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* Approved by the IRE Standards Committee, November 19, 1959.

Part 1—INTRODUCTION

Chapter 1—General

1.1 Object

THIS standard replaces IRE Standard 48 IRE 22. S1, "Standards on Television: Methods of Testing Television Receivers, 1948."

At a later date, a standard for color television receivers will be introduced. Reference will be made in that standard to many portions of the present standard which are applicable to color television receivers as well as to monochrome receivers.

1.2 Scope

This standard describes procedures for measurement of the performance characteristics of the picture and sound sections of television receivers. Where specific test conditions are stated, these apply to home broadcast receivers designed to receive transmissions in accordance with the specifications of the United States Federal Communications Commission.¹ Where other conditions apply, appropriate modifications must be made.²

Emphasis is placed on over-all receiver performance. Internal characteristics such as the gains and bandwidths of individual stages are not generally considered.

1.3 Standard Test Frequencies

The range of standard test frequencies includes all of the allocated television channels. The present television channel allocations, where A includes frequencies from $470+6(C-14)$ to $470+6(C-13)$, and

$$P = 471.25 + 6(C-14)$$

$$S = 475.75 + 6(C-14),$$

are as follows:

Channel No.	Channel Allocation mc	Picture Carrier Frequency mc	Sound Carrier Frequency mc
2	54-60	55.25	59.75
3	60-66	61.25	65.75
4	66-72	67.25	71.75
5	76-82	77.25	81.75
6	82-88	83.25	87.75
7	174-180	175.25	179.75
8	180-186	181.25	185.75
9	186-192	187.25	191.75
10	192-198	193.25	197.75
11	198-204	199.25	203.75
12	204-210	205.25	209.75
13	210-216	211.25	215.75
14	470-476	471.25	475.75
15	476-482	477.25	481.75
.	.	.	.
.	.	.	.
.	.	.	.
C	A	P	S
.	.	.	.
.	.	.	.
82	878-884	879.25	883.75
83	884-890	885.25	889.75

When measurements are not performed on all VHF channels, they should be made on Channels 4 and 10. The picture and sound carriers of these two channels are referred to as the *VHF standard test frequencies*.

Receivers which cover the entire UHF range should be measured on Channels 18, 48 and 79. The picture and sound carriers of these three channels are referred to as the *UHF standard test frequencies*.

1.4 Standard Test Input Levels

Input signal levels may be expressed in either of two ways:

a) In terms of available power (Section 1.4.1), in which case the input is preferably expressed in decibels below one watt.

b) In terms of input voltage, in which case the input is frequently expressed in microvolts or in decibels below one volt and the intended source resistance is stated.

When a standard composite picture signal is used, input level refers to the value during the synchronizing pulse interval. Where a picture carrier with sine-wave modulation is used, the input level is the value of the carrier in the absence of modulation.

Normally, two signal generators will be used so as to supply both the sound and picture carriers. Unless otherwise specified, the outputs of these generators will be maintained equal.

1.4.1 Available Power. The available power is the power delivered by a generator to a matched load. It is equal to $E^2/(4R)$, where E is the rms open-circuit voltage of the generator and R is the internal resistance of the generator (including the dummy-antenna resistance). It is preferably expressed in decibels below 1 watt. The signal generator may be calibrated in terms of the available signal power and used on that basis, even though not matched exactly by the load impedance. If a signal generator is to be used with various values of dummy-antenna resistance, it should be calibrated in terms of the open-circuit voltage and the available power should be calculated from the above formula. When reference is made to values of power input, it is understood that the available power is meant.

1.4.2 Input Voltage. Input level in terms of voltage refers to the open-circuit voltage of a generator with an internal resistance, including the dummy-antenna resistance (Section 1.7), equal to the nominal input resistance of the receiver. By this definition, when the receiver input impedance is a resistance equal to the nominal input resistance, the input voltage (open-circuit voltage) is twice the voltage appearing across the antenna terminals of the receiver.

