U.S. Department of Justice
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National Institute of Justice / *Technology Assessment Program*

Courtroom Reel-to-Reel Audio Tape Recorders

NIJ Standard 0901.00

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FOREWORD

This document, NIJ Standard-0901.00, Courtroom Reel-to-Reel Audio Tape Recorders, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high quality service. Purchasers can use the test methods described in this standard to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be attested to by an independent laboratory or guaranteed by the vendor.

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National Institute of Justice

NIJ STANDARD
FOR
COURTROOM REEL-TO-REEL AUDIO TAPE RECORDERS

CONTENTS

COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
ac	alternating current	h	hour	No.	number
AM	amplitude modulation	hf	high frequency	o.d.	outside diameter
cd	candela	Hz	hertz (c/s)	Ω	ohm
cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	in	inch	Pa	pascal
c/s	cycle per second	ir	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	part per million
dc	direct current	L	liter	qt	quart
°C	degree Celsius	lb	pound	rad	radian
°F	degree Fahrenheit	lbf	pound-force	rf	radio frequency
diam	diameter	lbf·in	pound-force inch	rh	relative humidity
emf	electromotive force	lm	lumen	s	second
eq	equation	ln	logarithm (natural)	SD	standard deviation
F	farad	log	logarithm (common)	sec.	section
fc	footcandle	*M*	molar	SWR	standing wave radio
fig.	figure	m	meter	uhf	ultrahigh frequency
FM	frequency modulation	min	minute	uv	ultraviolet
ft	foot	mm	millimeter	V	volt
ft/s	foot per second	mph	mile per hour	vhf	very high frequency
g	acceleration	m/s	meter per second	W	watt
g	gram	N	newton	λ	wavelength
gr	grain	N·m	newton meter	wt	weight

area = unit^2 (e.g., ft^2, in^2, etc.); volume = unit^3 (e.g., ft^3, m^3, etc.)

PREFIXES

d	deci (10^{-1})	da	deka (10)
c	centi (10^{-2})	h	hecto (10^2)
m	milli (10^{-3})	k	kilo (10^3)
μ	micro (10^{-6})	M	mega (10^6)
n	nano (10^{-9})	G	giga (10^9)
p	pico (10^{-12})	T	tera (10^{12})

COMMON CONVERSIONS
(See ASTM E380)

ft/s × 0.3048000 = m/s	lb × 0.4535924 = kg
ft × 0.3048 = m	lbf × 4.448222 = N
ft·lbf × 1.355818 = J	lbf/ft × 14.59390 = N/m
gr × 0.06479891 = g	lbf·in × 0.1129848 = N·m
in × 2.54 = cm	lbf/in^2 × 6894.757 = Pa
kWh × 3 600 000 = J	mph × 1.609344 = km/h
	qt × 0.9463529 = L

Temperature: $(T_{°F} - 32) \times 5/9 = T_{°C}$

Temperature: $(T_{°C} \times 9/5) + 32 = T_{°F}$

NIJ STANDARD FOR COURTROOM REEL-TO-REEL AUDIO TAPE RECORDERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for reel-to-reel audio tape recorders and tape players used in the courtroom and to ensure the interchangeability of magnetic tapes between different recorders and between recorders and players.

2. CLASSIFICATION

For purposes of this standard, audio tape recorders and players are classified by whether or not the device contains a recorder. Units with recorders are classified by whether they also contain a recorded tape protection system. The various type units have the following functions:

	Sense	Erase	Record	Playback
Type I				X
Type II		X	X	X
Type III	X		X	X

2.1 Type I

Units which are capable only of playing tapes.

2.2 Type II

Units which are capable of erasing, recording, and playing tapes.

2.3 Type III

Units which are capable of recording and playing tapes, but are not capable of erasing tapes or recording on unerased tapes.

3. DEFINITIONS

The principal terms used in this document are defined in this section.

3.1 Capstan

The spindle or shaft which drives the pinch roller and tape.

3.2 Common Mode Rejection

The ratio of the interference voltage that appears between the differential input terminals, with respect to ground, to the output voltage produced by this interference voltage, when the output voltage is divided by the amplifier gain.

3.3 Differential Input Circuit

A circuit whose output voltage is proportional to the algebraic difference between two input voltages when each of these voltages is measured with respect to ground.

3.4 Flutter and Wow

Distortion due to variations of frequency which occur at 0.1 to 250 Hz, caused by nonuiform tape motion during recording or playback.

3.5 Frequency Response

The variation of signal amplitude as a function of frequency.

3.6 Gap

The space between the poles of a record, playback or erase head.

3.7 Harmonic Distortion

Distortion characterized by the appearance in the output of harmonics of the fundamental frequency when the input wave is sinusoidal.

3.8 In-Phase Signals

Signals in a common waveform mode position applied equally to the recording head input or from the playback head output through the playback amplifiers.

3.9 NAB Type B Reel

A standard "7-in" reel which holds "1/4-in" magnetic tape used for recording and reproducing [1][1]. See figure 1.

3.10 Pinch Roller

A roller, usually made of rubber or plastic, which presses the tape against the rotating capstan, when activated, and results in the linear motion of the tape.

3.11 Reproduce Amplitude Frequency Response

The measure of the response of the playback heads and amplifiers to a standard frequency response test tape.

3.12 Standard Recorded Program Level

The level produced by a 500-Hz signal at a recording head magnetization of 185 nanoteslas.

3.13 Tape Player

A tape device for playing an audio magnetic recording but which lacks the capability to record and erase.

3.14 Tape Recorder

A tape device for making and playing back an audio magnetic tape recording. This device may or may not have an erase capability.

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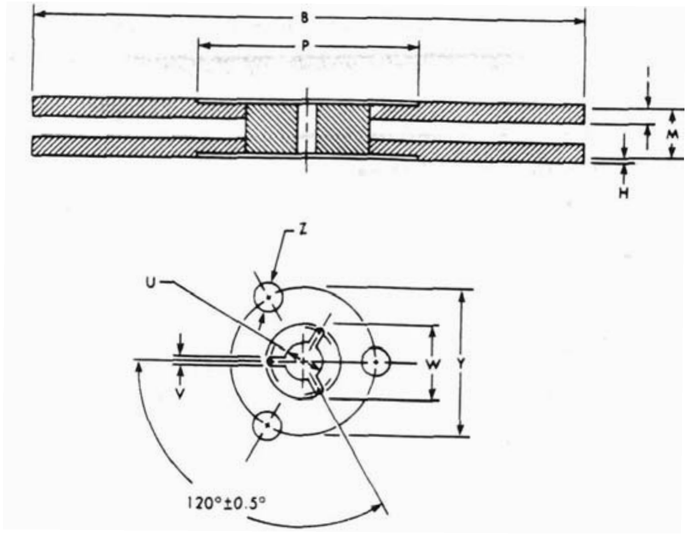
[1]Numbers in brackets refer to references in appendix A.



