

RECOMMENDATION ITU-R BT.1204*

**Measuring methods for digital video equipment
with analogue input/output**

(1995)

The ITU Radiocommunication Assembly,

considering

- a) that analogue/digital conversion processes will continue even in “totally-digital” studio systems;
- b) that there is the problem of instability in measuring the analogue characteristics of digital video equipment with analogue input/output;
- c) that stable measuring methods are essential for improving the performance of digital video equipment with analogue input/output;
- d) that it is desirable that such measuring methods should make use of existing instruments as much as possible;
- e) that the dithering method is effective for randomizing the quantization errors;
- f) that a shallow-ramp signal is a suitable test signal to measure signal-to-noise ratio,

recommends

1 that the measuring method described in Annex 1 should be used for digital video equipment with analogue input/output based on 525-line or 625-line systems.

ANNEX 1

1 Introduction

This Recommendation is intended to assist in measuring the characteristics of studio digital video equipment with analogue input/output. When measuring analogue characteristics such as signal-to-noise ratio (S/N), differential gain/phase (DG/DP), and the luminance non-linearity of the equipment, the quantization error of the coding process causes variations in the results of the measurement. Considering the S/N of 8-bit video equipment, for example, the measured S/N shows some number within 50 dB and 70 dB when using a conventional method with a noise meter. To solve these problems, the Broadcasting Technology Association of Japan (BTA), has organized a Working Group to study new measurement methods for digital video equipment with analogue input/output. Similar work has been carried out in the United Kingdom.

* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2002 in accordance with Resolution ITU-R 44.

The approach described in the Recommendation provides stable measuring results using the following methods to avoid quantization errors:

- superimposing a dither signal on a test signal, and removing the dither signal prior to the measurement with frequency band limitation filters; and
- using a shallow-ramp signal instead of a flat signal for an S/N measurement to make the test signal cross the quantizing levels as much as possible.

Measurement items described in the Recommendation are S/N , DG/DP, pulse characteristics and luminance non-linearity (see Note 1).

Although the Recommendation addresses measuring methods for equipment of 525-line and 625-line systems, the concept of the methods is applicable to other systems such as HDTV and EDTV.

NOTE 1 – Gain/frequency characteristics are important in specifying the performance of television equipment. However, a special measuring instrument with an averaging function is required to remove the dither signal, so the measuring method for gain/frequency characteristics is described in Appendix 1.

2 General definitions

2.1 Video equipment and test signals

The video equipment and test signals are based on 525-line systems or 625-line systems.

2.2 DUT

DUT stands for a device under test, namely, a piece of video equipment being measured. The A/D or D/A conversion in DUTs to be measured using the recommended methods should have a resolution of 8 bits or more.

2.3 IRE units

An IRE unit is a linear scale for measuring the relative amplitudes of a television signal with a zero reference at blanking level. 100 IRE units correspond to the reference white level, and -40 IRE units correspond to the bottom of the synchronization pulses. 525-line systems are often operated with 100 IRE units = 0.714 V p-p, while 625-line systems are often operated with 100 IRE units = 0.7 V p-p.

2.4 Video analyser

In this Recommendation, the video analyser is defined as an automatic video signal measuring instrument which has the functions to average and interpolate the signals to reduce the noise components of the measured signals.

3 The definition of dither signal

3.1 Dither signal

A dither signal is used to stabilize measured values by causing very small random changes to the level of test signals and thus dispersing quantization errors evenly in relation to the quantization levels. Since it is necessary to remove the dither signal easily before measuring, in this Recommendation a sine-wave signal is used as a dither signal, which can be removed with a simple filter. The sine-wave signal should be asynchronous (non-locked) with the test signal in order to work as a dither signal.

The frequency of the sine-wave signal for this purpose should preferably be outside the nominal cut-off frequency of the system, but within the bandwidth of the A/D and D/A converter of the DUT. For the 525-line system, it is recommended to use a frequency of 5.162 MHz which is the second-null point of a 4.2 MHz low pass filter (LPF) in a video noise meter, and for the 625-line system, to use a frequency of 6.145 MHz which is the null-point of 5.0 MHz LPF.

This assumes that DUTs are operating at a sampling frequency significantly greater than twice the highest frequency of the noise measurement filters; for example, at a sampling frequency of four times colour subcarrier frequency as in SMPTE 244 format for composite signals and 13.5 MHz as in Recommendation ITU-R BT.601 for component signals.

The amplitude of the sine-wave signal should be 30 mV p-p \pm 10%. It is desirable that the sine-wave signal is superimposed during the active period of the test video signal.

3.2 Notes

3.2.1 Superimposing the dither signal

Superimposing the dither signal onto a test signal can be realized by the circuits shown in Fig. 1.

3.2.2 Removing the dither signal before measurements

When measuring a DUT using the dither signal, it is necessary to observe and measure the DUT's output waveform after removing the dither signal. The dither signal using a non-locked sine-wave signal can be removed by the following methods:

- by using band-limiting filters;
- by means of averaging with the video analyser;
- by cancelling with an operational amplifier.

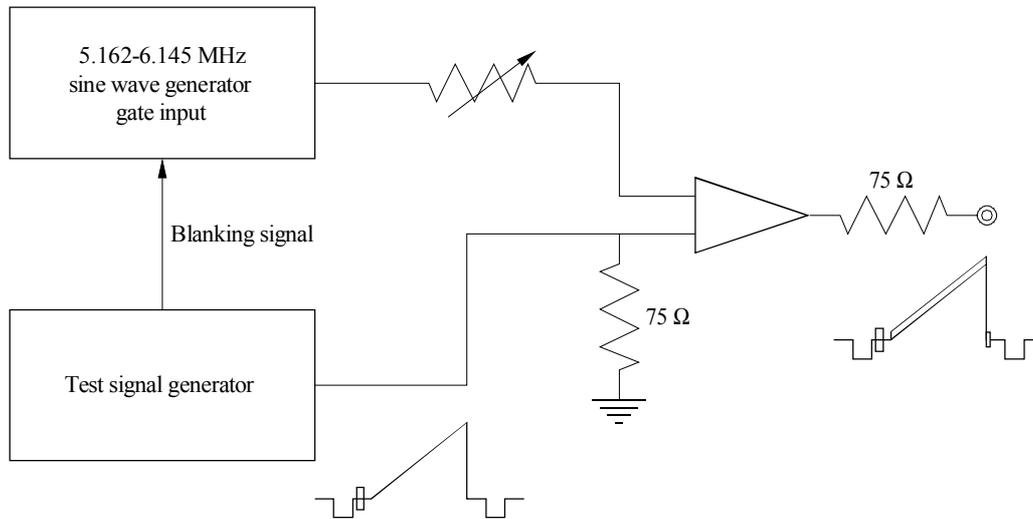
The latter two methods are effective but require special measuring instruments.

