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TECHNOLOGY ASSESSMENT PROGRAM

Mobile Digital Equipment

NIJ Standard–0215.01

ABOUT THE TECHNOLOGY ASSESSMENT PROGRAM

The Technology Assessment Program is sponsored by the Office of Development, Testing, and Dissemination of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Technology Assessment Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationwide and internationally.

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U.S. DEPARTMENT OF JUSTICE
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FOREWORD

This document, NIJ Standard-0215.01, Mobile Digital Equipment, 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 (NIJ). 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 must meet to conform to the needs of criminal justice agencies for high quality service. Purchasers may use the test methods described in this report to determine firsthand whether a particular piece of equipment meets the standards, 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, with compliance guaranteed by the vendor or attested to by an independent laboratory.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance about the capabilities of mobile digital equipment, user guides are also published. The guides explain in nontechnical language how to select equipment capable of performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

Lester D. Shubin
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National Institute of Justice

NIJ STANDARD FOR MOBILE DIGITAL EQUIPMENT

CONTENTS

COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere
ac	alternating current
AM	amplitude modulation
cd	candela
cm	centimeter
CP	chemically pure
c/s	cycle per second
d	day
dB	decibel
dc	direct current
°C	degree Celsius
°F	degree Fahrenheit
diam	diameter
emf	electromotive force
eq	equation
F	farad
fc	footcandle
fig.	figure
FM	frequency modulation
ft	foot
ft/s	foot per second
g	acceleration
g	gram
gr	grain
H	henry
h	hour
hf	high frequency
Hz	hertz (c/s)
i.d.	inside diameter
in	inch
ir	infrared
J	joule
L	lambert
L	liter
lb	pound
lbf	pound-force
lbf·in	pound-force inch
lm	lumen
ln	logarithm (natural)
log	logarithm (common)
M	molar
m	meter
min	minute
mm	millimeter
mph	mile per hour
m/s	meter per second
N	newton
N·m	newton meter
nm	nanometer
No.	number
o.d.	outside diameter
Ω	ohm
p.	page
Pa	pascal
pe	probable error
pp.	pages
ppm	part per million
qt	quart
rad	radian
rf	radio frequency
rh	relative humidity
s	second
SD	standard deviation
sec.	section
SWR	standing wave radio
uhf	ultrahigh frequency
uv	ultraviolet
V	volt
vhf	very high frequency
W	watt
λ	wavelength
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})
c	centi (10^{-2})
m	milli (10^{-3})
μ	micro (10^{-6})
n	nano (10^{-9})
p	pico (10^{-12})
da	deka (10)
h	hecto (10^{2})
k	kilo (10^{3})
M	mega (10^{6})
G	giga (10^{9})
T	tera (10^{12})

COMMON CONVERSIONS
(See ASTM E380)

ft/s×0.3048000=m/s
ft×0.3048=m
ft·lbf×1.355818=J
gr×0.06479891=g
in×2.54=cm
kWh×3 600 000=J
lb×0.4535924=kg
lbf×4.448222=N
lbf/ft×14.59390=N/m
lbf·in×0.1129848=N·m
lbf/in^2×6894.757=Pa
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 MOBILE DIGITAL EQUIPMENT

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for mobile digital equipment used by law enforcement agencies. This standard supersedes NIJ Standard-0215.00 dated May 1983 and incorporates changes in the requirements for error sensitivity, keyboard and the interface with mobile transceivers. This revision was necessitated by the improvements in transmission speeds and information throughput of the past decade.

2. CLASSIFICATION

For the purpose of this standard, mobile digital equipment is classified as follows:

2.1 Type 1

Mobile digital devices that transmit and/or receive preformatted messages.

2.2 Type II

Mobile digital devices that transmit and receive randomly composed messages using a keyboard and either a hard-copy or soft-copy display.

2.3 Type III

Mobile digital devices that receive randomly composed messages and utilize either a hard-copy or a soft-copy display.

3. DEFINITIONS

The principal terms used in this document are defined in this section. Additional definitions relating to law enforcement communications are given in LESP-RPT-0203.00, Technical Terms and Definitions Used with Law Enforcement Communications Equipment (Radio Antennas, Transmitters, and Receivers) [1][1].

3.1 Audio Output Power

The audiofrequency power dissipated in a load across the receiver output terminals of an unsquelched receiver having a modulated radio frequency (rf) signal input.

3.2 Baud (Bd)

A unit of signaling speed equal to the number of discrete conditions or signal events per second. For example, 1 Bd equals 1 bit per second (b/s) in a train of binary signals, one 2-b value per second in a train of signals each of which can assume one of four different states, etc.

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

3.3 Buffer

A storage device used to compensate for a difference in rate of flow of information or time of occurrence of events when transferring data from one device to another.

3.4 Carrier Attack Time

The time required, after the carrier control switch is activated, for the transmitter to produce 90 percent of the rated carrier output power.

3.5 Character

A group of bits that are used to form a letter, numeral, punctuation, or other symbol.

3.6 Data Rate

The amount of representation in a form such as bits or characters per unit time.

3.7 Digital Message

A digital transmission or a series of digital transmissions that provide recognizable information.

3.8 Error Rate

The ratio of the number of elements of a digital transmission incorrectly received to the number of elements of the transmission received (e.g., bit error rate, character error rate, or transmission error rate). If the number of digital transmissions used to formulate a message is unidentifiable to the user, then message error rate may be used.

3.9 Error Sensitivity

The level of receiver audio output (expressed as SINAD ratio), at which the error rate achieves a specified value. (See sec. 3.19).

3.10 Frequency Deviation

In frequency modulation, the peak difference between the instantaneous frequency of the modulated wave and the unmodulated carrier frequency.

3.11 Harmonic Distortion

The nonlinear distortion of a system or transducer characterized by the appearance in the output of harmonics, in addition to the fundamental component, when the input wave is sinusoidal.

3.12 Information Throughput

The amount of usable data received per unit time.

3.13 Luminance (Photometric Brightness)

The luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction.

3.14 Luminance Contrast

The relationship between the luminance of an object and the luminance of its immediate background.

3.15 Nominal Value

The numerical value of a performance characteristic as specified by the manufacturer.

3.16 Photometer

An instrument for measuring photometric quantities such as luminance, luminous intensity, luminous flux, and illumination.

3.17 Receiver Attack Time

The time required for a receiver to reach 90 percent of rated audio output power after application of a modulated rf signal.

3.18 Sampler

A device that couples rf energy from a transmission line into a third port without changing the signal waveform.

3.19 SINAD Ratio

A measure of the audio output of a receiver expressed in decibels, equal to the ratio of (1) signal plus noise plus distortion to (2) noise plus distortion; from *SI*gnal *N*oise *A*nd *D*istortion *Ratio*.

3.20 Simple Character Parity

A self-checking code, whereby a single binary digit is appended to a character to make the sum of all the bits either even or odd.

3.21 Simple Parity

A self-checking code, whereby a single binary digit is appended to an array of bits to make the sum of all the bits either even or odd.

3.22 System Attack Time

The time required, after the transmitter control switch is activated, to produce 90 percent of a designated amount of audio output power at a system receiver when energized by a modulated rf signal generated by the system transmitter.

4. REQUIREMENTS

4.1 Minimum Performance Requirements

The mobile digital equipment shall meet or exceed the requirement for each characteristic as given below and as summarized in table 1.