DIMENSION	MIN mm	MAX mm	MIN in	MAX in
B	177.80	178.59	7.000	7.031
H	0.00	1.27	0.000	0.050
I		2.92		0.115
M	12.32	13.34	0.485	0.525
P	57.15		2.250	
U	8.03	8.18	0.316	0.322
V	1.47	1.73	0.058	0.068
W	15.75	16.00	0.620	0.630
Y Z	See NAB Standard on "Magnetic Tape Recording and Reproducing (Reel-to-Reel)" April, 1965			

FIGURE 1. *NAB type B 178 mm (7 in) magnetic tape reel.*

3.15 Tape Transport Assembly

All objects which contact the tape and all supports and drives for those objects including the mechanical means of moving the tape over the erase, record and playback heads.

3.16 Tesla

Unit of magnetic flux density, or weber per square meter (one tesla = 10,000 gauss).

3.17 Track

The area of tape surface that contains the recorded magnetization produced by one record-head gap.

4. REQUIREMENTS

The requirements for each tape recorder or player are presented in the sections that follow and are summarized in table 1.

4.1 User Information

Each tape recorder or player shall be accompanied by complete operating instructions, instructions for any recommended maintenance, and schematic circuit diagrams for the device.

TABLE 1. *Performance requirements for courtroom audio tape recorders*

	Characteristic	Requirement	See section number
Tape Transport Assembly Characteristics			
A.	Spindle diameter	7.95 mm (0.313 in) to 8.00 mm (0.315 in)	4.3.2
B.	Nominal tape speed	4.76 cm/s (1 7/8 ips)	4.3.3
C.	Tape speed error	±3%	4.3.3
D.	Tape speed error (supply voltage varied +10%)	±3%	4.3.3
E.	Unweighted flutter content	< 0.5% rms	4.3.3
F.	Fast forward or rewind time	< 105 s for 550 m (1800 ft)	4.3.4
G.	Tape position indicator error	< 50 cm (20 in)	4.3.5
Head Assembly Characteristics			
H.	Number of tracks	4	4.4.2
I.	Track width	1.04 ±0.10 mm (.041 ±0.004 in)	4.4.2
J.	Track spacing	1.71 ±0.10 mm (0.067 ±0.004 in)	4.4.2
Input-Output Characteristics			
K.	Microphone input source impedance[a]	≃ 200	4.5.3
L.	Microphone input sensitivity[a]	≃ 0.7 mV rms	4.5.3
M.	Microphone input record and playback harmonic distortion[a]	< 3%	4.5.3
N.	Microphone input common mode rejection ratio[a]	> 100	4.5.3
O.	High-level input impedance[a]	> 600 Ω	4.5.4
P.	High-level input sensitivity[a]	< 250 mV rms	4.5.4
Q.	High-level input record and playback harmonic distortion[a]	< 3%	4.5.4
R.	High-level input common mode rejection ratio[a]	> 100	4.5.4
S.	High-level output impedance	< 600 Ω	4.5.5
T.	High-level output level	> 250 mV rms into 600 Ω	4.5.5
U.	High-level output distortion	< 3%	4.5.5
V.	Speaker output impedance	< 8.4	4.5.6
W.	Speaker output level	> 7 V rms into 8 Ω	4.5.6
X.	Speaker output distortion	< 3%	4.5.6
Y.	Monitor output impedance	< 8.4 Ω	4.5.7
Z.	Monitor output level	> 100 mV rms into 8 Ω	4.5.7
AA.	Monitor output distortion	< 3%	4.5.7
Electronic Characteristics			
AB.	Low frequency end of response	< 250 Hz	4.6.1
AC.	High frequency end of response	> 6.5 kHz	4.6.1
AD.	Response, 250–6500 Hz	< 5 dB	4.6.1
AE.	Response, 6500–20,000 Hz	< Response 250–6500 +3 dB	4.6.1
AF.	Signal-to-noise ratio	> 40 dB	4.6.2
AG.	Interchannel crosstalk ratio[a]	> 30 dB	4.6.3
AH.	Recorded tape protection sensitivity[b]	> 28 dB	4.6.4

[a] Not applicable to Type I units.
[b] Applicable only to Type III units.

4.2 Track Designation

The magnetic tracks shall be designated as follows. If the tape moves from left to right during recording, with the coated side facing away from the observer, the top track is designated no. 1 track, the next lower track is designated no. 2 track, etc.

4.3 Tape Transport Assembly Requirements

The tape transport assembly requirements given below shall be checked in accordance with the procedures in section 5.3.

4.3.1 Configuration

The tape transport assembly shall accept NAB Type B reels (sec. 3.9) and recording tape whose width is 6.25+0.05 mm (0.246+0.002 in), with the tape wound with its magnetic coating facing the center of the reel. The tape speed shall be controlled solely by the peripheral motion of the capstan, whose rotation shall be produced by a separate motor.

4.3.2 Supply and Take-up Mechanism

The tape tension, when operating in the record, playback, fast forward, or rewind mode, shall be supplied by two heavy-duty motors, one of which is directly coupled to the supply spindle and the other directly coupled to the take-up spindle. This system shall hold the tape in sufficient tension to meet the appropriate performance requirements in this standard. This spindle diameter shall not be larger than 8.00 mm (0.315 in) and not smaller than 7.95 mm (0.313 in). Means shall be provided to ensure that the reels will not fall off the spindles during normal operation.

4.3.3 Tape Speed and Flutter and Wow

The tape speed in the record and playback mode of operation shall be 6.76 cm/s (1 7/8 in/s), with an allowable constant deviation no greater than 3 percent. When the standard supply voltage is varied +10 percent, the tape speed shall not vary more than 3 percent. When reproducing an essentially flutter-free recording of 3 kHz, the unweighted flutter and wow content shall not exceed 0.5 percent at any portion of the tape.

4.3.4 Fast Forward and Rewind

Each recorder or player shall wind and rewind 550 m (1800 ft) of tape in less than 105 s. The use of fast forward or rewind shall not cause a visible deterioration of the tape.

4.3.5 Tape Position Indicator

Each recorder or player shall have a means for locating any given position on a 550 m (1800 ft) tape within 50 cm (20 in) from any other position on the tape.

4.3.6 Operating Modes and Controls

Each recorder or player shall have at least the following distinct operating modes: Playback, Fast Forward, Rewind, and Stop. Types II and III shall also have a record mode. All controls essential to the operation of the tape transport, with the exception of the record-interlock feature, shall be grouped together on the same panel of the equipment. All controls shall be plainly identified in English or universal symbols. The record-mode control on type II and III devices shall be designed to make accidental recording with the equipment unlikely. (A record-lockout key operated lock is desirable.) There shall be a record-mode indicator in plain view of the operator for type II and III devices.

