PUB 48005

PRELIMINARY

Bell System Voice Communications
TECHNICAL REFERENCE

Functional Product Class Criteria

Telephones

January 1980

DIRECTOR—BUSINESS PREMISES ENGINEERING—
DATA AND SPECIAL SYSTEMS

PRELIMINARY

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this Technical Reference is to provide standards containing the information necessary to design and manufacture telephones which are compatible with the Bell System telecommunications network and which will provide service capability consistent with Bell System quality of service objectives for telephone service.

This Technical Reference presents criteria which are the minimum necessary to determine if a telephone is technically suitable to be considered for standardization by the American Telephone and Telegraph Co. for use by the Bell Operating Companies. The information in this Technical Reference will be useful to anyone engaged in the manufacture of telephones intended for connection to Bell System facilities and/or equipment and to those purchasing, operating, or using such equipment. The criteria and illustrative test circuits are used to evaluate the compliance of an equipment with FCC Part 68, Subpart D registration rules, its compatibility with Bell System facilities, its potential safety hazards, its performance characteristics and its susceptibility to failure under normal and abnormal environmental conditions. A telephone complies with this Technical Reference if it meets these requirements over the life of the product as specified by the manufacturer.

There are two levels of criteria in this document: mandatory (identified by the work "shall") and objective (identified by the word "desirable"). The mandatory criteria are generally concerned with safety and protection, signaling compatibility, and absolute minimum acceptable performance levels in such areas as transmission, equipment parameters, and environmental durability. But for the few exceptions which may occur under extreme or unusual circumstances (for example, an unusual circumstance would be one in which a product is shown to comply with the intent of a particular mandatory criterion but does not meet the letter of that criterion), products are required to meet all mandatory criteria in order to be considered technically suitable for standardization by AT&T.

Objective criteria represent product goals. In some instances these criteria are included in an effort to assure universal product compatibility, even with the atypical operation of certain Bell System equipment and/or facilities present in statistically small percentages. In other cases objective criteria are presented because their attainment enhances the general performance of the product in all of its contemplated Bell System applications. Where both a mandatory and objective level are presented for the same criteria, the objective level presents a goal currently identifiable as having distinct compatibility and/or performance advantages toward which future designs must strive.

This Technical Reference attempts to characterize the telephone interface to the Bell System (see 1.2, Scope) as completely and accurately as possible. However, the electrical characteristics of the equipment and facilities utilized by Bell Operating Companies to provide service in certain locations may differ from the characteristics described herein and facilities described may not be available in all locations. Furthermore, conformance with all the specifications herein will not guarantee performance or compatibility in all cases. When cases arise which have not been adequately addressed in this document, the local operating company, equipment manufacturer/supplier, and customer must mutually cooperate to resolve any resultant problems.

Criteria of a nonoperational, support nature such as administration and maintenance (documentation, installation, and maintainability) and product manufacture and support (design change classification and control, advice and assistance, training programs, engineering complaint procedures and quality assurance) are not addressed in this document. It should be recognized that technical suitability is only one of many factors which influence a decision to standardize a given product for the Bell System. Market need, economics, and feature content associated with the product also weigh heavily in standardization decisions.

1.2 Scope

This Technical Reference addresses the minimum requirements of a generic instrument which will hereinafter be called the "Basic Telephone Set" having at least a minimum set of generic functions which are necessary and sufficient to provide adequate telephone service. The Basic Telephone Set is also expected to provide the same degree of universality as is presently provided by most current Bell System single line telephones. Therefore, it may be used for either single-party or multi-party service. It may also be used with extensions, or as an extension. (If more than one set is off-hook, the resulting service over the network may not be satisfactory with respect to transmission and sidetone.) While a particular telephone design may perform additional functions to the Basic Telephone Set (such as those automatic functions described in Section 1.3), such functions shall not cause any impairment of the generic functions with respect to these requirements. Conversely, telephones designed for special uses may provide less than the generic functions of the Basic Telephone Set, for example telephones without dials, telephones without ringers or telephones not intended for use on party lines. Since these telephones are not intended to provide the service capabilities of the Basic Telephone Set, the criteria for those generic functions which are not implemented or only partially implemented obviously are not applicable.

Generally speaking the generic functions of the Basic Telephone Set are:

1. to signify when it is "on-hook" by presenting an open circuit to the dc loop supervisory circuit;

2. to signify when it is "off-hook" by drawing a certain minimum loop current;

3. to perform a user alerting function when it is on-hook and being called;

4. to provide means for dialing a number to be called;

5. to transduce voiceband acoustic energy to electrical signals for transmission on the loop;

6. to transduce voiceband electrical signals received on the loop to acoustic power;

7. to provide the necessary two port to one port hybrid connection between the above two transducers and the loop respectively;

8. to control the level of sidetone between the transmitting transducer and the receiving transducer;

9. to control the levels of each of items 5, 6 and 8 as a function of the loop loss;

10. to reduce the transmission between both transducers and the loop to an acceptably low level when on-hook, for privacy.

In concept, these standards apply to telephones not only as a single instrument, but also to all combinations of a basic instrument and its integrated components, where each combination is intended to be a marketable product. Furthermore, it is not required that every physical telephone entity complies, but that the telephone arrangement, in total, provided for a particular service complies. For example, it may be economical in some cases to provide for compatibility with the extreme of some network parameter (say the upper one percent of loop length) with an optional adjunct.

The telephone boundaries are the electrical interface with the network or PBX (tip and ring), leads to non-registered equipment, and the acoustic and mechanical interfaces with the user. The telephone may also have an electrical interface with commercial power. These interfaces are shown in Figure 1.1.

This document is restricted to telephone sets employing a close-speaking microphone and an earphone which permit a single user to carry on two-way, real-time voice communication (handset type telephone). Not included in these standards are telephone features which might be exclusively found in:

Emergency telephones
Coin telephones
Telephones with A-lead control
Telephones which contain recording devices for voice or audio information
Video and video text telephones
Special use telephones such as elevator sets and call boxes
Telephones designed for ground start operation
Telephones used in data set arrangements
Speakerphone-type telephones.

1.3 Definition of a Telephone

A telephone is a terminal instrument which permits two-way, realtime voice communication with a distant party over a network or customer premises connection. It converts realtime voice and voiceband acoustic signals into electrical signals suitable for transmission over the telephone network, and converts received electrical signals into acoustic signals. A telephone generates network control signals necessary for originating and placing an outgoing call, or it alerts the user and generates network control signals necessary for answering an incoming call or both. For the purposes of this document, the telephone generates network control signals through the following functions only:

1. One or more distinct manual actions which permit origination of an outgoing call (transfer from a steady on-hook state to a steady off-hook state) and generation of the address signals to direct the call to the called party.

2. A distinct manual action which causes cessation of the alerting signal and permits answer of an incoming call (transfer from a steady on-hook state to a steady off-hook state).

3. A distinct manual action which causes disconnection (transfer from a steady off-hook state to a steady on-hook state).

4. A distinct manual action which causes generation of a user controlled duration flash signal (short, temporary transition to an on-hook state during a steady off-hook state).

5. A distinct manual action which automatically causes machine generation of a timed disconnect signal followed by reorigination and redial of the last called number or the dialing of another number.

1.4 Part 68 of FCC Rules

Criteria which are indicated as being requirements under the Federal Communications Commission's Telephone Registration Program are not verbatim reproductions and in some cases only paraphrase the wording of Part 68, Subpart D of Title 47 of the Code of Federal Regulations. In the event that requirements which are more stringent than those in this Technical Reference are adopted in Part 68, the latter take precedence. It is important to note that the criteria of Section 2.1.5 C, D and E conform to an AT&T petition (May 10, 1977) to the FCC for a rule change to Section 68.308, Signal Power Limitations, and not to the current rule as of the date of this publication. It should also be noted that, whereas this Technical Reference addresses features applicable to party line operation (such as tip-party identification and grounded ringing), Part 68 does not. In addition, the illustrative test arrangements and procedures of this document are not derived from the Part 68, Subpart D rules but are added to the text in an attempt to clarify the intent of the criteria. The illustrative test circuits and procedures in most cases should not be considered as being representative of actual functioning test arrangements but should be viewed as simple illustrations provided to assist the reader's understanding of the rules, nor should it be construed that the illustrative test circuits and procedures are acceptable to, or have been approved by, the FCC for equipment registration purposes. Because of the foregoing, equipment designers using this Technical Reference will be required to verify that their products will be in compliance with the most current FCC Rules. Official copies of the rules related to the registration of telephone terminal equipment can be found in Volume II (containing Part 2 and Subpart L) and Volume X (containing Part 68 of the Commission's Rules and Regulations), copies of which may be purchased from the Superintendent of Documents, Government Printing Office, Washington D.C. 20402.

1.5 Continuity of Service

If a particular design of telephone makes use of commercial or battery power, it shall meet the requirements of the Basic Telephone Set if said power is removed.

1.6 Human Factors

Instructions shall be available to the user of customer owned telephones giving simple, concise instructions for all operations of the set with illustrations of controls and indicators, if any, so that use of the telephone as a Basic Telephone Set is facilitated.

Dials and controls if any, shall be arranged on the telephone so as to facilitate unencumbered use of the Basic Telephone Set.

1.7 Ringer Equivalence Number

Paragraphs 2.4.1 and 2.5.1 describe minimum on-hook resistances and impedances that are allowed to terminate a loop in order to assure proper operation of network supervisory and ringing circuits. To allow more than one telephone or a combination of telephones and other devices to terminate a loop, a Ringer Equivalence Number (REN) is assigned to each telephone. This is a weighting factor determined by its relative on-hook loading of the loop as specified in Section 68.312(c) of the FCC Rules and Regulations. In no case shall the REN of a telephone exceed 5, nor can the sum of all REN's on a particular loop exceed 5.

1.8 Environmental Conditions

Environmental conditions which can occur during the shipment, installation, storage and use are specified in Sections 5.0 and 6.0. Environmental conditions are presented as being either "normal" or "abnormal". Normal conditions are those which are likely to occur to a telephone. Because of this, the Bell System requires telephones to continue to function normally after the application of normal environmental stresses and during normal operating conditions. Conversely, abnormal conditions have a low incidence of occurrence. Equipment designers and manufacturers may find it uneconomical to develop equipment which would continue to function normally after the application of abnormal stresses or during abnormal operating conditions (although it is desirable that the equipment does). Notwithstanding the foregoing, it is required that a telephone continues to comply with the criteria in paragraph 4.0, Safety and Protection, and to all FCC Part 68 requirements after being subjected to abnormal environmental stresses and during abnormal operating conditions.

Function normally in this context has a specific meaning: a telephone functions normally when it complies with the criteria as specified in this document including all features and transmission performance requirements. In addition, a telephone that has been subjected to stresses which only occur before or during installation, functions normally if it can be installed by normal procedures and provide the intended service. A telephone that has been subjected to stresses after installation functions normally only if it does not require the attention of a craftsperson to realign it for satisfactory service. It can, however, suffer damage of a cosmetic nature after being subjected to environmental stressing.

1.9 Demonstration of Compliance

A satisfactory demonstration of compliance with the criteria specified in this Technical Reference may be accomplished by valid engineering analyses, or laboratory test results, or both.

2.0 NETWORK COMPATIBILITY

2.1 Transmission Characteristics

The electroacoustic transmission requirements given in this Technical References are based on telephones having a carbon transmitter as currently in general use in the United States. New telephones having design features differing from the above should undergo subjective testing to determine their transmission equivalence to the types in current use. Since methods for subjective testing of telephone sets have not been standardized, they will not be described in this issue.

2.1.1 Transmit Response

A. The transmit response of a telephone is a measure of its acoustic-to-electric transfer characteristics. To define the transmit response, the output voltage, the frequency response and the equalization over a given range of loop resistances are specified. No attempt is made to specify either transmit linearity or distortion in this standard.

B. The transmission level shall be measured in accordance with IEEE Standard 269 1971.* The test circuit of Figure 2B of that standard shall be used.

C. The measurement procedure shall also include the following conditions:

1. The battery feed circuit shall be that shown in Figure 2 II in IEEE Standard 269-1971.

2. Measurements shall be made for each of the following loop conditions (Wilcom Products, Inc. Artificial Cable Sections, or equivalent, may be used):

    a) 0 kilofeet,

    b) 9 kilofeet #26 GA AWG non-loaded cable,

    c) 15 kilofeet #26 GA AWG non-loaded cable.

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*IEEE Standard "Method for Measuring Transmission Performance of Telephone Sets", obtainable from the Institute of Electrical and Electronic Engineers, 345 East 47 Street, New York, New York 10017.

3. The artificial mouth (B & K Instruments, Inc. type 4219 Artificial Voice, or equivalent) shall meet the requirements of Section 4.2 of IEEE Standard 269-1971. However, the artificial mouth output shall be measured at 25 $\pm$ 1 millimeters from the mouth reference plane (lip ring) instead of 7.6 millimeters (0.3 inch). The artificial mouth output shall be adjusted to a sound pressure of 88 $\pm$ 1 dB relative to 20 micro-Pascals (uPa)* for all frequencies between 180 and 5000 Hz. The zero degree incidence free field response of the microphone shall be used in determining the sound pressure.

4. A level recorder (per Section 4.8 of IEEE Standard 269-1971) shall be connected across the 900 ohm load resistor to produce a graph of the frequency response**. The horizontal axis shall be frequency (Hz) on a logarithmic scale. The vertical axis shall be in dB relative to 1 millivolt. The recorder shall have a writing speed of approximately 100 dB per second.

5. The generator shall logarithmically sweep the frequency range from 180 to 5000 Hz. The sweep rate shall be such that one complete traverse of the 180 to 5000 Hz band requires approximately 10 seconds.

6. The telephone handset shall be mounted in a modal position (per Figure 1 of IEEE Standard 269-1971) on a test head designed for telephone measurements (B & K Instruments, Inc. type 4905 Telephone Test Head, or equivalent). The receiver shall be acoustically terminated on the artificial ear. With the handset in the modal position, the location of the microphone relative to the lip ring of the artificial mouth is thus determined by the shape of the handset.

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*1 Pa is equal to 1 Newton per square meter. 20 uPa is also the reference pressure for the commonly used term, "Sound Pressure Level (SPL)", and is equivalent to $2X10^{-5}$ Newtons per square meter, or .0002 dynes per square centimeter.

**If the input impedance of the level recorder is less than 50 Kohms, it will effectively lower the value of the 900 ohm load resistor. One solution is to change the value of the resistor so that it in parallel with the input impedance of the level recorder results in a 900 ohm load for the circuit. Alternatively, a high input impedance amplifier with known gain can be inserted between the resistor and the level recorder.

7. If the telephone has a carbon transmitter, the following additional conditions shall also apply:

    (a) The transmitter shall be conditioned using the procedure described in Paragraph 5.2.2 of IEEE Standard 269-1971 prior to the recording of each response curve.

    (b) Measurements shall be made with the transmitter diaphragm in the 45^{o} face up position to determine compliance with the loudness requirement of Paragraph. 2.1.1D and the frequency response shape requirement of Paragraph 2.1.1E.

The Transmit Objective Loudness Rating (TOLR) shall be determined for each loop condition in 2 above. Either of the methods described in IEEE Standard 661-1979* may be used.

D. Requirements:

1. The transmit objective loudness rating (TOLR) shall fall between the upper and lower limits as given in Table 2.1-1.

2. It is desirable that the TOLR for telephones not limited by present carbon technology have the mean and upper and lower limits given in Table 2.1-2.

E. The transmit frequency response curves recorded for the 0 kilofeet loop condition shall fall within the upper and lower limits of the curve shown in Fig. 2.1-1. The 1000 Hz point on the frequency response curve shall be placed at the 0 dB level in the figure when checking for compliance.

2.1.2 Receive Response

A. The receive response of a telephone is a measure of its electrical-to-acoustic transfer characteristics. To define the receive response, the acoustic output or loudness level, the frequency response, and the regulation over a given set of loop conditions are specified.

B. The its receive acoustic level shall be measured in accordance with IEEE Standard 269-1971. The test circuit of Figure 2C of that standard shall be used.

C. The measurement procedure shall also include the following conditions:

*IEEE Standard "Method for Determining Objective Loudness Ratings of Telephone Connections", obtainable from the Institute of Electrical and Electronic Engineers, 345 East 47 Street, New York, New York 10017.

(1) The battery feed circuit shall be that shown in Figure 2 II of IEEE Standard 269-1971.

(2) Measurements shall be made for each of the following loop conditions (Wilcom Products, Inc. Artificial Cable Sections, or equivalent, may be used:)

(a) 0 kilofeet.

(b) 9 kilofeet #26 GA AWG non-loaded cable.

(c) 15 kilofeet #26 GA AWG non-loaded cable.

(3) The artificial ear shall be the IEC coupler for supra-aural earphones per ANSI S3.7-1973, Method for Coupler Calibration of Earphones, instead of the one specified in IEEE Standard 269-1971. The pressure response of the microphone shall be used in determining the sound pressure generated in the coupler by the receiver.

(4) The generator shall logarithmically sweep the frequency range from 180 to 5000 Hz. The sweep rate shall be such that one complete traverse of the 180 to 5000 Hz band requires approximately 10 seconds. The generator output shall be adjusted so that the ac voltage across the 10 ohm resistor in the test circuit is -12 dBV (dBV = 20 $\log_{10}$ voltage).

(5) A level recorder (per Section 4.8 of IEEE 269-1971) shall be connected to the output of the microphone amplifier for the artificial ear to produce a graph of the frequency response. The horizontal axis shall be frequency (Hz) on a logarithmic scale. The vertical axis shall be in dB relative to 1 Pa. The recorder shall have a writing speed of approximately 100 dB per second.

(6) A sound attenuating cover (per Section 4.15 of IEEE Standard 269-1971) for the handset transmitter may be required during the recording of the receive characteristics. If the sound pressure measured in the artificial ear with the cover removed and no electrical signal applied to the test circuit is at least 20 dB below the 1000 Hz sound pressure with a-12dBV signal applied, the sound attenuating cover is not required.

(7) If the telephone being measured uses a carbon transmitter, and if the receive characteristic depends on the transmitter resistance, then the following additional conditions shall also apply:

(a) The transmitter shall be conditioned using the procedure described in Paragraph 5.2.2 of IEEE Standard 269-1971 prior to the recording of each response curve.

(b) Measurements shall be made with the transmitter in the 45° face-up position to determine compliance with the loudness requirement of Paragraph 2.1.2E and the frequency response requirement of Paragraph 2.1.2F.

D. The Receive Objective Loudness Rating (ROLR) shall be determined for each loop condition in (2) above. Either of the methods described in IEEE Standard 661 may be used.

E. Requirements:

1. The ROLR shall fall between the upper and lower limits as given in Table 2.1-3.

2. It is desirable that the ROLR for telephones not limited by present carbon technology have the mean and upper and lower limits given in Table 2.1-4.

F. The receive frequency response curves recorded for the 0 kilofeet loop condition shall fall within the upper and lower limits of the curve shown in Figure 2.1-2. The 1000 Hz point on the frequency response curve shall be placed at the 0 dB level in the figure when checking for compliance.

2.1.3 <u>Sidetone Response</u>

A. The sidetone path loss of a telephone is defined as the number of dB by which the acoustic output level of the receiver of the telephone, as measured in an artificial ear, is less than the acoustic input level to the transmitter of the same telephone set, as measured at a specified reference point of an artificial mouth.

B. Due to the limited information available, requirements concerning this parameter have not been included in this issue. However it should be noted that the subjective evaluation of the performance of a telephone and the loss/noise quality received by a far end party can be influenced by sidetone characteristics of a talker's phone.

2.1.4 <u>Noise</u>

A. Telephone noise is internally generated noise present at the tip and ring terminals of the set. It is defined as the weighted signal power delivered to a specified termination in the absence of an acoustic input to the set.

B. The telephone noise shall be measured using the test circuit shown in Figure 8 of IEEE Standard 269-1971 using a noise meter as specified in Sec. 4.14 of IEEE Standard 269-1971. The noise shall be measured with the following amounts of direct current supplied to the telephone:

90 milliamperes
60 milliamperes
30 milliamperes

C. When making the noise measurement the transmitter must be isolated from acoustic input and mechanical disturbances. The measurement shall be taken over a period of 5 seconds minimum. If the telephone being measured uses a carbon transmitter the conditioning procedure described in IEEE Standard 269-1971 paragraph 5.2.2 shall be performed prior to the measurement and the measurement shall be carried out with the transmitter diaphragm in the following positions:

vertical plane
45^{0} degrees face-up
face-up
face-down

D. The telephone noise shall not exceed 15 dBrnc.

2.1.5 <u>Signal Power Limitations</u>

A. Voiceband Metallic Signal Power in the 200 to 4000 Hz Band

(1) For internal signal sources not intended for network control signaling, the maximum power of other than live voice signals delivered to a loop simulator circuit of Figure G2 shall not exceed -9 dB with respect to one milliwatt, when averaged over any 3 second interval. No manufacturing tolerance is allowed which would permit this power to be exceeded by any unit of equipment. For manually generated tones, this limitation applies to the average power with a 40 percent duty cycle.

(2) For internal signal sources primarily intended for network control signaling, the maximum power delivered to a loop simulator circuit shall not exceed one milliwatt when averaged over any 3 second interval, during normal usage. For manually originated dual tone multifrequency (DTMF) signals, this limitation applies to the average power with a 40 percent duty cycle.

B. Metallic Signal Power in the 3995 to 4005 Hz Band

The maximum power delivered by internal signaling sources (other than those sources intended for network control signaling) in the 3995 to 4005 Hz band to a loop simulator circuit, shall be 18 dB below the maximum permitted power specified in (A) above, for the 200 to 4000 Hz band.

C. Longitudinal Voltage in the 100 Hz to 4 Kilohertz Frequency Range

The weighted root-mean-squared voltage* averaged over 100 milliseconds that is the resultant of all the component longitudinal voltages in this band after weighting according to the curve in Figure 2.1-3 shall not exceed the maximum indicated below under the conditions stated in paragraph E below. The weighting curve in Figure 2.1-3 has an absolute gain of unity at 4 kilohertz.