4.2 User Information

A nominal value for audio output power and for each applicable characteristic listed in table 1 shall be included in the information supplied to the purchaser by the mobile digital equipment manufacturer or distributor. The supplier shall also furnish the operating data rate of the digital device, the range of temperatures within which the device is designed to be operated and, if applicable, the printing speed. Information on the total message structure including header, if any, source code, and any channel error detection and/or correction scheme used shall also be provided. In addition, the manufacturer shall indicate any special equipment necessary to perform the tests detailed herein, and shall provide the data necessary to enable the FM transceiver equipment to interface with the digital equipment being tested.

4.3 Test Sequence

It is suggested that each mobile digital device be subjected to the environmental tests before being tested for conformance with sections 4.5 through 4.10. For type II and III devices that use hard copy, the paper used for the subsequent tests shall be in the device during environmental testing.

TABLE 1. *Minimum performance requirements for mobile digital equipment.*

Performance Characteristic	*Requirement*		
	Type I	*Type II*	*Type III*
A. Message Duration (Maximum)	1.2 s	6.0 s	6.0 s
B. Message Duration Variance (supply voltage varied ±10% and −20%)	±0.05 s	±0.1 s	±0.1 s
C. Information Throughput	0.5 s	50 char/s	30 char/s
D. Error Sensitivity (75% error free) (12 db SINAD Reference)	15 dB	18 dB	18 dB
E. Error Sensitivity (75% error free) (12 dB SINAD Reference) (supply voltage varied ±10%)	17 dB	20 dB	20 dB
F. Error Sensitivity (75% error free) (12 dB SINAD Reference) (supply voltage varied −20%)	18 dB	21 dB	21 dB
G. Audio Output Power Loading	10%	10%	10%
H. Audio Distortion Loading	6%	6%	6%
I. Display Readability (Contrast)	2.5	2.5	2.5
J. Display Readability Variance (supply voltage varied ±10%)	±3%	±3%	±3%
K. Display Readability Variance (supply voltage varied −20%)	±5%	±5%	±5%
L. Display Brightness Adjustment	--	10%	10%
M. Display Brightness Adjustment	--	6.85 cd/m^2	6.85 cd/m^2
N. Display Memory Retention	5 V	5 V	5 V
O. Display Capacity	--	10%	10%
Environmental Characteristic			
Temperature			
R. Message Duration Variance	±0.05 s	±0.1 s	±0.1 s
S. Error Sensitivity Variance	±2 dB	±2 dB	±2 dB
Humidity			
T. Message Duration Variance	±0.05 s	±0.1 s	±0.1 s
U. Error Sensitivity Variance	±2 dB	±2 dB	±2 dB

4.4 Environmental Characteristics

The ability of the mobile digital device to operate in environmental extremes shall be determined using the test methods described in section 5.3.

4.4.1 Temperature Range

When the mobile digital device is operated at temperatures of −30 °C (−22 °F) or the lowest temperature at which the manufacturer states that the device will operate properly (sec. 4.2), whichever is lower, and is operated at 60 °C (140 °F) or the highest temperature at which the manufacturer states that the device will operate properly (sec. 4.2), whichever is higher, its performance shall not vary, with respect to the nominal value, more than item R in table 1 for message duration and ±2 dB (item S) for error sensitivity.

4.4.2 Humidity Range

After the mobile digital device has been maintained at 50 °C (122 °F) and 90 percent relative humidity for at least 8 h, its performance shall not vary, with respect to the nominal value, more than item T for message duration and ±2 dB (item U) for error sensitivity.

4.4.3 Vibration Stability

No fixed part of the mobile digital device shall come loose, nor any movable part be shifted in position or adjustment, as a result of this test.

4.4.4 Shock Stability

No fixed part of the mobile digital device shall come loose, nor any movable part be shifted in position or adjustment, as a result of this test.

4.5 Message Duration

The message duration characteristics of the mobile digital device shall be measured in accordance with section 5.4.

4.5.1 Type I Devices

The maximum message duration shall be 1.2 s (item A) including all automatic transmissions needed for error correction and/or acknowledgment and excluding system attack time. When the standard supply voltage is varied ±10 percent and −20 percent, the message duration shall not vary more than 0.05 s (item B).

4.5.2 Type II and III Devices

The maximum message duration shall be 6.0 s (item A) including all automatic transmissions needed for error correction and/or acknowledgment and excluding system attack time. When the standard supply voltage is varied ±10 percent and −20 percent, the message duration shall not vary more than 0.1 s (item B).

4.6 Information Throughput

The information throughput of the mobile digital device shall be calculated in accordance with section 5.5.

4.6.1 Type I Devices

The information throughput per error-free digital transmission shall be at least one preformatted message including all identifiers per 0.5 s (item C).

4.6.2 Type II Devices

The information throughput per error-free transmission shall be at least 50 alphanumeric characters per second (item C).

4.6.3 Type III Devices

The information throughput per error-free transmission shall be at least 30 alphanumeric characters per second (item C).

4.7 Error Sensitivity

The error sensitivity characteristics of the mobile digital device shall be measured in accordance with section 5.6.

4.7.1 Type I Devices

At least 75 percent of the preformatted digital transmissions shall be error free when the rf input to the receiver is at the 15-dB SINAD level (item D).

When the standard supply voltage is varied ±10 percent, at least 75 percent of the preformatted digital transmissions shall be error free when the rf input to the receiver is at the 17-dB SINAD level (item E). When the standard supply voltage is reduced by 20 percent, at least 75 percent of the preformatted digital transmissions shall be error free when the rf input to the receiver is at the 18-dB SINAD level (item F).

4.7.2 Type II and III Devices

When tested with a transmission consisting of a random sequence of the maximum number of characters that the device under test is capable of transmitting and/or receiving or 250 characters, whichever is smaller, at least 75 percent of all digital test transmissions shall be error free when the rf input to the receiver is at the 18-dB SINAD level (item D).

When the standard supply voltage is varied ±10 percent, at least 75 percent of the digital test transmissions shall be error free when the rf input to the receiver is at the 20-dB SINAD level (item E). When the standard supply voltage is reduced by 20 percent, at least 75 percent of the digital test transmissions shall be error free when the rf input to the receiver is at the 21-dB SINAD level (item F).

4.8 FM Transceiver Interface

The FM transceiver interface characteristics of the mobile digital device shall be measured in accordance with section 5.7.

4.8.1 Audio Output Power Loading

When connected to the mobile digital device, the interfaced receiver shall not have its audio output power decreased more than 10 percent (item G) from its value prior to connection.

4.8.2 Audio Distortion Loading

When connected to the mobile digital device, the interfaced receiver shall not have its audio distortion increased more than 6 percent (item H) from its value prior to connection.

4.8.3 Digital Data Decode Interface

The error sensitivity requirement (sec. 4.7) shall be met with the volume and squelch controls of the FM transceiver in any position.

4.8.4 General Interface Considerations

The interface between the mobile digital equipment and the mobile transceiver system shall be made using a single cable and two connectors. If it is necessary to make any interface connections to the transceiver trunk mount, then all transceiver connections shall be made at the trunk mount. In addition, the power connections from the digital equipment to the 12-V power source shall be independent of the transceiver.