4.3.7 Remote Control

Devices which do not have an automatic backspace feature shall have an electrical means that allows foot-actuated remote control of tape motion during the playback mode. During playback, the combined effect of stopping and starting the tape by the remote control shall not cause more than 1/2 s of the tape to be rendered unintelligible.

4.3.8 Fail-Safe Features

The design shall ensure that the tape will not form abnormal loops by common failure modes or operator errors. The tape motion shall stop at the end of each tape or when broken tape is encountered while in any operating mode, and interruption of primary power during either rewind or fast forward shall not cause tape spillage or breakage. It shall be impossible to enter more than one operating mode at the same time or to operate the motion controls in a way that would cause mechanical damage to the recording tape.

4.4 Head Assembly Requirements

The head assembly requirements given below shall be measured in accordance with the procedures in section 5.4.

4.4.1 Gap Orientation and Phase

There shall be a separate head gap for each function of each track. All gaps of a given function shall be in line and perpendicular to the line of tape travel so that, when in-phase signals are applied to all channels, they produce in-phase magnetization of all tracks on the tape and, when such a tape is played back, in-phase signals are produced by all tracks.

4.4.2 Track Format

The tape shall have four equally spaced tracks, each with a width of 1.04±0.10 mm (0.041±0.004 in). The center lines of adjacent tracks shall be separated by 1.71±0.10 mm (0.067±0.004 in). The center lines of alternate tracks shall be 3.42±0.10 mm (0.135±0.004 in) apart, and the center lines of the two outermost tracks shall be separated by 5.13±0.10 mm (0.202±0.004 in).

4.5 Input-Output Requirements

The input-output requirements given below shall be measured in accordance with the procedures in section 5.5.

4.5.1 Terminals and Controls

Each input terminal for type II and III devices and each output terminal for all devices shall be clearly marked as to the channel it serves. There shall be a clearly marked control to adjust individually the input signal level for each channel of type II and III devices. There shall be a clearly marked control to adjust the output signal level. One control may be used to adjust simultaneously the signal level of all the output channels, as in the example shown in figure 2.

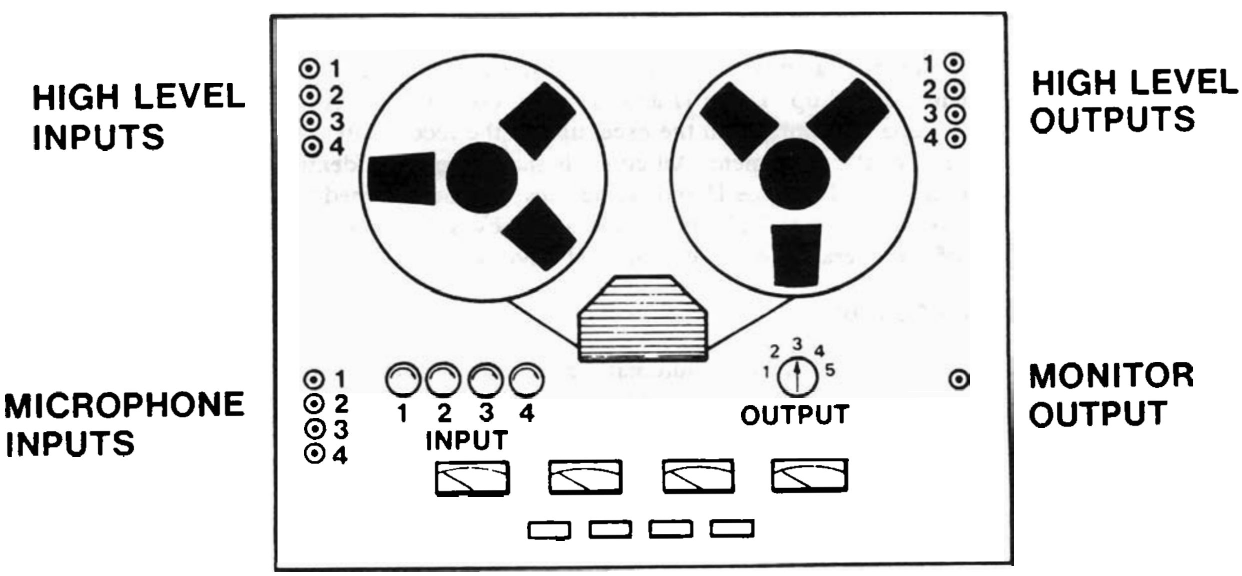


FIGURE 2. *Typical reel-type audio tape recorder.*

4.5.2 Track Correspondence

There shall be a one-to-one correspondence between each numbered tape track (sec. 4.2) and the channel numbers of the recorder or player. Type II and III devices shall also have a one-to-one correspondence between each numbered input channel and the corresponding numbered output channel, and with the corresponding channel controls.

4.5.3 Microphone Input (Type II and III Only)

A differential microphone input shall be provided for each recording channel. An open circuit voltage of 0.7 mV rms from a 200-Ω generator shall produce the standard recorded program level (sec. 3.12) on the tape for each microphone input channel. The overall record and playback harmonic distortion for each microphone input channel, including tape, shall be less than 3 percent for a 500 Hz sine wave signal recorded to produce a playback level 6 dB above the standard recorded program level. The common mode rejection ratio of each microphone input channel shall be at least 100.

4.5.4 High-Level Input (Type II and III Only)

A differential high-level input shall be provided for each recording channel. Each high-level input channel shall have an input impedance greater than 600 Ω and an input of 250 mV rms shall produce a standard recorded program level on the tape for each high-level input channel. Each high-level input shall accommodate an input voltage 6 dB higher than 250 mV rms without exceeding a record and playback harmonic distortion of 3 percent. The common mode rejection ratio of each high-level input channel shall be at least 100.

4.5.5 High-Level Output

A high-level output shall be provided for each playback channel. Each high-level output channel shall have an output impedance less than 600 Ω and, when playing back a tape recorded with the standard recorded program level, shall be capable of producing an output of 250 mV rms into a load of 600 Ω, with a harmonic distortion no greater than 3 percent.

4.5.6 Speaker Output

Any speaker output channel that is provided shall have an output impedance less than 8.4 Ω and, when playing back a tape recorded with the standard recorded program level, shall be capable of producing an output of 7.0 V rms into a load of 8 Ω with a harmonic distortion no greater than 3 percent.

4.5.7 Monitor Output

A headphone monitor jack shall be provided for monitoring the output during the record or playback mode of operation. The capability shall exist for monitoring all of the channels both singly or simultaneously. For type II and III devices, it shall be possible to monitor the audio signal both before and immediately after it is recorded. Each monitor amplifier shall have an output impedance less than 8.4 Ω and, when playing back a tape recorded with the standard recorded program level, shall be capable of producing an output of 100 mV rms into a load of 8 Ω with a harmonic distortion no greater than 3 percent.