¹ Rules and regulations of the Federal Communications Commission, pt. 3, Sec. 3.682.

² A related IEC Standard, "Recommended Methods of Measurement on Receivers for Television Broadcast Transmissions," is published by the International Electrotechnical Commission, 39, rue de Malignou, Geneva, Switzerland.

Since the input impedance of television receivers built in the United States has been standardized at a value of 300 ohms, it has become common practice to express the input in microvolts, or in decibels below one volt. However, voltage measurements made on receivers designed for a different input impedance will not be directly comparable to those made on receivers designed for the standard 300-ohm impedance unless correction is made for the difference in input impedance.

1.4.3 Values of Standard Test Input Levels. Standard input levels are specified in Table I. Corresponding to these values of available power, which are independent of the receiver input impedance, are shown the approximate equivalent values of open-circuit voltage for the standard impedance level of 300 ohms.

TABLE I

Available Power, db below 1 watt	Approximate Equivalent Input Voltage for $R = 300$ Ohms	
	microvolts	db below 1 volt
131	10	100
121	32	90
111	100	80
101	320	70
91	1000	60
81	3200	50
71	10,000	40
61	32,000	30
51	100,000	20

1.4.4 Standard Mean-Signal Input Power. The standard mean-signal input power is 81 db below 1 watt, corresponding to 3200 μ v at 300 ohms.

1.5 Standard Picture Test Modulation

1.5.1 Sine Wave. The standard test modulation for sine-wave modulated signals shall be 30 per cent amplitude modulation at 400 cps.

1.5.2 White-Pattern Modulation. The standard test modulation envelope for white-pattern modulation shall be an RF signal modulated by the waveform standardized by the Federal Communications Commission and shown in Fig. 1.5.2 with the picture portion of the signal constant at 15 per cent of the carrier level during the synchronizing peaks.

1.5.3 Gray-Pattern Modulation. The standard test modulation envelope for gray-pattern modulation shall be an RF signal modulated by the synchronizing waveform of Fig. 1.5.2 with the picture portion of the signal constant at 40 per cent of the carrier level during the synchronizing peaks.

1.5.4 Test-Pattern Modulation. The standard for test-pattern modulation shall be an RF signal modulated by the EIA (Electronic Industries Association) test pattern (Fig. 1.5.4) with the white peaks at 15 per cent of the carrier level during the synchronizing peaks.

1.6 Standard Sound Test Modulation

Standard test modulation of the sound carrier is frequency modulation at 400 cps with a deviation of 7.5

kc; this is 30 per cent of the maximum system deviation of 25 kc.

The standard transmitter pre-emphasis provided by a time constant of 75 μ sec is normally not employed in fidelity testing of the sound channel. Instead, the corresponding standard de-emphasis characteristic, shown in Fig. 1.6, is applied as a compensating correction to the amplitude-vs-frequency response. This procedure is described in Section 10.2.2.

1.7 Standard Dummy Antenna

The standard dummy antenna presents a balanced, resistive, 300-ohm source impedance to the antenna terminals of the television receiver. Signal generators that do not have these properties must be provided with an external network which may consist of resistors or of a balun.

The resistors used should have negligible reactive components, and in the case of two or more generators, the resistance networks should be located at the signal generators with a 300-ohm balanced line to the receiver. Most of the networks used with two or more signal generators require a correction factor for determining the open-circuit voltage from the generator voltage.

If a balun is used in place of a resistance network, its voltage transformation and impedance characteristics must be known with respect to frequency. If either of these characteristics is not reasonably flat, an iterative resistance attenuator network may be used to minimize departures from uniform transmission or termination.

The effect of reversing the connections to the receiver antenna terminals and reversing the power-line connections of either the signal generator or the receiver or both should be noted. A change in the receiver output is an indication of unbalance in the dummy-antenna system; however, no change in receiver output does not necessarily indicate a balanced dummy-antenna system.