a) *Dither removal using band-limiting filters*

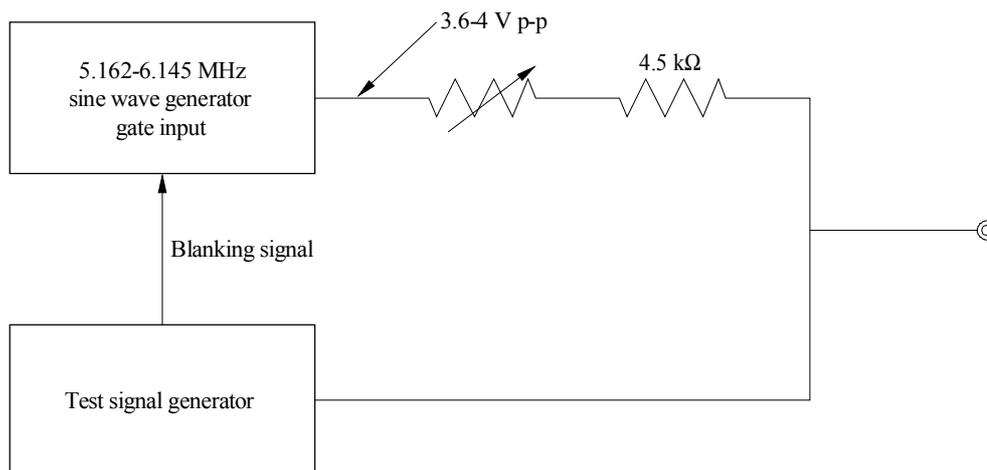
Video signal measuring instruments incorporate various types of filters for easy and accurate measurements. These filters are efficient in removing the dither signal if it has a relatively high frequency such as 5.162 MHz for 525-line systems and 6.145 MHz for 625-line systems.

FIGURE 1

Example circuits for superimposing the dither signal



a) Normal superimposer



b) Simple superimposer

Note 1 – The amplitude of test signals may decrease after passing through this circuit.

D01

A vector scope, for example, employs a band-pass filter which passes only chrominance signals. This means that the dither signal is outside the range of the band-pass filter. Accordingly, the vector scope can observe the output signal from the DUT without any dither influence when measuring DG/DP.

Waveform monitors and noise meters incorporate the following filters for measurements. All these filters are able to reduce the dither signal.

- *Low-pass filter*: Observes the low-frequency components of a video signal, such as filters for measuring signal-to-noise ratio, IRE units filters, and luminance filters which have a notch at the frequency of the chrominance signal.

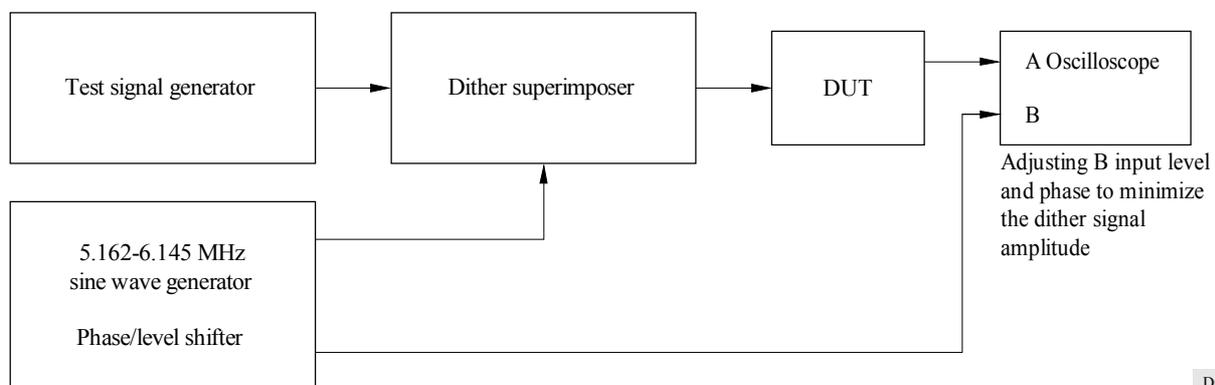
- *Band-pass filter*: A chrominance filter for observing chrominance signals and a staircase differentiating network defined in Annex II to Part C, § 4.3 of ITU-T Recommendation J.61, are used to measure luminance linearity using a staircase signal.
- b) *Dither removal using the video analyser*

As described in § 2 of this Annex, the video analyser has a data averaging capability to increase the stability and consistency of measured results. This function removes the dither signal efficiently.

- c) *Dither removal using a cancellation circuit*

As shown in Fig. 2 the output signal from the DUT being measured and a sine-wave signal with the same phase and amplitude as those of the dither signal components of the DUT output are put into a subtractor to cancel the dither component. Note that this method requires a subtractor with superior performance.

FIGURE 2

Block diagram of dither cancellation procedure

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3.2.3 Amplitude of the dither signal

From the experiments, it has been proved that the minimum amplitude of the dither signal is 20 to 30 mV p-p for an 8-bit DUT. The value of 30 mV p-p is equivalent to 4 to 6 LSB for an 8-bit DUT. For DUTs with a resolution of 9 bits or over, amplitudes of 30 mV are acceptable. Therefore, 30 mV has been selected as the recommended amplitude of the superimposing dither signal for measuring any DUTs irrespective of the number of their bits.

4 Measuring methods

4.1 Signal-to-noise ratio (the measurement of continuous random noise including dispersed quantizing noise)

4.1.1 Definition

The signal-to-noise ratio (S/N) is defined as the ratio of the 100 IRE units p-p amplitude of a luminance signal to the r.m.s. value of the random noise including the quantizing noise, denoted in decibels.

4.1.2 Test signals

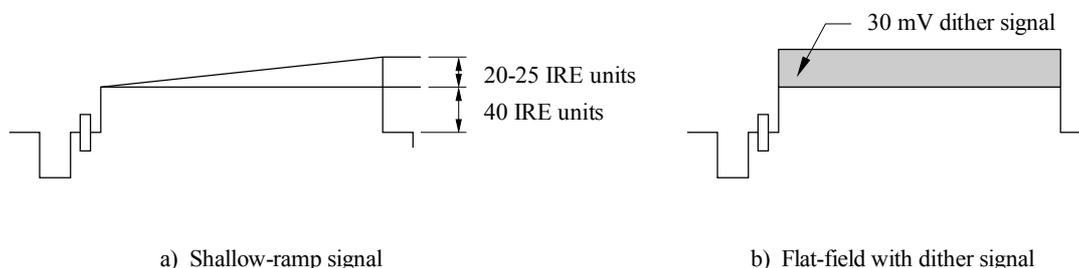
- A horizontal shallow-ramp signal of about 20 to 25 IRE units amplitude with a pedestal level of 40 IRE units.

If this shallow-ramp test signal is not available,

- a 50 IRE units flat-field signal with the dither signal could be used.

These test signals are shown in Fig. 3.

FIGURE 3
Test signals for S/N measurements



D03

4.1.3 Measuring instruments

- A test signal generator which can generate a shallow-ramp signal or a flat-field test signal.
- A dither signal generator and dither signal superimposer when the flat-field test signal is applied.
- A video noise meter or video analyser, with a tilt-null function and band-limiting low-pass and high-pass filters.
- An external 200 kHz high-pass filter, if necessary.