4.5.8 Record-Level Indicators (Type II and III Only)

Each record-level indicator shall be plainly marked as to the channel it serves, and it shall provide a visible indication of the record level for that channel. The indication shall be proportional to the recording voltage and shall be calibrated so that the nominal indicated recording level (as specified by the manufacturer) results in a tape being recorded with the standard recorded program level. Record levels which are 20 dB below the standard recorded program level shall not cause any indicator to read zero, and the indicator shall not be harmed by levels which are 15 dB above the standard recorded program level.

4.6 Electronic Requirements

The electronic requirements given below shall be measured in accordance with the procedures in section 5.6.

4.6.1 Frequency Response

Both the playback frequency response and the overall frequency response shall meet the following criteria. In the frequency range from 250 Hz to 6.5 kHz, the difference between the minimum and maximum response shall not exceed 5 dB for all devices. For type II and III devices, the response at any frequency between 20 and 250 Hz shall not exceed the maximum response within the band between 250 Hz and 6.5 kHz, and the response at any frequency between 6.5 and 20 kHz shall not exceed the maximum response within the band between 250 Hz and 6.5 kHz by more than 3 dB.

4.6.2 Signal-to-Noise Ratio

The ratio of the standard recorded program level to unweighted noise on unrecorded tape shall result in a signal-to-noise ratio of no less than 40 dB in the frequency range from 20 Hz to 20 kHz.

4.6.3 Interchannel Crosstalk Ratio (Type II and III Only)

The adjacent track signal-to-crosstalk ratio shall be no less than 30 dB at a frequency of 500 Hz.

4.6.4 Recorded Tape Protection (Type III Only)

Type III units shall not record on tapes that already contain signals on one or more tracks at a level not less than 28 dB below the standard recorded program level.

5. TEST METHODS

5.1 Standard Test Conditions

The recorder or player shall be operated at standard test conditions while it is being tested. Disable or bypass all special features, such as automatic gain control, before testing.

5.1.1 Standard Temperatures

Standard ambient temperature shall be between 18 °C (64 °F) and 25 °C (77 °F).

5.1.2 Standard Relative Humidity

Standard ambient relative humidity shall be between 10 and 70 percent.

5.1.3 Standard Power Voltage

The standard line voltage shall be 117 to 120 V at 59.8 to 60.2 Hz.

5.1.4 Standard Reference Frequency

The standard reference frequency shall be 500 Hz.

5.2 Test Equipment

This section is limited to that equipment which is the most critical in making the measurements given in this standard. All other test equipment shall be of comparable quality.

5.2.1 Audiofrequency Generator

The audiofrequency generator shall have an output impedance of no more than 600 Ω, a graduated variable output level, and shall cover the frequency range from 20 Hz to 20 kHz. The output signal shall be adjustable from 0.1 mV to 10 V rms and have a noise and distortion content no greater than 1 percent. The output amplitude shall not vary by more than 1 dB over the complete frequency range.

5.2.2 Standard Audio Output Load

The standard audio output load shall be a noninductive resistor having a resistance equal to the specified output impedance of the output under test and a power rating equal to or exceeding the specified maximum audio output power for that output. No filter shall be used between the audio output terminals and the audio output load. The resistance shall be within 2 percent of the specified value.

5.2.3 Audiofrequency Voltmeter

The audiofrequency voltmeter shall have a true rms response and be capable of measuring ac voltages from 0.7 mV to 10V rms (with an equivalent dB scale) over a frequency range of 20 Hz to 20 kHz. Its measurement uncertainty shall be 3 percent or less of the measured voltage, and its input impedance shall be at least 0.5 MΩ at 1000 Hz.

5.2.4 Frequency Counter

The frequency counter shall have at least 50 mV sensitivity and be capable of measuring sinusoidal signals in the frequency range from 20 Hz to 20 kHz with a measurement uncertainty of ±2 Hz or less below 10 kHz.

5.2.5 Distortion Analyzer

The distortion analyzer shall be capable of measuring harmonic distortion at 500 Hz with a distortion scale of 0 to 10 percent. Its measurement uncertainty shall be no greater than 3 percent of full scale.

5.2.6 Flutter and Wow Meter

The flutter and wow meter shall operate in accordance with the NAB standard [1]. The response of the flutter and wow meter shall be at least 3 dB down at 0.5 and 200 Hz, and falling at a rate of at least 6 dB per octave below and above these frequencies respectively. The indicating meter shall have the dynamics of the Standard Volume Indicator (ASA C16.5-1961), a full-wave rectified average measurement law, and shall be calibrated to read the rms value of a sinusoidal frequency variation.

5.2.7 Tape Position Indicator Test Tape

The tape position indicator test tape shall be a magnetic tape 550±5 m (1800±16 ft) in length and 6.25±0.05 mm (0.246±0.002 in) in width, wound on a 178 mm (7 in) reel. Attached to the beginning of the tape shall be a multicolored leader constructed with 50 cm (20 in) of red leader, followed by 50 cm (20 in) of blue leader, followed by 5 m (16 ft) of white leader. Attached to the trailing end of the tape shall be a 5 m (16 ft) length of white trailer.

5.2.8 Standard Level Set Test Tape

The standard level set test tape shall be 6.25 ± 0.05 mm (0.246±0.002 in) in width and shall contain the standard reference frequency (500 Hz) recorded across the full width at a tape speed of 4.76 cm/s (1 7/8 in/s), at the standard recorded program level.

5.2.9 Reproduce Alignment Test Tape

The reproduce alignment test tape shall be recorded across the full width, at 10 dB below the standard program level, at a tape speed of 4.76 cm/s (1 7/8 in/s), with a minimum of 10 distinct frequencies covering the frequency range from 250 Hz to 5 kHz, one of which is 500 Hz.

5.2.10 Flutter Test Tape

The flutter test tape shall be approximately 550 m (1800 ft) in length with a 3.0 kHz frequency recorded near the beginning and the end. The recorded sections must be long enough to allow easy measurement of flutter and wow and tape speed.

5.2.11 Blank Test Tape

The blank test tape shall be a magnetic recording tape with a uniform oxide coating on a polyester backing, approximately 0.025 mm (0.001 in) thick, 6.25±0.05 mm (0.246±0.002 in) wide, and 550 m (1800 ft) long.

5.2.12 Measuring Magnifier

The measuring magnifier shall be capable of measuring linear distances in a flat image with an accuracy better than±0.025 mm (0.001 in). A microscope with an interior or exterior reticle, a traveling microscope or an optical comparator may be used.

5.3 Tape Transport Assembly Tests

5.3.1 Configuration Test

Verify that the appropriate size reels fit on each spindle. Visually inspect and play the tape device to ascertain that the tape is wound with the magnetic coating facing the center of the reel and that the magnetic coating side of the tape also moves across the heads as it is unwound. Visually inspect the tape drive system to see that, in the record and playback modes, tape motion is controlled by a capstan which is driven by a separate moter.