When more than one signal generator is used, a comparison should be made of the relative receiver output as each signal generator is tuned in turn to the same frequency, to obtain the appropriate correction.

The following paragraphs describe several examples of dummy-antenna configurations. In many instances, balun transformers can be used advantageously, particularly where it is desirable to effect impedance matching with a minimum power loss, or when the receiver has little unbalanced signal rejection.

1.7.1 Single Balanced Signal Generator. The network consists of two resistors of equal value, one connected in series with each terminal of the signal generator and of such value that the total output impedance, including the signal generator, is 300 ohms.

1.7.2 Single Unbalanced Signal Generator. The network consists of two resistors, a 150-ohm resistor connected in series with the "ground" terminal of the signal generator and a resistor (equal to 150 ohms minus

TELEVISION SYNCHRONIZING WAVEFORM FOR MONOCHROME TRANSMISSION ONLY

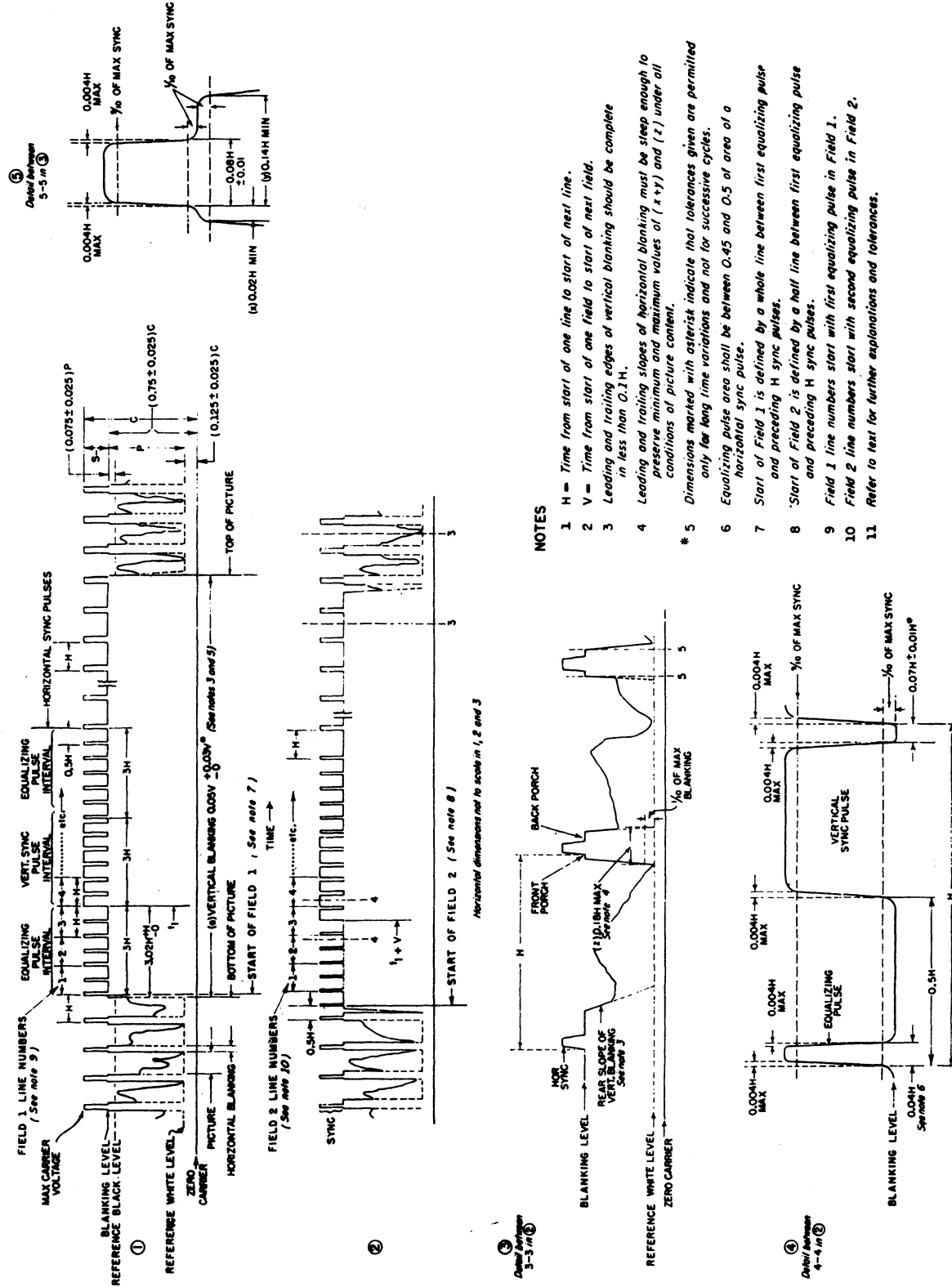


Fig. 1.5.2—Television synchronizing waveform for monochrome transmission.