Frequency Range	Max RMS Voltage	Longitudinal Terminating Impedance
100 Hz to 4 kHz	-30 dBV	500 ohms

D. Voltages in the 4 Kilohertz to 1 Megahertz Frequency Range

The root-mean-squared voltage* averaged over 100 milliseconds in all of the possible 8 kilohertz bands within the indicated frequency range and under the conditions specified in paragraph E shall not exceed the maximum indicated below.

(1) Metallic Voltage

Center Frequency of 8 kHz Band	Max Voltage in All 8 kHz Bands	Metallic Terminating Impedance
8 kHz to 12 kHz	-(6.4+12.6 log f) dBV	300 ohms
12 kHz to 90 kHz	(23 - 40 log f) dBV	135 ohms
90 kHz to 1 mHz	-55 dBV	135 ohms

where f = center frequency in kilohertz of each of the possible 8 kilohertz bands beginning at 8 kHz, and

dBV = 20 $\log_{10}$ (voltage in volts).

(2) Longitudinal Voltage

*Average magnitudes may be used for signals that have peak to rms ratios of 20 dB and less. RMS limitations must be used instead of average values if the peak to rms ratio of the interfering signal exceeds this value.

Center Frequency of 8 kHz Band	Max Voltage in All 8 kHz Bands	Longitudinal Terminating Impedance
8 kHz to 12 kHz	-(18.4 + 20 log f) dBV	500 ohms
12 kHz to 60 kHz	(3 - 40 log f) dBV	90 ohms
60 kHz to 90 kHz	-68 dBV	90 ohms
90 kHz to 1 MHz	-62 dBV	90 ohms

E. Requirements in paragraphs C and D apply under the following conditions:

(1) Equipment shall comply with the limitations when connected to a termination equivalent to the circuit depicted in Figure 2.1-4 and when placed in all operating states of the equipment except during network control signaling.

(2) Equipment shall comply with the limitations in off-hook states over the range of loop currents that would flow with the equipment connected to a loop simulator circuit.

(3) Equipment shall comply with the limitations with a 1000 Hz acoustic signal applied to the electroacoustic transducer that results in a power delivered into the 600 ohm load impedance of 13 dBm.

F. Demonstration of Compliance (Paragraphs A-E)

The signal power is measured with the equipment in all of its on-hook and off-hook modes and for all values of dc loop current that it can draw from the loop simulator circuit.

Figure 2.1-5 is an illustrative test circuit for estimating the voice band signal power averaged over a 3 second interval. The measurement is made by using a Hewlett-Packard Transmission and Noise Measuring Set, Model 3555B or a Western Electric 3-Type Noise Measuring Set, or the equivalent, when measuring speech signals (these meters do not have a 3 second averaging time, but when used on speech they give a reliable estimate of a 3 second average). While these meters are nearly equivalent, the arrangement of their control switches differ. The control settings on these meters are as follows:

WESTERN ELECTRIC 3-TYPE NOISE MEASURING SET		HEWLETT PACKARD TRANSMISSION AND NOISE MEASURING SET MODEL 3555B	
Control	Setting	Control	Setting
FUNCTION (Switch)	BRDG	INPUT (Switch)	NOISE/BRDG
NORM/DAMP (Switch)	DAMP	FUNCTION (Pushbutton)	VF/Nm 600BAL
WTG (Plug-In Network)	3Kc FLAT	NOISE WTG (Switch)	3kHz
		NORM/DAMP (Switch)	DAMP

The accuracy of this method can be somewhat improved by increasing the size of the damping capacitance in the Western Elctric 3-Type Noise Measuring Set by 150 microfarads. To do this connect the negative lead of a 150 microfarad capacitor to either terminal of the NORM/DAMP switch and connect the positive lead to ground. This allows the meter to more nearly approximate a 3 second averaging meter. (NOTE: This modification does not necessarily hold for noise meters other than the Western Electric 3-Type.)

For non-speech signals a true rms meter such as the Hewlett-Packard 3400A or equivalent can be used to estimate signal power in the voice band.

Figure 2.1-6 is an illustrative test circuit for measuring longitudinal voltage in the 100 Hz to 4 kilohertz band. The Tektronix model 7L5 Spectrum Analyzer has the capability to average signals over a 100-millisecond interval.

Paragraph D specifies voltage limits "in all possible 8 kilohertz bands" within the indicated frequency range. Common laboratory equipments such as the Tektronix model 7L5 Spectrum Analyzer shown in Figure 2.1-6, are not normally equipped with a bandwidth resolution which precisely matches the 8 kilohertz requirement. However, many spectrum analyzers are equipped with a 10 kilohertz bandwidth resolution which is acceptable for assuring compliance with the voltage limitations of this section as long as the equipment under test meets the voltage limitation. Conversely, an equipment which fails the voltage limitation in any 8 kilohertz band will also fail the voltage limitation in the corresponding 10 kilohertz band. Many spectrum analyzers also have the capability to average signals over a 100 millisecond interval.

G. On-Hook Signal Power Requirements

The power delivered into the loop simulator circuit in the on-hook state shall not exceed -55dBm within the frequency band from 200 to 4000 Hz.

H. Signaling Interference Requirements

For compliance to these signal interference requirements, the telephone shall either comply with both Paragraphs (1) and (2) below, or shall comply with the criteria of Paragraph (1) during all times and while in all states.

(1) Billing Protection

, and only

During the first 2 seconds after the telephone transfers to an off-hook state on an incoming call (answer), if the signal in the 2450 to 2750 Hz band exceeds -55 dBm, the telephone shall not deliver signals into the loop simulator circuit from sources internal to the equipment with power in the 2450 to 2750 Hz band unless at least equal power is present in the 800 to 2450 Hz band. The power of concern in both frequency bands is the power averaged over a 30 millisecond interval. In demonstrating compliance, the 2450 to 2750 Hz band may be defined with a band pass filter having a 3 dB point (3 dB loss relative to midband loss) at a frequency of 2450 Hz or lower and a 3 dB point at a frequency of 2750 Hz or higher. The 800 to 2450 Hz band may be defined by a band pass filter having a 3 dB point at a frequency of 800 Hz or higher and a 3 dB point at a frequency of 2450 Hz or lower. The midband loss of the filter defining the 2450 to 2750 Hz band shall be less than or equal to the midband loss of the filter defining the 800 to 2450 Hz band.

(2) Disconnect Prevention

The following criteria apply throughout the entire duration of a call starting 2 seconds after the telephone transfers to an off-hook state on an incoming call (answer). They apply at all times after the telephone transfers to an off-hook state on an outgoing call (origination). The criteria apply to all signals which the telephone may deliver or be caused to deliver (e.g., by a digital sequence) into the loop simulator circuit in all intended applications and modes of operation. The frequency weighted and rectified voltages in the signal band (2450 to 2730 Hz) are compared to the greater of (a) the rectified voltage of a -44 dBm sine wave or (b) the frequency weighted and rectified voltage in the guard band (800 to 2450 Hz) when the rectified voltages are averaged and compared as defined by the configuration in Figure 2.1-8. Frequency weighting functions for the two bands are as indicated in the acceptable regions of Figures 2.1-9 and 2.1-10.

The output voltage of the configuration shall not exceed zero more often than an average of once in fifteen minutes. The output voltage of the configuration shall not remain intermittently above zero for an interval of greater than 150 milliseconds in duration more often than an average of once in an hour. The voltage is considered to be intermittently above zero providing that, once it exceeds zero, it does not fall below zero for more than 30 milliseconds (i.e., each interval includes at its end a 30 millisecond interval during which the voltage is continuously below zero).

2.1.6 Peak Acoustic Pressure

A. The peak acoustic pressure is the maximum telephone handset receiver sound pressure in an artificial ear, resulting from a short high amplitude electrical pulse occurring at the tip and ring terminals of the telephone.

B. The peak acoustic pressure shall be measured by applying between the tip and ring terminals voltage surges (one of each polarity) of 800 volts peak, having a 10 microsecond maximum rise time to crest and a 560 microsecond minimum decay time to half crest and measuring the peak acoustic pressure developed in the artificial ear. The test configuration shown in Figure 2C of IEEE Standard 269-1971 may be used, except that all components shown connected externally to tip and ring shall be removed from the configuration before the surge is applied.

The received acoustic pressure shall be measured in accordance with paragraph 2.1.2 except that the sound pressure within the artificial ear shall be measured with a sound level meter having an unweighted "peak hold" mode setting.

C. The peak acoustic pressure measured in the artificial ear shall not exceed 130 dB relative to 20 uPa.

(The specified level is higher than desirable. Several subjective studies have shown that customer annoyance when experiencing loud clicks is directly related to the peak level of the clicks. Thus, it is extremely important to set the peak pressure as low as possible, but not so low as to interfere with the peaks of normal speech signals).

D. The limiting means shall not distort acoustic signals at pressures below 100 dB relative to 20 Pa.

2.1.7 Privacy

It is desirable that the telephones in the idle state not transmit intelligible speech signals to the lines.

2.1.8 Features For The Hearing Impaired

A. It is desirable that the telephone provide, or be compatible with, adjuncts which provide a magnetic field for use with hearing aid telephone coils.

B. It is desirable that the telephone have a version which is capable of amplifying the receive signal for users with hearing impairments, or be compatible with devices which provide this capability.

2.2 Loop Supervision Characteristics

A. Supervisory signals are the means by which a telephone generates a request for service, holds or releases a connection or initiates recall signals.

B. Standard call progress signals are given in AT&T Technical References PUB 47001 and PUB 47002.

C. There are four possible situations of interest in the supervision of telephone lines; these are 1) idle 2) originating 3) busy and 4) disconnect.

2.2.1 Idle State

A. This state is characterized by the combination of an on-hook signal and the absence of a connection to the talking path in the central office. The on-hook condition is defined by the on-hook resistance and impedance criteria specified in paragraphs 2.4.1 and 2.5.1.

B. To limit noise introduced into a connection by an idle (on-hook) telephone on the same line, the power delivered into the loop simulator of Figure G2 shall not exceed 10 dBrnC.

C. No dc potential shall be transmitted from the telephone to the network.

2.2.2 Originating State

A. This state is characterized by the combination of an off-hook signal and the absence of a connection to a talking path. The off-hook condition is defined by the off-hook resistance and impedance criteria specified in paragraphs 2.4.2 and 2.5.2.

B. Telephones which detect the presence of dial tone shall distinguish between dial tone and noise, where dial tone consists of 350 Hz and 440 Hz ($\pm 2\%$) at a level in excess of -26 dBm (-29 dBm per frequency) measured across a 600-ohm termination at the interface, with a noise level of 40 dBrnC. The maximum expected dial tone level is -7dBm (-10 dBm per frequency).

C. If the telephone initiates address signaling without a separate manual action subsequent to the appearance of dial tone, dialing shall commence between 70 milliseconds and 10 seconds after receipt of dial tone. Delays of 10 seconds or more may result in time-out at the central office.

D. Spurious opens, other than those due to contact bounce, that cause the loop current to fall below 17 milliamperes for longer than 1 millisecond shall not occur, unless the address signaling sequence is completed.

E. The telephone set shall maintain dc loop continuity (i.e., maintain the off-hook condition of Paragraph A above and comply with Paragraph D above) regardless of the polarity of the serving loop.

2.2.3 Talking State

A. This state is characterized by the combination of an off-hook signal and the connection to a talking path. The off-hook condition is defined by the off-hook resistance and impedance criteria specified in paragraphs 2.4.2 and 2.5.2.

B. During this state, a telephone which has originated a call shall not generate an on-hook indication longer than 100 milliseconds in duration, except to disconnect or for flash signaling.

C. A telephone which has answered an incoming call shall not generate an on-hook signal longer than 10 seconds except to signal a disconnect request.

D. If flash signaling is generated automatically, the telephone shall generate an on-hook indication of 300 milliseconds to 1 second to signal a flash request.

E. Continuity of dc loop current is not guaranteed, therefore the telephone shall not depend on such continuity for proper operation. Loop current interruption shall not cause the telephone to make a transition from one state to another.

2.2.4 Disconnect

A. This state is characterized by an on-hook signal during a connection to a talking path. The on-hook condition is defined by the on-hook resistance and impedance criteria specified in paragraphs 2.4.1 and 2.5.1.

B. A telephone with a re-dial button that provides a disconnect signal shall go on-hook for at least 1.5 seconds prior to re-origination.

2.2.5 Transitions

A. Transitions from the on-hook state to the off-hook state shall not activate the telephone receive path prior to application of the station set circuitry to the loop.

B. The loop current through a telephone when connected to a loop simulator circuit with the 600 ohm resistor and 500 microfarad capacitor therein disconnected, shall, for at least 5 seconds after the telephone goes to the normal off-hook state which would occur in response to ringing shall meet either of two conditions:

(1) be at least as great as the current obtained in the same loop simulator circuit with a 200 ohm resistance connected across tip and ring in place of the telephone, or

(2) not decrease by more than 25 percent from its maximum value attained during this 5 second interval; unless the telephone is returned to the on-hook state during the above 5 second interval.

C. Demonstration of Compliance

A telephone which has an off-hook tip to ring dc resistance of 200 ohms or less satisfies this requirement. Otherwise, the decrease in loop current during the first 5 seconds after the equipment goes off-hook is measured by using the illustrative circuit of Figure 2.4-2.

2.2.6 Spurious Off-Hook

An idle telephone shall not cause spurious off-hook signals of greater than 6 milliseconds.

2.3 ADDRESS SIGNALING

2.3.1 General

Addressing shall not be by means of a mixture of dc pulses and DTMF pulses during any single call origination.

2.3.2 DC Pulsing

NOTES:

1. The following standards apply for loop current as measured through a nonreactive load on tip and ring.

2. The following criteria insure that dial pulses generated by a telephone are compatible with dial pulse receivers. These requirements apply to both mechanical and semiconductor dialers. Failure to meet the following criteria can cause improper registration of digits, missed digits or pulse splitting. This can result in misdirected calls, time-outs, and other undesirable effects. The following requirements apply when dial pulses are generated by equipment with a dial pulsing contact bridged by a passive RC contact protection network

(resistor in series with a capacitor). In addition an optional Zener diode may be placed across the contact. The dial pulse contacts of a mechanical dial are assumed to be ideal. That is, upon opening, the dial contact impedance is essentially infinite; and upon closing, there is no voltage drop across the contact. While only mechanical dials approximate this ideal switch, the assumption is that the switching of either mechanical or semiconductor dials occurs almost instantly. Further refinements of the criteria dealing with the characteristics of semiconductor dialers are under study, e.g. quiscent currents and rise and fall times, and the need for a contact protection network in semiconductor dials.

3. Definitions:

The dial pulse break interval (break) is the time interval corresponding to the open state of the dial pulsing contact during dialing. It begins at the instant the pulsing contact stops conducting and ends at the instant the contact starts conducting. The dial pulse make interval (make) is the time interval corresponding to the closed state of the dial pulsing contact between two break intervals. It begins at the instant the pulsing contact starts conducting and ends at the instant the pulsing contact stops conducting. A break interval and an adjacent make interval constitute a dial pulse cycle. The percent break is the proportion of the dial pulse cycle occupied by the break interval, i.e., it is the percentage ratio of the dial pulse break interval to the sum of the break plus make intervals of a particular dial pulse cycle. Repetition rate (speed) in pulses per second (pps) is the reciprocal of the dial pulse cycle in seconds. A sequence of dial pulse break intervals, each pair separated by a make interval, corresponding to a digit is a dial pulse train. An interdigital interval is the interval from the end of the last break interval of a digit to the beginning of the first break interval of the succeeding digit. The terms dial pulse cycle, percent break, repetition rate, dial pulse train, and interdigital interval do not apply to the digit "1". This digit, being represented by a single break pulse, is a singular case and this break pulse shall satisfy the same requirements as break pulses in other digits. Make and break intervals are not to be confused with the time the loop current is at steady state or (approximately) zero, respectively. The transitory effects on loop currents due to bridged reactive elements are covered by requirements on bridged impedance that are included below.

A. Dial pulse address signaling shall consist of a sequence of momentary openings (breaks) of the closed loop in response to pulsing contact operation. (When tip is bridged to ring through the circuit off-hook dc resistance, the loop is closed.) The numerical value of each dialed digit shall be identical to the number of break intervals in a dial pulse train, except for the digit "0" which shall be represented by 10 break intervals.

B. The pulsing contact shall operate at repetition rates between 8 and 11 pulses per second.

C. The percent break of outgoing dial pulses generated by the telephone shall be between 58 and 64 percent. (The break interval generated by the telephone to represent the digit 1 shall be between 53 and 80 milliseconds).

D. For telephones that pulse through the transmission network, the dial pulsing contact shall be shunted by a capacitive-resistive network of minimum 0.1 microfarad (nominal 0.15 microfarad) in series with 100 to 600 ohms. This network is needed for contact generated noise suppression and to hold the peak voltage below the air breakdown voltage when dialing into step-by-step offices. (Using a Zener diode alone could hold the voltage below the air breakdown value of 300 volts, but the noise producing sharp voltage rises would still be present.)

E. For telephones that shunt the transmission network during pulsing, the contact shall be shunted by a protective network consisting of 0.33 microfarads $\pm$ 10% in series with 100 ohms $\pm$ 10%.

F. For telephones that pulse through the transmission network, the requirements of dial repetition rate (pulses per second) and minimum 58 percent break are satisfactory when the pulsing contact is shunted by a capacitive-resistive network of minimum 0.1 microfarad (nominal 0.15 microfarad) in series with 100 to 600 ohms and the Zener breakdown voltage of the pulsing contact exceeds 300 volts. If the RC network capacitance is increased above 0.1 microfarad, the speed and percent break requirements for the dial pulses shall be modified as shown in Figure 2.3-1. If the Zener breakdown voltage is decreased below 300 volts the speed and percent break requirements for the dial pulses shall be modified as shown in Figure 2.3-2. If the network capacitance is increased above 0.1 microfarad <u>and</u> the Zener voltage is decreased below 300 volts, Figure 2.3-3 shows which compensation curve to use.

G. For telephones that shunt the transmission network during dial pulsing, the dial requirements in the range of 8 to 11 pulses per second and 58 to 64 percent break are satisfactory, when the contact is shunted by an RC network consisting of 0.33 microfarads ± 10% in series with 100 ohms ± 10%.

H. Each break interval plus the succeeding make interval (if any) and each break interval plus the preceeding make interval (if any) shall fall within the area of speed and percent break specified above.

I. The minimum ac impedance across the tip and ring terminals for voltages from 1 to 10 volts rms across the device during break intervals shall conform to the requirements of Figure 2.3 4.

J. During the break intervals of the dial pulse train, the steady state resistance from tip to ring with tip grounded and tip to ring with ring grounded shall be at least 50 kilohms. This resistance is to be measured with a voltage applied across tip and ring of:

(1) Up to 300 volts when the pulsing contact is shunted by the RC contact protection network.

(2) Up to the maximum voltage that will not cause the Zener diode to break down when the pulsing contact is shunted by a Zener diode.

K. During make intervals the steady state resistance from tip and ring shorted together to ground shall be at least 150 kilohms. This resistance is measured with voltages up to 300 volts.

L. During make intervals, the equipment shall have a steady state voltage versus current characteristic V(I) that satisfies the conditions given in Figure 2.3-5.

M. If both numeric and alphabetical designations are provided, they shall be in accordance with the Figure 2.3-6.

N. At the initiation of a make interval, the total duration of transients as evidenced by a series of short makes and breaks shall not exceed 3 milliseconds in duration.

O. Spurious breaks other than those of paragraph P during any off-hook interval while in the address signaling state (after dial tone but prior to dial pulsing, during an interdigital interval, during a make interval, and after dial pulsing through a period of time equivalent to an interdigital interval) shall not exceed 1 millisecond in duration.

P. The duration of pulsing contact arcing, if any, at the initiation of a break interval, shall not exceed 0.2 milliseconds. Compliance with this requirement shall be determined by inserting the contact with its protective network in a resistive circuit with a potential of 50 volts across the open contact.

Q. Spurious makes shall not occur during a break interval.

R. If the voice transmission path is removed during dialing of each digit, it is desirable that it be reestablished as soon as possible after dialing is completed. It shall remain removed for less than 2 seconds after a single digit is dialed.

S. Whenever a special pulsing termination is bridged across tip and ring within the telephone during dialing to overcome the detrimental effects which a lumped inductance (e.g., a repeat coil) can have on dial pulses, the following standards apply:

   1. The termination shall be inserted prior to or during the first break of each dialed digit and shall remain until the last break of the digit has occurred.

   2. The termination shall be removed when the transmission path is restored.

   3. Removal of the termination shall not cause a spurious break (inductive open) that causes the loop current to fall below 17 milliamperes for longer than 1.0 millisecond.

T. For telephones that initiate dialing automatically, the first digit shall be outpulsed between 70 milliseconds and 10 seconds after reception of dial tone. The interdigital time shall be between 600 milliseconds and 3 seconds. Desirable minimum and maximum interdigital times are 700 milliseconds and 1 second, respectively.

V. In rotary dial sets, the interdigital time consists of the times required to wind up the dial plus the spinback allowance. For compatibility with dial pulse receivers, it is desirable that a time greater than 300 milliseconds be inherent in the mechanical design of the dial.

W. Dialing transients such as clicks and pops shall not occur in the receiver of the handset during dialing.

2.3.3 Dual Tone Multifrequency (DTMF)

NOTES:

(1) The elements of DTMF address signaling are defined as follows:

DTMF pulse duration is the time interval in which the instantaneous DTMF signal amplitude is at 90 percent, or greater, of its steady state amplitude.

Rise time of a DTMF pulse is the time for the instantaneous DTMF signal amplitude to reach 90 percent of steady state amplitude from the time at which both of the component frequencies (taken separately) first exceed -55 dBm.

Fall time of a DTMF pulse is the time for the DTMF signal to fall to a point where at least one of the component frequencies is -55 dBm or less from the time at which the instantaneous DTMF signal amplitude is 90 percent of its steady state value.