5.3.2 Supply and Take-up Mechanism Test

Verify that the supply and take-up spindles are each driven by a directly coupled moter (no clutch, gears or pulley). Measure each spindle with a micrometer to verify that it is within the required diameter. Verify that a means is provided to prevent reels from falling off the spindles during normal operations.

5.3.3 Tape Speed and Flutter and Wow Tests

Load the flutter test tape on the tape device and connect a frequency counter and the flutter and wow meter to the output. Perform each of the following tests using flutter test sections located near the start and near the finish of the flutter test tape, so that the difference in the diameters of the supply and take up spools is a maximum. Play the tape at the nominal speed of 4.76 cm/s (1 7/8 ips) and measure the frequency using a 1 or 10-s gate time. Repeat the above measurements with the supply voltage increased 10 percent above the standard supply voltage level, and then again with the supply voltage decreased 10 percent from the standard value. Calculate the percent deviation from the nominal tape speed for each of the above measurements. Monitor the flutter and wow meter indication, but disregard peak readings which do not recur more than three times in any 10-s period. Find the average value of the peak readings.

5.3.4 Fast Forward and Rewind Test

Load the tape position indicator test tape on the tape device. Measure the time required to run the entire reel of tape through the machine in the fast forward mode. Reset the device to rewind, and measure the elapsed time required to run the entire reel of tape through the device in the rewind mode.

5.3.5 Tape Position Indicator Test

Load the tape position indicator test tape on the tape device. Run the tape in the playback mode until the junction of the red and blue leaders of the tape lines up with any visual reference point on the tape path. Either reset or note the reading of the tape position indicator. Place the tape device in the fast forward mode and stop the tape as soon as the trailer is visible. Rewind the tape and stop it when the original reading of the tape position indicator is obtained, using, if necessary, the play and rewind controls. Note whether the visual reference point used above is adjacent to either the red or blue leaders. (The red and blue leaders are the acceptance zones for this test.) Repeat this test twice. Stop the recorder four times during the rewind phase of the first test. Stop the recorder four times during the fast forward phase of the second test.

5.3.6 Operating Modes and Controls Test

Visually inspect the tape device to verify that it has the required operating modes and controls. If it is a type II or III device, verify that there is an adequate record interlock and record-mode indicator.

5.3.7 Remote Control Test

Load the blank test tape on the tape device. Record a 500-Hz signal on the tape for about 3 s with unrecorded leading and trailing sections of 5 to 10 s each. Play back this tape, measuring a convenient output with the frequency counter and a voltmeter, noting the signal voltage, V_o. V_o must be within the operating range of the counter. Disconnect these two measuring instruments from the output of the tape device and connect them to the signal generator. Then set the signal generator to about 350 Hz and adjust its output to be 0.7 V_o. Adjust the input level controls (discriminator) of the frequency counter so that the latter output causes the counter to register some count, but not necessarily the full count. Check to determine that a 350 Hz signal at 0.5 V_o causes less than 5 counts per second and, furthermore, a 350 Hz signal at 0.9 V_o gives the correct full count. With these conditions met, reattach the frequency counter and voltmeter to the previously used output of the tape device and replay the full 3-s record of the 500-Hz signal with the counter gate open to obtain the full count. Note the full count of the signal. Rewind and replay this section of tape. Stop and start the tape device in the middle of the recorded signal. Determine the duration of the lost signal from the count lost to ensure that not more than 250 counts were lost.

5.3.8 Fail-Safe Features Test

With the blank test tape still loaded, wind the tape completely off the supply reel during the playback mode and fast forward mode. Wind the tape completely off the take-up reel during rewind mode. Attempt to put the tape device simultaneously into more than one operating mode. Interrupt primary power while in fast forward mode, while in the rewind mode and while in the playback mode. Inspect to ensure that the tape has not been damaged.

5.4 Head Assembly Tests

5.4.1 Gap Orientation and Phase Tests

Visually verify that the tape device has the required number of head gaps. Inspect the heads with the measuring magnifier and determine that all gaps of a given function are in line and nominally perpendicular to the line of tape travel.

5.4.1.1 Playback Phase Test

Load a reproduce alignment test tape on the tape device and connect the audiofrequency voltmeter to the monitor output. Set the playback controls to produce an output within 1 dB of the same output of each channel at 250 Hz. Play back the 250 Hz recording and note the output voltage, first on channel 1 and then on channel 2. Connect the outputs of channel 1 and channel 2 to the network shown in figure 3 and note the combined voltage output on the voltmeter. If playback channels 1 and 2 are in phase, this combined voltage should be approximately equal to the sum of the channel 1 and channel 2 output voltages. A 2 dB or greater decrease in the voltage sum indicates an out-of-phase condition. Repeat the above test for channels 1 and 3, and then for channels 1 and 4.

5.4.1.2 Recording Phase Test (Type II and III Only)

After successful completion of the above test for playback phasing, replace the reproduce alignment test tape with the blank test tape. Connect the audiofrequency generator to the microphone inputs of all channels simultaneously and record a 250 Hz signal on all tracks. Repeat the playback tests described above. Track phasing during recording is correct if all tracks are in phase during playback.

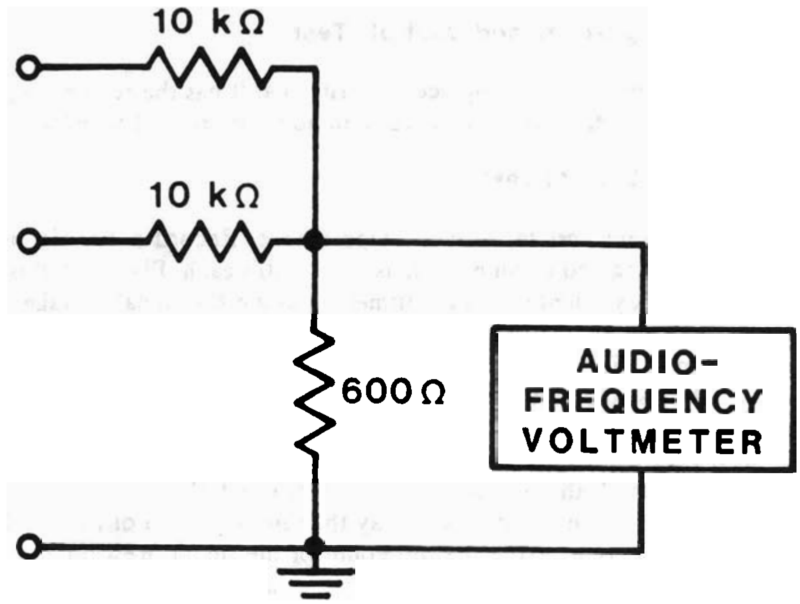


FIGURE 3. *Block diagram for circuit used in the playback phase, record phase and track format measurements.*

5.4.2 Track Format Test (Type II and III Only)

Bulk erase a reel of recording tape and load it on the tape device. For 2 s, record a signal on all channels simultaneously. Cut off this section of tape and dip it into a solution of alcohol and finely powdered iron so that the iron will adhere to the recorded segments. Examine the tape with the measuring magnifier to verify that the track width and spacings are correct.