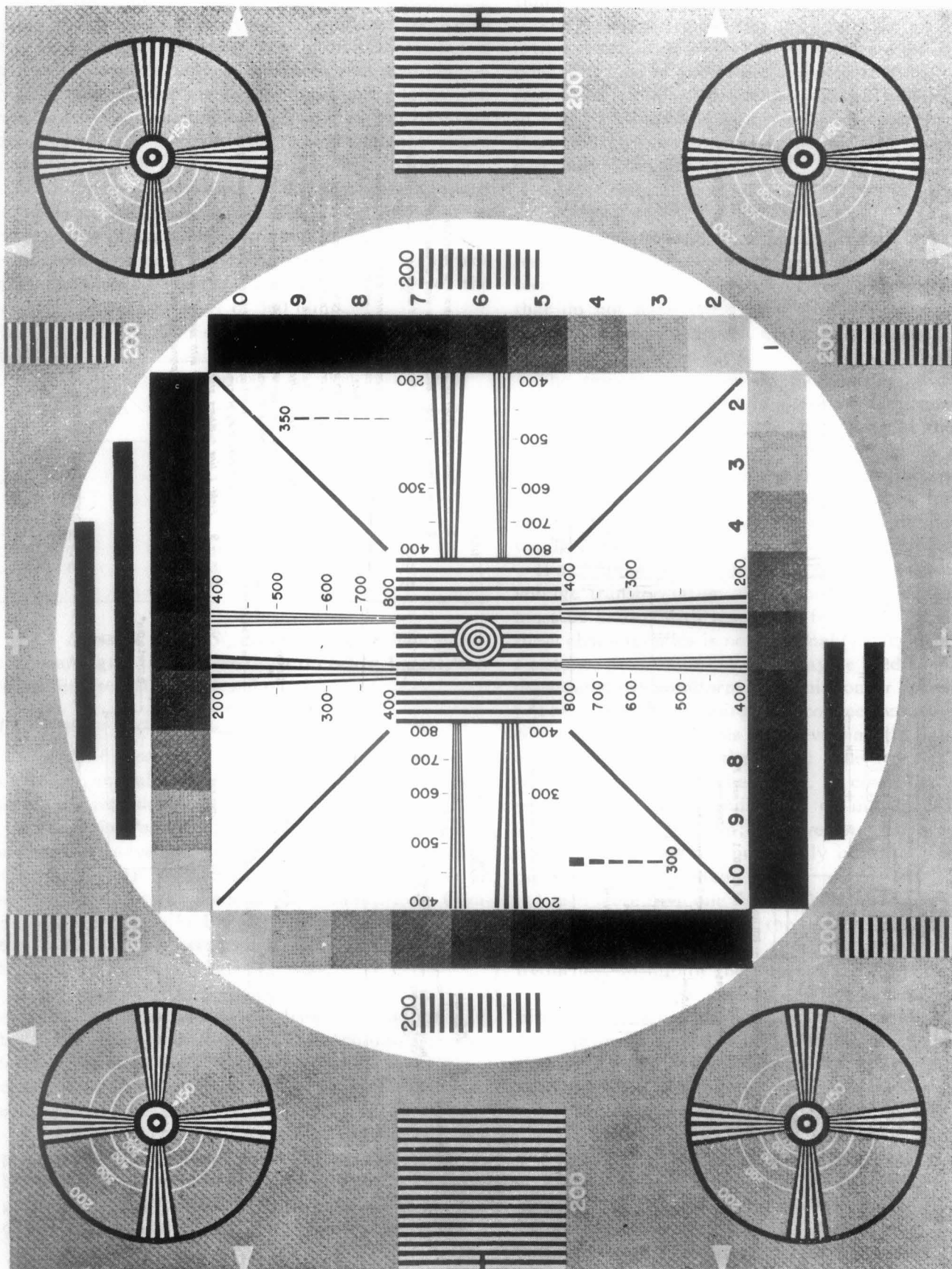


Fig. 1.5.4—EIA resolution chart.

the generator output impedance) in series with the output terminal of the signal generator.

1.7.3 Two Signal Generators. Separate picture and sound signal generators may be connected as shown in Fig. 1.7.3. The open-circuit voltages obtained from the connections of Fig. 1.7.3(a) and 1.7.3(c) are one-half the generator open-circuit voltages.

Fig. 1.7.3(c) illustrates a special case in which signal generators with 300-ohm output impedance are employed. The dummy-antenna network provides an impedance match to the signal generator outputs as well as the required source impedance to the receiver.

1.7.4 Three Signal Generators. For certain measurements, a third signal generator may be required. The

two connections shown in Fig. 1.7.4 provide an open-circuit voltage that is one-third the generator open-circuit voltage.

Fig. 1.7.4(b) illustrates a special case in which signal generators with 300-ohm output impedance are employed and the dummy-antenna network provides an impedance match to the generator output.

1.8 Standard Picture Test Output

The standard picture test output as delivered by the receiver to the controlled element of the picture tube shall have an amplitude of 20 volts between blanking level and white, as determined by a cathode-ray oscilloscope when using the standard white-pattern modu-

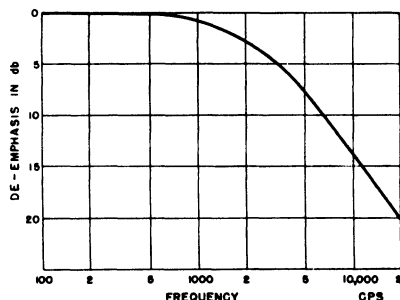


Fig. 1.6—Standard de-emphasis curve.