4.1.4 Band-limiting

The measuring instrument should use band-limiting filters. The lower band limit is normally 10 kHz to eliminate hum noise from the power supply. The 200 kHz high-pass filter (HPF) described in

Annex II to Part C of ITU-T Recommendation J.61 may be used to remove the slant component of the shallow-ramp signal, if necessary. The upper band limit is the highest frequency of the DUT. For 525-line systems, the upper band limit is 4.2 MHz, and for 625-line systems 5.0 MHz. When a 200 kHz high-pass filter is used, the measuring band must be indicated in the data sheet.

4.1.5 Measuring method

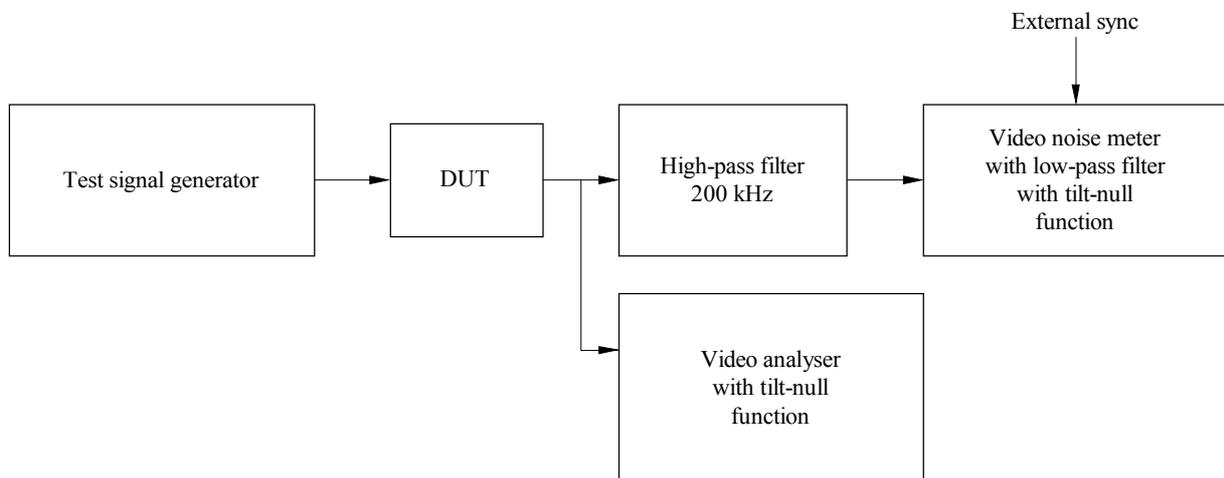
4.1.5.1 Measurement using the shallow-ramp test signal

A measurement block diagram is shown in Fig. 4. The external 200 kHz high-pass filter can be eliminated if the tilt-null function of the instrument is enough to eliminate the ramp component of the test signal. If an external high-pass filter is used, an external synchronization signal for the measuring instrument may be required to generate a measuring window signal.

The measuring window for the shallow-ramp test signal should be set to cover the ramp signal part only and not to cover the flat part of the test signal.

FIGURE 4

Block diagram for S/N measurement using a shallow-ramp signal



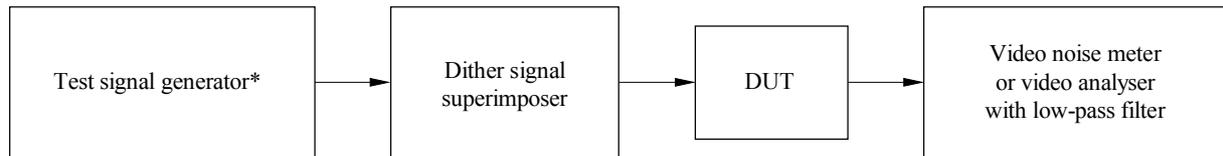
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4.1.5.2 Measurement using the 50 IRE units flat-field signal with mixed dither

A measurement block diagram is shown in Fig. 5. The dither frequency should be kept within the null-point range of the low-pass filter of the instrument.

FIGURE 5

Block diagram for *S/N* measurement using a flat-field signal with the dither signal



* Flat-field signal

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4.1.6 Notes

4.1.6.1 It is not recommended to use the weighting network because the quantizing noise using the ramp test signal has a special frequency spectrum depending on the shallow-ramp amplitude.

4.1.6.2 The bit resolution of the digitally generated shallow-ramp signal should be better than that of the DUT. Two bit higher resolution is desirable.

4.1.6.3 An external 200 kHz high-pass filter may be required if the tilt-null function of the video noise meter is not sufficient to eliminate the ramp-signal component or to avoid the saturation of the head-amplifier in the measuring instrument.

Use of the 200 kHz high pass filter has little effect on the quantizing noise component, because the basic frequency component is above 700 kHz even for the 20 IRE units shallow-ramp signal used for measuring an 8-bit DUT. The high-pass filter, however, decreases the random flat noise component. In the case of 525 systems, use of the 200 kHz high-pass filter increases the measured *S/N* data by 0.4 dB.

4.1.6.4 In some cases, a ramp test signal with an amplitude of 100 IRE units is used in *S/N* measurement of digital video equipment, because the 100 IRE units ramp signal covers the full dynamic range of DUTs.

Assuming a 100 IRE units ramp signal of 40 μ s duration as a test signal, the quantizing noise spectrum of 8-bit DUTs, which has 140 quantizing steps, appears at about 3.75 MHz, while that of 9-bit DUTs appears at about 7.5 MHz which is beyond the measuring frequency band.

The spectrum of 8-bit quantizing noise obtained with a 100 IRE units ramp signal (625/50 line-rate) without added dither and using 13.3 MHz sampling frequency (i.e. three times subcarrier frequency) is illustrated in Fig. 6.

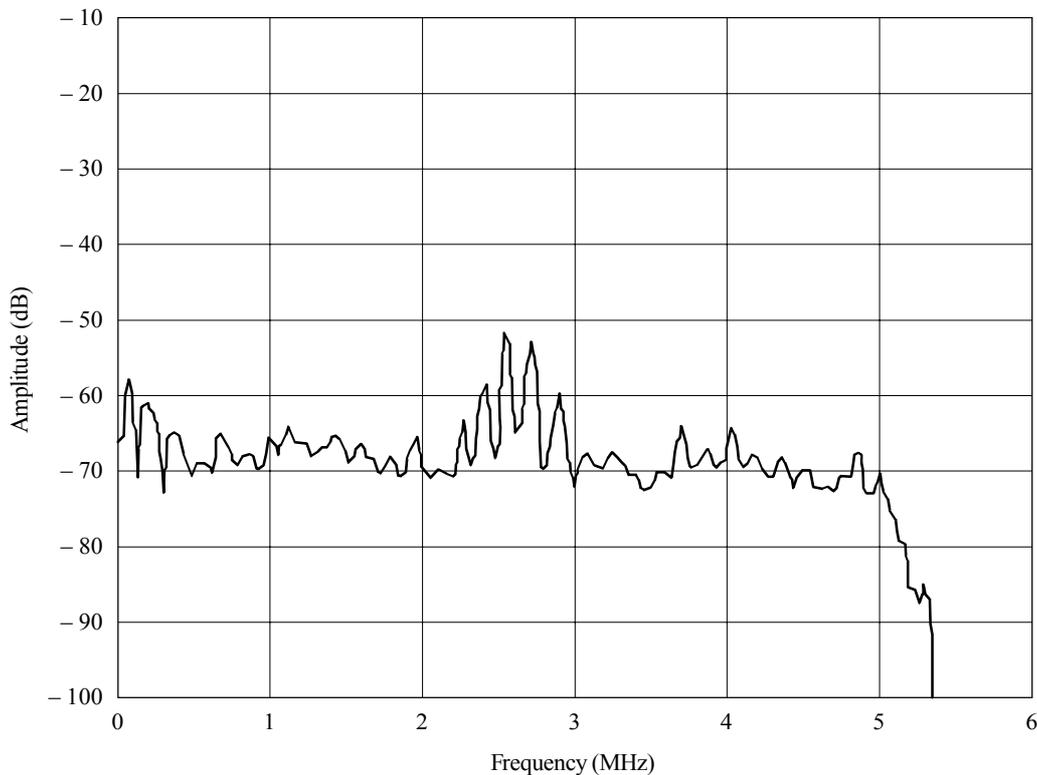
The discrete components shown in Fig. 6 in the range 2-3 MHz correspond to intermodulation of the sampling frequency of 13.3 MHz with quantizing error signal having a fundamental frequency of 2.7 MHz as generated by a ramp crossing 140 quantum levels in 52 μ s. Intermodulation products such as