5.5 Input-Output Tests

5.5.1 Terminals and Controls Test

Visually verify that the device has the required terminals and controls, and that they have the required labels.

5.5.2 Track Correspondence Test

Bulk erase a reel of recording tape and mount it on the tape device. Record a signal on channel 1 for approximately 1 s, change connections and repeat the procedure for channel 2, etc. Play back this tape on the tape device and verify that the signals recorded on each track can be reproduced on the same numbered playback channel. Cut off this section of tape making particular note of which end was the leading end of the tape. Dip this tape segment into a solution of alcohol and finely powdered iron as in section 5.4.2. Verify that one-to-one correspondence is satisfied between the numbered tape tracks (sec. 4.2) and the channel numbers of the device under test.

5.5.3 Microphone Input Tests (Type II and III Only)

5.5.3.1 Microphone Input Sensitivity Test

Load a standard level set test tape on the tape device and connect the audiofrequency voltmeter to the first high-level output terminal. Play the test tape and set the output level to a convenient meter reading or, if no adjustment is possible, note the meter reading. Remove the standard level set test tape and replace it with a blank test tape. Connect the audiofrequency generator to the first microphone input channel through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Set the frequency of the generator to 500 Hz and set the appropriate record level control to the maximum gain position. Set the recorder to monitor tape and place it in the record mode. Adjust the generator output

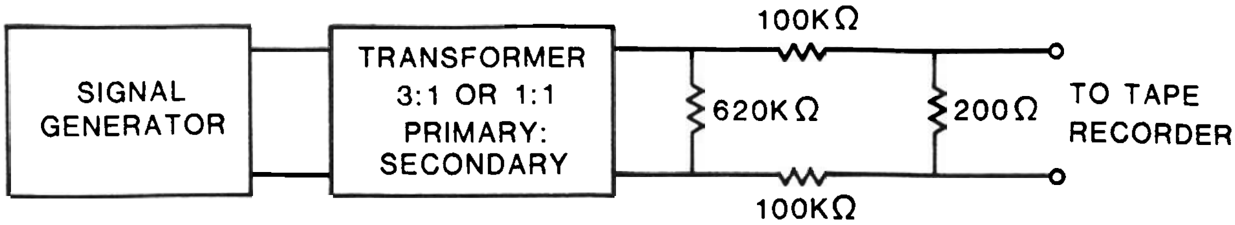


FIGURE 4. *Block diagram for transformer circuit used in the microphone input, record-level indicator, overall frequency response, signal-to-noise ratio, interchannel crosstalk ratio, and recorded tape protection measurements.*

amplitude so that the output level indication on the voltmeter is the same as for the standard level set test tape. Measure the input voltage at the microphone input terminal to verify that it is 0.7 V rms or less. Repeat for each microphone input channel and its corresponding high-level output terminal.

5.5.3.2 Microphone Input Harmonic Distortion Test

Connect the audiofrequency voltmeter to the first high-level output terminal in parallel with a 600-Ω resistor. Load the standard level set test tape on the tape device, play it, and adjust the output level controls to obtain 250 mV rms on the output voltmeter; if no adjustment is possible, note the meter reading. Remove the standard level set test tape and replace it with a blank test tape. Connect the audiofrequency generator to the first microphone input channel through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the microphone input terminal is 0.7 mV rms at 500 Hz. Record the generator signal for approximately 20 s on the blank test tape, with the record level controls set such that, upon playback, the tape device output level is 6 dB higher than that obtained from the reference level on the standard level set test tape.

Connect the distortion analyzer to the high-level output in parallel with the voltmeter and 600-Ω load, as in figure 5. Play the recorded tape and tune the distortion analyzer to reject the fundamental recorded frequency. Replay the tape and measure the harmonic distortion. Repeat for each microphone input channel and its corresponding high-level output terminal.

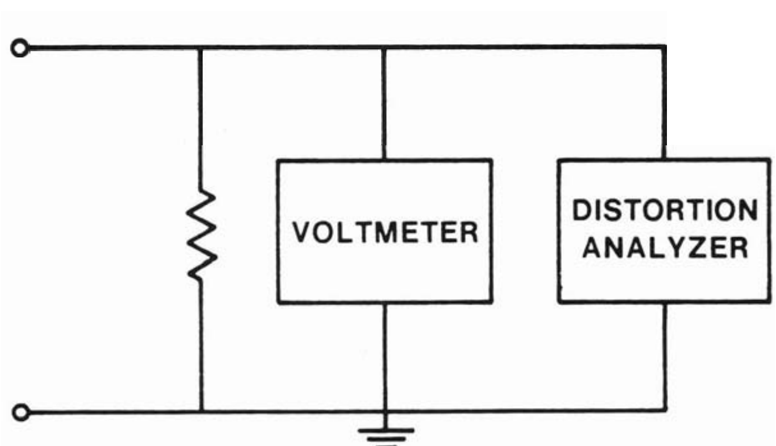


FIGURE 5. *Block diagram for circuit used in the harmonic distortion measurements.*

5.5.3.3 Microphone Input Common Mode Rejection Ratio Test

Connect the audiofrequency generator to the first microphone input channel throught the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the microphone input terminals is 0.7 mV rms at 500 Hz. Measure the output voltage with the voltmeter at the first high-level output channel terminal. Calculate the gain by dividing this output voltage by the differential input voltage (0.7 mV).

Next, connect the terminals for the first microphone input channel and apply 70 mV rms (V_{cm}) with respect to ground to these terminals. Measure the resulting output voltage, V_o, at the first high-level output terminal and calculate the common mode rejection ratio from ($V_{cm} \times$ gain)/V_o. Repeat for each microphone input channel and its corresponding high-level output terminal.

5.5.4 High-Level Input Tests (Type II and III Only)

5.5.4.1 High-Level Input Impedance Test

Connect the audiofrequency generator to the first high-level input channel through the circuit shown in figure 6 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Set the appropriate record level control to the maximum gain position and the frequency of the audiofrequency generator to 1 kHz. Adjust the generator voltage so that the voltage across the transformer secondary is 10 mV rms. Measure the differential voltage at the first high-level input channel terminal and verify that it is larger than 5 mV rms. Repeat for each high-level input channel.