The interdigital interval is the time when either or both of the component frequencies are at a level less than -55 dBm.

Cycle time equals the sum of the four intervals defined above (rise time, pulse duration, fall time, and interdigital interval).

DTMF signal-on time is composed of rise time, pulse duration, and fall time. All other periods which are not signal-on times are signal-off times.

(2) The following criteria insure that DTMF address signals generated by telephones are compatible with DTMF receivers. If incompatibilities exist misdirected calls might result.

(3) To insure compatibility with custom calling features provided by some switching systems, it is desirable that the DTMF signaling capability be provided during the talking state as well as in the address signaling state.

A. DTMF pulses shall consist of two sinusoidal signals, one from a high group of three frequencies and one from a low group of four frequencies, which represent one of the 12 character sets shown below.

Nominal High Group Frequencies (Hz)

Nominal Low Group Frequencies (Hz)	1209	1336	1477
697	1	ABC 2	DEF 3
770	GHI 4	JKL 5	MNO 6
852	PRS 7	TUV 8	WXY 9
941	*	OPERATOR 0	#

A fourth frequency in the high group, 1633 Hz, is reserved for future use. This frequency with the four frequencies of the low group will permit four additional characters. In some central offices, reception of a character that includes this frequency will result in failure of the call.

B. To insure compatibility with custom calling features in ESS offices, the # and * buttons shall be capable of generating DTMF pulses at the appropriate frequencies when used for network address signaling.

C. DTMF Frequency components shall be within $\pm$ 1.5% of their nominal values.

D. DTMF generators powered by station loop current shall have the levels per frequency component and per DTMF pulse as defined in Figure 2.3-7, over the loop current range 20 to 100 milliamperes, when measured into the test circuit of Figure 2.3-8. The maximum level per pulse shall not exceed +1.0 dBm at 100 milliamperes and +4.0 dBm at 20 milliamperes. The maximum difference in levels between the frequency components of a DTMF pulse shall not exceed 4 dB, and the level of the high frequency component shall equal or exceed the level of the low frequency component.

E. DTMF generators powered from a local power source shall have the following levels:

Per Frequency, Nominal	-6 to -4 dBm
Per Frequency, Minimum, Low Group	-10 dBm
Per Frequency, Minimum, High Group	-8 dBm
Per Frequency Pair, Maximum	+2 dBm

The maximum difference in levels between the frequency components of a DTMF pulse shall not exceed 4 dB, and the level of the high frequency component shall equal or exceed the level of the low frequency component.

F. The total power of all extraneous signals in the voiceband above 500 Hz accompanying DTMF pulses shall be at least 20 dB below the level of the DTMF pulse.

G. Signal timing and pulsing rate for DTMF senders (automatic dialers) shall be as follows:

Cycle time, minimum	100 milliseconds
Pulse duration, minimum	50 milliseconds
Interdigital interval, minimum	45 milliseconds
Interdigital interval, maximum	3 seconds

The recommended range for DTMF sending is 7 to 10 pulses per second. The delay from receipt of dial tone to start of DTMF sending shall be a minimum of 70 milliseconds and a maximum of 10 seconds.

H. Each of the two sinusoidal components of the DTMF pulse shall attain at least 90% of its steady state amplitude within 5 milliseconds, and desirably within 3 milliseconds, from the time that the first component begins (exceeds 55dBm).

I. Tone leak of DTMF component signals during signal-off times of the address signaling state shall be less than -55 dBm when measured into a 600 ohm resistive test termination at tip and ring.

J. Voice energy from an electroacoustic transducer shall be suppressed by at least 45 dB relative to the normal acoustic-to-electric transmit efficiency of the voice transmitter during DTMF signal transmission. When senders are used, the suppression shall be maintained continuously until address signaling is completed.

K. Any transient voltage generated by the DTMF generator shall be constrained to occur within the first 5 milliseconds of the signal on time of the DTMF pulses and shall have a zero-to-peak level no greater than 12 dB above the zero-to-peak voltage of the steady state amplitude of the DTMF pulse.

L. The telephone impedance during generation of DTMF address signals shall have the following properties:

1. DC voltage versus current characteristics shall meet the applicable requirement of paragraph 2.4.2.

2. Return loss at the output terminals against 600 ohms shall be greater than 3.5 dB at all DTMF frequencies over the range of loop currents.

M. Simultaneously depressing two DTMF buttons shall result in a non-valid DTMF signal.

N. It is desirable that some degree of tactile feedback during button operation be provided to the user.

O. The DTMF signaling unit shall be capable of transmitting DTMF signals in the presence of both normal and reverse polarity, and shall meet all requirements of this section.

P. It is desirable that a telephone having a handset of a type that can be held to the ear while dialing provides acoustic feedback to the user's receiver (when using the DTMF dial) at a level of 85 $\pm$ 13 dB relative to 20 μPa for all possible DTMF signals, when measured with a dc loop current of 80 milliamperes and in the manner stated in paragraph 2.1.2.

2.4 Direct Current Characteristics

2.4.1 On-Hook Resistance

A. The dc resistance between tip and ring conductors, and between each of the tip and ring conductors and earth ground shall be greater than 50 megohms divided by the REN (50/REN megohms), for all dc voltages up to and including 100 volts of either polarity.

B. The dc resistance between tip and ring conductors, and between each of the tip and ring conductors and earth ground shall be greater than 150/REN kilohms for all dc voltages between 100 and 200 volts of either polarity.

2.4.2 Off-Hook Resistance

A. The off-hook tip to ring voltage versus current characteristics shall conform to the limitations given in Figures 2.3-5 and 2.4-1 for all off-hook functions. The telephone shall be measured in accordance with IEEE Standard 269-1971*.

B. Off-hook dc resistance from tip to ground and ring to ground of the telephone shall be greater than 250/REN kilohms.

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*IEEE Standard "Method for Measuring Transmission Performance of Telephone Sets", obtainable from the Institute of Electrical and Electronic Engineers, 345 East 47 Street, New York, New York 10017.

2.4.3 Tip-Party Identification

NOTE: This section applies to telephone intended for multi-party service.

A. The telephone shall contain optional connections which insert a dc path between a simplexed connection of tip and ring to ground of an originating station when in the off-hook state. The available options shall consist of either one or both of the following:

   1. a dc resistance of between 1700 and 2100 ohms.

   2. two selectable dc resistances, one between 2400 and 2950 ohms, and the other between 920 and 1140 ohms.

B. The ac impedance of the telephone with each optional connection of paragraph A above shall meet the requirements of paragraph 2.5.1.2 when on-hook.

C. The off-hook balance requirements of paragraph 2.5.3 shall be satisfied with the optional connections of paragraph A above.

D. The on-hook dc resistance requirements of paragraph 2.4.1 shall be satisfied with the optional connections of paragraph A above.

2.5 Alternating Current Characteristics

2.5.1 On-Hook Impedance

2.5.1.1 Tip To Ring

A. The impedance for frequencies from 4 Hz to 200 Hz shall be in the acceptable region shown in Figure 2.3-4 for voltages of from 1 to 10 volts rms across tip and ring of a telephone with an REN of 1. For other than an REN of 1, the impedance levels shown in Figure 2.3-4 shall be divided by the REN.

B. The impedance at frequencies from 200 Hz to 3200 Hz shall be the acceptable region shown in Figure 2.5-1 for voltages of up to 3 volts rms across tip and ring of a telephone with an REN of 1. For other than an REN of 1, the impedance levels shown in Figure 2.5-1 shall be divided by the REN.

C. During the application of test voltages, as listed in Table 2.5-1, the impedance between tip and ring (defined as the quotient of applied ac voltage divided by resulting true rms current) shall be greater than the values specified in Table 2.5-1 and this impedance shall be less than 40 kilohms. The values in Table 2.5-1 are for an REN of 1. For other than an REN of 1, the impedance levels in the table shall be divided by the REN.

This impedance (for any Ringing Type A, B, or Q) shall exceed 7000 ohms at 17 Hz and 6000 ohms at 23 Hz for applied voltages of 40-130 volts rms superimposed on a dc voltage of 0-105 volts. For Ringing Types A and B only, this impedance shall exceed 5000 ohms at 27, 30, and 33 Hz for applied voltages of 40-130 volts rms superimposed on a dc voltage of 0-52.5 volts. This design impedance (for any Ringing Type A, B, or Q) at 20 Hz with an applied voltage of 40 volts rms superimposed on a dc voltage of up to 105 volts shall exceed 8000 ohms. The design impedance (for any Ringing Type A, B, or Q) at 17 Hz shall exceed 10,000 ohms with an applied voltage of 55 volts rms superimposed on a dc voltage of up to 105 volts. These impedance levels are for an REN of 1. For other than an REN of 1, these impedance levels shall be divided by the REN.

D. During the application of test voltages as listed in Table 2.5-1 (including 20 ± 3 Hz and 30 ± 3 Hz for Ringing Type A; 20 ± 3 Hz for Ringing Type Q), it is desirable that the total dc current flowing between tip and ring does not exceed 0.2 milliamperes multiplied by the REN. It shall not exceed 0.6 milliamperes multiplied by the REN.

E. It is desirable for telephone company mechanized loop testing purposes that the telephone present a signature consisting of a recognizable on-hook impedance corresponding to one of the following:

(1) Table 2.5-2 (LC Termination)

(2) Table 2.5-3 (RC Termination)

2.5.1.2 Tip and Ring to Ground

A. The tip to ground and ring to ground impedances at 20 ± 3 Hz and 30 ± 3 Hz over the range of 40 to 130 volts rms superimposed on a dc voltage of up to ± 105 volts shall be greater than 100 kilohms.

B. The tip to ground and ring to ground impedances over the frequency range of 60 to 660 Hz for voltages up to 50 volts rms shall exceed 20 kilohms.

2.5.2 Off-Hook Impedance

2.5.2.1 Return Loss

NOTE - The return loss of a telephone shall be controlled to provide adequate margins against singing and echo. The return loss is determined by the impedance match at the telephone interface, and is defined by the following relationship:

$$RL(dB) = 20 \log_{10} \left| \frac{Z_1 + Z_2}{Z_1 - Z_2} \right|$$

where Z_1, and Z_2 are the two impedances at the interface in the frequency band of 200 to 3500 Hz.

The circuit arrangement in Figure 2.5-2 is an illustrative test circuit for the measurement of return loss.

A. The return loss, with the telephone in the off-hook state, when measured at the tip and ring terminals against a 600 ohm resistance shall be:

   (1) greater than 3.5 dB at each frequency in the frequency band from 200 Hz to 3200 Hz, and

   (2) greater than 7 dB in the frequency band from 500 Hz to 2500 Hz over all loop operating conditions.

B. It is desirable that the off-hook impedance be 600 ohms (resulting in a return loss approaching infinity).

2.5.2.2 Signaling Impedance

The source and terminating impedances during transmission of all signals which are generated internally to the telephone (other than live voice and network control signals) shall be 600 + 120 ohms, except where the transmitted signal power is a function of loop current. These limitations apply for all frequencies within the 3 dB points of the applicable frequency spectrum.

2.5.3 Balance

A. The metallic-to-longitudinal balance coefficent, $BALANCE_{m-1}$, is expressed as:

$$BALANCE_{m-1} = 20 \log_{10} \left| \frac{e_m}{e_1} \right|$$

where e_1 is the longitudinal voltage produced across a 500 ohm longitudinal termination and e_m is the metallic voltage across the tip-ring interface of the input port when a voltage (at any frequency $200 < f < 4000$ Hz) is applied from a balanced 600 ohm metallic source. The source voltage shall be set such that e_m = 0.775 volts rms (0 dBm) when a 600 ohm termination is substituted for the telephone. The minimum balance coefficent specified in paragraph 2.5.3.1 below shall be equalled or exceeded at all values of dc loop current that the telephone under test is capable of drawing when attached to a loop simulator circuit and under all reasonable conditions of the exposure of earth ground to the telephone and its associated wiring.

The circuit in Figure 2.5-3 is an illustrative test circuit for measuring longitudinal balance. The metallic-to-longitudinal balance coefficient is determined for all frequencies in the range of 200 to 4000 Hz under the high and low loop current conditions and for all on-hook and off-hook operating modes of the telephone. Measurements shall be made with exposed conductive surfaces and leads to nonregistered equipment grounded during the test.

B. The longitudinal-to-metallic balance is specified to avoid introducing excessive noise through conversion of longitudinal voltages to metallic voltages.

The longitudinal-to-metallic balance in dB is expressed as:

$$BALANCE_{l-m} = 20 \log_{10} \left| \frac{e_l}{e_m} \right|$$

where e_l is the applied longitudinal voltage and e_m is the resultant metallic voltage.

C. The longitudinal-to-metallic balance requirements of paragraph 2.5.3.2 apply for all reasonable exposures of the telephone and its associated wiring to grounded surfaces, over the range of loop currents.

2.5.3.1 Metallic To Longitudinal

The minimum metallic-to-longitudinal balance shall be 60 dB for frequencies between and including 200 Hz and 1 kHz; and 40 dB for frequencies between 1 kHz and 4 kHz, when measured with the test circuit shown in Figure 2.5-3.

2.5.3.2 Longitudinal To Metallic

The on-hook and off hook longitudinal-to-metallic balance, in dB, shall be in the acceptable region of Figure 2.5-4 at all frequencies from 60 to 4000 Hz, as measured with the test arrangement shown in Figure 2.5 5, and in accordance with IEEE Standard 455 1976*, with the following recommended changes in paragraph 9.2:

(a) The ac source shall be capable of generating frequencies up to and including 4 kHz.

(b) A frequency selective voltmeter is recommended.

*"IEEE Standard Test Procedure for Measuring Longitudinal Balance of Telephone Equipment Operating in the Voice Band", obtainable from the Institute of Electrical and Electronic Engineers, 345 East 47 Street, New York, New York 10017.

2.6 Alerting

2.6.1 General

A. The following acoustic output criteria for the alerting device (whether an electronic tone ringer or an electromechanical or bell type alerter) shall be measured at 60 volts rms tip to ring, 20 Hz with the telephone set resting on a sound reflecting surface (i.e., a hardwood table top). The acoustic output power over all voltages and frequencies at which the device is expected to operate, as specified in paragraph 2.6.2A below shall not decrease relative to the power at 60 volts rms by more than 3 dB(A).

B. Acoustic output of all alerting devices whether general or special purpose shall meet the following restrictions:

(1) Energy in the 2600 ± 150 Hz band shall not exceed the energy present at the same time in the 800 to 2450 Hz band;

(2) Energy in the 4000 ± 5 Hz band shall be at least 18 dB below the energy present at the same time in the 200 to 3995 Hz band;

(3) Energy in any two frequency components comprising a valid DTMF address digit shall not be greater than the remainder of the energy in the 500 to 2000 Hz band.

C. The telephone shall meet the off hook dc and ac characteristics of paragraphs 2.4 and 2.5 to insure proper tripping of ringing under all variations of optional connections and settings of controls.

D. The telephone shall meet the on-hook impedance requirements of paragraph 2.5.1 during ringing.

2.6.1.1 General Application Telephones

General application telephones, by virtue of their acoustic power output and spectrum are appropriate for use as the only telephone in a location. Their loudness characteristics are adequate for nearly all applications.

A. The alerting signal of a telephone with an electromechanical or bell-type alerting device shall contain two or more major frequency components (f_1 and f_2) in the 500 to 6000 Hz range with at least one major component having a mean sound power of at least 73 dB relative to 1 picowatt and a second major component having a mean sound power of at least 68 dB relative to 1 picowatt. The total mean A-weighted acoustic output power shall be at least 80 dB relative to 1 picowatt. At least one of the major components (f_1) shall be below 2000 Hz, and the nominal frequency of the higher frequency major component (f_2) shall be equal or greater than 5/4 of the lower frequency major component (i.e. $f_2 \geq 5/4\ f_1$).

B. The alerting signal of a telephone equipped with an electronic tone ringer, which does not produce an acoustic spectrum rich in overtones, shall meet the requirements of paragraph A above, except that f_1 and f_2 shall each have a mean power of at least 73 dB relative to 1 picowatt.

C. It is desirable that the alerting signal of telephones with an electromechanical or electronic alerting device have a mean sound power output of at least 78 dB for each major component and 85 dB(A) for the total mean acoustic output with the volume control at maximum setting.

D. It is desirable that at least one of the major components of an acoustic alerting signal be below 1300 Hz.

E. A telephone with an acoustic alerting device shall have a loudness adjustment accessible to the user which produces at least a 8 dB mean and a 3 dB minimum total attenation when operated from its high to low volume position.

F. It is desirable that the volume control produce a 12 dB mean and an 6 dB minimum total attenuation when operated from its high to low volume position.

G. A switch or other means for optional disabling of the acoustic alerting function may be provided, however the on-hook impedance requirements of paragraph 2.5.1 shall be satisfied with the alerting function disabled.

H. For telephones intended for multi-party service, there shall be options provided which enable connection of the ringing voltage detector between:

(1) tip and ring
(2) tip and ground
(3) ring and ground

2.6.1.2 <u>Selected Application Telephones</u>

Applications exist where the criteria for general application telephones in 2.6.1.1 need not be met. Telephones not intended for use as the only station in a location, e.g., extension sets, may have lower acoustic output levels than general application sets, or may have no alerting device at all.

A. Station sets which are not intended for use as the only station in a location but which are designed to provide an alerting function shall have an alerting signal with a total mean A-weighted acoustic output power of at least 65 dB relative to 1 picowatt when at maximum volume.

B. It is desirable that station sets not intended for use as the only stations in a location have a customer accessible volume control mechanism, and a total mean output power of at least 72 dB(A) relative to 1 picowatt when at maximum volume.

2.6.2 Bridged Ringing

A. Telephone alerting devices shall respond to the following ringing signals between tip and ring.

1. 40 to 130 volts rms, 20 Hz, superimposed on a dc voltage of 0 to ± 105 volts.

2. 55 to 130 volts rms, 17 to 23 Hz, superimposed on a dc voltage of 0 to ± 105 volts.

3. 95 to 130 volts rms, 27 to 33 Hz, superimposed on a dc voltage of 0 to ± 52.5 volts.

B. The requirements of paragraph A above shall apply where the ringing voltage is applied in the following cycles:

1. repetitive bursts of 2 seconds out of every 6 seconds, where an individual burst may be as short as 0.8 seconds.

2. repetitive bursts of 1 second out of every 4 seconds, where an individual burst may be as short as 0.6 seconds.

C. To insure alerting in response to call forwarding ringing spurts currently provided by certain PBX's it is desirable that the requirements of paragraph A are also met when ringing bursts as short as 100 milliseconds are applied.

D. The telephone ringer and/or ring detector shall not respond to:

1. signals of 10 volts rms or less, 24 Hz superimposed on -70 to 70 volts dc on tip with ring grounded, ring with tip grounded, or on both tip and ring with respect to ground;

2. ac signals of 10 volts rms or less, tip to ring or tip and ring to ground at any frequency from 5 to 1000 Hz;

3. ground on tip or ring;

4. dc voltages from 0 to ± 202 volts, tip to ring; on tip with ring grounded; on ring with tip grounded; or on both tip and ring with respect to ground.

5. ac signals of 3 volts rms or less, tip to ring, at any frequency from 1000 to 2000 Hz.

6. switchhook transients generated as a result of such operations by themselves or by an associated bridged telephone when connected on zero length loop to any of the simulated central office terminations shown in Figure 2.5-6 or when connected to the simulated Dial Long Line circuit via the simulated loop shown in Figure 2.5-7.

7. dialing (at 8 to 11 pulses per second) as tested in 6 above.

The conditions described in 1 through 3 above may be applied during telephone company initiated mechanized maintenance procedures. Such tests are applied sequentially; the series of tests may last for up to 12 seconds.

E. It is desirable that the telephone not respond to ac signals of 5 volts rms or less, tip to ring, at any frequency from 1000 to 5000 Hz.

F. If the telephone does not present a signature as described in paragraph 2.5.1.1E, it is desirable that it not alert on application of 33 volts rms at 24 Hz for 2 seconds or less, tip to ring, or tip and ring with respect to ground.

G. If an internal sensitivity control is provided, requirements (1) through (5) of paragraph D above shall apply over the full range of settings of the control. It is permissible to meet the requirement of items (6) and (7) through adjustment of the sensitivity control to a less sensitive setting, for which a higher ringer operating voltage is permitted, provided that the remainder of the requirements in this Technical Reference are satisfied. The internal sensitivity control shall not be accessible to the user.

2.6.3 Grounded Ringing

A. The ringing voltage detector shall enable the alerting function in option 2 of paragraph 2.6.1.1H when ringing voltages of paragraph 2.6.2 A and B are applied between tip and ground.

B. The ringing voltage detector shall enable the alerting function in option 3 of paragraph 2.6.1.1H when ringing voltages of paragraph 2.6.2 A and B as applied between ring and ground.

C. The alerting function shall not occur when:

1. The telephone is connected for option 2 of paragraph 2.6.1.1H when ringing voltage is applied between ring and ground.

2. The telephone is connected for option 3 of paragraph 2.6.1.1H when ringing voltage is applied between tip and ground.

3. The voltages of 2.6.2 D are applied when connected for either option 2 or option 3 of paragraph 2.6.1.1H.

3.0 PHYSICAL CHARACTERISTICS

A. The telephone shall be free of dust, dirt, solder splatters, bits of wire, and excessive grease and corrosion.

B. Assembly welds, rivets, screws, etc., shall be secure.

C. It is desirable that the components of the equipment have the following characteristics:

1. Relay contacts have adequate thickness and composition.

2. The use of materials that might creep or vaporize and condense on relay contacts causing unreliable operation of the equipment is avoided.

3. Filters are used for incoming air on systems provided with forced air circulation.

4. Mechanical components associated with signaling and supervision (e.g., dials, line switches, etc.,) are able to function properly after 160,000 complete operations, 80,000 sending and 80,000 receiving (dialing a 7 digit number is, for example, one complete operation.)

4.0 SAFETY AND PROTECTION

Fundamental criteria for safety and protection are given in Sections 4.1 through 4.3. These criteria are supplemented in Section 4.4 with physical design requirements intended to be the minimum necessary to assure continued compliance with the fundamental requirements.