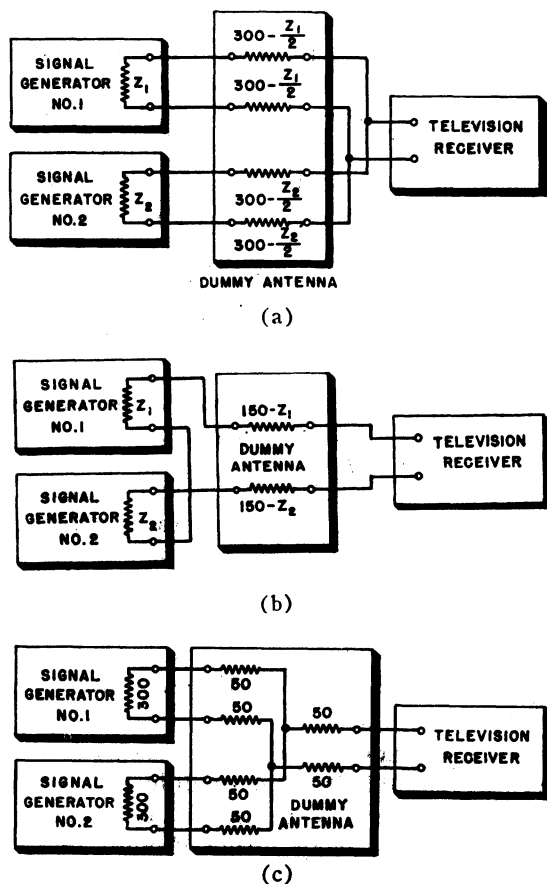


Fig. 1.7.3—Dummy-antenna connections for two signal generators. (a) Two signal generators in parallel. (b) Two signal generators in series. (c) Two 300-ohm signal generators in parallel.

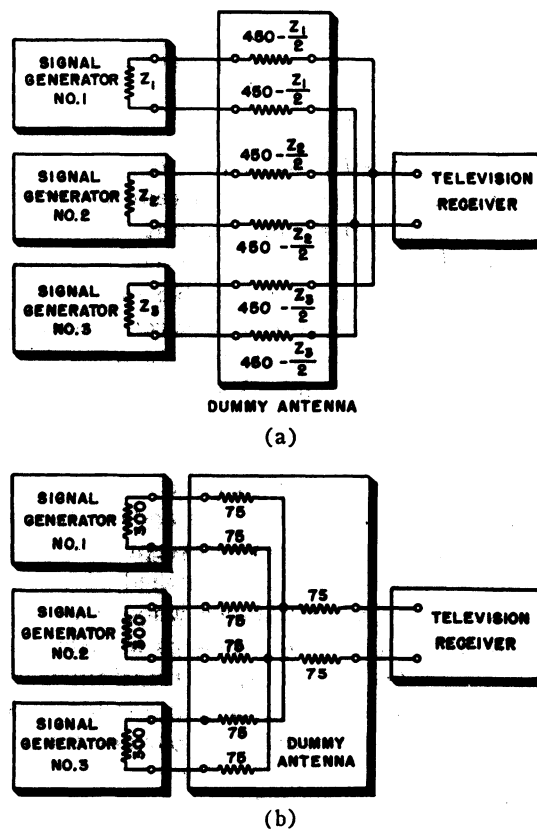


Fig. 1.7.4—Dummy-antenna connections for three signal generators. (a) Three signal generators in parallel. (b) Three 300-ohm signal generators in parallel.

lation (Section 1.5.2). When using symmetrical sine-wave modulation (Section 1.5.1), the standard output shall be 20 volts peak-to-peak. These outputs are equivalent for a receiver having a linear relationship between input and output over the amplitudes involved, as shown in Fig. 1.8. If the particular receiver being measured has been designed to operate with a picture device whose operating voltage requirements are so different from the conventional picture tube as to make the above value of 20 volts unsuitable, a value should be chosen to be approximately one-half of the normal maximum input voltage for the particular picture device being used. The value so chosen should be included in the data.

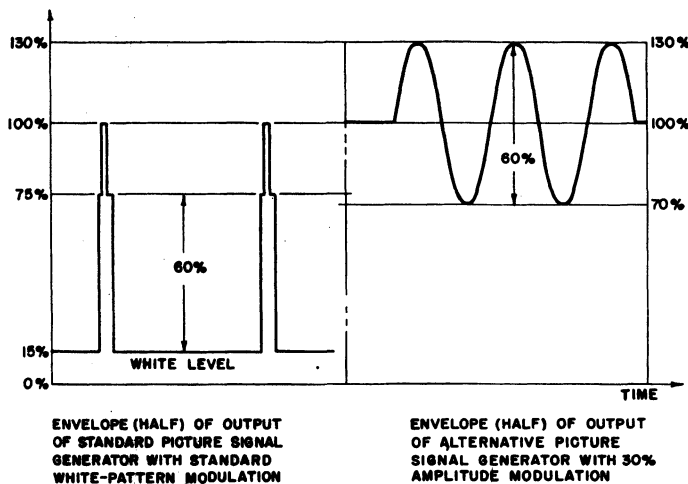


Fig. 1.8—Equivalence of output from standard white-pattern modulation and alternate 30 per cent amplitude modulation.