A standard mobile control head and a functional interface between the mobile control head and the mobile transceiver are defined in NIJ Standard-0216.00 [2]. The primary control head connector is a D-series, 25-pin subminiature connector available from several manufacturers. If the interface is at the control head, it is suggested that the mobile digital equipment be connected using a "tee" type connector (fig. 1) which is inserted between the male plug and the female receptacle specified in NIJ Standard-0216.00 [2]. A standard jumper shall be provided with the connector to assure continuity when some connections are unused.

4.9 Display Readability

The display readability characteristics of the mobile digital device shall be measured in accordance with section 5.8.

4.9.1 Type I Devices

If illuminated panel segments or other devices such as light emitting diodes are used to indicate status conditions, these elements shall have a minimum daylight luminance contrast of 2.5 (item I).

When the standard supply voltage is varied ±10 percent, the luminance shall not vary more than 3 percent (item J). When the standard supply voltage is reduced by 20 percent, the luminance shall not vary more than 5 percent (item K).

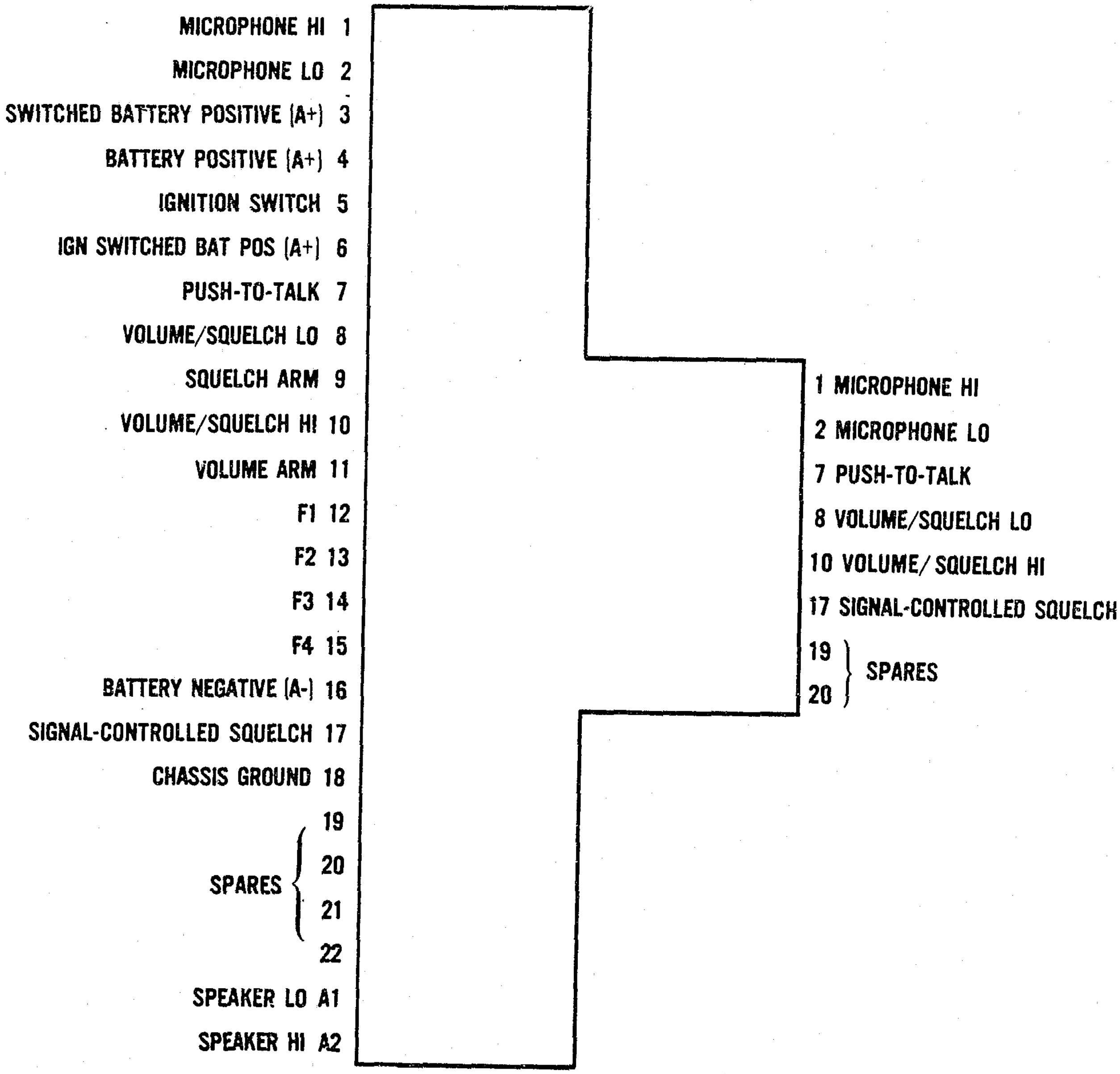


FIGURE 1. *Tee connector.*

4.9.2 Type II and III Devices with Illuminated Displays

Terminal displays which utilize luminous alphanumerics for the visual readout elements shall have a minimum daylight luminance contrast of 2.5 (item I). When the standard supply voltage is varied ±10 percent, the luminance shall not vary more than 3 percent (item J). When the standard supply voltage is reduced by 20 percent, the luminance shall not vary more than 5 percent (item K).

The luminous display brightness shall be capable of being continuously reduced by a suitable control to 10 percent (item L) of its maximum measured luminance or 6.85 cd/m^2 (20 fL) (item M), whichever is smaller.

4.10 Display Memory Retention

The display memory retention characteristics of the mobile digital device illuminated display shall be measured in accordance with section 5.9.

Once a digital message has been received and displayed on an illuminated display, all of the message shall be retained and no extraneous material added in memory when the supply voltage is reduced to 5 V (item N).

4.11 Keyboard (Type II Devices)

This portion of the standard is applicable only to mobile digital devices which have a rectangular commercial typewriter keyboard.

As shown in figure 2, it is suggested that the keyboard consist of 1 numeric row and 3 alphanumeric rows; 10 alphanumeric columns and 1 optional special character column; and 4 areas designated A, B, C, and D. In addition to the 10 numerics and the 26 letters of the alphabet shown in the diagram, three additional special characters should appear somewhere in columns 8–10. These special characters are: period (.), comma (,), and slash (/). The special character column (col. 11) and the remaining keys in columns 8–10 may be used for any other special characters.

The functions of the four designated areas should be as follows:

AREA A Status and/or special function keys or unused.

AREA B Status and/or special function keys or unused.

AREA C Status and/or special function keys, or display control, or unused.

AREA D Display control or unused.

In addition, the keyboard should be limited to the generation of upper-case letters, and the spacing control shall be at least the size of two alphanumeric keys.

The existing keys may also have alternate functions when used in combination with a special function key, and the keyboard may be skewed as on a conventional typewriter.