For the purposes of this Section, "Class I" interface leads are tip and ring. "Class II" interface leads are leads for connection to nonregistered equipment.

Unless otherwise specified, when measured voltage levels are referenced to interface leads, they apply as follows:

(i) Voltages are applied to associated tip and ring leads, between pairs of leads, or between either or both of the leads and ground. Voltages are measured between pairs of tip and ring leads or from any individual tip and ring lead to ground. Voltages are measured with tip and ring pairs terminated in a 1500 ohm resistive load, the center tap of which is connected to ground through 1000 ohms.

ii) Voltages are applied to leads for connection to nonregistered equipment and between any combination of such leads and between individual leads and ground. Voltages are measured from a lead for connection to nonregistered equipment to ground when such lead is terminated in a 1500 ohm resistive load to ground.

4.1 Fire Prevention

A. The equipment shall not become a fire hazard:

(1) under any normal or abnormal operating or storage condition including its being subjected to electrical and physical environmental stresses specified in Sections 5.0 and 6.0 but excluding those conditions in Section 5.2(c)(2);

(2) when operated with openings for ventilation, which can be blocked during normal use, appropriately covered;

(3) in the occurrence of possible component failures or shorts between wires or terminals and adjacent wires, terminals, or grounded metal.

B. The equipment shall not become a fire hazard when subjected to voltages or grounds on interface terminals, or short circuits between them, as follows:

(1) A 60 Hz voltage up to 600 volts rms applied between network tip and ring terminals or between either terminal and green wire ground.

(2) A 60 Hz voltage up to 300 volts rms applied between any combination of terminals used for the connection of nonregistered equipment or between any such terminals and ground.

(3) A 60 Hz voltage up to 300 volts rms applied between exposed conductive surfaces and ground.

The criteria apply with an initially applied continuous 60 Hz voltage of up to 30 volts rms or such lower voltage as necessary to limit the current which flows to 100 milliamperes. The voltage is increased thereafter at a rate which does not result in an increase in voltage or current of more than 20 percent in any 15 minute interval until:

(1) the current reaches 30 amperes for (1) above or 20 amperes for (2) and (3), or

(2) the voltage reaches the maximum value specified or,

(3) the equipment fails open circuited.

If the equipment fails open circuited prior to (1) or (2) above, then an original unit of the equipment (previously unstressed) shall, in addition, meet the following: it shall not become a fire hazard when subjected to the maximum voltage and current specified above for a 15 minute interval.

It is sufficient to demonstrate compliance of one sample of the equipment with voltages applied between applicable tip and ring interface terminals and between applicable leads to nonregistered equipment (exclusive of ground reference terminals) and green wire ground and with network ports off-hook; provided it is demonstrated that the equipment complies with all the criteria in 4.4.

4.2 Electrical Hazard Prevention

4.2.1 Maximum Voltages and Currents

A. Class II Interface Leads

Voltages to ground from any Class II interface lead and voltages between any two Class II interface leads shall not exceed those specified as Zone 1 or Zone 2 voltages in B(1) and B(2). This includes voltages that must be applied to these leads to assure proper functioning of the equipment. However, this is not to be construed as permitting higher voltages than specified in requirements given in other sections of this document.

B. Internal Equipment Voltages

Internal voltages (including voltages on unit interconnecting cord or cable conductors) to which craftspersons or maintenance personnel have access shall comply with the voltage limits and associated protection specified below. Voltage limits specified below are open circuit values unless otherwise noted. When the limits are specified with the condition that the current is limited to a specified value through a specified resistance load, the limits apply for any load having a resistance equal to or greater than the value specified. Voltage limits* are as follows:

* Zone 1, Zone 2, and Zone 3 limits are currently under investigation and may be subsequently modified.

(1) Zone 1 Voltage limits.

(i) DC Voltages and Pulses: DC voltages to ground of less than 80 volts except that a dc voltage of up to 160 volts is permitted if the current through a 4000 ohm resistive load is less than 12 milliamperes. A higher dc voltage of up to 320 volts is permitted if the current through a 4000 ohm resistive load is less than 5 milliamperes. DC voltages between conductors (or terminals) of less than 160 volts, except that a voltage to ground or between conductors (or terminals) of up to 320 volts is permitted if the current through a 4000 ohm resistive load is less than 5 milliamperes. Voltages between the terminal of a capacitor shall not exceed 100 volts, or 80 volts if one terminal of the capacitor is connected to a point having a low resistance path to ground, unless the stored energy is less than 2 joules.

The foregoing limits are also applicable to the peak amplitude of unidirectional pulses and the peak-to-peak amplitude of momentary oscillatory voltages with the maximum currents applying to the peak values of unidirectional waveforms and to the peak-to-peak values of momentary oscillatory waveforms. However, the steady state ac voltage limits specified below are applicable to oscillatory voltages having a duration of greater than 0.5 seconds.

(ii) AC Voltages: For frequencies up to 100 Hz, voltages to ground of less than 42.5 volts peak (30 volts rms for sine waves) except that voltages of up to twice these values are permitted if the current through a 4000 ohm resistive load to ground is less than 6 milliamperes peak. Ac voltages (up to 100 Hz) between conductors (or terminals) of less than 85 volts peak (60 volts rms for sine waves).

For frequencies from 100 Hz to 4000 Hz, voltages to ground of less than 24 volts peak except that voltages up to twice these values are permitted if the current through a 2400 ohm resistive load to ground is less than 10 milliamperes peak. AC voltages (from 100 Hz to 4000 Hz) between conductors (or terminals) of less than 48 volts peak.

For voltages containing frequencies both below and above 100 Hz, the limit for the dominant frequency applies. However, for any frequency up to 4000 Hz, ac voltages up to 130 volts rms are permitted to ground and voltages up to 260 volts rms are permitted between conductors if the current through a 2400 ohms resistive load is less than 2.5 milliamperes peak.

(iii) Combined AC and DC Voltages: For frequencies up to 100 Hz, combined ac and dc voltages to ground as specified in Figure 4.2A except that combined voltages of up to twice the limits in Figure 4.2A are permitted if the current through a 4000 ohm resistive load to ground is limited as specified in Figure 4.2B. Combined ac (frequencies up to 100 Hz) and dc voltages between conductors (or terminals) of less than twice the limits in Figure 4.2A.

For frequencies from 100 Hz to 4000 Hz, combined ac and dc voltages to ground as specified in Figure 4.2C, except that combined voltages of up to twice the limits in Figure 4.2C are permitted if the current through a 2400 ohms resistive load to ground is limited as specified in Figure 4.2B. Combined voltages between twice the limits in Figure 4.2C. However, regardless of the foregoing, for any frequency up to 4000 Hz, combined ac and dc voltages up to 320 volts peak are permitted to ground or between conductors if the current through a 2400 ohm resistive load is less than 5 milliamperes peak-to-peak and the ac component does not exceed the limit for ac voltages alone.

(2) Zone 2 Voltage Limits

Zone 2 voltages are those which exceed Zone 1 voltage levels but do not exceed the following:

Voltages to ground of 50 volts rms ac, 140 volts dc, or 140 volts peak-to-peak for combined ac and dc voltages. If the peak-to-peak current through a 4 kilohm resistive load does not exceed 20 milliamperes the voltage to ground limits are 130 volts rms ac, 320 volts dc, and 320 volts peak-to-peak for combined ac and dc. In addition, interrupted combined ac and dc voltages which comply with the requirements for ringing voltages in (3) below are permitted. Also, interrupted combined ac and dc voltages up to 350 volts peak-to-peak are permitted provided that:

(i) the voltage is interrupted such that the voltage during an interval of at least one second out of any 2.2 seconds interval does not exceed the Zone 1 limits and

(ii) the source does not deliver more than 100 milliamperes peak-to-peak into a 2 kilohm resistive load to ground (green wire ground or any other ground reference in the equipment) and does not deliver more than 140 milliamperes peak-to-peak into a 1 kilohm resistive load to ground.

If Zone 2 voltages appear internal to the equipment, they shall be insulated, baffled, or located to preclude inadvertant contact by craftspersons working on the equipment with any removable enclosures removed. With equipment enclosures in place, it shall not be possible to contact Zone 2 voltage sources with the small end of the accessibility probe when dimension A of Figure G1 is 9.0 cm (3.5 in).

(3) Zone 3 Voltage Limits

Zone 3 voltage limits are those which exceed Zone 2 voltage levels, but do not exceed the following:

Voltages to ground of 350 volts rms ac, 600 volts dc, or 1000 volts peak-to-peak for combined ac and dc (provided neither the ac nor dc components exceed their respective limits).

Sources of Zone 3 voltages shall have the additional protection of not being accessible without the use of tools. In addition, terminals or conductors carrying Zone 3 voltages, other than those connected to commercial power, shall be identified with a label "Hazardous Voltage". Sources of Zone 3 voltages shall not be accessible with enclosures removed. This is necessary to permit craftsperson access to part of the equipment which include sources of voltages within the Zone 2 limits. With equipment enclosures in place, it shall not be possible to contact Zone 3 voltage sources with the accessibility probe with the 5.08 cm (2 in) ring removed.

C. Class I Interface Leads

Voltages to ground from any Class I interface lead and voltages between Class I interface leads which are applied for signaling, supervisory, or transmission purposes shall not exceed the values specified for such voltages and/or currents in other sections of this document.

Except for currents resulting from voltages required for signaling, supervisory, or transmission purposes, the peak current shall not exceed 0.5 milliamperes through a 1.5 kilohms resistor when connected between any pair of Class I interface leads or between any such lead and ground.

D. Leakage Currents and Voltages on Exposed Surfaces

For ac, dc, and combined ac and dc voltages and currents, the following limits apply (with any enclosure(s) in place) under all normal conditions of applied voltages (exclusive of surge voltages) specified in Section 5.2 and for all modes of operation of an equipment:

(1) The current from any 100 cm^2 (15.5 in^2) area or the entire area, whichever is smaller, of exposed surfaces (exclusive of grounded metal surfaces) flowing through a 1.5 kilohm resistive load to ground shall be less than 0.3 milliamperes peak.

(2) The current from any one cm^2 (0.155 in^2) area of exposed surface (exclusive of grounded metal surfaces) flowing through a 10 kilohm resistor to ground shall be less than 0.15 milliamperes peak.

(3) The current flowing through a 10 kilohm resistor connected between any two areas of exposed surface (exclusive of grounded metal surfaces) of 1 cm^2 (0.155 $in.^2$) each shall be less than 0.15 milliamperes peak.

For the purpose of determining compliance with these criteria, a conducting surface or metal part shall be considered grounded only if it is securely grounded (to green wire ground or to an alternative secure external ground connection). If it is not securely grounded, such a conducting surface shall be considered ungrounded. Compliance with the above is then required with any such ground connection or contact to ground which is not secure, made open-circuit to ground.

4.2.2 Fault Conditions

A. Fault on Class II Interface Leads

As a result of equipment failure conditions and a 60 Hz voltage of up to 300 volts rms applied to Class II interface leads, the following limitations apply:

(1) The voltage on Class I interface leads shall not exceed 70 volts peak for more than 1 second.

(2) The voltage from any exposed conductive surface connected to ground through a 1.5 kilohm resistive load shall not exceed 42 volts peak for more than 1 second.

This requirement applies with both the commercial power source and the applied voltage source having the capability of delivering at least 20 amperes continuously and 50 amperes for at least 1 minute. The ground reference for this requirement is green wire ground. If, however, a ground reference is included in the Class II interface leads to which voltage is applied, the requirement applies with and without such ground reference connected to green wire ground, if such an optional connection exists. The requirement applies in all operating states.

In demonstrating compliance with this requirement it is sufficient to demonstrate the compliance of one sample of the equipment with a 60 Hz voltage of 106 to 127 volts applied between all Class II interface terminals (excluding any interface ground reference) and ground. Compliance must be demonstrated for at least one of each type of interface containing Class I leads, with such interface in both the off-hook state and the on-hook state. However, it shall be demonstrated that the equipment complies with all of the requirements in Section 4.4.

B. Fault on Tip and Ring Leads

With a 60 Hz voltage of up to 600 volts rms applied to network tip and ring leads, the following limitations apply:

(1) The voltage on Class II interface leads shall not exceed 42 volts peak for more than 1 second.

(2) The voltage from any exposed conductive surface connected to ground through a 1.5 kilohm resistive load shall not exceed 42 volts peak for more then 1 second.

(3) The voltage on all Class I Interface Leads, which are not connected by a through transmission path to the pair to which the 60 Hz voltage is applied, shall not exceed 70 volts peak for more than 1 second.

This requirement applies with both the commercial power source and the applied voltage source having the capability of delivering at least 20 amperes continuously and 50 amperes for at least 1 minute. The requirement applies in all operating states.

In demonstrating compliance with this requirement, it is sufficient to demonstrate the compliance of one sample of the equipment with a 60 Hz voltage of 106 to 127 volts rms applied between the tip and ring leads with one of the leads connected to ground. Compliance must be demonstrated for at least one of each type of interface containing Class I network leads, with such interface off hook. However, it shall be demonstrated that the equipment complies with all of the requirements in Section 4.4.

C. Fault on Exposed Surfaces

With a 60 Hz voltage of 120 volts rms applied between conducting exposed surfaces and ground, the following limitations apply:

(1) The voltage on Class I interface leads shall not exceed 70 volts peak for more than 1 second.

(2) The voltage on Class II interface leads shall not exceed 42 volts peak for more than 1 second.

The 60 Hz source must be capable of supplying 20 amperes continuously and not less than 50 amperes for one minute and must not be interrupted by an overcurrent device, time delay fuse or breaker, of smaller than 20 amperes rating. This requirement applies in all equipment operating states.

4.3 Mechanical Safety

These criteria are intended to help assure that an equipment is constructed such that it is not hazardous to users, installers or repairpersons.

A. Construction

The equipment shall not have any sharp edges, etc., that could be hazardous to the user, installer, or repairperson. The equipment shall not have any pre-loaded springs or any elements that can be released during disassembly to become missiles.

B. Surface Temperature

The temperature of conductive exposed surfaces, including metal covered with thin coatings, shall not exceed 140°F (60°C) at the highest operating ambient temperature of an equipment. However, the temperature of the external conductive surfaces of an equipment that must operate in an ambient temperature as high as 140°F(60°C) may reach 150°F (66°C). Other conductive surfaces having a temperature above 140°F (60°C) at the highest operating ambient of an equipment shall be identified with warnings and shall be baffled to prevent inadvertant contact by craftspersons.

C. Audible Noise Emission

Equipment noise emission shall not subject user or craftsperson to sound levels greater than those allowed in OSHA regulation 1910.95, considering exposure time and place of installation. However, these levels may be excessive in terms of speech interference and annoyance and therefore, except for user alerting signals and equipment which is not restricted in location to dedicated equipment rooms, it is desirable that the noise level of equipment be limited to 50 dBA continuously or 75 dBA intermittently (less than a 10 percent duty cycle), at normal working distances as measured on the A scale of a standard sound level meter at slow response. In addition, impulsive or impact noise shall not exceed 120 dB peak sound pressure level.

4.4 Design Standards

4.4.1 Materials

A. Plastics used in construction internal to the housing (not an exposed surface) and plastics used for housings exposed to electrical arcing or experiencing surface temperatures under fault conditions in excess of 170^{o}F (77^{o}C) shall have a limiting oxygen index (LOI) of at least 28, per ASTM D2863-70. Exceptions allowed are small piece parts requiring specialized material properties, such as bearings and dielectric insulators, not exposed to heat sources or electrical arcing.

B. External wiring, such as line and handset cords, when mounted in a horizontal plane, shall not propagate fire initiated from an external source.

4.4.2 Grounding Metal Chassis

Except as noted below, if a unit of the equipment connects directly to commercial ac power or if it connects to a voltage source that exceeds the Zone 2 limits specified in Section 4.2.1, its chassis shall be securely connected to green wire ground such that it is grounded whenever ac power or the source of high voltage, as applicable, is connected. In addition, all exposed conducting (metal) surfaces that are not removable parts of an equipment enclosure shall be securely grounded. However, the chassis of an equipment unit that is powered by a physically separate power supply or through a physically separate power transformer may be ungrounded but the voltage on the connecting leads must comply with the Zone 1 limit in Section 4.2.1 applicable to voltage source for which the available current is not restricted.

4.4.3 Overload Protection

A. If the equipment connects to commercial ac power, it shall include overload protection. Such protection shall assure that no component failure(s) or shorts between any two internal or external terminals or of any such terminals to ground will cause heating of any element (e.g., power transformer) sufficient to cause the equipment to become a fire hazard. The restriction applies with the equipment powered from a source capable of delivering at least 20 amperes continuously and at least 60 amperes for one minute. The required protection shall involve one or more of the following:

(1) Series resistance (e.g., transformer winding resistance) high enough to limit the current to a level that will not cause overheating of any element,

(2) A saturable core reactor or similar magnetic control of short circuit current,

(3) A thermal cut-out which shall not automatically reset if additional fusing is not used,

(4) A fuse, or

(5) A circuit breaker.

B. Large loads (power supply secondary) shall be split such that the maximum load per fuse or thermal cut-out is 125 volt-amperes, though loads up to 400 volt-amperes are acceptable for loop battery feed circuits. These limitations do not apply to points internal to power supplies but they do apply to any source of power, including batteries.

C. Fuses and circuit breakers shall not be rated in excess of the current carrying capacity of the wire in their circuits. In addition, wiring external to equipment cabinets or housings shall meet the requirements of Article 725 of the National Electrical Code.

D. Batteries shall be provided with protection (which may be the internal resistance of the battery) to assure that shorts between any two exposed terminals or from any exposed terminal to ground shall not cause the battery to become a fire hazard.

4.4.4 Connections and Wiring

A. Physical Separation

(1) Leads to, or any elements, having a conducting path to Class I interface terminals in any operating state of the equipment shall:

(i) Be reasonably physically separated and restrained from (not routed in the same cable as) nor use the same connectors as leads to metallic paths which may connect to commercial power (phase or neutral leads) or to a source of voltage exceeding the Zone 2 limits specified in 4.2.1.

(ii) Be reasonably physically separated and restrained from (not routed in the same cable as) nor use adjacent pins on the same connector as metallic paths or leads connected to Class II interface terminals if the interface voltages exceed the Zone 1 voltage limits (levels applicable without current restrictions) specified in 4.2.1.

(2) Leads having a conducting path to Class I interface terminals, in any operating states of the equipment, shall not use pins or terminals on a connector, terminal block, or terminal field when such pins or terminals are adjacent to pins or terminals used by either Class II interface leads or by a conducting path to ground unless one of the following is met:

(i) Pins or terminals (including spade tip lead connections) with a conducting path to Class I terminals are sleeved or prevented by a nonconductive spacer or other construction feature from being shorted to an adjacent pin or terminal.

(ii) Pins or terminals and adjacent pins or terminals have sufficient spacing or rigidity that an applied force of 5 lb (22 newtons) to a pin or terminal will not result in its making electrical contact with another. (It is assumed that the screw holding a spade tip cannot be tightened to make the connection sufficiently rigid.)

In addition, the means of restraint to maintain the alignment of wires in a cable that includes wires with a conductive path to a Class I terminal shall be such that individual wire insulation will not be cut during manufacture, operation or repair.

B. Power Cord

Cords for connection to commercial power and their attachment shall meet the requirements of the National Electric Code, Article 400 (Flexible cords and cables). The cord shall be protected with a suitable strain bushing where it enters the equipment capable of supporting a load of 35 lb (16 kilograms) or twice the weight of the equipment unit, whichever is less, applied to the cord. Ends of removeable cords which may contain live terminals shall have female connectors.

C. Bushings

For wires that connect to commercial power or to sources of voltage that exceed the Zone 2 limits specified in 4.2.1, insulating bushings shall be used where wires pass through an opening in metal within an equipment unless they are otherwise restrained from contacting the edge of the opening. Where wires that have a conductive path to a source of voltage that exceeds the Zone 1 limits specified in 4.2.1 or, in any operating state of the equipment, have a conductive path to Class I interface terminals, pass through an opening in metal within an equipment, a bushing also shall be used unless edges of the holes are smooth and rounded with a radius of a least 1/32 inch (0.08 cm) or unless the wires are otherwise restrained from contacting the edge of the opening.

4.4.5 Dielectrics

With the equipment in any possible operating state, breakdown shall not occur with a 60 Hz voltage applied between points on the equipment enumerated below (points 1-8) in the combinations listed in the table following, when the voltage is gradually increased from zero to the maximum value given in the table over a 30 second time interval, and then applied continuously for 1 minute.

Breakdown is defined as the voltage at which the peak current is 50 percent or more greater than the peak current which flowed at a voltage 10 percent less in magnitude. However, for applied 60 Hz voltages, the breakdown voltage shall be considered to have been exceeded if the peak current exceeds 10 milliamperes.

Where terminals have an intentional conducting path to ground or each other, the criteria apply without the terminals connected to that path.

(1) All exposed surfaces (exclusive of securely grounded metal surfaces) of the equipment.*

(2) Commercial ac power terminals (phase and neutral).

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* Dielectric compliance is assured for conductive exposed surfaces which are not securely grounded by either:

(i) Demonstrating compliance with the breakdown requirements and verifying that all such conductive exposed surfaces are separated from (and restrained from contacting) any securely grounded equipment parts by an air gap or solid dielectric of at least 0.062 inches (0.16 centimeters) thickness or

(ii) Demonstrating compliance with the breakdown requirements when the conductive exposed surfaces are insulated at all points of possible contact to securely grounded equipment parts.

(3) Telephone connections.

(4) (a) Terminals for connection to nonregistered equipment which can connect to commercial ac power.

(b) Terminals for connection to nonregistered equipment which cannot connect to commercial ac power.

(5) Terminals for connection to the secondary circuits of a power supply that has a direct connection to commercial ac power.

(6) Green wire ground terminals.

(7) The exposed surfaces of handsets, earphones, headsets, or their associated cords (exclusive of cord armor directly connected to equipment housings).