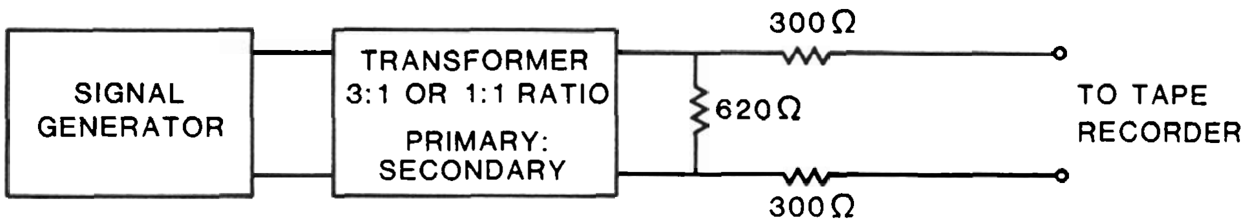


FIGURE 6. *Block diagram for transformer circuit used in the high-level input impedance measurement.*

5.5.4.2 High-Level Input Sensitivity Test

Load a standard level set test tape on the tape device and connect the audiofrequency voltmeter to the first high-level output. Play the test tape and set the output level to a convenient meter reading or, if no adjustment is possible, note the meter reading. Rewind and remove the standard level set test tape. Load a blank test tape and connect the audiofrequency generator to the first high-level input channel through the circuit shown in figure 4. Verify that the frequency response is within ±1 dB between 50 and 10,000 Hz.

Set the frequency of the generator to 500 Hz. Set the tape device to monitor tape and place it in the record mode. Adjust the generator output amplitude so that the output level indication on the voltmeter is the same as for the standard level set test tape. Measure the voltage at the high-level input to verify that it reads 250 mV rms or less. Repeat for each high-level input channel.

5.5.4.3 High-Level Input Harmonic Distortion Test

Connect the audiofrequency voltmeter to the first high-level output in parallel with a 600-Ω resistor. Load the standard level set test tape on the tape device, play it, and adjust the output level controls to obtain 250 mV rms on the output voltmeter; if no adjustment is possible, note that the meter reading. Remove the standard level set test tape and replace it with a blank test tape. Connect the audiofrequency generator to the first high-level input through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the high-level input is 250 mV rms at 500 Hz. Record the generator signal for approximately 20 s on the blank test tape with the record level controls set such that, upon playback, the tape device output level is equal to that obtained from the reference level on the standard level set test tape.

Now, readjust the generator so that the differential input voltage at the input terminals is 6 dB higher than 250 mV rms. Record this signal for approximately 20 s on a second portion of the blank test tape. Connect the distortion analyzer to the high-level output in parallel with the voltmeter and a 600-Ω load, as in figure 5. Play the second portion of the recorded tape and tune the distortion analyzer to reject the fundamental recorded frequency. Replay the second portion of the tape and measure the harmonic distortion. Repeat for each high-level input channel.

5.5.4.4 High-Level Input Common Mode Rejection Ratio Test

Connect the audiofrequency generator to the first high-level input through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the high-level input is 250 mV rms at 500 Hz. Measure the output voltage with the voltmeter at the first high-level output channel terminal. Calculate the gain by dividing this output voltage by the differential input voltage (250 mV).

Next, connect the terminals for the first high-level input channel and apply 25 V rms (V_{cm}) with respect to ground to these terminals. Measure the resulting output voltage, V_o, at the first high-level output and calculate the common mode rejection ratio from ($V_{cm} \times$ gain)/V_o. Repeat for each high-level input channel.

5.5.5 High-Level Output Tests

5.5.5.1 High-Level Output Impedance Test

Load a standard level set test tape on the tape device, set the output level control to approximately mid-range and play the tape. Use the audiofrequency voltmeter to measure the open circuit voltage at the high-level output terminal for the first channel, and then measure the voltage across a 600-Ω resistor connected across the same high-level output. Verify that the voltage measured across the 600-Ω resistor is greater than half the corresponding open circuit output voltage. Repeat for each high-level output channel.

5.5.5.2 High-Level Output Voltage Test

Load a standard level set test tape on the tape device and connect the audiofrequency voltmeter and a 600-Ω resistor in parallel with the first high-level output. Play the test tape and verify that it is possible to obtain the required output voltage (250 mV). Repeat for each high-level output channel.

5.5.5.3 High-Level Output Harmonic Distortion Test

Load a standard level set test tape on the tape device and connect the distortion analyzer, the audiofrequency voltmeter, and a 600-Ω resistor in parallel with the high-level output for the first channel, as in figure 5. Play the test tape and, if adjustment is possible, set the output level to 250 mV rms. Tune the distortion analyzer to reject the fundamental recorded frequency and measure the harmonic distortion present. Repeat for each high-level output channel.

5.5.6 Speaker Output Tests

These tests apply only to devices having speaker output terminals.

5.5.6.1 Speaker Output Impedance Test

Load a standard level set test tape on the tape device, set the output level control to approximately mid-range and play the tape. Use the audiofrequency voltmeter to measure the open circuit voltage at the speaker output for the first channel, and then the voltage across a resistor, R, having a nominal resistance of 8.4 Ω, connected across the same speaker output. Verify that the voltage measured across R is greater than 1/2(R/8.4) times the corresponding open circuit output voltage. Repeat for each speaker output channel.

5.5.6.2 Speaker Output Voltage Test

Load a standard level set test tape on the tape device and connect the audiofrequency voltmeter and an 8-Ω resistor in parallel with the first speaker output. Play the test tape and verify that it is possible to obtain the required output voltage (7 V). Repeat for each speaker output channel.

5.5.6.3 Speaker Output Harmonic Distortion Test

Load a standard level set test tape on the tape device and connect the distortion analyzer, the audiofrequency voltmeter, and an 8-Ω resistor in parallel with the speaker output for channel 1, as in figure 5. Play the test tape and, if adjustment is possible, set the output level to 7 V rms. Tune the distortion analyzer to reject the fundamental recorded frequency and measure the harmonic distortion present. Repeat for each speaker output channel.

5.5.7 Monitor Output Tests

5.5.7.1 Monitor Output Impedance Test

Load a standard level set test tape on the tape device, set the output level control to approximately mid-range and play the tape. Use the audiofrequency voltmeter to measure the open circuit voltage at the monitor output for the first channel, and then the voltage across a resistor, R, having a nominal resistance of 8.4 Ω, connected across the same monitor output. Verify that the voltage measured across R is greater than 1/2(R/8.4) times the corresponding open circuit output voltage. Repeat for each monitor output channel.

5.5.7.2 Monitor Output Voltage Test

Load a standard level set test tape on the tape device and connect the audiofrequency voltmeter and an 8-Ω resistor in parallel with the first monitor output. Play the test tape and verify that it is possible to obtain the required output voltage (100 mV). Repeat for each monitor output channel.