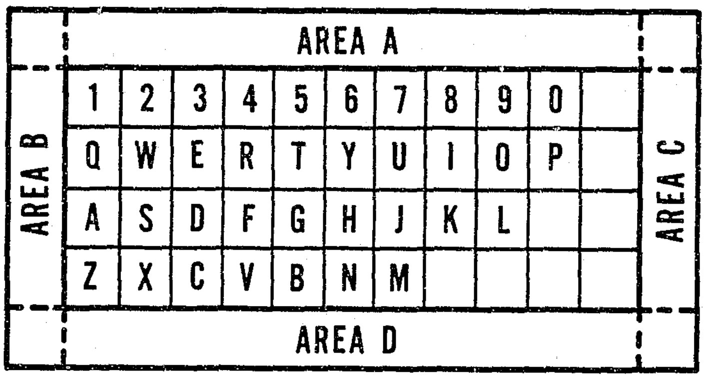


FIGURE 2. *Standard keyboard layout.*

4.12 Display Capacity (Type II and III Devices)

The mobile digital device display capacity shall be at least 10 percent (item O) of the transmit or receive buffer capacity, whichever is larger.

4.13 Error Control

4.13.1 Type I Devices

Protection against the decoding of false messages shall be provided by a method more secure than simple parity, based on a ratio of parity bits to information bits of 1-in-8.

4.13.2 Type II and III Devices

If simple character parity or a similar method of error detection is used, a single parity error shall be cause to discard the entire transmission. Transmission redundancy in excess of 50 percent of the total transmission shall not be used.

4.14 External Data Interface (Type I and II Devices)

The mobile digital equipment should provide logic outputs and logic inputs compatible with the signal levels given in EIA Standard RS-232-C [3] or transistor-transistor logic (TTL) signal levels. The data transmission format used by the mobile digital equipment shall provide four bit positions in each of the transmit and receive data formats in order to accommodate the external data. The logic interfaces shall remain in the "zero state" when not in use or unenergized. The logic functions shall be transmitted with each transmission to and from the vehicle. The logic "one" conditions received by the vehicle from the base shall be cleared (returned to the "zero state") when the primary digital message is cleared or acknowledged by the mobile terminal operator.

5. TEST METHODS

5.1 Standard Test Conditions

Allow all measurement equipment and equipment under test to warm up at least 30 min or until the system has achieved sufficient stability to perform the measurement. Unless otherwise specified, perform all measurements under standard test conditions.

5.1.1 Standard Temperature

Standard ambient temperature shall be between 20 °C (68 °F) and 30 °C (86 °F).

5.1.2 Standard Relative Humidity

Standard ambient relative humidity shall be between 10 and 85 percent.

5.1.3 Standard Power Supply Voltage

5.1.3.1 Mobile Transceiver

The standard supply voltage for the mobile transceiver used in these tests shall be 13.8 V.

5.1.3.2 Mobile Digital Equipment

In a nominal 12-V system, the standard supply voltage shall be determined from the equation $V = 13.8 - 0.02\ (I_D + I_m)$ where I_D is the current (in amperes) delivered to the mobile digital equipment and I_m is the current (in amperes) delivered to the mobile transceiver with which the digital equipment interfaces. For example, if the currents while transmitting are 4 A and 12 A for I_D and I_m, respectively, the standard supply voltage should be approximately 13.5 V. If the currents while receiving are 4 A and 1 A, respectively, the standard supply voltage will be 13.7 V. Two standard supply voltages shall be used, one for the transmit mode and the other for the receive mode. A well-filtered electronic power source should be used in place of a battery for safety and convenience. The standard supply voltage shall be applied to the input terminals of the dc supply cables (including all connectors and circuit protectors of the mobile digital equipment) and adjusted to within 1 percent of the value calculated above.

5.1.4 Standard Test Configuration

The standard test configuration shall consist of two independent equipment configurations, one designated as a base station unit and the other as a mobile unit. All the tests shall be performed on the mobile unit, although some measurements shall be taken at the base station unit in order to collect the necessary data. The transceivers used as part of the test configuration shall conform to NIJ Standard-0210.00 [4] and shall either not have special subsystems such as selective signaling or voice privacy, or shall have such subsystems bypassed or disabled during testing for compliance with this standard. The two transceivers shall be coupled to each other through coaxial cable and variable attenuator(s). A minimum of 100 dB of rf shielding shall be required between the base station and mobile unit configurations.

5.1.5 Standard Test Frequencies

The standard test frequencies shall be the transmitter and receiver operating frequencies.

5.1.6 Standard Test Modulations

5.1.6.1 Audiofrequency Test Modulation

Audiofrequency test modulation shall be a 1-kHz signal (from a source with distortion of less than 1 percent) at the level required to produce 60 percent of rated system deviation (i.e., ±3 kHz).

5.1.6.2 Digital Test Modulation

The digital audio test modulation injected into the transceiver shall be at a level required to produce 60 percent of rated system deviation (i.e., ±3 kHz).

5.2 Test Equipment

The test equipment discussed in this section is limited to that equipment which is the most critical in making the measurements discussed in this standard. Any other test equipment shall be of comparable quality.

5.2.1 Environmental Chamber

The environmental chamber(s) shall produce air temperatures of −30 and 60 °C (−22 and 140 °F) and a relative humidity of 90 percent while shielding the equipment under test from heating or cooling air currents blowing directly on it. The temperature of the equipment under test shall be measured with a thermometer separate from the sensor used to control the chamber air temperature. Likewise, humidity shall be measured with a hygrometer separate from the sensor used to control humidity.

5.2.2 Vibration Tester

The vibration tester shall be adjustable in frequency from 10 to 60 Hz, in a linear-sweep mode, and it shall be servo-controlled, with a reference signal derived from a suitable calibrated accelerometer or other calibrated sensor. It shall also provide an adjustable simple harmonic motion in at least one plane for a total excursion of 1 mm (0.04 in).

5.2.3 FM Signal Generator

The FM signal generator shall have a 50-Ω output impedance, a maximum SWR of 1.2 and a calibrated variable output level accurate to ±2 dB when terminated in a 50-Ω load. It shall also have a single sideband 1-Hz bandwidth phase noise less than −135 dB below the carrier at 25-kHz separation for carrier frequencies of 500 MHz and lower (−130 dB at 900 MHz). The generator should include a digital frequency counter having an uncertainty no greater than one part in 10^6, and a deviation monitor or calibrated control for determining the peak frequency deviation with an uncertainty of no greater than 5 percent. If an integral frequency counter is not included, a separate frequency counter having the required accuracy shall be provided.

5.2.4 Distortion Analyzer

The distortion analyzer shall have a required input level of between 1 and 5 V rms, an input impedance of at least 50,000 Ω shunted by less than 100 pF, and an accuracy of at least ±1 dB. It shall have the capability to measure both audio distortion and the rms voltage of audio signals to within ±3 percent. The analyzer shall incorporate a 1000-Hz band elimination filter for the audio distortion measurements.

5.2.5 Isolation Transformer

The isolation transformer shall have a turns ratio of 1 to 1, an impedance of 600 Ω, a frequency response within ±0.1 dB from at least 300 to 3000 Hz, and a power handling capability of 20 dBm. The isolation transformer is needed when the receiver audio output does not have an isolating circuit such as an output transformer or capacitor and the following measuring instrument (e.g., distortion analyzer) has a single ended input.

5.2.6 Standard Audio Output Load

5.2.6.1 FM Transceiver

The FM transceiver standard audio output load shall be a resistor having an impedance equal to the output impedance of the receiver and a power rating equal to or exceeding the nominal audio output power of the receiver. A filter network shall not be used between the audio output terminals and the audio output load. If an external monitor speaker is used, a matching network to maintain the standard output load impedance at the audio output terminals shall be provided.