(8) A conductive surface over the contour of the transmitter and receiver areas of handsets.

Combinations of Electrical Connections for Dielectric Breakdown Evaluations

Combination	Points	Maximum Voltage (Volts rms)
A	from (1) to (2)* & (4)(a)	1500
B	from (1) to (3)*, (4)(b) & (5)	1000
C	from (2) to (3), (4)*, (5)*, & (6)	1500
D	from (3) to (4)*, & (6)	1000
E	from (3) to (7)	2500
F	from (3) to (8)	5000

(i) If the power supply secondary voltage source exceeds the Zone 2 limits in Section 4.2.1, breakdown shall not occur with up to 1500 volts rms at 60 Hz applied as in A above from point (5) to points (1) or (3) and the ground reference shall be capable of carrying current four times greater than the capability of the high voltage source. In addition, if the equipment includes a voltage source that

* Includes Part 68 Requirements

exceeds the Zone 3 limits, breakdown shall not occur with a 60 Hz voltage up to 1000 volts greater than the peak-to-peak voltage of the source divided by $2\sqrt{2}$ applied between the points specified and from point (5) to point (2).

(ii) In demonstrating compliance with these criteria, it is sufficient to demonstrate that between the points specified there is a dielectric barrier with the required strength. For example, dielectric breakdown shall not be considered to occur between any two points if the peak current limit would not be exceeded with any series element(s) short circuited.

4.4.6 Fault Isolation

General requirements for the isolation of faults on Class II Interface Leads and network tip and ring leads are specified in Sections 4.2.2(a) and (b) respectively. Compliance is assured for all possible applications of the hazardous voltage by a relatively few elements which can be evaluated as specified in Sections A and B below, and, if necessary, tested independently. Requirements in all these sections are intended to influence the design of equipment to assure that the protection provided is determined by controlled equipment characteristics.

A. Fault on Class II Interface Leads

If the requirements specified in 4.4.5 for Class I (point 3) interface leads are applicable in at least one operating state, any physical element (e.g. transformer) that provides a transmission path through such dielectric barriers shall, together with any specified associated components, assure that the voltage appearing on all Class I interface leads does not exceed 70 volts peak for more than 1 second, if a 60 Hz voltage of up to 300 volts rms is applied between any combination of Class II interface leads (in a given interface).

There is no restriction on the number of elements that may be included in the circuitry defined as providing the required protection, or on the number of conducting paths in the interface of such circuitry with other circuitry comprising the equipment. For all elements included, however, the characteristics relevant to achieving compliance with this requirement shall be specified as part of the individual component specifications. E.g., if compliance depends upon a particular resistor acting as a fuse, its relevant fusing characteristics shall be included in the specification.

B. Fault on Network Tip and Ring Leads

If the requirements specified in 4.4.5 for Class I (point 3) interface leads are applicable in at least one operating state, any physical element (e.g. transformer) that provides a transmission path through any such dielectric barriers shall, together with any associated components, assure that the voltage appearing on any Class II interface leads does not exceed 42 volts peak for more than 1 second if a 60 Hz voltage of up to 600 volts rms is applied between a pair of tip and ring interface terminals (with one terminal connected to ground).

There is no restriction on the number of elements that may be included in the circuitry defined as providing the required protection or on the number of conducting paths in the interface of such circuitry with other circuitry comprising the equipment. For all elements included, however, the characteristics relevant to achieving compliance with this criterion shall be specified as part of the individual component specifications. E.g., if compliance depends upon a particular resistor acting as a fuse, its relevant fusing characteristics shall be included in the specification.

4.5 Mercury Hazard

Because of the high vapor pressure of mercury, the possibility of poisoning is very real if components containing mercury are ruptured. Such components shall not rupture when placed under the stresses of paragraph 6.0, Physical Environment.

4.6 Radiation Hazards

While it is doubtful that hazardous radiation would emanate from a telephone, attention is directed to these potential hazards and to the standards governing them:

(a) Microwave - Occupational Safety and Health Administration (OSHA) Safety and Health Standard 1910.97

(b) Ionizing - OSHA 1910.96

5.0 ELECTRICAL ENVIRONMENT

Equipment shall meet all of the requirements, i.e., function normally in the presence of or after subjection to those electrical environmental conditions or stresses which are designated as "normal" in this section.

In addition, the equipment shall meet FCC Part 68 Requirements and the requirements of Section 4.0, Safety and Protection, in the presence of or after subjection to those electrical environmental conditions or stresses which are designated here as "abnormal." This is necessary so that, at a minimum, in unusual situations, the equipment does not become a potential source of network harm or a hazard to users. In addition, it is desirable that the equipment meet all other requirements when subjected to the "abnormal" conditions or stresses contained herein.

With respect to FCC Part 68 compliance, if the equipment is damaged (by an environmental stress) such that a particular requirement cannot be met, the requirement is deemed not applicable. E.g., if the equipment cannot be placed in the off-hook state, it cannot comply with and need not be tested to off-hook state requirements.

5.1 Telephone Line Working Potentials and Currents (Normal)

The following are normal operating potentials and currents:

A. Central Office and PBX Battery

DC voltage applied to loops (including central office loops where range extension circuitry is employed) is normally in the range of 19 to 78.75 volts dc and negative with respect to ground. In addition to this, there are other range extension circuits where the voltage applied to one conductor may be up to a positive 52.5 volts dc, while the voltage applied to the other conductor will be negative and up to 52.5 volts dc in magnitude. The voltage source provided by some subscriber carrier systems is floating with respect to ground and as low as 7.5 volts dc. Voltages are shown in tabular format below.

Condition	DC Voltage (volts)
Normal loops	-19 to -78.75
Certain Range Extension Circuits	+52.5 on one conductor -52.5 on the other conductor
Subscriber Carrier	as low as 7.5

B. Loop Current

The normal ranges of dc loop currents are those which result from an equipment being connected to voltage sources, applied ring to tip, when the voltages and loop resistances are varied over the ranges specified below.

Source	DC Voltage (volts)	Loop Resistance (ohms)
(1)	±42.5 to ±52.5	400[1] to 1740
(2)	±105	1300 to 2000

In addition to the above, an older feed circuit known as toll grade battery remains in existence but is to be eliminated shortly. Toll grade battery consists of an 11B resistance lamp (characteristics shown in Figure 5.1) in series with an equivalent resistance of 31 ohms and connected to a negative voltage that can be up to 52.5 volts dc. If two switchboard operators seize the same switchboard trunk, two toll grade battery sources may be connected in parallel for about 1 second.

C. Ringing Signals

Ringing signals occur as repetitive bursts of nominally 2 seconds duration (1 second for some PBXs) of each nominally 6 second interval (4 second for some PBXs), though bursts may be as short as 0.8 seconds (0.6 seconds for some PBXs with the first burst still shorter). The ac and dc voltages are applied between the ring conductor and ground.

Ringing signal source voltages are as follows:

AC Voltage[2] (rms)	Frequency (Hz)	DC Voltage[2]
65 to 130[3]	20 ±3	21 to 105[4]
110 to 130	30 ±3	21 to 52.5

1. This may be as low as 330 ohms on some loops.

2. Measured across source without a loop connected.

3. The ac voltage provided by nearly all central offices under all except emergency conditions will be 86 ±2 V.

4. The maximum dc voltage to ground will be 52.5 V and the dc voltage applied during the silent interval nominally may be different than during the ringing interval.

However, some subscriber carrier systems provide ringing signals with frequencies of 20 to 26 Hz and the dc voltage source may be floating with respect to ground and as low as 7.5 volts.

D. Test Voltages

Voltages applied for test purposes to the loop at a central office with the equipment on-hook may be up to a maximum of 202 volts dc between the tip and ring (either polarity) or between either conductor and ground. The voltage is positive with respect to ground. For voltages that are negative with respect to ground, the maximum that can be applied to the loop with the equipment on-hook is 52.5 volts dc. AC maintenance testing signals of up to 10 volts rms also may be applied from either tip to ring, tip to ground, or ring to ground in the frequency range 5 Hz to 1000 Hz, except in the frequency range 17 Hz to 33 Hz where ringing voltages given in subsection (c) above are applicable, when the equipment is in the on-hook state.

The maximum voltage that can be applied to the loop (1300 ohms or less) with the equipment off-hook is 54 volts dc (permanent signal release test) and the source resistance may be as low as 10 ohms for 0.5 second duration.

E. Tip and Ring Reversals

Reversals of the tip and ring conductors connected to central office battery may occur during the progress of a call. Normally the central office applies negative battery voltage to the ring conductor and ground to the tip conductor. The normal exchange loop polarity is applied to all lines in the idle condition, to the calling line during dialing and to the called line during ringing. Upon answer, the loop polarity applied to the calling line and the loop polarity applied to the called line may be reversed, by a reversal of the tip and ring conductors connected between negative battery and ground, depending on the type of call and the type of central office serving the particular station.

Some central offices provide a reversal of tip and ring to indicate that a toll call is being dialed. Reversals to indicate a toll call are not returned from step by step central offices. In other than step by step offices, reversals to indicate a toll call can be anywhere from 50 to 210 milliseconds in duration. They are transmitted at the end of address signaling. In some cases, a continuous polarity reversal will be retu~ned after all digits of a toll call have been dialed.

5.2 Non-Telephone System Potentials and Currents

A. High Voltage Surges

Lightning can cause high voltage surges on tip and ring leads connected to exposed outside plant facilities, and on commercial power conductors. Surges on power conductors also occur as a result of load switching.

Surges are specified in Table 5.1 and are applicable as follows:

(1) All surges are applicable in any operating state of an equipment. All other equipment leads (telephone connections and terminals for connection to nonregistered equipment) not being surged or connected to those being surged shall be terminated in a manner which is no less severe than that which occurs in normal use. Also, equipment states which cannot be achieved by normal means of power shall be achieved artificially by appropriate means if necessary, to comply with the above requirements.

(2) Type P surges are applicable to equipment that uses commercial power and are applied to power lead terminals between the phase conductor and neutral conductor with green wire ground connected to the neutral conductor, and between neutral conductor and phase conductor with green wire ground connected to the phase conductor.

With respect to Surge P2, compliance with the requirements in Sections 4.2.1c (second paragraph), 4.2.1D and 4.4.5 (combination C) are not required provided that, following the applications of such a surge, the voltage on Class I interface leads does not exceed 70 volts peak for more than 1 second and the voltage on Class II interface leads does not exceed 42 volts peak for more than 1 second. Further, following the application of such a surge, the voltage from any exposed conductive surface connected to ground through a 1.5 kilohm resistive load shall not exceed 42 volts peak for more than 1 second.

(3) Type M and L surges are applicable to all leads of an equipment which may be exposed to lightning. They are applicable with and without ungrounded exposed conductive surfaces treated as a ground reference (connected to green wire ground).

(4) Type M surges are applicable between tip and ring terminals and between any other pair of interface terminals which may connect to outside plant metallic pairs with each one of the terminals individually connected to green wire ground (if such a ground connection exists).

(5) Type L surges are applicable between the tip and ring terminals (also pairs of connections other than tip and ring on which lightning surges may occur) connected together, and individually to (i) and (ii) below:

(i) earth ground; and

(ii) all leads on the device intended for connection to nonregistered equipment when these leads are connected together.

Type L surges are applicable under all reasonably foreseeable possibilities of disconnection from commercial power (e.g., without any associated plug-ended primary power cord connected). Also, Type L surges are applicable with only the third-wire ground connection in a primary power source plug disconnected. In these cases, the surges are applicable with the source ground serving as the ground reference for interface lead terminations which could, in service, have a path for surge currents to green wire ground.

Figure 5.2 shows an illustrative circuit which can be used for generating high voltage surges. The input impedance, Z, of the device being tested will affect the rise and decay time of the surge unless $Z \gg R1$.

B. Very High Voltage Surges

Surges having a peak amplitude of up to 10,000 volts, a peak available current of up to 1000 amperes, and maximum rise and minimum decay times of 2 and 10 microseconds, respectively, may occur from tip and ring terminals and from any other interface terminals which may connect to conductors in outside plant metallic facilities (connected together) to ground, green wire ground and/or the neutral conductor of commercial power.

A surge of this magnitude shall not cause any component to shatter such that solid material is thrown outside the equipment housing. It shall neither cause the equipment to become a fire hazard nor result in a voltage greater than 70 volts peak appearing for more than 1 second between tip and ring or between any such terminal and ground.

Also, it shall not result in a voltage greater than 42 volts peak to peak for more than one second between any pair of terminals for connection of leads to nonregistered equipment, or from any such terminal and ground. This interface terminal voltage restriction applies when interface leads are terminated as in Section 4.0 (i) and (ii). However, the restrictions do not apply to interface terminals on which a voltage greater than 70 volts peak appears during normal operation.

An equipment shall be considered to comply with this criterion if:

(1) It complies with the restriction on materials in Section 4.4.

(2) All components, such as line transformers, which might have dielectrics broken down by the specified surge are either (a) contained within metal enclosures, or (b) not potted (in a solid or liquid material). If a component is mounted in a metal enclosure, (a) above, which does not fully enclose the mounting surface side, then it must be mounted within an additional equipment enclosure.

(3) The physical structure of any power transformer is maintained and the secondary voltages do not increase when the transformer is subjected to such surges from the secondary or primary windings to green wire ground with nominal voltage applied to the primary winding and the secondaries loaded as in normal use.

C. Voltages Due to Commercial Power

(1) Induction (Normal)

Induction resulting from magnetic fields surrounding power distribution systems can cause the appearance of longitudinal mode (tip and ring to ground) voltages of 50 volts rms or less at 60 Hz and 15 volts rms or less at 180 Hz, with a combined voltage of 50 volts rms or less. Since the induced voltage is in series with and generally distributed along the loop or metallic facility involved, the longitudinal mode voltage will be a function of the far end termination of the loop as well as the loop characteristics. At the network interface the source impedance of induced voltages may be lower than 100 ohms, but, for voltages greater than 50 volts rms, the source impedance normally (under non-fault conditions) will be at least 400 ohms.

(2) Power Line Faults and Line Crosses (Abnormal)

Under power line fault conditions or with a line cross (metallic contact between commercial power conductors and telephone cables), protectors normally limit potentials appearing between the tip and ring (or to ground) to no more than 600 volts rms. In most cases, power system fault detectors or telephone line protectors will limit the duration of such voltages to a few seconds. However, they could last indefinitely. Such fault conditions can cause a protector to permanently short either the tip or the ring conductor to ground in which case the power line fault, line cross voltage, or induced voltage may appear as metallic voltages. The source impedance of the power contact voltage may be as low as 3 ohms, the source impedance of the induced voltage is at least 400 ohms.

D. Electromagnetic Interference (Normal)

Under normal operating conditions, equipment may encounter electromagnetic fields with strengths up to 2 volts per meter and frequencies from 10 kHz to 1.0 GHz.

In addition, in some customer locations, field strengths up to 20 volts per meter at frequencies up to 1 GHz have been observed (an abnormal condition). If the equipment cannot function normally in the presence of such fields, instructions for the mitigation of resultant problems shall be provided.

E. Static Discharge (Normal)

The specified discharges are considered normal stress conditions.

The equipment is subjected to static discharges in a controlled environment of less than 20 percent relative humidity after drying in this environment for a least one hour. Discharges are made at a rate that avoids damage to the equipment from the cumulative effects of the discharges. All equipment interface terminals, including power leads, that may have a path to ground for static discharge currents during operation shall be appropriately terminated. The equipment shall function normally following static discharge simulations, and, in addition, it is desirable that it not change operating states (except for changes which are momentary and self-correcting) as a result of type 1 static discharge (paragraph (i) below) simulations:

(i) 50 discharges of each polarity, through a 10 kilohm resistor connected to a 60 picofarad capacitor charged to 20 kilovolts, uniformly distributed over all exposed surfaces except resting surfaces, in each operational state.

(ii) 20 discharges of each polarity, through a 500 ohm resistor connected to a 100 picofarad capacitor charged to 10 kilovolts, uniformly distributed over all exposed surfaces of the equipment, except resting surfaces.

Discharges shall be directly placed on those internal points which are likely to be touched during normal installation, adjustment, or field repair. Maintenance information supplied to field personnel shall contain explicit warnings as to procedures to be followed to prevent electrostatic damage during installation, adjustment, or field repair.

5.3 Telephone Network Continuity (Normal)

DC loop current interruptions and the establishment of momentary transmission path continuity may occur under normal conditions during the course of a call as demonstrated below.

A. DC loop Current Continuity

(1) Call Setup

DC loop current interruptions may occur during call setup regardless of whether the equipment is at the originating or terminating end of the call. These interruptions usually occur within 750 milliseconds (switching interval) after the terminating end of the connection goes off-hook (answer). They are usually no greater than 350 milliseconds in duration.

(2) Network Reswitching

Equipment intended to be compatible with central office customer calling features, such as conference service and call waiting alerting, are subjected to dc loop interruptions (reswitch) from the local serving central office after the end-to-end talking path has been established. These reswitch loop interruptions may be up to 20 milliseconds from non-ESS type offices and are normally less than 350 milliseconds from ESS type offices. Under abnormal traffic conditions the reswitch interruption from an ESS office can exceed 350 milliseconds.

(3) Network Release

When the originating end of a connection disconnects, the terminating end loop current may eventually be interrupted, but such interruptions vary among central offices, among lines terminated on an individual central office, and among calls to a particular line. Loop current interruptions also occur in some situations at the originating end after the terminating end disconnects.

If an equipment at either the originating or terminating end of a connection remains off-hook after the other end has disconnected, central office timeout usually occurs, followed by dial tone being returned to the off-hook terminal equipment. Permanent signal or partial dial timeout usually will take effect if an incomplete number is dialed after the application of dial tone. Loop current interruptions may occur during this process, in most cases after dial tone timeout, when the line is connected to a permanent signal trunk. Loop interruptions associated with permanent signal trunks vary in length from 90 milliseconds to greater than 600 milliseconds.

B. Transmission Path Continuity

(1) Switching Interval

The switching interval begins when the terminating end of the connection goes off-hook (answer) and persists for up to 750 milliseconds. During this time, dc loop current interruptions may occur at both the originating and terminating ends of the connection.

Momentary transmission path continuity, in both directions between the originating and terminating ends, may exist for up to 225 milliseconds preceding a switching interval dc loop current (and transmission path) interrupt of less than 10 milliseconds in duration (this momentary transmission continuity may contain several momentary transmission interruptions, each $\leq$ 30 milliseconds). Switching interval dc interrupts at the originating end which are longer than 10 milliseconds have no transmission path continuity prior to their occurrence. In any case, transmission path continuity never occurs until after all switching interval dc interrupts have occurred at the terminating end of the connection.

(2) Signaling of Answer Supervision

The signaling of answer supervision occurs after the switching interval discussed in (1) above. Answer supervision is an interval normally less than 600 milliseconds in duration, but can extend up to 1.0 second. During this time no dc loop current interruptions occur. However, forward transmission continuity may be interrupted from the originating end towards the terminating end of the connection. This transmission interruption can be up to 30 milliseconds in duration.

Transmission continuity from the terminating end towards the originating end of the connection may be interrupted for the duration of the signaling of answer supervision. Momentary transmission continuity, in this direction, of up to 300 milliseconds, may occur prior to the establishment of a continuous transmission path. However, the signaling of answer supervision interval, which is a function of many factors including the number of trunks in the connection, normally will be less than 600 milliseconds with the interval of transmission interruption between momentary tranmission continuity and continuous transmission continuity correspondingly reduced.

(3) Single Frequency (SF) Unit Compatibility

Equipment signal spectrum restrictions necessary to prevent transmission path discontinuities from being introduced by SF units are under investigation and will be provided when available. Signal spectrum restrictions necessary to prevent false billing due to interaction with SF units are contained in Section 2.1.5H.

5.4 Commercial Power Fluctuations

A. Normal Utilization Voltages and Brownout Conditions

If the operates with 120 volts 60 Hz commercial power, it shall function normally with a minimum utilization voltage (at the line terminals of the equipment) of 100 volts rms and a maximum of 127 volts rms, at a frequency of 60 ± 0.1 Hz.

B. Abnormal Brownout and Emergency Conditions

If the equipment operates with 120 volts 60 Hz commercial power, it shall meet FCC Part 68 Requirements and the requirements of the Safety and Protection Section with utilization voltages (at the line terminals of the equipment) ranging from 96 to 127 volts rms at 60 ± .1 Hz.

C. Reserve Power

If the equipment is designed to function with a nominal 120 volts rms noncommercial ac energy source, it shall meet FCC Part 68 Requirements and the requirements of the Safety and Protection Section with ac power of 105 to 129 volts rms at 60 ± 3 Hz. It is desirable that the equipment function normally over this range of ac power.

6.0 PHYSICAL ENVIRONMENT

Equipment shall meet all the requirements, i.e., function normally, in the presence of or after subjection to those physical environmental conditions or stresses which are designated as "normal" in this section. In addition, the equipment shall meet FCC Part 68 Requirements and the requirements of Section 4.0, Safety and Protection, in the presence of or after subjection to those physical environmental conditions or stresses which are designated here as "abnormal." This is necessary so that, at a minimum, in unusual situations, the equipment does not become a potential source of network harm or a hazard to users. In addition, it is desirable that the equipment meet all other requirements when subjected to the "abnormal" conditions or stresses contained herein.

With respect to FCC Part 68 compliance, if the equipment is damaged (by an environmental stress) such that a particular requirement can not be met, the requirement is deemed not applicable. E.g., if the equipment cannot be placed in the off-hook state, it cannot comply with and need not be tested to off-hook state requirements. In addition, an equipment subjected to stresses which only occur before or during installation is considered as complying if it meets the requirement of the above paragraph after it is installed at the customer's premises through normal, well documented procedures.

6.1 Shock (Normal)

Stresses are specified below for each weight class. Impact and test surfaces are chosen such that they are perpendicular to the direction of motion of the unit at the time of impact. Tests are performed as follows:

Face Drop

The unit is dropped such that the face struck is approximately parallel to the impact surface.