$$13.3 - (4 \times 2.7) = 2.5 \text{ MHz}$$

$$13.3 - (6 \times 2.7) = -2.9 \text{ MHz}$$

are generated by the non-linear quantization process. It is seen that, in addition to these discrete components, the quantizing noise obtained without dither has a reasonably flat spectrum extending over the entire video spectrum.

FIGURE 6
Spectrum of 8-bit quantized, 100 IRE units, line-rate ramp with no added dither



Noise spectrum:

Amplitude 0 dB = 700 mV p-p
Noise level = -53.9 dB r.m.s
Bandwidth = 200 kHz to 5.0 MHz

D06

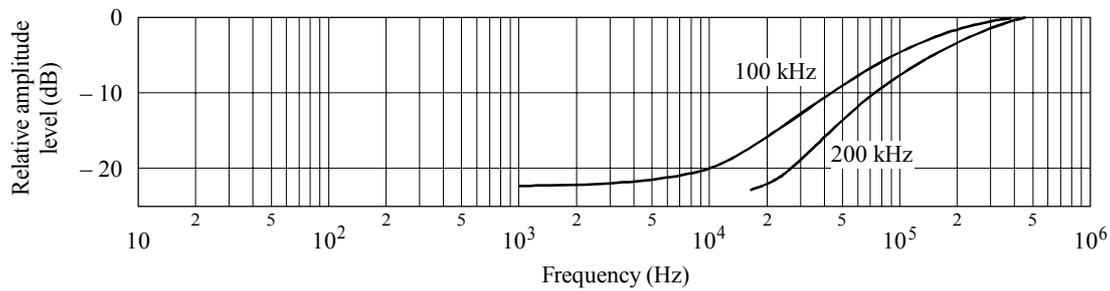
The shallow-ramp test signal with a 50 IRE units amplitude contains the quantizing noise spectrum within the measuring band even for a 9-bit DUT but with the deficiency of only covering half the dynamic range. Yet a 50 IRE units ramp signal amplitude gives less stability because of the variation between the quantizing phase and measuring window edge of the test signal.

On the other hand, if the shallow-ramp signal is lower than 20 IRE units, the number of quantizing steps is too low and the results of the measurement give less stability, varying according to the quantizing phase and the measuring window edges of the test signal.

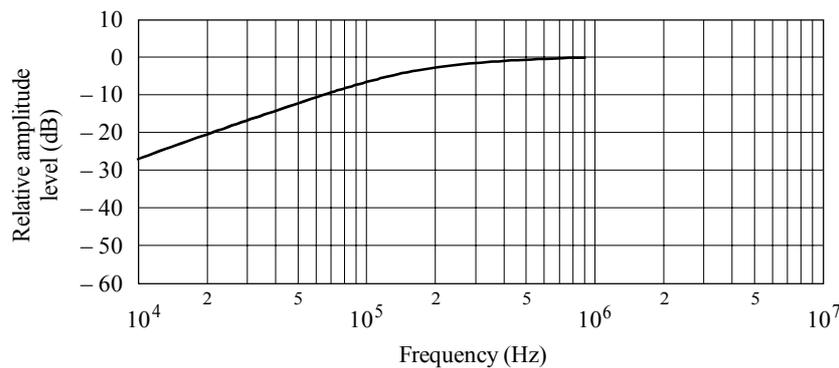
This is the reason that an amplitude of 20 to 25 IRE units for the ramp test signal is selected as this keeps the quantizing noise spectrum within the system bandwidth even for a 10-bit DUT measurement.

4.1.6.5 Two examples of frequency characteristics of the 200 kHz high-pass filter are shown in Fig. 7.

FIGURE 7
Examples of frequency characteristics of the 200 kHz high-pass filter



a)



b)

D07

4.1.6.6 The worst value of the flat-field test signal superimposed with the dither signal will nearly coincide with the shallow-ramp test signal value (see Appendix 1, § 1). It is better to use a flat-field signal because the conventional test signal generators can be used for this purpose and a 200 kHz high-pass filter is not required.

4.2 Differential gain and differential phase

4.2.1 Definition

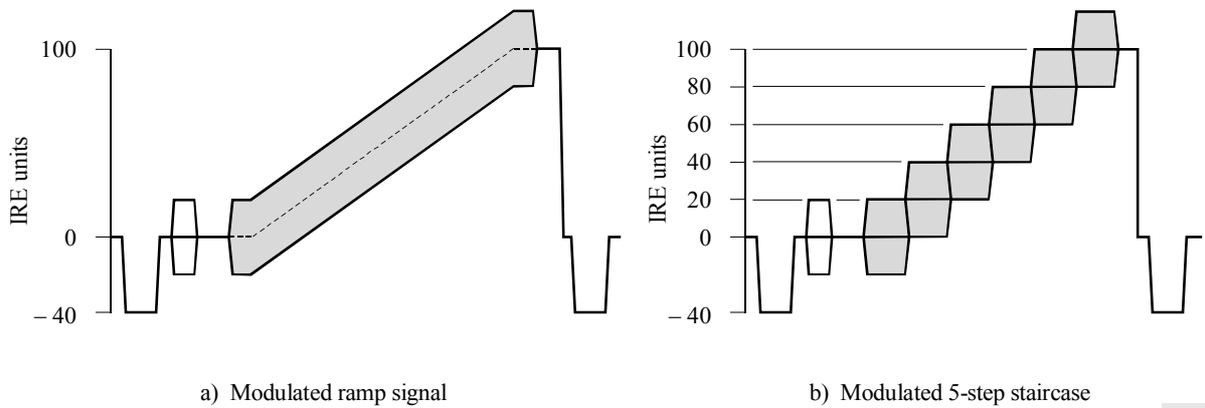
The DG and DP are the non-linear distortions appearing as the deviation in the amplitude and phase of the chrominance subcarrier which is caused by the changes in the luminance signal level. The DG is defined as the gain deviation of the subcarrier, expressed as a percent (%), while the DP is defined as phase deviation, expressed by degree. The measured DG, DP data should be independent from the bit resolution of DUTs.