5.2.6.2 Digital Equipment

The digital equipment standard audio output load shall be a resistor whose impedance is equal to the impedance into which the digital device normally operates. The audio output load shall have a power rating equal to or exceeding the nominal audio output of the digital device.

5.2.7 Deviation Meter

The deviation meter shall be capable of measuring the peak deviation of a modulating waveform with an uncertainty no greater than 5 percent of the deviation being monitored.

5.2.8 Attenuator

One rf attenuator shall be of the step-coaxial type, adjustable in 1-dB steps with each step accurate to within 0.1 dB, with a total range of at least 10 dB.

5.2.9 Oscilloscope

The oscilloscope shall be of the variable persistence-storage type with a time base accurate to 1 percent.

5.2.10 Audio Voltmeter

The audio voltmeter shall measure rms voltage with an uncertainty of 1 percent or less.

5.2.11 Photometer

The photometer shall be of the physical type (nonvisual) with a photopic response which closely approximates the Commission International de l'Eclairage (CIE)[2] luminous efficiency function and have optics which allow the measurement of circular areas as small as 0.01 cm (0.004 in) in diameter. The photometer shall have a full-scale sensitivity of at least 34 cd/m^2 (0.1 fL). Measurement uncertainty of the calibrated photometer shall be less than 5 percent of the reading.

5.3 Environmental Tests

Before conducting the temperature tests (sec. 5.3.1) and humidity test (sec. 5.3.2), determine the system attack time using the procedure in section 5.4.1.

5.3.1 Temperature Tests

Place the mobile digital device, with outer cases installed and with power turned off, in an environmental chamber whose temperature is maintained at the required low temperature ±2 °C (±3.6 °F). Allow the digital device to reach temperature equilibrium and maintain it at this temperature for 30 min. Turn on the power and wait 2 min. Conduct the message duration tests (sec. 5.4). With the digital device still at the required low temperature, conduct the error sensitivity tests (sec. 5.6). Repeat the above procedure at the required high temperature ±2 °C (±3.6 °F).

[2] CIE, 4 Av. du Recteur Poincare, E-75016-Paris, France.

5.3.2 Humidity Test

Place the mobile digital device, with outer cases installed and with power turned off, in the environmental chamber. Adjust the relative humidity to not less than 90 percent at 50 °C (122 °F) or more and maintain the digital device at these conditions for at least 8 h. With the digital device still in this environment, turn on the power and wait 2 min. Conduct the message duration (sec. 5.4) and error sensitivity (sec. 5.6) tests.

5.3.3 Vibration Test

Fasten the mobile digital device to the vibration tester using a rigid mounting fixture. Perform a two-part test for 30 min in each of three directions, namely parallel to each axis of the base and perpendicular to the plane of the base of the mobile digital device.

First subject the device to three 5-min cycles of simple harmonic motion having an amplitude of 0.38 mm (0.015 in) [total excursion of 0.76 mm (0.03 in)] applied initially at a frequency of 10 Hz and increased at a uniform rate to 30 Hz in 2.5 min, then decreased at a uniform rate to 10 Hz in 2.5 min.

Then subject the device to three 5-min cycles of simple harmonic motion having an amplitude of 0.19 mm (0.0075 in) [total excursion 0.38 mm (0.015 in)] applied initially at a frequency of 30 Hz and increased at a uniform rate to 60 Hz in 2.5 min, then decreased at a uniform rate to 30 Hz in 2.5 min.

Repeat for each of the other two directions.

5.3.4 Shock Test

Fasten the mobile digital device to a rigid mounting fixture and subject the digital device to a series of 10 impacts in each of three mutually perpendicular directions (sec. 5.3.3). Each impact shall consist of a half sine wave acceleration of 20-g peak amplitude[3] and 11-ms total duration applied to the mounting fixture and measured with an accelerometer.

5.4 Message Duration Tests

5.4.1 System Attack Time

In order to determine the data needed to evaluate the message duration requirement, the system attack time of the FM transceiver equipment must be determined.

Prior to measuring the system attack time, determine the 12-dB SINAD sensitivity of the receiver as follows. Connect the receiver and test equipment as shown in figure 3 for those receivers with a balanced audio output. For those receivers with an unbalanced audio output, the isolation transformer is not required.

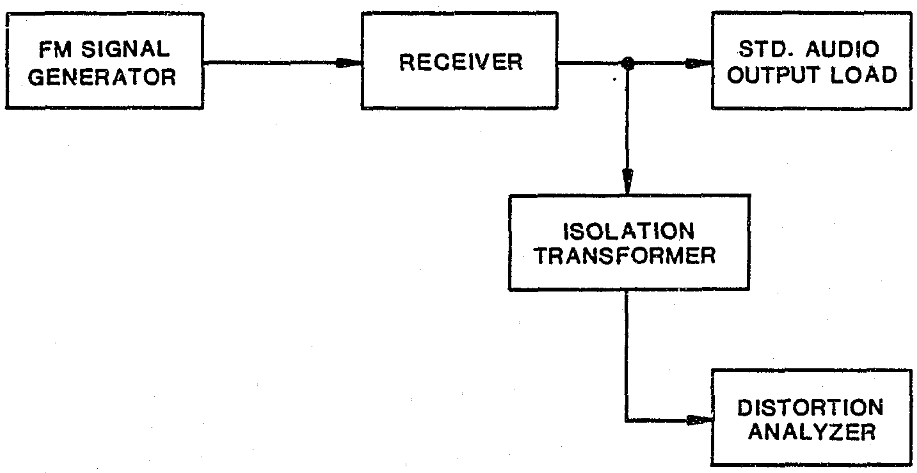


FIGURE 3. *Block diagram for SINAD sensitivity measurement.*

[3] g-acceleration due to gravity at sea level, equivalent to 9.8 m/s^2 (32.16 ft/s^2).

In either case, modulate the FM signal generator with the standard audiofrequency test modulation and adjust the generator to one of the standard test frequencies. Adjust the generator for 1-mV output, and the receiver volume control for nominal audio output power. Do not readjust the volume control for the remainder of the measurement. Decrease the output level of the generator until the SINAD ratio of the receiver is 12 dB, as determined with the distortion analyzer. Measure the audio output power to make certain it is at least 50 percent of nominal output power and record the generator output voltage. This is the 12-dB SINAD sensitivity level.

Connect the transmitter, receiver, and test equipment as shown in figure 4. Adjust the attenuator so that the rf input to the receiver is 12 dB above the 12-dB SINAD level. Adjust the volume control for nominal audio output power and the squelch control to threshold squelch. Connect the vertical input of the oscilloscope to the data receive point designated by the digital equipment supplier. Adjust the oscilloscope display so that a 10-percent change in audio output can be readily observed. Adjust the scope sync to trigger when the transmitter control is turned on. Turn the transmitter off. Leave the transmitter in the unkeyed state for at least 1 min. Operate the transmitter control switch and record the time for the recovered audio displayed on the oscilloscope to reach 90 percent of its maximum value. Record the average of three trials.