Corner Drop

The unit is dropped such that upon impact a line from the struck corner to the center of gravity of the packaged equipment is approximately perpendicular to the impact surface.

Edgewise Drop

The unit is positioned on a flat test surface. One edge of the rest face is supported with a block so that the rest face makes an angle of 20° with the horizontal. The opposite edge is lifted the designated height above the test surface and dropped.

Cornerwise Drop

The unit is positioned on a flat test surface. One corner of the rest face is supported with a block so that the rest face makes an angle of 20^{o} with the horizontal. The opposite corner is lifted the designated height above the test surface and dropped.

Random Drop

The unit is positioned prior to release to ensure as nearly as possible that for every six drops there is one impact on each of the six major surfaces and that the surface to be struck is approximately parallel to the impact surface.

6.1.1 <u>Equipment Packaged for Shipment:</u>

These tests are performed on a concrete surface with one package and its normal contents. If after six or more successive drops a package has sustained visible damage, the equipment under test may be repackaged before the packaged drop tests are resumed.

A. 0-20 lbs (0-9 kg):

One 30 inch (76 cm) face drop on each face and one 30 inch (76 cm) corner drop on each corner.

B. 20-50 lbs (9-23 kg):

One 24 inch face (16 cm) drop on each face and one 24 inch (61 cm) corner drop on each corner.

C. 50-100 lbs (23-45 kg):

One 21 inch (53 cm) face drop on each face and one 21 inch (53 cm) corner drop on each corner.

D. 100-200 lbs (45-91 kg):

One 18 inch (46 cm) face drop on each normal or designated rest face. One edgewise drop and one cornerwise drop from a height of 18 inches (46 cm) on each edge and corner adjacent to the rest face.

E. 200-600 lbs (91-272 kg):

One 12 inch (30.5 cm) face drop on each normal or designated rest face. One edgewise drop and one cornerwise drop from a height of 12 inches (30.5 cm) on each edge and corner adjacent to the rest face.

F. 600-1000 lbs (272-454 kg):

One 8 inch (20 cm) face drop on each normal or designated rest face. One edgewise drop and one cornerwise drop from a height of 8 inches (20 cm) on each edge and corner adjacent to the rest face.

G. Over 1000 lbs (454 kg):

One 6 inch (15 cm) face drop on each normal or designated rest face. One edgewise drop from a height of 6 inches (15 cm) on each edge adjacent to the rest face.

6.1.2 <u>Equipment Unpackaged:</u>

A. Hand-Held Items Normally Used at Head Height:

18 random drops from a height of 60 inches (152 cm) onto concrete covered with 1/8 inch (.3 cm) asphalt tile or similar surface.

B. Normally Customer Carried Equipment:

Six random drops from a height of 30 inches (76 cm) onto concrete covered with 1/8 inch (.3 cm) asphalt tile or similar surface.

C. Equipment Not Normally Customer Carried:

These tests are made onto concrete covered with 1/8 inch (.3 cm) asphalt tile or similar surface.

(1) 0-20 lbs (0-9 kg):

One 6 inch (15 cm) face drop on each normal or designated rest face, one 3 inch (8 cm) drop on all other faces, and one 3 inch (8 cm) corner drop on each corner.

(2) 20-50 lbs (9-23 kg):

One 4 inch (10 cm) face drop on each normal or designated rest face, one 2 inch (5 cm) face drop on all other faces, and one 2 inch (5 cm) corner drop on each corner.

(3) 50-100 lbs (23-45 kg):

One 2 inch (5 cm) face drop on each normal or designated rest face. One edgewise drop and one cornerwise drop from a height of 2 inches (5 cm) on each edge and corner adjacent to the rest face.

(4) 100-1000 lbs (45-454 kg):

One 1 inch (2.5 cm) face drop on each normal or designated rest face. One edgewise drop and one cornerwise drop from a height of 1 inch (2.5 cm) on each edge and corner adjacent to the rest face.

(5) 1000 lbs (454 kg) and over:

One 1 inch (2.5 cm) face drop on each normal or designated rest face. One edgewise drop from a height of 1 inch (2.5 cm) on each edge adjacent to this rest face.

6.2 Vibration (Normal)

The equipment shall be subjected to vibration while in the condition that it is normally shipped or transported. That is, during the following vibration test the equipment shall be vibrated while packaged if shipped packaged, or the equipment shall be vibrated while unpackaged if shipped unpackaged.

The following sinusoidal vibration shall be applied once in each of three orthogonal directions: One sweep at a level of 0.5g peak from 5 to 100 Hz, and one sweep at a level of 1.5g peak from 100 to 500 Hz. The 5 to 100 Hz sweep is conducted at a sweep rate of 0.1 octave/min. (approximately 45 minutes) and the 100 to 500 Hz sweep at a rate of 0.25 octave/min. (approximately 10 minutes).

6.3 Horizontal Transportation Impact Stresses (Normal)

Under normal conditions, the operation of certain vehicles, such as coupling of railway freight cars, creates peak accelerations greater than those continuously experienced during transportation. The criteria specified below correspond to a typical transporting vehicle impact speed of approximately 9 miles (14.5 km) per hour.

A. Packaged Weight 0 - 100 lbs (0-45 kg):

No requirement; impact shocks are insignificant compared to handling shocks.

B. Packaged weight over 100 lbs (45 kg):

One shock pulse applied on each face that might be perpendicular to the longitudinal axis (direction of motion) of a transporting vehicle. The shock pulse is a half-sine acceleration, 30g peak, 20-millisecond duration.

6.4 Earthquake Environment (Abnormal)

The acceleration levels given below which occur during earthquake environments are considered to occur under abnormal conditions.

For equipment over 100 pounds (45 kg), a synthesized time history waveform (Figure 6.4-1) is applied along each of the three orthogonal equipment axes. The time history of the simulation must satisfy the following requirements:

(1) The shock spectrum (damped) of the time history matches (within +3 dB and -2 dB above 2 Hz) the Figure 6.4-2 spectrum corresponding to the equipment damping. Where the equipment damping is unknown or a range of values exist, the spectrum corresponding to the lowest value of damping is matched.

(2) The peak acceleration of the time history is 1g (+3 dB and -2 dB).

(3) The duration of the time history is approximately 30 seconds.

If facilities for stressing the equipment to the specifications above are not available, the equipment may be stressed to the following specifications: a sinusoidal vibration of 0.25g peak in the two orthogonal horizontal directions and 0.16g peak in the vertical direction. The sweep is linear from 1 Hz to 10 Hz at 0.05 Hz per second. The horizontal and the vertical portions of the test may be applied separately.

6.5 Storage Environment (Normal)

6.5.1 Requirement

Equipment under normal conditions may encounter storage conditions at temperatures between -40°F(-40°C) and 150°F(66°C) and relative humidities between 5 percent and 95 percent, except that above 84°F(29°C) the maximum relative humidity may be limited to that corresponding to a specified humidity of 168 grains per pound of dry air (e.g., 15 percent relative humidity at 150°F(66°C).

6.5.2 Demonstration of Compliance

Equipment is soaked for 6 hours or longer (nonoperational state) after temperature stabilization at least at the low temperature point (-40°F/ -40°C), at the high temperature-high specific humidity point (150°F/66°C,168 grains of water per pound of dry air), and at the high relative humidity-high specific humidity point (84°F/29°C, 95 percent relative humidity). Stabilization as used here means the conditions in which a centrally located component of the device does not change its temperature by more than 3.6°F(2°C) per hour. After each 6 hour soak, the unit is returned to room temperature (70°F/21°C) and checked for proper operation. These storage tests may be combined with the thermal shock tests of paragraph 6.7, except that at 150°F (66°C), the relative humidity is to be reduced from 15 percent to less than 9 percent after the 6 hour soak to prevent condensation during the thermal shock to room temperature.

6.6 Operational Ambient (Normal)

6.6.1 Requirement

Equipment shall function normally under the temperature and humidity extremes of the intended environment as described below.

A. Outdoors:

Equipment intended for use in an outdoor environment shall be capable of continuous operation at temperatures between -30°F (-34°C) and +140°F (+60°C) and relative humidities between 5 percent and 95 percent except that above 84°F(29°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 168 grains of water per pound of dry air (e.g., 19 percent relative humidity at 140°F(60°C).

B. Indoors - No Environmental Control:

Equipment intended for use in an indoor environment that has no environmental control shall be capable of continuous operation at temperatures between 0°F(-18°C) and +120°F(49°C) and relative humidities between 5 percent and 95 percent, except that above 84°F(29°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 168 grains per pound of air (e.g., 34 percent relative humidity at 120°F(49°C)).

C. Indoors - With Heating Only:

Equipment intended for use in a heated, indoor environment shall be capable of continuous operation at temperatures between 40°F(4°C) and 120°F(49°C) and relative humidities between 5 percent and 95 percent, except that above 84°F(29°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 168 grains per pound of dry air (e.g., 34 percent relative humidity at +120°F/49°C).

D. Indoors - With Environmental Control:

Equipment intended for use in a controlled environment shall be capable of continuous operation at temperatures between 40°F(4°C) and 100°F(38°C) and relative humidities between 5 percent and 95 percent, except that above 78°F(26°C), the maximum relative humidity may be limited to that corresponding to a specific humidity of 140 grains per pound of dry air (e.g., 49 percent relative humidity at 100°F(38°C)).

E. Special Environment:

Equipment intended for use in a special environment where extraordinary environmental controls are employed shall be capable of continuous operation over the extremes of the special environment. In addition, documentation shall be provided for the equipment regarding the limitations and or failure modes when such equipment is operated at the extremes of temperature and humidity specified above in (b) through (d).

6.6.2 Demonstration of Compliance

The equipment is tested for continuous operation at the low temperature point, the high temperature-high specific humidity point and the high relative humidity-high specific humidity point. The unit is allowed to reach temperature stabilization in the specified temperature and humidity environment. Stabilization is defined as the condition in which a centrally located component of the device does not change its temperature by more than 3.6°F(2°C) per hour. The unit is then soaked for 30 minutes or longer and checked for proper operation at the specified temperature and humidity condition.

6.7 Thermal Shock (Normal)

6.7.1 Requirement

Equipment under normal conditions may be exposed to drastic changes in temperature during transportation or installation. The equipment shall function normally after three of each of the thermal shocks specified below.

(1) 150°F(66°C) to 70°F(21°C)
(2) -40°F(-40°C) to 70°F(21°C)

6.7.2 Demonstration of Compliance

A. After reaching temperature stabilization at 150°F(66°C), the equipment is subjected to a change in temperature from 150°F(66°C), and a relative humidity less than 9 percent to 70°F(21°C) within 5 minutes. It shall function normally within 30 minutes after thermal shock.

B. After reaching temperature stabilization at -40°F(-40°C), the equipment is subject to a change in temperature from -40°F(-40°C) to 70°F(21°C) within 5 minutes. It shall function normally within 30 minutes after the thermal shock.

6.8 Temperature and Humidity Cycling (Normal)

6.8.1 Requirement

Cycle the equipment at any convenient rate through the following temperature and humidity conditions three times: 30 minutes at 150°F (66°C) and 15 percent relative humidity, followed by 30 minutes at 90°F (32°C) and 90 percent relative humidity, followed by 30 minutes at -40°F (-40°C) and any convenient humidity.

6.8.2 Demonstration of Compliance

Use an environmental chamber capable of producing the following temperature and humidity conditions:

Temperature °F	Relative Humidity	Time
150° ± 5°	15% ± 3%	30 min.
90° ± 5°	90% ± 3%	30 min.
-40° ± 5°	uncontrolled	30 min.

Cycle the equipment through these conditions three times, removing the equipment from the chamber after the high temperature condition to minimize condensation. The 30-minute time soak at each condition begins after the chamber has stabilized at that condition.

6.9 Pressure (Normal)

Equipment under normal conditions may be operated at altitudes up to 10,000 feet (3.0 km). Air pressures between sea level and this altitude range from 9.4 to 15.2 psia (648 to 1048 millibars). The equipment shall be capable of continuous operation over this pressure range.

6.10 Fungus Growth

Under conditions of high temperature and high humidity, fungus may develop on organic materials which can cause discoloration and/or imbrittlement which subsequently leads to loss of insulation resistance. In critical appearance parts, insulators and electrical protection devices, it is desirable that the following materials be treated with an appropriate fungicide, or other equivalent means:

(1) Cellulose nitrate
(2) Cork
(3) Cotton
(4) Hair and felt
(5) Leather
(6) Linen
(7) Melamine resin compound with cellulose fiber
(8) Paper and cardboard
(9) Phenolic resin compound with cellulose filler
(10) Plastic material using cotton, linen, paper, or wood flour as a filler
(11) Regenerated cellulose
(12) Thread or twine
(13) Wood

6.11 Corrosion

A. Protective finishes necessary to impede corrosion shall be free of visually perceptive defects at critical areas.

B. It is desirable that the components have the following characteristics:

(1) Mechanical joining of dissimilar metals widely separated in the galvanic series is avoided.

(2) Protective plating and coating of metals are of adequate thickness.

(3) It is desirable that the materials used do not degrade the reliability of the equipment in the following environment:

Contaminant	Annual Average Concentration
Particulate matter	185 g/m^3
Nitrate in particulate matter	12 g/m^3
Total hydrocarbons equivalent to methane	10 g/m^3
Sulphur dioxide	0.20 ppm
Oxides of Nitrogen	0.30 ppm
Total oxidants equivalent to ozone	0.05 ppm
Hydrogen sulphide	0.10 ppm

6.12 Sand, Dust and Insects

A. The presence of sand and dust can cause adverse effects such as

(1) Abrasion of finished surfaces
(2) Increased friction and wear on moving parts
(3) Contamination of lubricants
(4) Penetration of resilient materials
(5) Electrical breakdown
(6) Malfunctioning of electrical contacts
(7) Increased potential for fungus or mildew

B. Insects can gain access to equipment, causing many of the effects noted in paragraph A above. Under moist conditions, for example, spiders have been known to produce electrical malfunctions by bridging the gap between conductors.

C. It is desirable that precautions are taken to prevent the effects of sand, dust and insects such as:

(1) Use of sealed bearings
(2) Encapsulation or hermetic sealing
(3) Positioning of components to minimize accumulation, particularly where electrical malfunctions can occur
(4) Dust covers installed over sliding contacts
(5) Fitting of vents or louvers with filters

7.0 INTERFERENCE

7.1 Radio Frequency Interference (RFI)

The telephone shall conform to criteria for radiated emission which are specified in Part 15, FCC Rules. No conducted emission criteria have yet been established by the FCC.

GLOSSARY

Accessibility Probe

The probe shown in Figure G1 (as specified in Underwriters Laboratory standard UL 1012 with an added 5.08 centimeter diameter ring).

Breakdown Voltage, Dielectric

The voltage, applied across an insulator, at which the peak current is 50 percent or more greater than the peak current which flowed at a voltage 10 percent less in magnitude. However, for applied 60 Hz voltages the breakdown voltage shall be considered to have been exceeded if the peak current exceeds 10 milliamperes.

Direct Connection

Connection of terminal equipment to the telephone network by means other than acoustic and/or inductive coupling.

External Ground

A connection to ground, external to the product, including green wire ground or a connection meeting the requirements of protector and signaling ground connections.

Exposed Surfaces

Surfaces of equipment and of interconnecting cords or cables, with any removable housing or cover in place and with interconnecting cords or cables connected, which may be contacted with the small end of the accessibility probe where dimension A is 3.5 centimeters.

Fire Hazard

The existence of temperatures, sparks, or flame sufficient to:

(a) cause ignition or charring of untreated cotton cheesecloth used as an indicator,

(b) produce harmful quantities of toxic fumes, or

(c) cause the escape of molten material which can ignite or char untreated cotton cheesecloth used as an indicator.

Function Normally

Compliance with the criteria as specified in this document including all features and transmission performance requirements. In addition, an equipment that has been subjected to stresses which only occur before or during installation, functions normally if it can be installed by normal procedures and provide the intended service. An equipment that has been subjected to stresses occurring after installation functions normally only if it does not require the attention of a craftsperson to realign it for satisfactory service.

Green Wire Ground

The equipment grounding conductor as defined in the National Electrical Code.

Interface

The point of interconnection between terminal equipment and telephone company communication facilities.

Longitudinal Voltage

One half of the vector sum of the potentials between the tip connection and earth ground, and the ring connection and earth ground.

Loop Simulator Circuit

A source of dc power and a load impedance for connection, in lieu of a telephone loop, to terminal equipment during testing. The schematic diagram of Figure G2 is illustrative of the type of circuit which will be required; alternative implementations may be used provided that the same dc voltage and current characteristics and ac impedance characteristics will be presented to the equipment under test as are presented in the illustrative schematic diagram. When used, the simulator shall be operated over the entire range of loop resistance as indicated in the Figure, and with the indicated polarities and voltage limits. Whenever loop current is changed, sufficient time shall be allocated for the current to reach a steady state condition before continuing testing.

Metallic Voltage

The electrical potential difference between the tip and ring connections.

Network Control Signals

Signals applied to the tip and ring of a loop for transmission to a switched network for its control, excluding all signals exchanged between called and calling stations.

Network Port

An interface of a customer premises product for connection to Bell System outside plant facilities either directly or through another product such as a PBX.

Power Connections

The connections between commercial power and a transformer, power supply rectifier, converter or other circuitry associated with registered terminal equipment or registered protective circuitry.

Ringer Equivalence Number (REN)

The largest of the unitless quotients as defined below for a network port in the on-hook state:

1. 50 megohms divided by the smaller of the dc resistances (1) between tip and ring terminals or (2) between either terminal and ground, for any dc voltage up to 100 volts.

2. 150 kilohms divided by the smaller of the dc resistances between (1) the tip and ring terminals or (2) either terminal and ground, for any dc voltage between 100 and 200 volts.

3. The maximum total dc current flowing between tip and ring during the application of simulated ringing as listed in Table 2.5-1, in milliamperes, divided by 0.6 milliamperes.

4. Five times the impedance limitation listed in Table 2.5-1 divided by the minimum measured ac impedance during the application of simulated ringing as listed in Table 2.5-1.

Secure Ground Connection

A connection to green wire ground or external earth ground which is electrically equivalent, at frequencies from dc to 60 Hz, to at least an 18-gauge copper conductor but not smaller than a conductor which is 6 gauge numbers less than the gauge of wires providing any connection of the product involved to commercial power. Secure ground paths internal to equipment and the connection of secure ground path conductors shall not depend upon solder or a screw serving any other purposes that could result in its removal for maintenance or operational purposes. If such a path or connection depends upon a press fit, such as a rivet, the contact area must be sealed with solder.

Telephone Connection

Connection to telephone tip and ring and all connections that are not separated from telephone tip and ring by a sufficiently protective dielectric barrier.

Appendix A

The following AT&T publications may be of interest to designers and manufacturers of terminal equipment:

Bell System Technical References

PUB 40000 Technical Reference Catalog - June 1979

PUB 41009 Transmission Parameters Affecting Voice Band Data Transmission - Measuring Techniques - May 1975

PUB 43601 Lightning and 60 Hz Disturbances at the Bell System Network Terminal Interface - Preliminary - August 1976

PUB 47001 Electrical Characteristics of Bell System Network Facilities at the Interface With Voiceband Ancillary and Data Equipment - Preliminary - August 1976

PUB 47002 Electrical Characteristics of Bell System PBX and Key Equipment at the Interface With Voiceband Ancillary and Data Equipment - Preliminary - August 1976

Bell System Information Publications

IP 10020 - Writer's Guide

IP 10260 - TOP Standards

IP 10040 - Cost Studies Manual

IP 10300 - Engineering and Installation Documentation Guide

Requests for Technical References and related pricing information may be submitted in writing to:

American Telephone and Telegraph Company
Information Distribution Center, Room C190
Att: Technical References
P. O. Box 3513
New Brunswick, NJ 08903

Request for Information Publications and related pricing information may be submitted in writing to:

Wayne Distribution Center
P. O. Box 420
Wayne, NJ 07470

Appendix B

FCC Part 68 Cross Reference List

FCC Rules and Regulations Part 68 - Subpart D		Location in PUB 48005 of Subject Material
Sections:		
68.302	Environment Simulation	
(A)	Vibration	6.2
(B)	Temperature and Humidity	6.8
(C)	Shock	6.1
(D)	Metallic Voltage Surge	5.2
(E)	Longitudinal Voltage Surge	5.2
68.304	Leakage Current Limitations	4.4.5
68.306	Hazardous Voltage Limitations	
(A)	General	4.2.2A, 4.2.2C
(B)	Connection of Non-Registered Equipment	4.4.4A(1), 4.2.2A, 4.2.1B
(C)	Hazards From Exposed Surfaces	4.2.2C
68.308	Signal Power Limitations	
(A)	Voiceband Metallic Signal Power	2.1.5A
(B)	Metallic Signal Power at Frequencies Above Voiceband	2.1.5B, 2.1.5D
(C)	Longitudinal Voltage Except During Network Control Signaling	2.1.5C, 2.1.5D
68.310	Longitudinal Balance Limitations	2.5.3.1
68.312	On-Hook Impedance Limitations	
(A)	Loop Start	2.5.1
(B)	Ground Start	Not Applicable
(C)	Ringer Equivalence	1.7 and Glossary
68.314	Billing Protection	
(A)	Data Equipment	Not Applicable
(B)	Voice and Data Equipment	2.1.5G
(C)	Loop Current	2.2.5.B
(D)	Signaling Interference	2.1.5H

MANDATORY TRANSMIT OBJECTIVE LOUDNESS RATING (TOLR)

Loop(26GA)	Upper Limit	Lower Limit
0 Kft	-59 dB	-41 dB
9 Kft	-53	-36
15 Kft	-49	-32

TABLE 2.1-1

DESIRABLE TRANSMIT OBJECTIVE LOUDNESS RATING (TOLR)

Loop(26GA)	Upper Limit	Mean	Lower Limit
0 Kft	-53 dB	-48 dB	-43 dB
9 Kft	-51	-46	-41
15 Kft	-49	-44	-39

NOTE - These limits reflect studies assuming a 500-type telephone with a carbon transmitter. Studies have not been completed on their applicability to other designs. It is anticipated that limits for telephones with linear transmitters will differ from those of the above table in order to achieve the same subjective effects.