4.2.2 Test signals

- 100 IRE units ramp signal modulated by 40 IRE units amplitude colour subcarrier with the dither signal, or
- 100 IRE units 5-step staircase signal modulated by 40 IRE units amplitude colour subcarrier with the dither signal.

The colour subcarrier should be locked to the burst signal of the test signal. Figure 8 shows these test signals.

FIGURE 8
Test signals for DG/DP measurement



D08

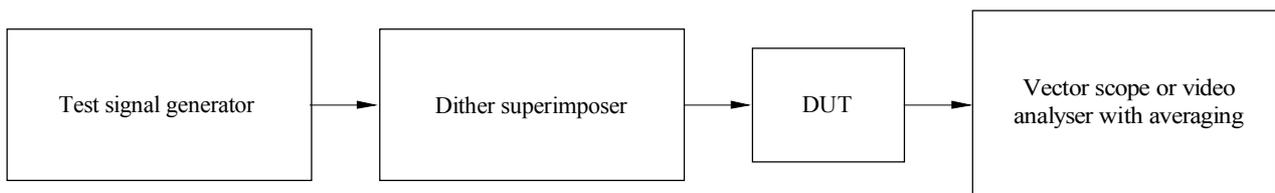
4.2.3 Measuring instruments

- A test signal generator which provides the modulated ramp or staircase signal.
- A dither signal generator and the dither signal superimposer.
- A vector scope, a video analyser, or any other DG, DP measuring instruments.

4.2.4 Measuring method

A measurement block diagram is shown in Fig. 9. Either a modulated ramp or modulated staircase test signal with the dither can be used. The measuring procedure and the data expressions are defined in ITU-T Recommendation J.61, Part C.

FIGURE 9
Block diagram for DG/DP measurements



40 IRE units subcarrier-superimposed
100 IRE units ramp/5 step signal

D09

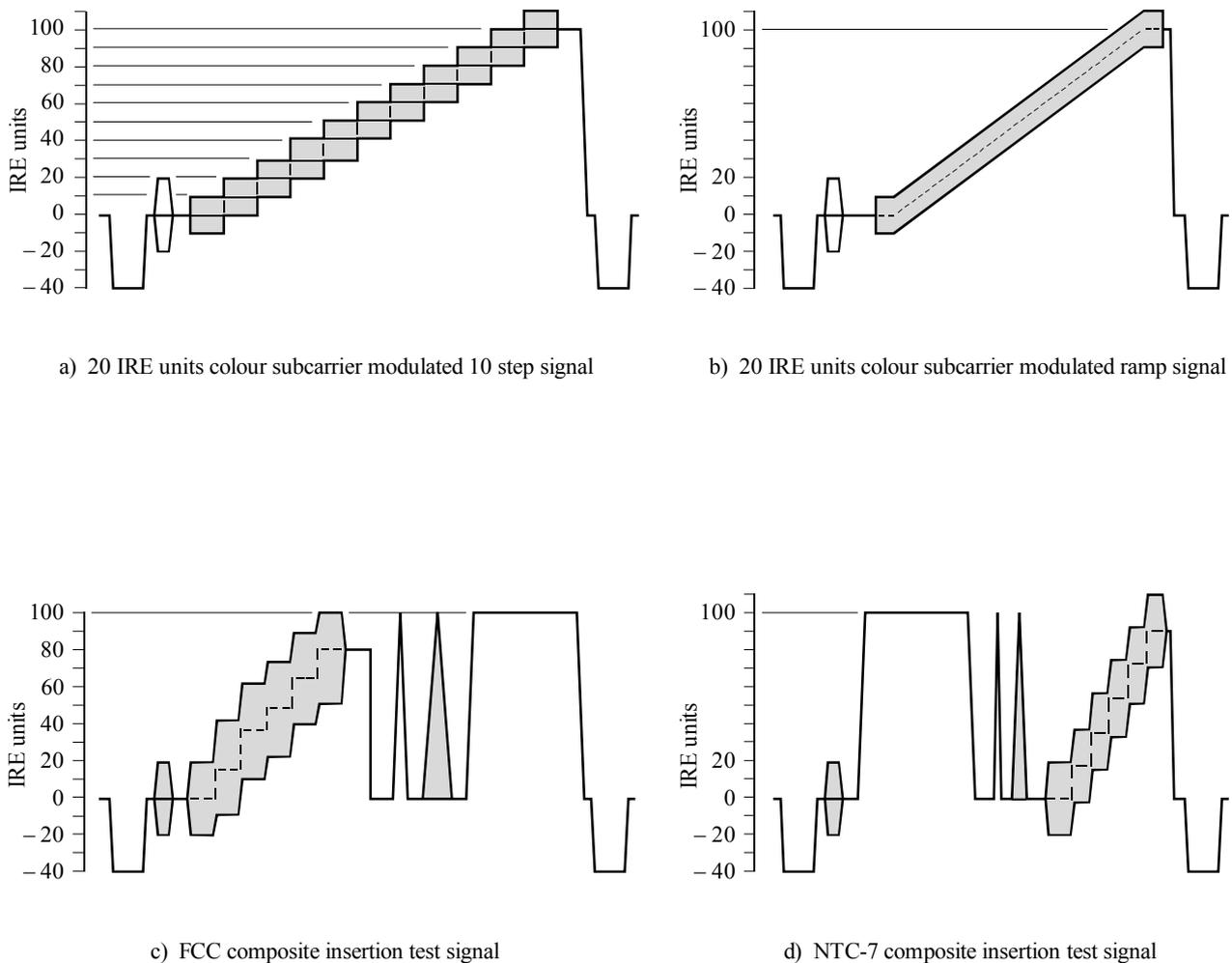
4.2.5 Notes

4.2.5.1 The bit resolution of the digital test signal generator should be the same or better than that for DUTs.

4.2.5.2 Test signal amplitude

For DUTs which cannot accept the over-level test signals defined in § 4.2.2, such as analogue VTR and equipment with the white clip function, lower amplitude colour subcarrier test signals as shown in Fig. 10 can be used with the dither signal.

FIGURE 10
Alternative test signals for DG/DP measurements



D10

4.2.5.3 Noise reduction and averaging

Due to the quantizing errors dispersed by the superimposed dither signal, the DG and DP waveforms on the vector-scope screen become broadened, so the measurement should be carried out by reading the envelope of the broadened waveform without the broadened line width.

Using the DG/DP noise reduction function in a vector-scope makes for reading ease. Because this noise reduction is performed by line averaging, noise reduction cannot be employed when using the APL changing DG/DP measuring method. The video analyser offers good results with the help of its averaging function even when making the APL changing measurement.

4.2.5.4 The 5-step staircase waveform normally used for DG/DP measurement is not the most suitable form of signal for testing digital video equipment, its disadvantages being:

- since measurements are performed at only 6 different luminance levels, irregularities in the quantization process will have different effects depending on their position relative to the 6 steps. This is a particular problem if the sampling frequency is an integer multiple of colour subcarrier frequency;
- different results are obtained depending on the sampling frequency and whether or not dither is in use;
- it is difficult to distinguish between instrumental and fundamental quantizing errors.