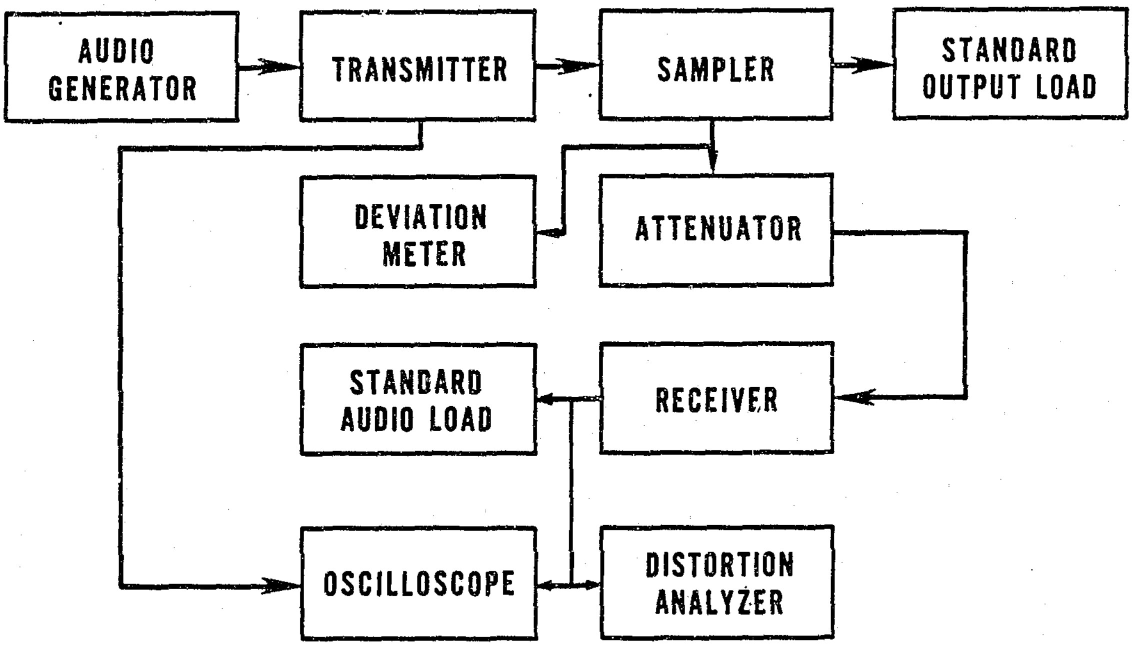


FIGURE 4. *Block diagram for system attack time measurement.*

5.4.2 Maximum Digital Transmission Duration

Connect the mobile digital device and the test equipment as shown in figure 5. Set the mobile digital device to produce a single test transmission (for type I—a single preformatted message; for type II and III—a full buffer or 250 characters, whichever is smaller). Make no further adjustments to the transmitter, attenuator, or receiver settings (they must remain the same as those used in sec. 5.4.1). However, the oscilloscope vertical displacement control may be altered so that a 10 percent change in the audio output produced by the digital transmission can be observed. Apply the keying signal to the transmitter using the digital device. Take the input to the oscilloscope sync from the FM transmitter. Leave the transmitter in the unkeyed state for at least 1 min. Initiate the test transmission by pressing the appropriate button on the digital device. Measure the time it takes for the audio produced by the digital transmission to fall to 10 percent of its maximum value. Record the average of three trials. To obtain the true digital transmission duration, subtract the average system attack time (sec. 5.4.1) from the average of the measured times.

Connect the digital audio output of the mobile digital device, which is normally connected to the FM transmitter microphone input, to a standard audio output load. Use an audio voltmeter to monitor the voltage across the load. Initiate a test transmission which will automatically repeat after a specified time delay, due to the fact that an acknowledgment has not been received by the digital device. Count the maximum number of transmissions by observing the response of the audio voltmeter and multiply by the digital transmission duration calculated in the previous paragraph to determine the maximum message duration.

Then increase the supply voltage 10 percent, allow it to stabilize 15 s, and repeat the test. Repeat the test at standard supply voltage −10 percent and −20 percent.

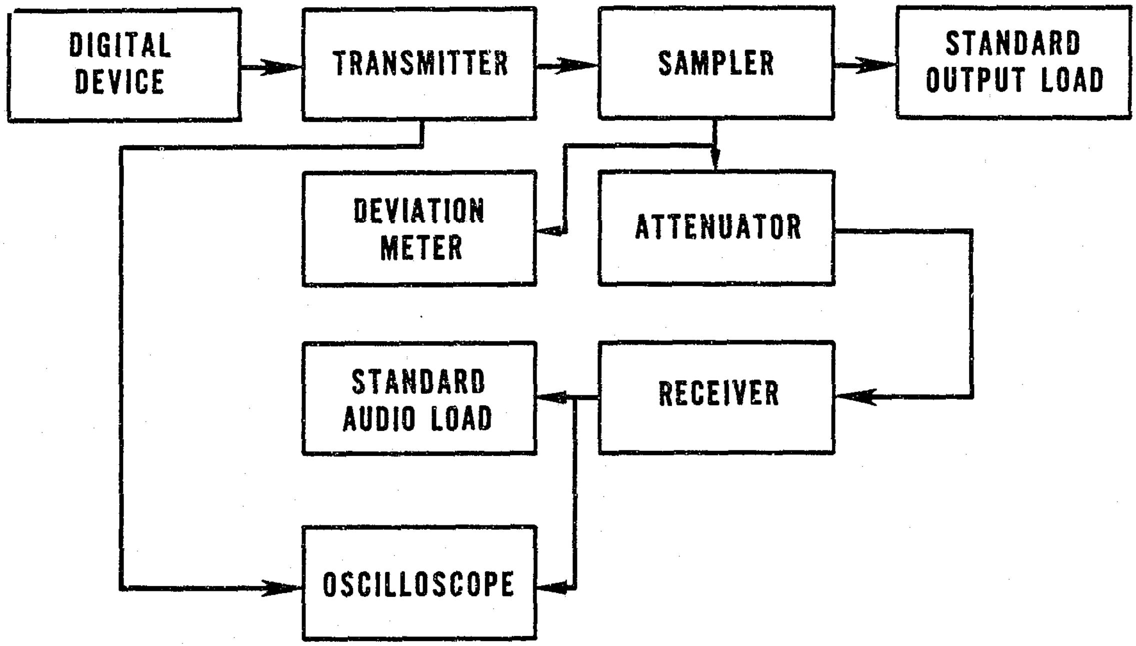


FIGURE 5. *Block diagram for digital transmission duration measurement.*

5.5 Information Throughput Tests

5.5.1 Type I Devices

Determine the information throughput rate for type I devices by examining the test data from the maximum digital transmission duration tests.

5.5.2 Type II and III Devices

Determine the information throughput rate for type II and III devices by dividing the number of characters sent by the maximum digital transmission duration measured.

5.6 Error Sensitivity Tests

Using two FM transceivers that meet the requirements of NIJ Standard-0210.00 [4], measure the 12-dB SINAD sensitivity of each receiver using the method described in section 5.4.1.

5.6.1 Type I Devices

Connect the mobile digital device to the mobile transceiver and the base station digital device to the base station transceiver as shown in figure 6. Connect the mobile transmitter to the base station receiver through a coaxial cable and attenuators (one a step attenuator). Energize all equipment. Adjust the attenuation so that the rf input to the base station receiver is 1 mV. Adjust the volume and squelch controls to that required for nominal audio output and threshold squelch, respectively. Readjust the attenuation, keeping the step attenuator approximately at midrange, so that the rf power input to the base station receiver will be 3 dB greater than that required to produce a 12-dB SINAD ratio. Select a random sample of preformatted test transmissions and transmit 40 preformatted transmissions from the mobile digital device to the base station digital device. Record the number of transmissions correctly received. Remove 2 dB of attenuation from the transmission path and increase the standard supply voltage applied to the mobile digital device by 10 percent. Transmit the 40 test transmissions again and record the number of test transmissions correctly received. Repeat this test at standard supply voltage −10 percent. Remove another 1 dB of attenuation from the transmission path and repeat the test at standard supply voltage −20 percent.