TABLE 2.1-2

MANDATORY RECEIVE OBJECTIVE LOUDNESS RATING (ROLR)

Loop(26GA)	Upper Limit	Lower Limit
0 Kft	38 dB	54 dB
9 Kft	40	55
15 Kft	43	58

TABLE 2.1-3

DESIRABLE RECEIVE OBJECTIVE LOUDNESS RATING (ROLR)

Loop(26GA)	Upper Limit	Mean	Lower Limit
0 Kft	41 dB	46dB	51 dB
9 Kft	43	48	53
15 Kft	45	50	55

NOTE - These limits reflect studies assuming a 500-type telephone with a carbon transmitter. Studies have not been completed on their applicability to other designs.

TABLE 2.1-4

RINGING TYPE	RANGE OF COMPATIBLE RINGING FREQUENCIES (Hz)	VOLTAGE RANGE (V rms	Vdc)	MINIMUM IMPEDANCE (Ω)
A	20 ± 3 and 30 ± 3	40 to 130 40 to 130	0-105* 0-52.5	7000*** 5000
B	15.3 to 68.0	40 to 150	0-105*	8000
Q**	20 ± 3	40 to 130	0-105*	7000***

* Most central offices supply 52.5 Vdc. Where range extension is employed voltage may be as high as ± 105 Vdc. Part 68 of the FCC Rules does not specifically note the higher range extension voltage.

** This ringing type conforms to an AT&T Petition (May 19, 1978) to the FCC for a rule change to Section 68.312, On-Hook Impedance Limitations. Type Q ringing is not included as part of the current Part 68 FCC Rules as of the date of this publication.

*** It is intended that these impedances be met at 20 or 30 Hertz.

AC IMPEDANCE PRETRIP REQUIREMENTS

Table 2.5-1

FREQUENCY (Hz)	REAL PART OF IMPEDANCE (Ω)	IMAGINARY PART OF IMPEDANCE (Ω)
5	$R < 15{,}000$	$X = -67{,}000 \pm 15\%$*
24	$5000^* < R < 15{,}000$	$\lvert X \rvert \leq 8000$
85 _ f _ 200	$\lvert R + jX \rvert > 30{,}000$*	

NOTES:

1. R AND X ARE THE REAL AND IMAGINARY PARTS OF THE SERIES IMPEDANCE, RESPECTIVELY.

2. THESE CHARACTERISTICS APPLY FOR ALL TEST VOLTAGES BETWEEN 3 AND 10 VOLTS RMS.

*3 THESE CHARACTERISTICS APPLY FOR A TELEPHONE HAVING A RINGER EQUIVALENCE NUMBER (REN) OF 1 OR LESS. FOR TELEPHONES HAVING AN REN GREATER THAN 1, THE VALUES IN THE TABLE NOTED BY AN ASTERISK SHALL BE APPROPRIATELY DIVIDED BY THE ACTUAL REN OF THE TELEPHONE.

ACCEPTABLE LC TERMINATION

TABLE 2.5-2

AC VOLTAGE	IMPEDANCE (Ω)
10 V RMS 24 Hz	$Z_1 = \lvert R - j X \rvert < 40{,}000$
2.5 V RMS 24 Hz	$Z_2 \geq 4 Z_1$
1-10 V RMS 5 Hz	$Z_3 \geq 50{,}000$

NOTES:

1. R AND X ARE THE REAL AND IMAGINARY PARTS OF THE SERIES IMPEDANCE, RESPECTIVELY.

*2. THESE CHARACTERISTICS APPLY FOR A TELEPHONE HAVING A RINGER EQUIVALENCE NUMBER (REN) OF 1 OR LESS AS SPECIFIED IN SECTION 68.312 (C) OF THE FCC RULES AND REGULATIONS. FOR TELEPHONES HAVING AN REN GREATER THAN 1, THE VALUE IN THE TABLE NOTED BY AN ASTERISK SHALL BE APPROPRIATELY DIVIDED BY THE ACTUAL REN OF THE TELEPHONE.

ACCEPTABLE RC TERMINATION

TABLE 2.5-3

TYPE		PEAK AMPLITUDE* (volts)	PEAK AVAILABLE CURRENT+ (amperes)	MAXIMUM RISE TIME+ (microseconds)	MINIMUM DECAY TIME+ (microseconds)	NUMBER OF SURGES OF EACH POLARITY
P_1	Normal (Part 68)	2500	1000	2	10	4
P_2	Abnormal	5000	1000	2	10	1
M_1	Normal	600	100	10	1000	4
M_2	Normal (Part 68)	800	100	10	560	2
M_3	Abnormal	600	100	10	2500	1
M_4	Abnormal	1000	200	10	1000	1
L_1	Normal	600	200	10	1000	4
L_2	Normal	1000	200	10	360	2
L_3	Normal (Part 68)	1500	200	10	160	2
L_4	Abnormal	600	200	10	2500	1
L_5	Abnormal	1500	400	10	1000	1

* Peak Amplitude is the peak surge voltage with the source terminated in 10,000 ohms.

\+ Rise and decay times apply to voltage waveforms measured into an open circuit and to the wave form of the current that flows through a short circuit. Available current, rise time and decay time are defined as follows:

<u>Available Current</u> is the peak current that the surge voltage source can deliver into a short circuit.

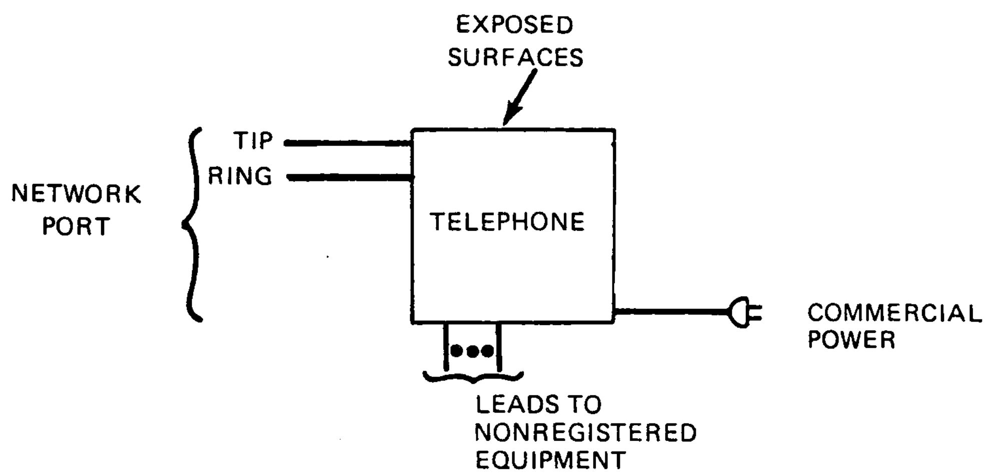
<u>Rise Time</u> is the time interval between the 10 percent and 90 percent of peak points on the leading edge multiplied by 1.25.

<u>Decay Time</u> is the time interval between the 10 percent of peak point on the leading edge and the 50 percent peak point on the training edge.

The number of surges specified is not necessarily adequate to assure any particular service life for the equipment particularly in areas where lightning strikes occur frequently. It is desirable that equipment withstand numbers of surges in excess of those specified.