All these problems can be largely overcome if a ramp waveform is used instead of a staircase, but there are still advantages to be gained by the addition of dither. It is recommended that the test waveform should consist of a 100 IRE units ramp with peak-to-peak colour subcarrier plus dither as discussed above.

4.3 Pulse characteristics

4.3.1 Definitions

4.3.1.1 Short-time waveform distortion

If a short pulse (or a rapid step-function) with nominal luminance amplitude and defined shape is applied to the input of the DUT, the short-time waveform distortion is defined as the difference of the output pulse (or step) from its original shape. The choices of the half-amplitude duration of the pulse (or rise-time of the step) will be determined by the nominal cut-off frequency, f_c , of the television system.

a) *2 T pulse response (K 2 T)*

The *K 2 T* is the waveform distortion of ringing, overshoot, and smear of the *2 T* pulse signal, expressed as a percentage (%).

b) *2 T pulse/bar ratio (P/B)*

The *2 T* pulse/bar ratio (P/B) is the ratio of the amplitude of *2 T* pulse (P) and bar centre (B), expressed in percent (%).

4.3.1.2 Line-time waveform distortion

If a square-wave signal with almost the same interval of one TV line and with nominal luminance amplitude is used as the input of the DUT, the line-time waveform distortion is defined as the change in shape waveform of the square wave at the output. The first and last $1 \mu\text{s}$ parts of the pulse edge are excluded from the measurement.

The line-time distortion is the ratio of the magnitude of bar-top distortion and the bar centre amplitude, expressed as a percent (%).

4.3.1.3 Field-time waveform distortion

If a square-wave signal with a period of the same order as one field and of nominal luminance amplitude is applied to the input of the DUT, the field-time waveform distortion is defined as the change in shape of the square wave at the output. The first and last 0.2 ms periods of the field-time pulse edge are excluded from the measurement.

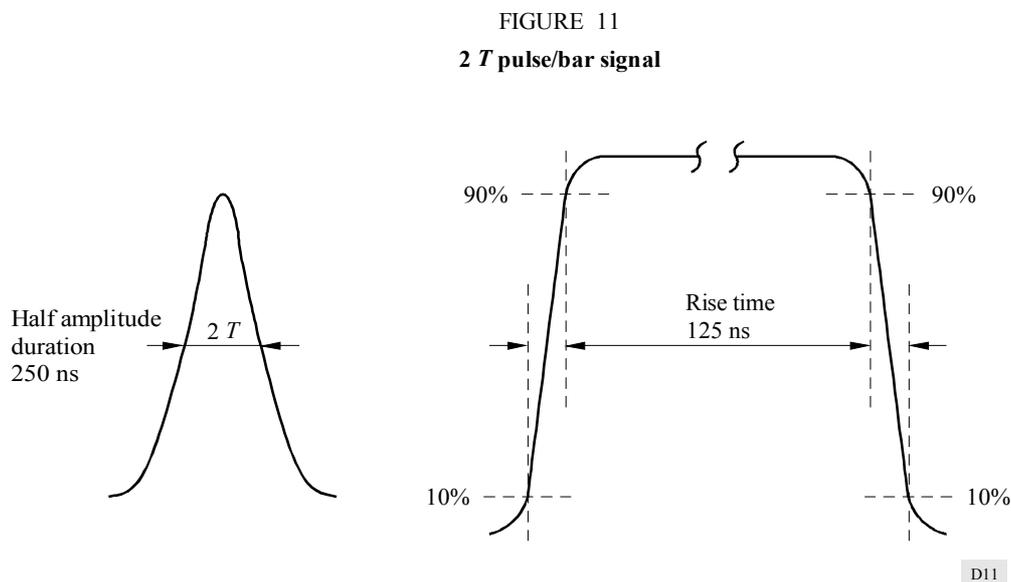
The field-time distortion is the ratio of the magnitude of bar-top distortion and the bar centre amplitude, expressed as a percent (%).

The deviation caused by quantizing error is not included in the measuring results of § 4.3.1.1 to 4.3.1.3.

4.3.2 Test signals

The test signals are the following signals all of which are superimposed by the dither signal.

- 1a) $2T$ pulse: defined as the signal B1 of Fig. 7 or Fig. 8 in ITU-T Recommendation J.61, Annex I, Part C;
- 1b) $2T$ pulse/bar: shown in Fig. 11.
- 2) Line-time field frequency square pulse: defined as the signal of Fig. 6 or the signals B2 and B3 of Fig. 7 and Fig. 8 of ITU-T Recommendation J.61, Annex I, Part C.
- 3) Field-time field frequency square pulse: defined as signal A in Figs. 5, 6a, or 6b (window) of ITU-T Recommendation J.61, Annex I, Part C.



4.3.3 Measuring instruments

- a) A test signal generator which generates test signals described in § 4.3.2.
- b) A dither generator and the dither signal superimposer.
- c) A waveform monitor or a video analyser, with the band limiting filter described in C.3.5.1.3 of ITU-T Recommendation J.64, Annex, Part C or a luminance filter which is equivalent to an IRE unit luminance filter with a notch in the colour subcarrier frequency incorporated in conventional waveform instruments.

4.3.4 Measuring methods

A measurement block diagram is shown in Fig. 12.

4.3.4.1 Short-time distortion

- a) $2 T$ pulse response ($K 2 T$)
- b) $2 T$ pulse/bar ratio (P/B)

The sine square $2 T$ pulse/bar signal from the DUT may be measured by the K factor mask shown in Fig. 29a or Fig. 29b of ITU-T Recommendation J.61, Part D. No filter is used for this measurement. Only a video analyser with an averaging function can be used for the measurement with the dither signal.

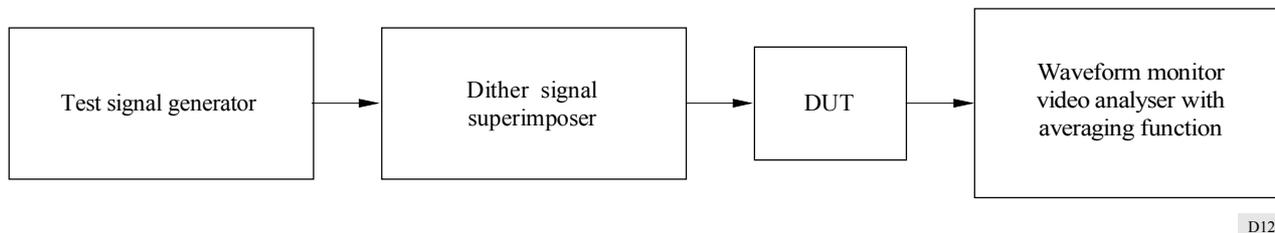
4.3.4.2 Line-time distortion

Using the band limiting filter or the luminance filter described in c), § 4.3.3, the superimposed dither signal can be removed before measurement. The first and the last $1 \mu\text{s}$ parts of the waveform should be ignored.

4.3.4.3 Field-time distortion

Using the band limiting filter or the luminance filter described in c), § 4.3.3, the superimposed dither signal can be removed before measurement. The first and the last 0.2 ms of the waveform should be ignored.