If the mobile unit is capable of receiving digital transmissions from the base station unit, interchange the transmit/receive functions of the base station and mobile units. Readjust the mobile unit supply voltage to the standard value. Readjust the attenuator to provide a 1-mV rf level to the mobile receiver. Adjust the volume and squelch controls to that required for nominal audio output and threshold squelch, respectively. Readjust the attenuator again to provide a signal level 3 dB greater than that required to produce a 12-dB SINAD rf level to the mobile receiver. Select a random sample of preformatted test transmissions and transmit 40 preformatted transmissions from the base station digital device to the mobile digital device and proceed as in the previous paragraph.

5.6.2 Type II Devices

Connect the mobile digital device to the mobile transceiver and the base station digital device to the base station transceiver as shown in figure 6. Connect the mobile receiver to the base station transmitter through a coaxial cable and attenuators (one a step attenuator). Energize all equipment. Adjust the attenuation so that the rf input to the mobile receiver is 1 mV. Adjust the volume and squelch controls to that required for nominal audio output and threshold squelch, respectively. Readjust the attenuation, keeping the step attenuator approximately at midrange, so that the rf power input to the receiver will be 6 dB greater than that required to produce a 12-dB SINAD ratio. Select a random sample of characters that formulates a test transmission not to exceed the transmit buffer of the transmitting unit, the receive buffer of the receiving unit, or 250 characters, whichever is smallest. Transmit 40 test transmissions from the base station digital device to the mobile digital device. Record the number of transmissions correctly received and continue this test as in the first paragraph of 5.6.1.

Interchange the transmit/receive functions of the base station and mobile transceivers. Adjust the mobile transceiver supply voltage to the standard value. Adjust the attenuator, if necessary, to provide a signal level 6 dB greater than that required to produce a 12-dB SINAD level to the base station receiver. Adjust the volume and squelch controls to that required for rated audio output and threshold squelch, respectively. Transmit 40 test transmissions from the mobile digital device to the base station digital device and proceed as in the above paragraph.

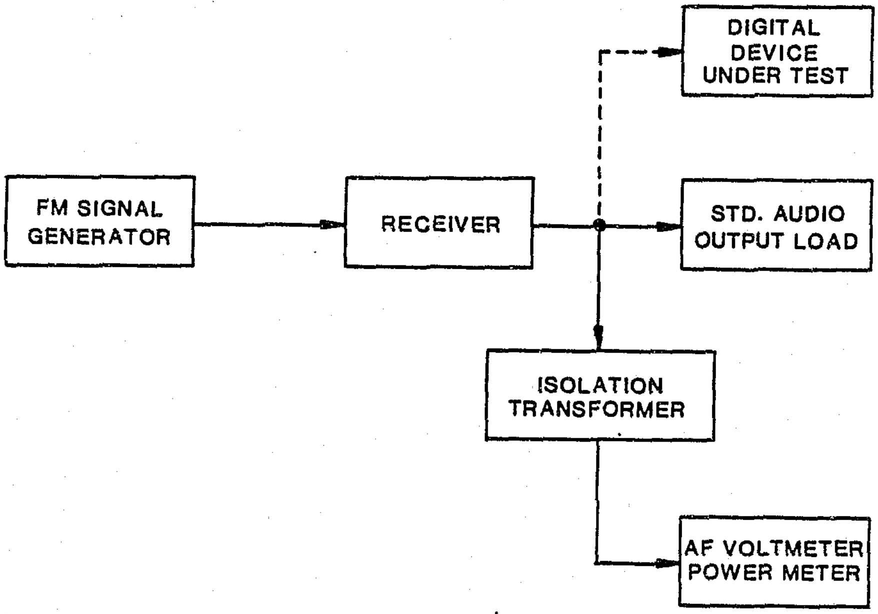
5.6.3 Type III Devices

Conduct this test exactly as in the first paragraph of 5.6.2 except that the number of characters in the test transmission shall be equal to the size of the receive buffer or 250 characters, whichever is smaller.

5.7 FM Transceiver Interface Tests

5.7.1 Audio Output Power Loading Test

Using an FM receiver which meets the requirements of NIJ Standard-0210.00 [4], connect the receiver and test equipment as shown in figure 7 with or without the isolation transformer, as necessary. Set the FM signal generator to the standard test frequency and modulate it with the standard audiofrequency test modu-



lation. With the signal generator adjusted for 1-mV output, set the receiver volume control to the maximum position. Measure the audio output power.

Connect the data receive terminals of the mobile digital device to the FM receiver and measure the audio output power.

5.7.2 Audio Distortion Loading Test

Using an FM receiver which meets the requirements of NIJ Standard-0210.00 [4], connect the receiver and test equipment as shown in figure 8 with or without the isolation transformer, as necessary. Set the FM signal generator to the standard test frequency and modulate it with the standard audiofrequency test modulation. With the generator adjusted for 1-mV output, adjust the receiver volume control until the audio output power is 5 W. Measure the audio distortion.

Connect the data receive terminals of the mobile digital device to the FM receiver and measure the audio distortion.

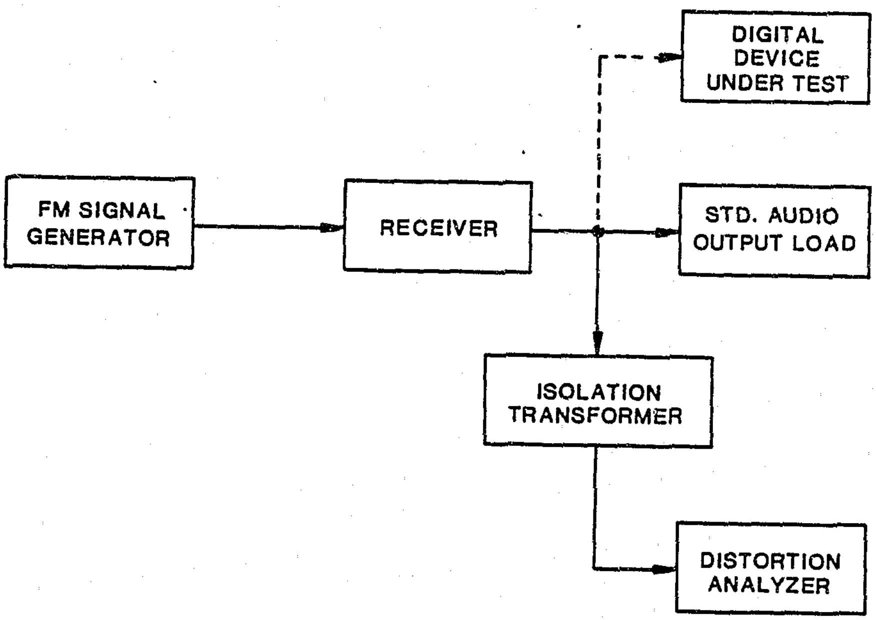


FIGURE 8. *Block diagram for audio distortion loading measurement.*

5.7.3 Digital Data Decode Interface Tests

With the FM receiver volume and squelch controls at their maximum settings, subject the mobile digital device to the error sensitivity tests outlined in section 5.6. Record the number of transmissions received correctly. Repeat for FM receiver minimum volume and squelch control positions.