1.9 Standard Sound Test Output

1.9.1 Standard Test Output. For receivers capable of delivering at least 1 watt at 10 per cent distortion (Section 10.3), the standard test output is an audio-frequency power of 0.5 watt delivered to a standard dummy load. For receivers capable of delivering 0.1 watt but less than 1 watt at 10 per cent distortion, the standard test output is 0.05 watt of audio-frequency power delivered to a standard dummy load. When this latter value is used, it should be specified.

1.9.2 Standard Dummy Load. Output measurements of the sound section of a television receiver are made in terms of the power delivered to a standard dummy load substituted for the loudspeaker, except in special cases where other terminations are specified. The standard dummy load is a pure resistance whose value is equal to the absolute value of the 400-cps impedance of the loudspeaker. Where an output transformer is connected between the receiver and the loudspeaker, the output transformer is treated as part of the receiver.

1.10 Standard Test Conditions

1.10.1 General. It is assumed that the following standard test conditions are in effect during all tests unless noted otherwise.

1.10.2 Power Supply. Receiver measurements are made at the supply voltage for which the receiver is designed. Mean values of voltage and frequency are arbitrarily selected, such as 117 volts and 60 cps for ac operated receivers. Certain receiver characteristics may be desired at other than standard supply voltages and frequencies, or over a range of operating values. Tests should be made to check whether the receiver operates satisfactorily over the range of operating voltage and frequency likely to be encountered in service.

1.10.3 Ambient Temperature and Humidity. The ambient temperature should be between 20° and 35° C, and the relative humidity should be below 90 per cent.

1.10.4 Electron Devices. The electron tubes or other devices used should have standard rated values of those characteristics which significantly affect the performance of the receiver.

1.10.5 Television Receiver Adjustments.

1.10.5.1 General. All control settings not otherwise specified should be adjusted for normal reception. The synchronizing controls are adjusted for proper synchronization and best interlace. The contrast control is adjusted for maximum focused luminance (Section 3.9), unless otherwise stated, and the brightness control is set so that the line structure just disappears in the darkest portion of the gray scale. The scanning linearity, the scanning amplitude, and the focus adjustments are optimized.

1.10.5.2 Tuning adjustments. The receiver is normally tuned so that the local oscillator operates at the correct frequency, corresponding to the selected channel. This adjustment can be made by measuring either the local oscillator frequency or the picture carrier intermediate frequency (nominally 45.75 mc) with a frequency meter.

When measuring peak picture and peak sound sensitivity, the receiver is tuned as described for these tests (Sections 4.3 and 8.4).

Chapter 2—Requirements and Characteristics of Test Apparatus

2.1 Standard Picture Signal Generator

The standard picture signal generator should provide a signal with the following characteristics:

a) The generator should be capable of modulation by the waveform of Fig. 1.5.2 to produce a modulated signal whose characteristics are in accordance with the Rules and Regulations of the Federal Communications Commission.¹

b) The amplitude-vs-frequency characteristic should display less than 0.5-db response difference for any two modulating frequencies in the range from 30 cps to 4.5 mc. The time-delay errors should be negligible within this frequency band. Ideally a vestigial-sideband filter is required; however, most receiver tests can be made without this filter (Section 6.2.2).

c) The output voltage should be adjustable to any value over the range between 1 and at least 200,000 μv . Higher outputs up to 2 volts are desirable. The output-level indicator should measure the output during synchronizing peaks.

d) Incidental phase modulation of the carrier should not exceed 10 degrees swing at full video modulation at any carrier frequency.

e) Extraneous frequency modulation (hum) of the carrier should be negligible with respect to the characteristic under observation, especially when the generator is to be used in connection with the sound signal generator (Section 2.3) for tests on the sound channel.