FIGURE 12
Measurement block diagram for pulse characteristics



D12

4.3.5 Notes

4.3.5.1 The bit resolution of the digitally generated test signal shall be equal to or better than that of the DUT.

4.3.5.2 The bar-top distortion is defined as the maximum difference from the centre, or peak to peak level variations, as described in Part C of ITU-T Recommendation J.61.

4.4 Luminance non-linearity

4.4.1 Definition

Luminance non-linearity is defined as the difference from the amplitude of a small step function at the input to the DUT and the corresponding amplitude at the output, as the initial level of the step is shifted from blanking level to white level. The deviation caused by the quantizing error is not included in the measurement results.

4.4.2 Test signal

The 5-step staircase signal defined as signal D1 in Figs. 11a and 12a of ITU-T Recommendation J.61, Annex to Part C with the dither signal.

4.4.3 Measuring instrument

- A test signal generator which generates a 5-step staircase signal.
- A dither generator and dither signal superimposer.
- A waveform monitor or video analyser.
- A differentiating filter defined in Annex II, § 4.3 of ITU-T Recommendation J.61. This filter is a differentiating and shaping network to transform the staircase into a train of 5 pulses. The response of the network approximates the pulses to the sine squared shape.

4.4.4 Measuring method

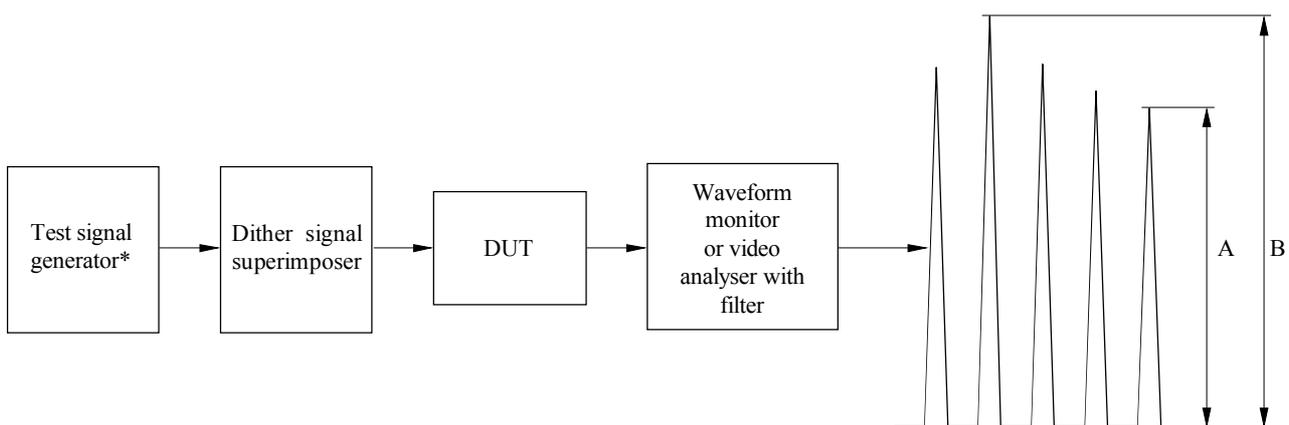
A measurement block diagram is shown in Fig. 13. The non-linearity is represented by the equation $[(B - A)/B] \times 100 (\%)$, where B is the amplitude of the largest pulse in the differentiated staircase and A is the amplitude of the smallest one.

4.4.5 Notes and explanations

The superimposed dither is removed by a differentiating network since it works as a band-pass filter.

FIGURE 13

Measurement block diagram for luminance non-linearity



* 5 step staircase test signal

D13

4.5 New field-interval ITS signals

The measurement techniques, above mentioned, using out-of-band dither are well suited for measuring isolated equipment employing a pre-filter with a cut-off frequency higher than the dither frequency.

However, operational networks may contain video low-pass filters at 4.2 MHz (525/60 system), 5 or 5.5 MHz (625/50 system) prior to any A/D conversion process, thus removing out-of-band dither. It is also possible that isolated equipment may contain such video low-pass filters.

To overcome the problems of measuring digital quantizing effects in operational networks of this type, it is recommended that field-interval ITS signals should include a 100 (or 80) IRE units ramp waveform with added 40 IRE units peak-to-peak colour subcarrier plus 4 IRE units peak-to-peak sinusoidal dither at a frequency between 3.58 and 4.2 MHz for 525/60 systems and between 4.43 and 5 MHz for 625/50 systems. This waveform could be used for measuring both S/N and DG/DP and could replace the existing 5-step staircase plus added colour subcarrier waveform. It is probably not worth adding dither to other test waveforms in the ITS signals since the effects of digitizing are less significant on other measurements, such as K -rating, as compared with S/N and DG/DP measurements.

APPENDIX 1

TO ANNEX 1

1 Experimental measuring results using the recommended methods

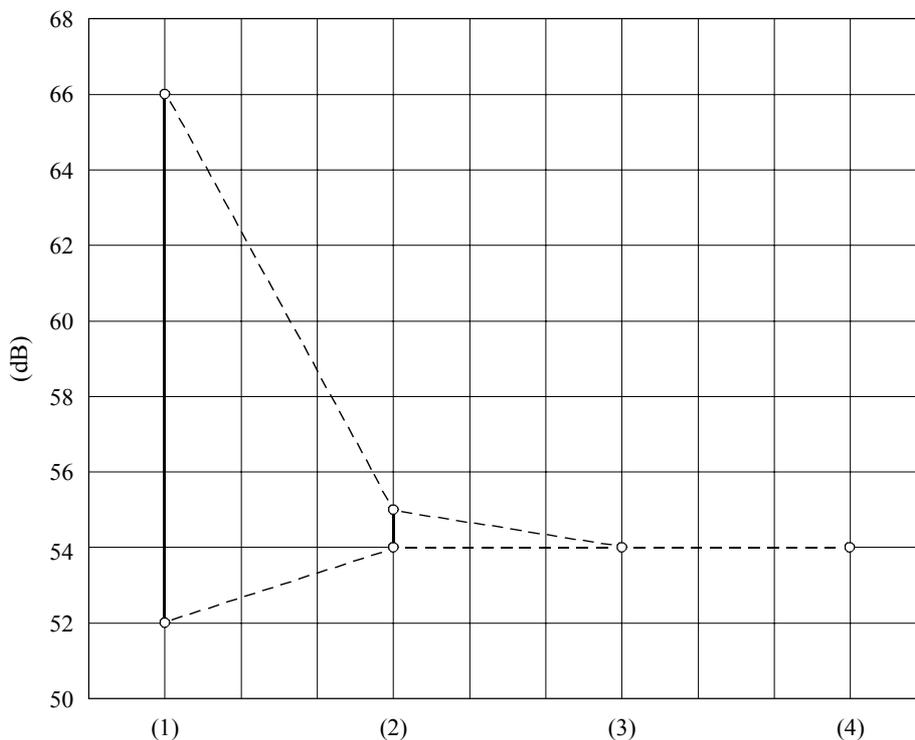
In this section, experimental measuring results using the recommended methods and conventional methods are introduced taking S/N and DG/DP for an 8-bit DUT as an example.