5.7.4 General Interface Inspection

Visually inspect the connections between the mobile digital device and the mobile transceiver to ensure that the requirements of section 4.8.4 are met.

5.8 Display Readability Tests

5.8.1 Type I Devices

5.8.1.1 Daylight Luminance Contrast Tests

Place the digital device under test in a darkened room with the illuminated face perpendicular to the optical axis of the luminance photometer as shown in figure 9. Position a light source at an angle of 30° from the perpendicular such that 10,760 lm/m^2 (1000 fc) of illumination will be measured across the display area of the digital device. Turn on the display using standard supply voltage and activate a line segment or dot. Take luminance measurements for the elements and backgrounds of, if possible, at least three activated line segments or dots representing the left, center, and right portions of the display. Move the photometer in the horizontal plane and repeat for illumination angles of 45° and 60°. Record the values of daylight luminance contrast for each of the nine tests and calculate the average value of L_1 and L_2 (defined below). Calculate the daylight luminance contrast values from

$$C=\frac{L_1-L_2}{L_2}$$

where C is the luminance contrast, L_1 is the luminance in candelas per square meter of the luminous display element, and L_2 is the luminance in candelas per square meter of the background immediately surrounding the display element.

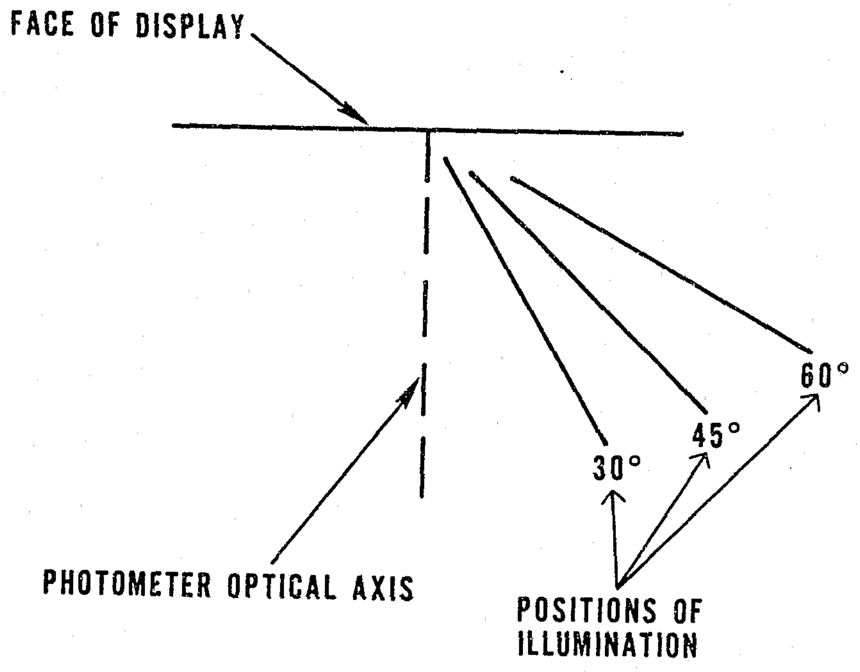


FIGURE 9. *Block diagram for display readability measurement.*

5.8.1.2 Luminance Variation Test

Place the digital device in a darkened room so that the illuminated face is perpendicular to the optical axis of the luminance photometer as shown in figure 9. Turn on the display using standard supply voltage and activate a line segment or dot. Measure the luminance of the illuminated display element and record the value. Increase the standard supply voltage +10 percent, allow it to stabilize at least 15 s, and record the luminance. Repeat the above using −10 percent and −20 percent changes in standard supply voltage.

5.8.2 Type II or III Devices with Illuminated Displays

5.8.2.1 Daylight Luminance Contrast Tests

Place the digital device in a darkened room with the illuminated face perpendicular to the optical axis of the luminance photometer as shown in figure 9. Position a light source at an angle of 30° from the perpendicular such that 10,760 lm/m^2 (1000 fc) of illumination will be measured across the display area of the digital device. Turn on the display using standard supply voltage and fill the screen with a random sample of alphanumerics. Use the photometer to measure the luminance of an individual element of a character; i.e., a single bar of a bar segment character or a single dot of a dot-matrix character. Then take luminance measurements for elements and backgrounds of at least three characters representing the left, center, and right portions of the display. Move the photometer in the horizontal plane and repeat for illumination angles of 45° and 60°. Record the values of daylight luminance contrast for each of the nine tests and calculate the average value of L_1 and L_2. Calculate the daylight luminous contrast values as in section 5.8.1.1.

5.8.2.2 Luminance Variation Tests

Place the digital device in a darkened room with the illuminated face perpendicular to the optical axis of the luminance photometer as shown in figure 9. Turn on the display using standard supply voltage and fill the screen with a random sample of alphanumerics. Measure the luminance of an individual element of a character and record the value. Change the standard supply voltage +10 percent, allow it to stabilize for 15 s, and record the luminance. Repeat the above using −10 percent and −20 percent changes in standard supply voltage.

5.8.2.3 Display Brightness Adjustment Tests

Place the digital device in a darkened room with the illuminated face perpendicular to the optical axis of the luminance photometer as shown in figure 9. Turn on the display using standard supply voltage and fill the screen with a random sample of alphanumerics. Measure the luminance of an individual element of a character. Reduce the display illumination by adjusting the control provided on the digital device. Record the values of luminance as the display illumination is reduced to its minimum value.

5.9 Display Memory Retention Test

Connect the mobile digital device to the standard supply voltage. Cause the digital device to display a random status condition or message. At a rate of 0.5 to 1 V/s, change the supply voltage to 5 V and then increase it to the standard value.

5.10 Keyboard Inspection (Type II Devices)

Visually inspect the keyboard layout of each type II mobile digital device to ensure that it meets the requirements of section 4.11.

5.11 Display Capacity Test (Type II and III Devices)

Verify that the number of characters able to be displayed by the mobile digital device is at least 10 percent of the maximum buffer capacity.

5.12 Error Control Tests

5.12.1 Type I Devices

Examine the procedure by which error control is obtained to ensure that a method more secure than simple parity is used.

5.12.2 Type II and III Devices

Examine the data obtained from the appropriate error sensitivity test (sec. 5.6.2 or 5.6.3) to ensure that the requirement of section 4.13.2 is met.

APPENDIX A—REFERENCES

[1] Technical terms and definitions used with law enforcement communications equipment (radio antennas, transmitters and receivers). LESP-RPT-0203.00. National Institute of Justice, U.S. Department of Justice, Washington, DC; 1973 July.

[2] Control heads and cable assemblies for mobile FM transceivers. NIJ Standard-0216.00. National Institute of Justice, U.S. Department of Justice, Washington, DC; 1981 December.

[3] Interface between data terminal equipment and data communications equipment employing serial binary interchange. EIA Standard RS-232-C. Electronic Industries Association; 1969 August, Reaffirmed 1981 June.

[4] Mobile FM transceivers. NIJ Standard-0210.00. National Institute of Justice, DC; 1986 May.

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