A, a $\sin^2$ pulse is obtained by squaring a half-cycle of a sine wave.

$\sin^2$ step. A step function whose transition from zero to the final value is the sum of a ramp and a negative sinusoid of equal durations, with zero slope at both the zero and the final value of the step.

NOTES:

(1) As shown in detail in Appendix A, a $\sin^2$ step is obtained by integrating a $\sin^2$ pulse.

(2) The attractiveness of both the $\sin^2$ pulse and the $\sin^2$ step lies in the fact that their frequency spectra are limited; that is, they are effectively at zero amplitude beyond a given frequency. For the $\sin^2$ pulse this frequency is a function of the half-amplitude duration (HAD) of the pulse; for the $\sin^2$ step the frequency is a function of the 10 percent to 90 percent rise time.

T. Letter symbol for the duration of a half-period of the nominal upper cut-off frequency of a transmission system. Therefore

$$T = \frac{1}{2f_c}$$

Note: For the TV system M

$$T = \frac{1}{2 \times 4 \text{ (MHz)}} = 125 \text{ (ns)}$$

The duration *T* is commonly referred to as the Nyquist interval. The concept of *T* is employed not only when the frequency cut-off is a physical property of a given system but also when the system is flat and there is no interest in the performance of the system beyond a given frequency.

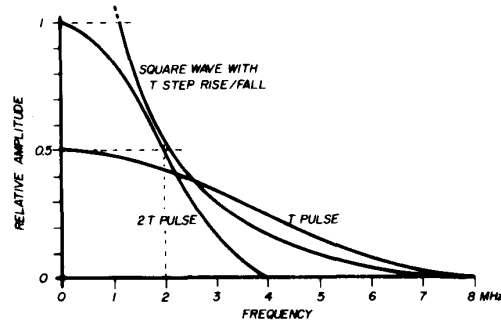


Fig 2
Envelope of Frequency Spectrum of
2T Pulse, T Pulse and Square Wave
with T Step Rise and Fall

2.2 Terms for Waveform Test Signals in TV System M

T pulse. A $\sin^2$ pulse with a half-amplitude duration (HAD) of 125 ns. The amplitude of the envelope of the frequency spectrum at 4 MHz is 0.5 of the amplitude at zero frequency and effectively zero at and beyond 8 MHz (see Figs 1 and 2).

2T pulse. A $\sin^2$ pulse with a HAD of 250 ns. The amplitude of the envelope of the frequency spectrum at 2 MHz is 0.5 of the amplitude at zero frequency and effectively zero at and beyond 4 MHz (see Figs 1 and 2).

NOTE: The *2T* pulse is mentioned here for the sake of completeness. The short-time domain may be tested by the *2T* pulse in conjunction with the *T* pulse and a reference signal. This method is not used in this standard since the *T* step alone tests the short-time domain in a simpler and more direct manner.

T step. A $\sin^2$ step with a 10 percent to 90 percent rise (fall) time of nominally 125 ns. The amplitude of the envelope of the frequency spectrum is effectively zero at and beyond 8 MHz (see Figs 1 and 2).

NOTE: In practice the *T* step is part of a square wave (or line bar as described below), so that there is a *T* step rise and fall.

modulated 12.5T pulse (MOD 12.5T). A burst of color subcarrier frequency of nominally 3.58 MHz. The envelope of the burst is $\sin^2$ shaped with a HAD of nominally 1.56 μs . The MOD 12.5T pulse consists of a luminance and a chrominance component. The envelope of the frequency spectrum consists of two parts, namely signal energy concentrated in the luminance region below 0.6 MHz and in the chrominance region from roughly 3 MHz to 4.2 MHz (see Figs 3 and 4).

line bar. A pulse, nominally of 18 μs duration, of reference-white amplitude (see Fig 5). The rise and fall portions of the line bar are T steps as defined.

field bar. A composite pulse, nominally of 8 ms duration, of reference-white amplitude. The field bar is composed of line bars as defined. This signal when displayed on a picture monitor has the form of the window signal shown in Fig 5.

2.3 Discussion. Linear distortions in any transmission system may be represented by distorted gain versus frequency or phase versus frequency response, or both. In video transmission systems, because of the transient or waveform nature of the television signal, ideally it is important that all input frequencies arrive at the output with unchanged relative amplitudes as well as at unchanged relative times. The knowledge of both responses, however, does not help us to predict directly their effect on a television signal. This effect can only be calculated by mathematical transformation processes.

This indicates that in a television system “good” gain versus frequency and phase versus frequency response is merely a means to the end of “good” amplitude versus time or waveform response. It is, therefore, more meaningful to use waveform signals to measure directly the linear waveform distortions of the television system. If the waveform signals are properly chosen, their linear waveform distortions will indicate the impairment that the television program signal will suffer. All amplitude inaccuracies of the test waveform signal will produce corresponding brightness inaccuracies in the TV picture. Thus:

(1) Field-time waveform distortion (FD) will cause brightness inaccuracy between the top and bottom of a large TV picture detail

(2) Line-time waveform distortion (LD) will cause brightness inaccuracy between the left and right of a large TV picture detail

(3) Short-time waveform distortion (SD) will cause a brightness inaccuracy in the horizontal direction of sharp vertical edges or thin vertical lines of a TV picture detail. The brightness inaccuracy may be in the form of blurring, brightness overshoot, and brightness fluctuations to the left or to the right of the vertical edge or line, or both

The above three waveform distortions suffice to describe the linear waveform distortions of a monochrome TV signal or of the luminance component of a color TV signal. Additional linear distortions have to be considered for the chrominance component of a color TV signal; namely, the chrominance amplitude with respect to the luminance amplitude and the chrominance time with respect to the luminance time. Thus, the linear chrominance distortions:

relative chrominance level (RCL). The difference between the level of the luminance and chrominance signal components.

An inaccuracy in RCL will cause saturation inaccuracy of all colors in a color TV picture.

relative chrominance time (RCT). The difference in absolute time between the luminance and chrominance signal components.

An inaccuracy in RCT will cause registration inaccuracy of all colors relative to their luminance components in a color TV picture.

3. Requirements for Measurements

3.1 The Test Signal. A suitable signal that contains all the necessary components for the various measurements is shown in Fig 6. The relative positions of the components are not critical, provided that the linear waveform distortions of any one component do not mask the distortions of any other component.

The test signal as shown in Fig 6 may contain other components such as color burst and setup. If setup is employed, then the reference test signal amplitude shall be taken between the reference-black level and the reference-white level.