5.5.7.3 Monitor Output Harmonic Distortion Test

Load a standard level set test tape on the tape device and connect the distortion analyzer, the audiofrequency voltmeter, and an 8-Ω resistor in parallel with the monitor output for the first channel, as in figure 5. Play the test tape and, if adjustment is possible, set the output level to 100 mV rms. Tune the distortion analyzer to reject the fundamental recorded frequency and measure the harmonic distortion present. Repeat for each monitor output channel.

5.5.8 Record-Level Indicator Tests (Type II and III Only)

Inspect the record-level indicators to verify that they are plainly marked as to the channel they serve. Load a blank test tape on the tape device and connect the audiofrequency generator to the first high-level input channel through the transformer circuit shown in figure 4. Verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Connect the audiofrequency voltmeter in parallel with the high-level input of the channel being tested and set the generator frequency to 500 Hz. Set the tape device controls as follows: record level control to 3/4 maximum rotation, monitor audio source, and record mode. Adjust the generator output voltage to produce a typical record-level indication, and note the generator output voltage shown on the voltmeter. Reduce the generator output voltage to 1/20 (−20 dB) its initial value. This action should produce a perceptible indication on the record-level indicator. Increase the generator output to 5.6 (15 dB) times the initial voltage for 30 s, and return to the initial voltage. Verify that the record-level indicator is undamaged. Repeat for each tape device channel.

5.6 Electronic Tests

5.6.1 Frequency Response Tests

5.6.1.1 Playback Frequency Response Test

Connect the audiofrequency voltmeter to the high-level audio output in parallel with a 600-Ω resistor and load the reproduce alignment test tape on the tape device. Play the test tape which may be monitored via the monitor earphone jack. Using the reference frequency, adjust the output level controls to a convenient reading on the output voltmeter or, if no adjustment is possible, note the meter reading. Vary the audio output frequency from 250 Hz to 6.5 kHz and note the maximum and minimum voltmeter readings. Calculate the maximum output deviation in decibels from the formula

$$20 \log_{10} \left(\frac{V_{max}}{V_{min}} \right)$$

where V_{max} is the maximum voltage reading and V_{min} is the minimum voltage reading between 250 Hz and 6.5 kHz.

Repeat for each high-level audio output channel.

5.6.1.2 Overall Frequency Response Test (Type II and III Only)

Connect the audiofrequency generator to the first microphone input channel through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the microphone input terminal is 0.7 mV at 500 Hz. Record this frequency on the blank test tape, adjusting the record level control so that, on playback, the output voltage obtained is the same as that produced by the playback of the reference frequency on the reproduce alignment test tape. Vary the signal generator frequency from 250 Hz to 6.5 kHz and record and play back all frequencies. Note the output level at points of maximum and minimum response and calculate the maximum output deviation as in section 5.6.1.1.

Vary the audio generator frequency slowly from 20 to 250 Hz and from 6.5 to 20 kHz while again recording on the blank tape. During playback, note the maximum reproduced output in these frequency bands. Compare these maxima with the maximum response previously noted. Repeat for each tape device channel.

5.6.2 Signal-to-Noise Ratio Test

5.6.2.1 Type I

Connect the audiofrequency voltmeter to the high-level output in parallel with a 600-Ω resistor and load the standard level set test tape on the tape device. Replay the reference level from the test tape and adjust the output level control to obtain an output of 250 mV, or if no adjustment is possible, note the output voltmeter reading (V_s). Advance the tape to the unrecorded portion of the tape and note the new meter reading (V_n). Calculate the signal-to-noise ratio from the formula $20 \log_{10} (V_s/V_n)$.

Repeat for each playback channel.

5.6.2.2 Type II and III

Connect the audiofrequency voltmeter to the high-level output in parallel with a 600-Ω resistor. Load the standard level set test tape on the tape device, play it, and adjust the output level controls to obtain 250 mV rms on the output voltmeter or, if no adjustment is possible, note the meter reading. Remove the standard level set test tape and replace it with a blank test tape. Connect the audiofrequency generator to the first microphone input channel through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the input terminals is 0.7 mV rms at 500 Hz. Record the generator signal for approximately 20 s on the blank test tape with the record level controls set such that, upon playback, the tape device output level is equal to that obtained from the reference level on the standard level set test tape. Then disconnect the signal generator and replace it with a 200-Ω resistor. Record several additional feet of tape in the absence of an input signal. Replay this tape, and note the output level voltage of the recorded signal (V_s) and the output voltage of the recording in the absence of a signal (V_n). Calculate the signal-to-noise ratio from the formula $20 \log_{10} (V_s/V_n)$. Repeat for each tape device channel.

5.6.3 Interchannel Crosstalk Ratio Test (Type II and III Only)

Connect a 600-Ω resistor to the high-level output for each channel of the tape device and load the standard level set test tape on the tape device. Play the level set test tape and set the output level controls to produce an output of 250 mV (V_s) for each channel or, if no adjustment is possible, note the meter readings for each channel. Replace the standard level set test tape with a blank test tape and connect the audiofrequency generator output to all microphone inputs of the tape device through the circuit shown in figure 4 and verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Adjust the generator so that the differential input voltage at the microphone input terminal is 0.7 mV rms at 500 Hz. Record the generator signal on the test tape and set the record-level volume controls such that, upon playback, the output voltage, V_s, for each channel is the same as that obtained during the playback of the standard level set test tape. For the channel under test, disconnect the generator from the corresponding microphone input and replace it with a 200-Ω resistor. Continue to apply the signal to the remaining channels and correct for any change in level due to loading. Record about 15 s of tape with each channel, in turn, as the blank channel (only the resistor as input). Play back the recorded sections of tape noting the output voltages of the blank channels, V_c. Calculate the crosstalk ratio from the formula $20 \log_{10} (V_s/V_c)$. Repeat for each tape device channel.

5.6.4 Recorded Tape Protection Test (Type III Only)

Load the standard level set test tape on the tape device and connect the audiofrequency voltmeter in parallel with a 600-Ω resistor to the first high-level output channel. Play the standard level set test tape and set the output level to a convenient meter reading or, if no adjustment is possible, note the meter reading. Replace the standard level set test tape with a blank test tape and connect the audiofrequency generator to the input channel being tested through the circuit shown in figure 4. Verify that the frequency response is within ±1 dB between 50 and 10,000 Hz. Set the frequency of the generator to 500 Hz and reduce the generator output to zero. Set the tape device to monitor tape and place it in the record mode. Note the tape position indicator reading and then record for 30 s with zero input. Adjust the generator output amplitude until the output level on the audiofrequency voltmeter is 28 dB below the output voltage noted for the standard level set test tape. Continue recording and slowly increase the generator output voltage until the differential input voltage at the microphone terminals is 0.7 mV rms. Do not exceed this voltage. Record for 30 s more. Rewind the tape and position it at the noted tape position indicator setting. Place the tape device in the record mode and start it. Verify that it operates for approximately 30 s and then stops when the tape reaches the part with the previously recorded signal.

Repeat for each input channel.

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