1.1 Signal-to-noise ratio

Flat-field signals have conventionally been used as a test signal for the measurement of S/N and the data obtained therefrom are severely affected by quantization errors. With the dither signal superimposed on the flat signal, fairly good data are obtained with slight quantization effects left in them. Meanwhile, use of a 100 IRE units ramp signal or a shallow-ramp signal provides stable data. Use of a ramp signal provides the most stable data. However, for DUTs with a resolution of 9 bits or over, the ramp signal method is liable to produce data better than the shallow-ramp method or flat-plus-dither method because major parts of the quantization noise occur outside the frequency band in the DUTs.

Figure 14 shows the measuring results of S/N .

FIGURE 14
Results of S/N measurement



- (1) Flat field
- (2) Flat field with dither
- (3) 100 IRE units ramp
- (4) 20 IRE units shallow ramp

S/N
8 bit DUT measured
by video noise meter
0.2-4.2 MHz band

D14

1.2 Differential gain and differential phase

In the conventional measuring method without the dither, the measured DG, DP values fluctuate due to the quantizing error. The amount of the fluctuation depends on the bit resolution of the DUT and the amplitude of the modulating colour subcarrier.

Table 1 lists the theoretical maximum values of the fluctuations of DG and DP due to quantizing error.

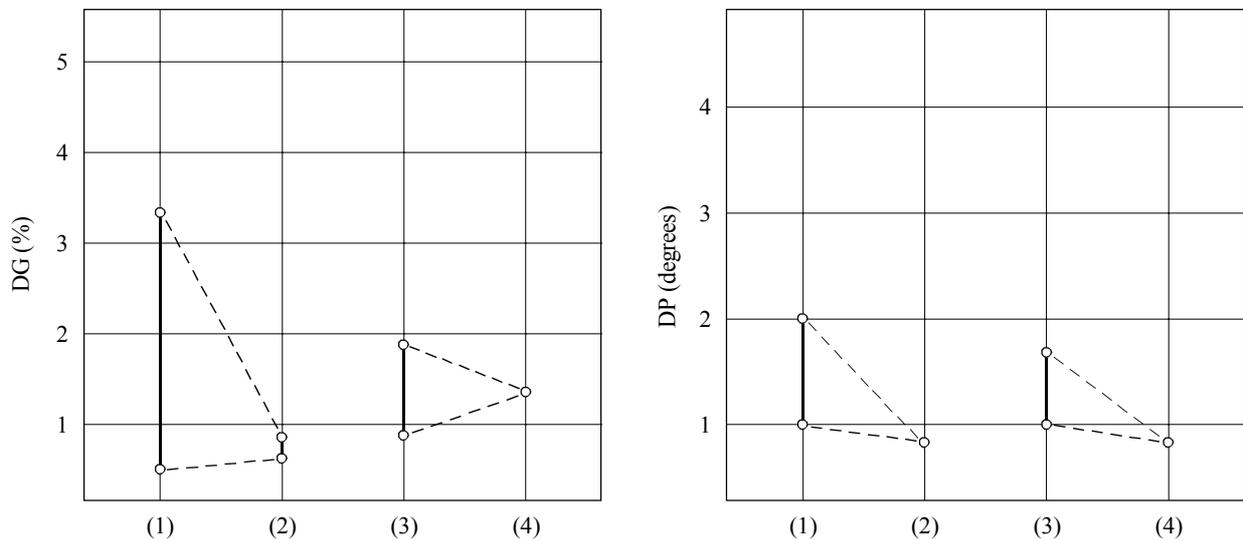
Figure 15 shows the results of DG and DP measurement. Without the dither signal, the method with the modulated ramp causes less data fluctuation than other methods. With the dither signal, both methods using the modulated 5-step staircase and the modulated-ramp produce stable data. These data appear to be better than those obtained by conventional methods due to eliminated quantization

effects, irrespective of the bit number of the DUT. The method using the modulated 5-step staircase, which measures only at 5 points, is liable to make data better than that using the modulated ramp signal.

TABLE 1
Theoretical maximum values of the fluctuations of DG and DP due to quantizing error

No. of bits	Subcarrier amplitude (IRE units)	DG (% p-p)	DP (degrees)
8	20	10	5.8
8	40	5.1	2.9
9	20	5.1	2.9
9	40	2.5	1.4
10	20	2.5	1.4
10	40	1.3	0.7

FIGURE 15
Results of DG/DP measurement



- (1) 5 step without dither
- (2) With dither
- (3) Ramp without dither
- (4) With dither

8 bit DUT measured by vectorscope

2 Measuring method for gain/frequency characteristics

Frequency characteristics are important in specifying the performance of television equipment. But a special measuring instrument with an averaging function as described in § 3.2 of Annex 1 is required to remove the dither signal, so the measuring method for frequency characteristics is described in this Appendix.

2.1 Definition

The gain/frequency characteristics are defined as the variation in gain between the input and output of the DUT over the frequency band extending from the field repetition frequency to the nominal cut-off frequency of the system, relative to the gain at a suitable reference frequency.

2.2 Test signals

Multi-burst signal with the dither signal.

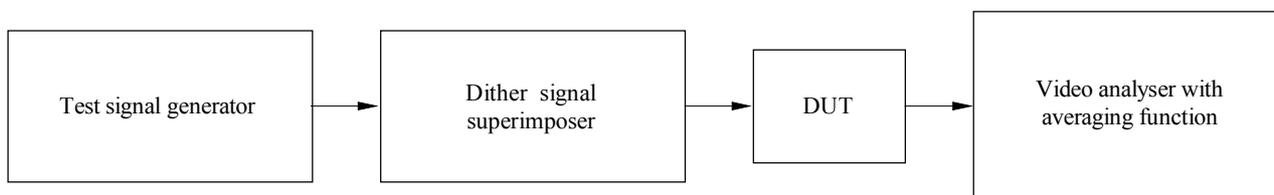
2.3 Measuring instruments

- A test signal generator which generates the multi-burst signal.
- A dither generator and dither signal superimposer.
- The video analyser.

2.4 Measuring method

A measurement block diagram is shown in Fig. 16. Only the video analyser with an averaging function can be used to remove the dither. The peak-to-peak amplitude of the first square pulse is set to 0 dB. The differences between other frequency burst amplitudes and that of the square pulse are expressed in decibels.

FIGURE 16
Block diagram for gain/frequency measurement



D16

2.5 Notes

2.5.1 The bit resolution of the digitally generated test signal should be equal to or better than that of the DUT.

2.5.2 There are many types of multi-burst signal now used for frequency characteristic measurement. Any of the multi-burst signals can be used with the dither.

2.5.3 Field sweep test signals with dither are not desirable since a special video analyser with the function of averaging over a field period is required.

2.5.4 Care should be taken that the characteristics of the dither signal superimposer inserted in the front of the DUT does not affect the measuring results.

2.5.5 Where the conventional waveform monitor or oscilloscope is used, superimposing dither is not allowed to stabilize the measurement since no filter can be used to remove the dither. The only effective means to cope with the quantizing error is to use sweep or multi-burst test signals with as large an amplitude as possible without dither.