2.2 Alternative Picture Signal Generator

Although the complete performance testing of the picture section cannot be accomplished without the use of a standard picture signal generator and a pattern generator, as described in Sections 2.1 and 2.4, many tests can be made with a standard signal generator producing a sine-wave 30 per cent amplitude-modulated signal. Furthermore, certain of the standard tests can be facilitated by the use of this type of signal generator. This generator should have a frequency range extending from below the intermediate frequency up to the highest television channel plus twice the intermediate frequency of the receiver under test, should be capable of amplitude modulation at 400 cps, and should have a variable output voltage up to at least 200,000 μv and preferably 2 volts.

Extraneous frequency modulation of the carrier should be negligible with respect to the characteristic under observation, especially when the generator is to be used in connection with the sound signal generator (Section 2.3) for tests on the sound channel. The carrier frequency stability should be consistent with the requirement of Section 2.3(d).

2.3 Sound Signal Generator

The sound signal generator should have the following characteristics:

a) The output should be calibrated from 1 to 200,000 μv with a constant source impedance.

b) It should be capable of frequency modulation at rates of 30 to 15,000 cps to a deviation of at least 25 kc and preferably to 50 kc with negligible distortion, and negligible incidental amplitude modulation.

c) Amplitude and frequency modulation at power-line frequencies should be negligibly small.

d) The carrier frequency should be sufficiently stable to maintain an accuracy of ± 5 kc in the 4.5-mc difference frequency between the sound and picture carriers.

2.4 Pattern Generator

This equipment, which supplies a modulating signal to the picture signal generator, must contain means for generating a composite signal which will contain not

only those picture elements which comprise a test pattern, but also correctly timed blanking and synchronizing pulses. The characteristics of the standard synchronizing waveforms are given in Fig. 1.5.2.

The pattern generator must be provided with the necessary controls and monitoring means to assure the correct levels of the various components of the composite picture signal. It must be free of hum, noise, and other extraneous components.

In addition to the standard synchronizing-signal waveforms, the pattern generator should be capable of providing the following composite picture test patterns:

a) The white-pattern modulation of Section 1.5.2.

b) Gray-pattern modulation of Section 1.5.3.

c) Sine-wave modulation for frequencies of 100 kc to 4.5 mc.

d) Square-wave modulation of variable repetition rate capable of being synchronized with the sweep frequencies.

e) Staircase patterns arranged to appear as vertical stripes and to be movable over the entire picture.

f) The monoscope type of test pattern (Fig. 1.5.4).

g) A cross-hatch pattern in which the video component consists of two sets of synchronized narrow rectangular pulses at time intervals equal respectively to not more than $\frac{1}{16}$ of the vertical and horizontal scanning intervals. These pulses produce a cross-hatch pattern of stationary vertical and horizontal lines.

2.5 Wide-Band Cathode-Ray Oscilloscope

A calibrated wide-band oscilloscope is required for testing the performance of the picture circuits of a television receiver. Its phase and amplitude response must be such as to avoid significant distortion of any waveform of interest; the major requirements are that the deflection sensitivity difference between any two frequencies from 30 cps to 4.5 mc should be less than 0.5 db and that the time-delay error be negligible.

The input impedance should be high enough so that the performance of the circuits to which the oscilloscope is connected is not affected by the resistance or capacitance of the oscilloscope input circuits.

2.6 Audio-Output and Distortion-Measuring Devices

Apparatus for the measurement of audio output and distortion is the same as that required for the testing of frequency-modulation receivers.³ The output meter should measure true rms values.

2.7 Measurement of Luminance

The photometer used in all luminance measurements should be capable of operating over a small area of the image. An instrument having an acceptance angle of 1

³ See Section 3 of IRE Standards, 47 IRE 17. S1, "Standards of Radio Receivers: Methods of Testing Frequency-Modulation Broadcast Receivers, 1947."