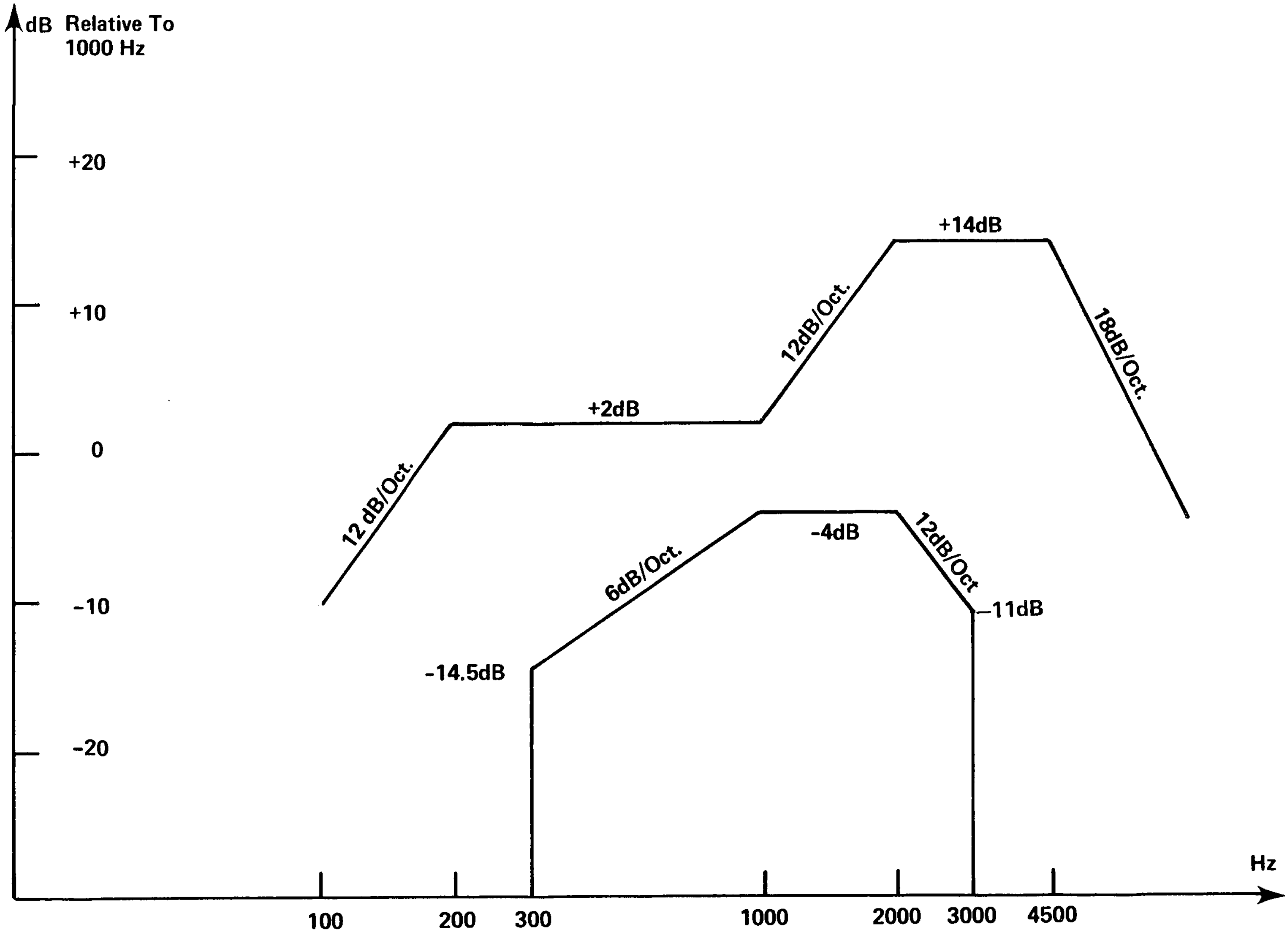
SURGE TABLE

TABLE 5.1



EQUIPMENT INTERFACES

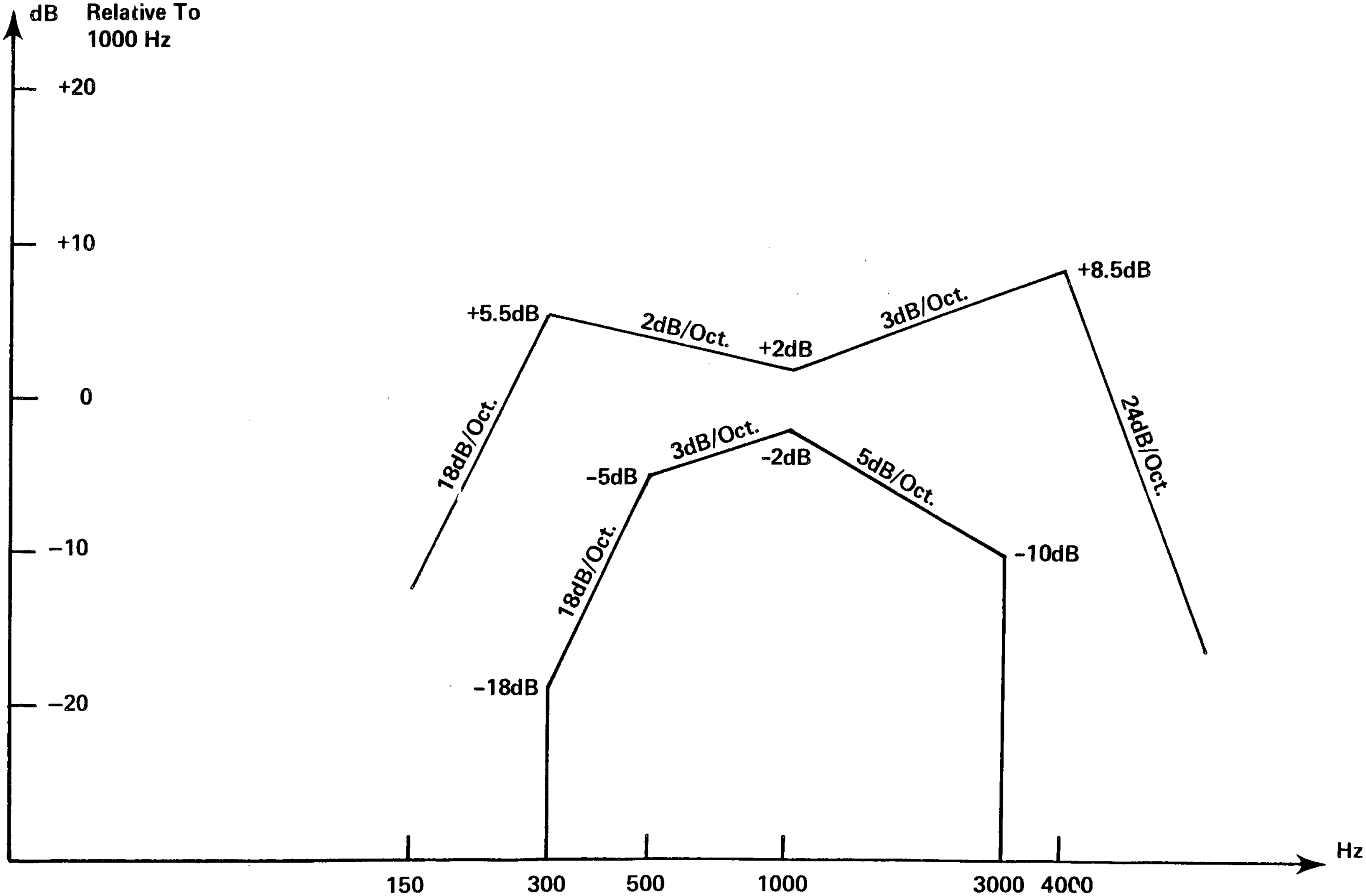
FIGURE 1.1



TRANSMIT FREQUENCY RESPONSE

FIGURE 2.1-1

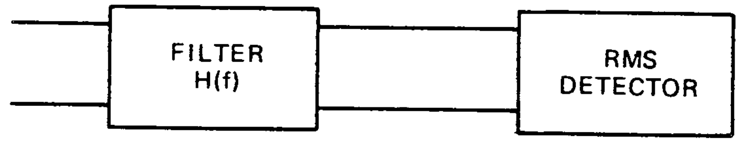
PRELIMINARY



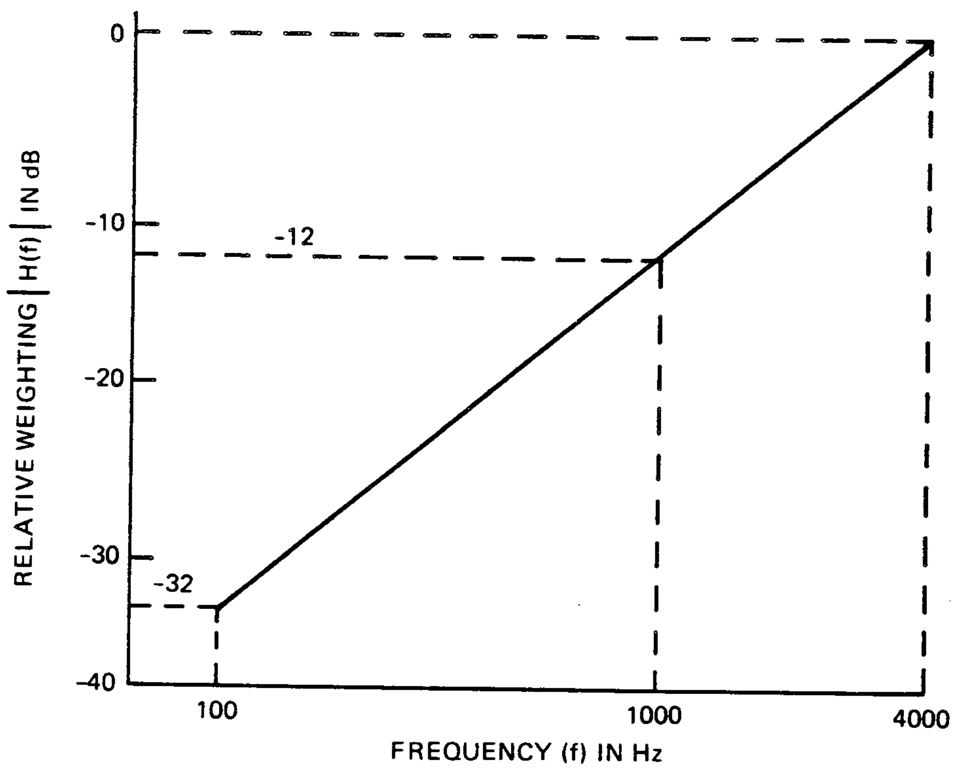
RECEIVE FREQUENCY RESPONSE

FIGURE 2.1-2

PRELIMINARY

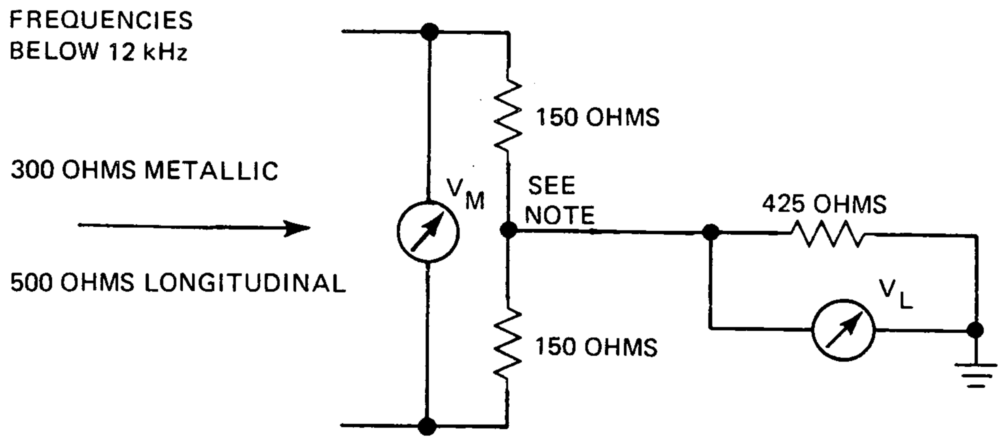


$$|H(f)| = \frac{f}{4000}$$

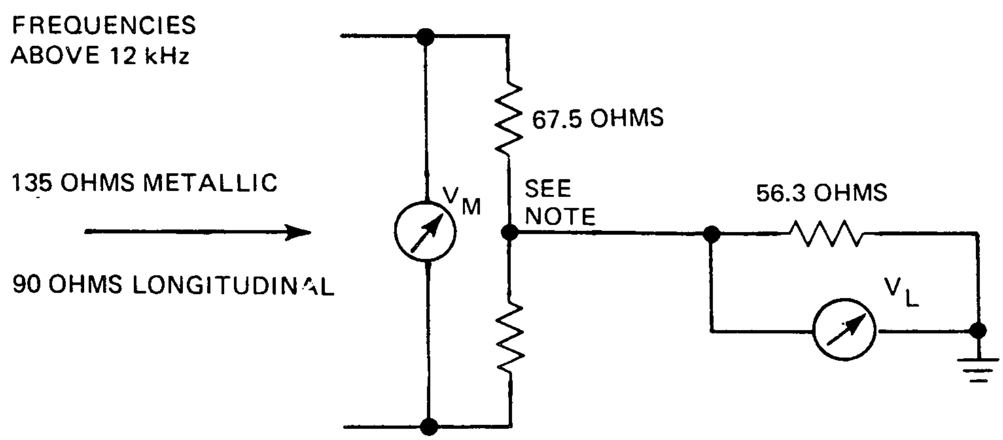


WEIGHTING FUNCTION RESPONSE

FIGURE 2.1-3



$V_{LONGITUDINAL}$ (dB) =V (dB) + 1.4 dB

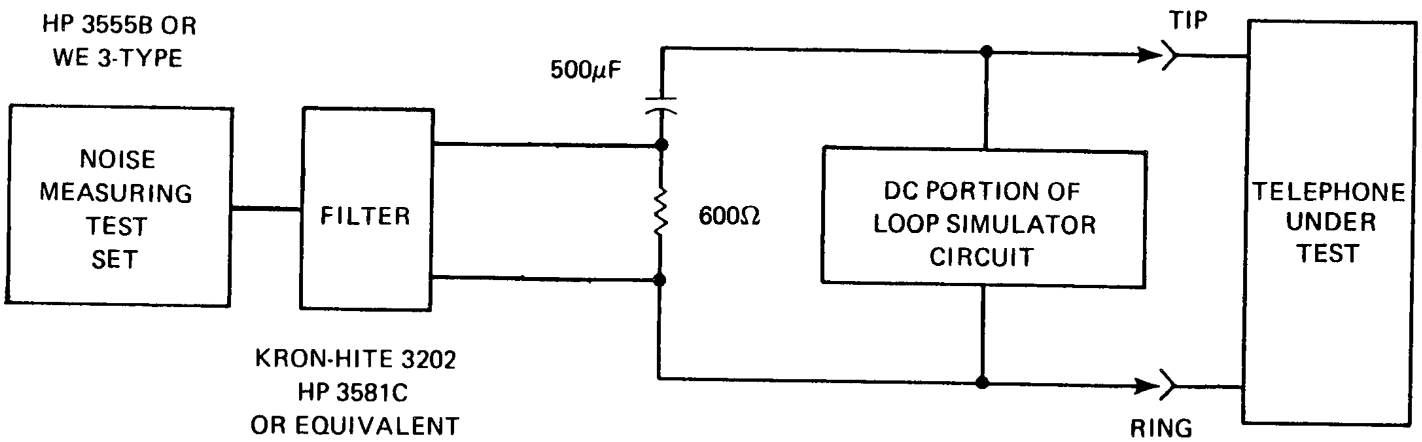


$V_{LONGITUDINAL}$ (dB) = V(dB) + 4.1 dB

NOTE: OPEN THIS PATH FOR METALLIC MEASUREMENTS

RESISTIVE TERMINATIONS

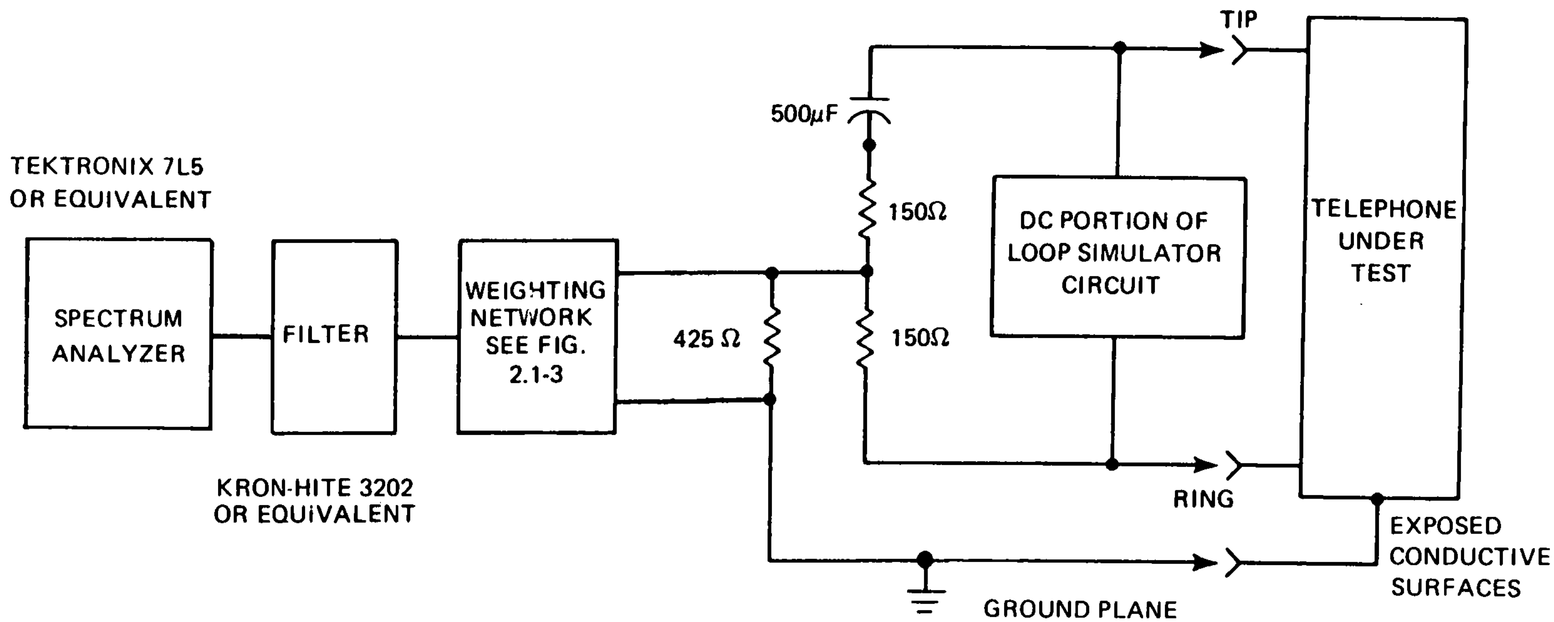
FIGURE 2.1-4



SIGNAL POWER TEST CIRCUIT
METALLIC SIGNAL POWER IN THE 100 TO 4000 HERTZ
BAND AND 3995 TO 4005 HERTZ BAND

FIGURE 2.1-5

PRELIMINARY

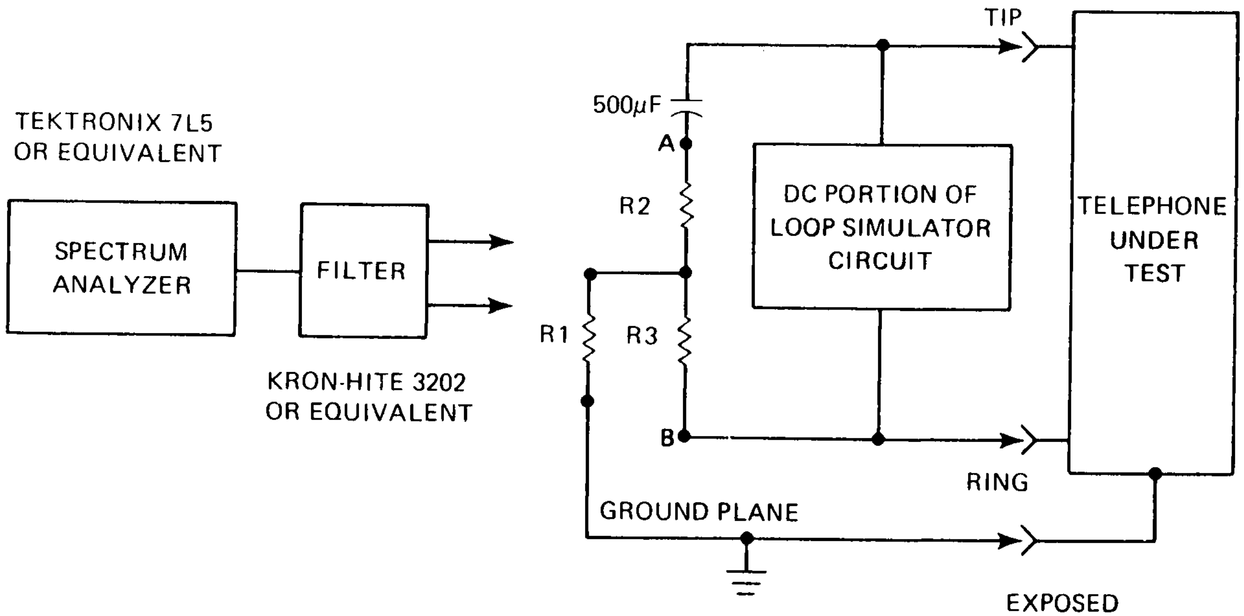


$V_{LONGITUDINAL}$ (dB) = V(dB) + 1.4 dB

SIGNAL POWER TEST CIRCUIT
LONGITUDINAL VOLTAGE IN THE 100 TO 4000 HERTZ BAND

FIGURE 2.1-6

PRELIMINARY



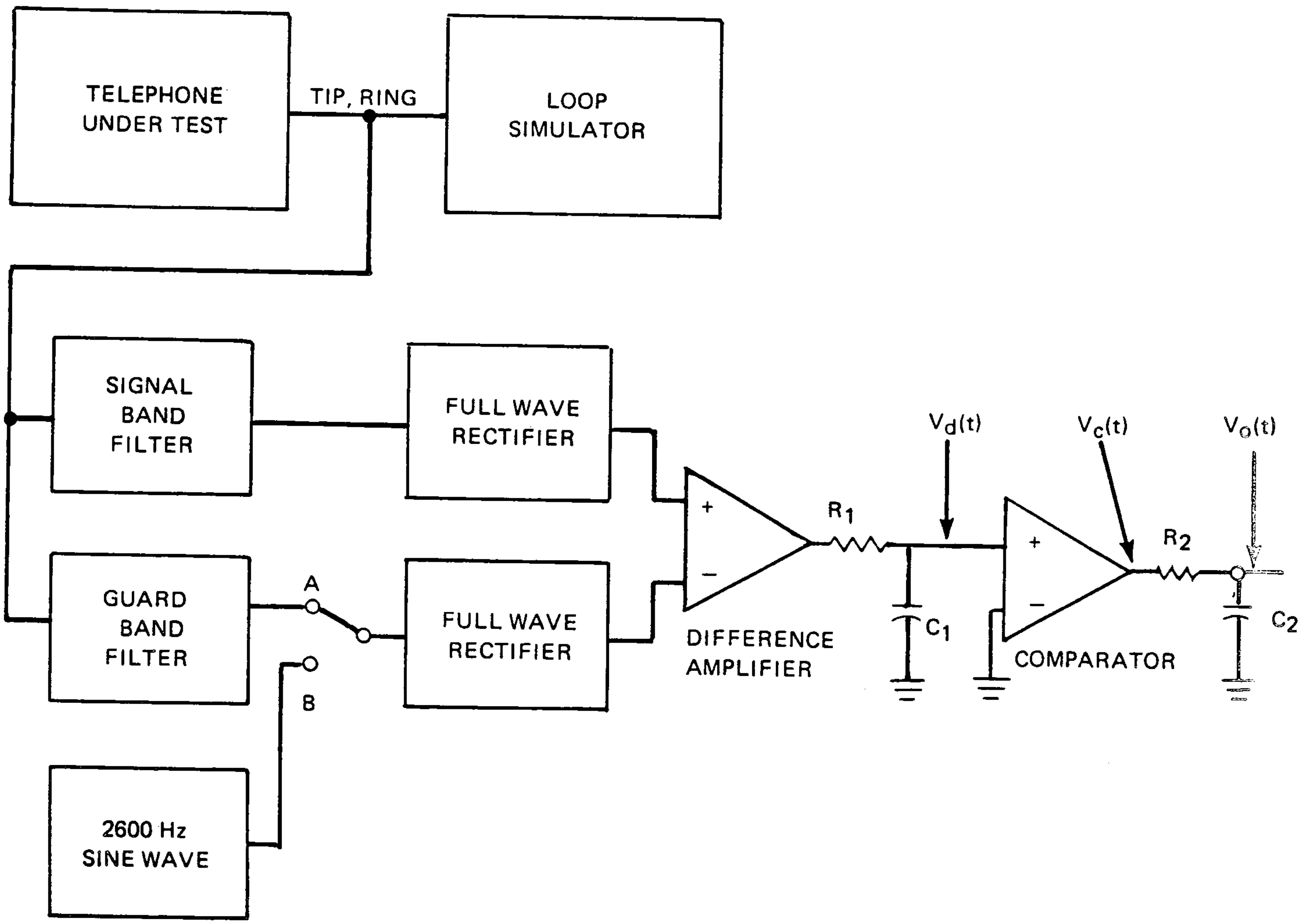
NOTES

1. R1, R2, AND R3 ARE CHOSEN AS SHOWN IN FIGURE 2.1-3
2. LONGITUDINAL VOLTAGE IS MEASURED ACROSS R1, SEE FIGURE 2.1-3
3. METALLIC VOLTAGE IS MEASURED ACROSS R2 AND R3 (BETWEEN NODES A AND B) WITH THE PATH THROUGH R1 OPENED

SIGNAL POWER TEST CIRCUIT
LONGITUDINAL AND METALLIC VOLTAGE
ABOVE 4000 HERTZ

FIGURE 2.1-7

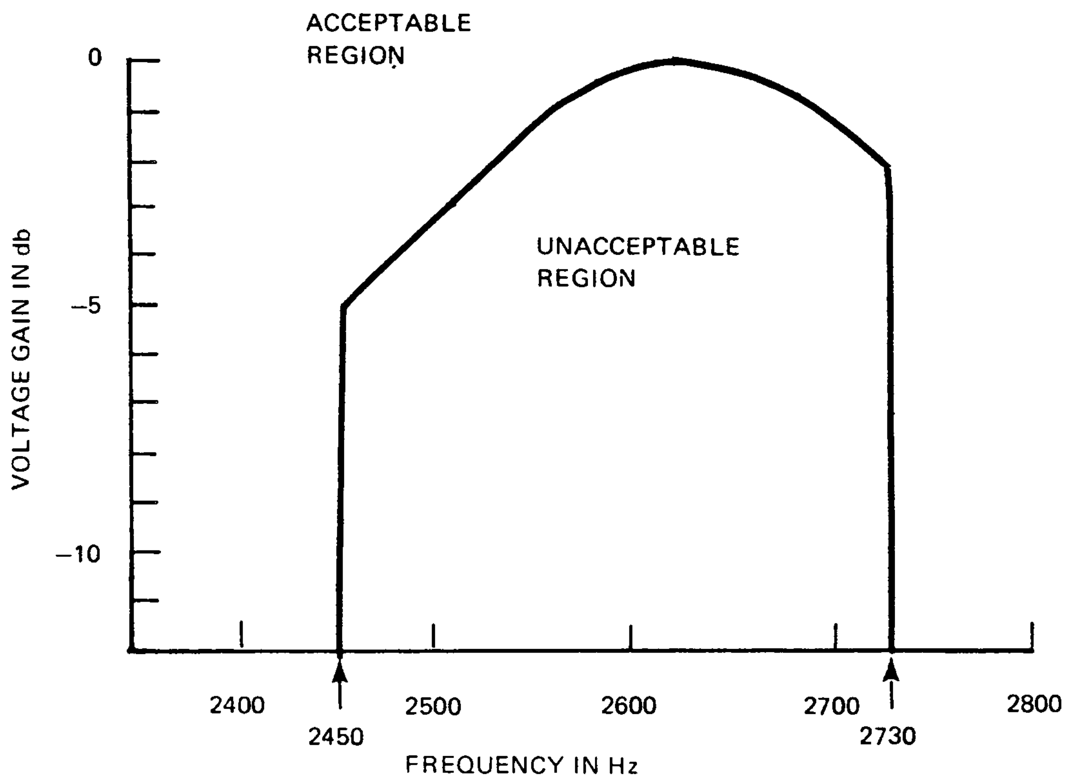
PRELIMINARY



NOTES:
1. THE FILTERS HAVE HIGH IMPUT IMPEDANCE
2. $R_1C_1 = 3.5 \pm 0.5$ MILLISECONDS
3. $R_2C_2 \leqslant 43$ MILLISECONDS
4. THE 2600 Hz SINE WAVE VOLTAGE IS NOT GREATER THAN 5 MILLIVOLTS RMS
5. $V_c = V \text{ sgn } (V_d)$; V IS A CONSTANT
6. EQUIPMENT PASSES THE TEST IF $V_o(t)$ DOES NOT EXCEED ZERO WITH THE SWITCH IN ONE OF ITS TWO POSITIONS (A OR B)

SIGNALLING INTERFACE TEST ARRANGEMENT

FIGURE 2.1-8



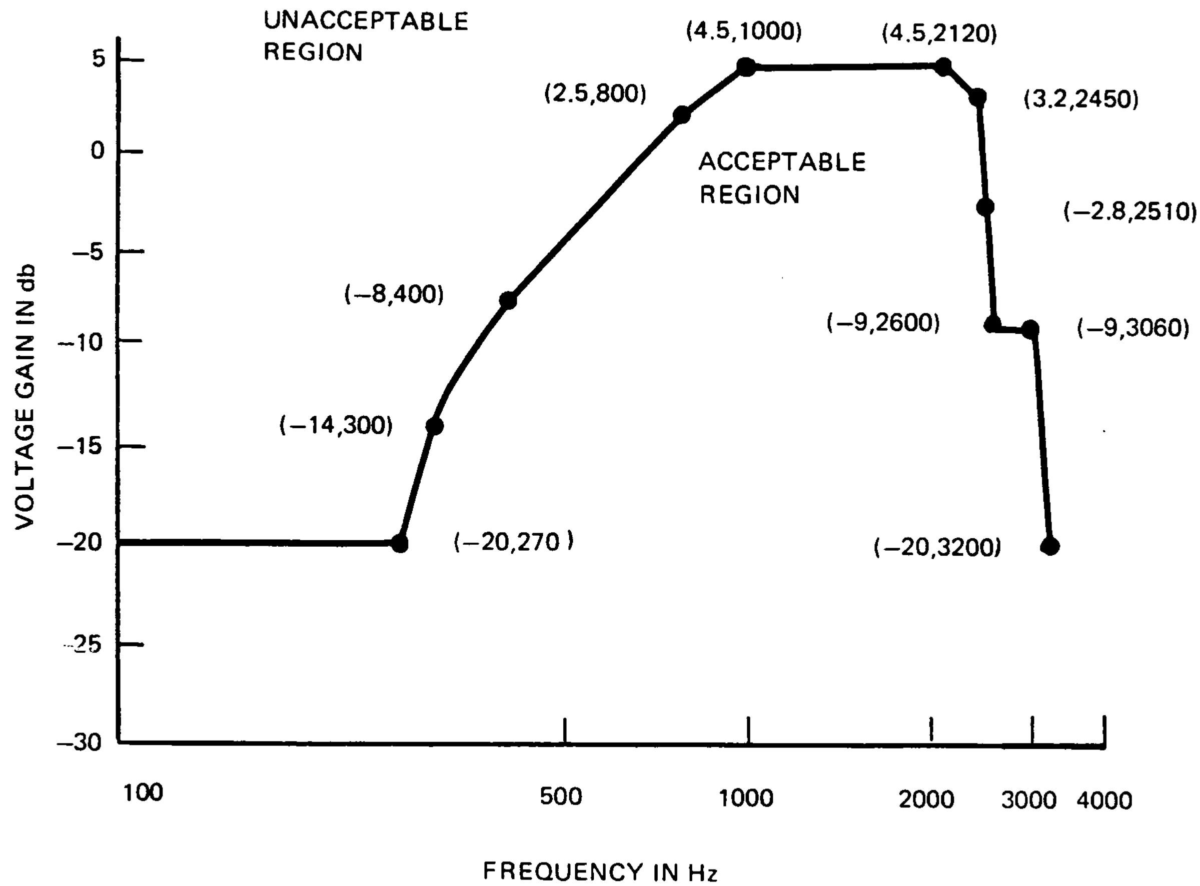
THE SIGNAL BAND FILTER GAIN VS FREQUENCY IS NOT LESS THAN THE GAIN INDICATED BY THIS FIGURE. THE SHAPE OF THE CURVED PORTION OF THE FIGURE IS DEFINED BY:

$$\text{GAIN (db)} = -10 \log_{10} \left[1 + Q^2 \left(\frac{f}{f_o} - \frac{f_o}{f} \right)^2 \right]$$

WITH $Q = 11.3$ AND $f_o = 2618$Hz

SIGNAL BAND WEIGHTING FUNCTION

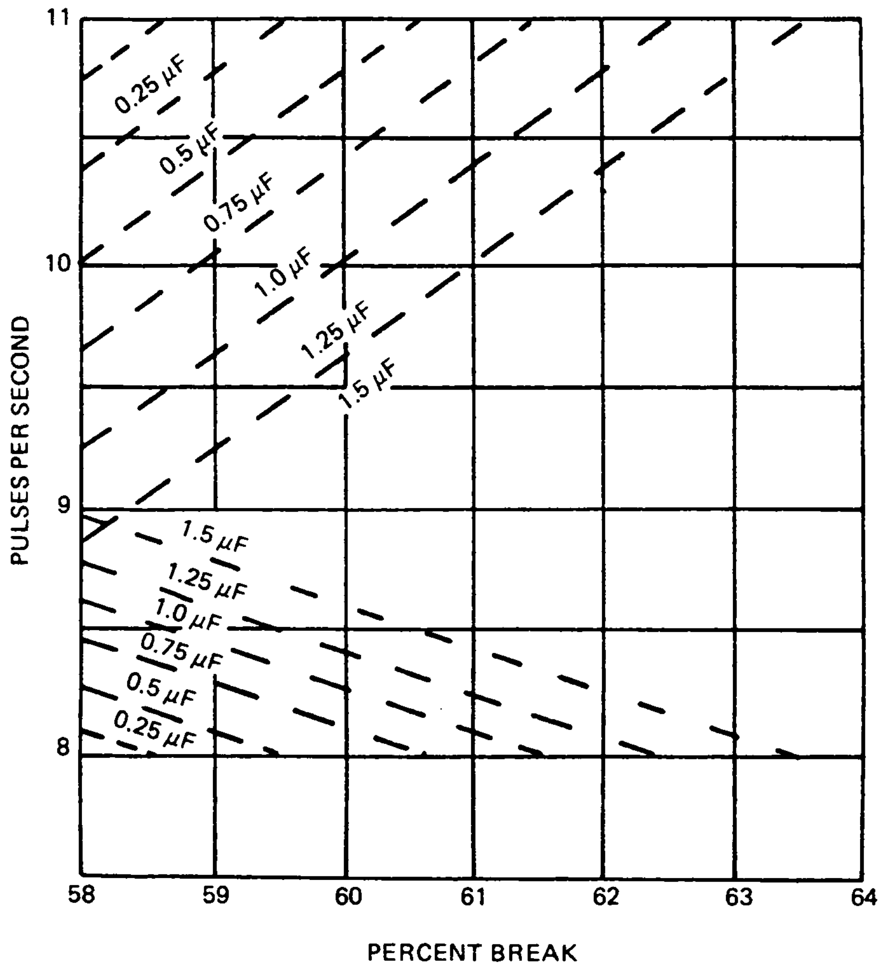
FIGURE 2.1-9



THE GUARD BAND FILTER GAIN VS FREQUENCY IS NO GREATER THAN THE GAIN INDICATED BY THE STRAIGHT LINES OF THIS FIGURE. THE NUMBERS IN PARENTHESES ARE GAIN AND FREQUENCY, AND DEFINE THE END POINTS OF THE LINE SEGMENTS.

GUARD BAND WEIGHTING FUNCTION

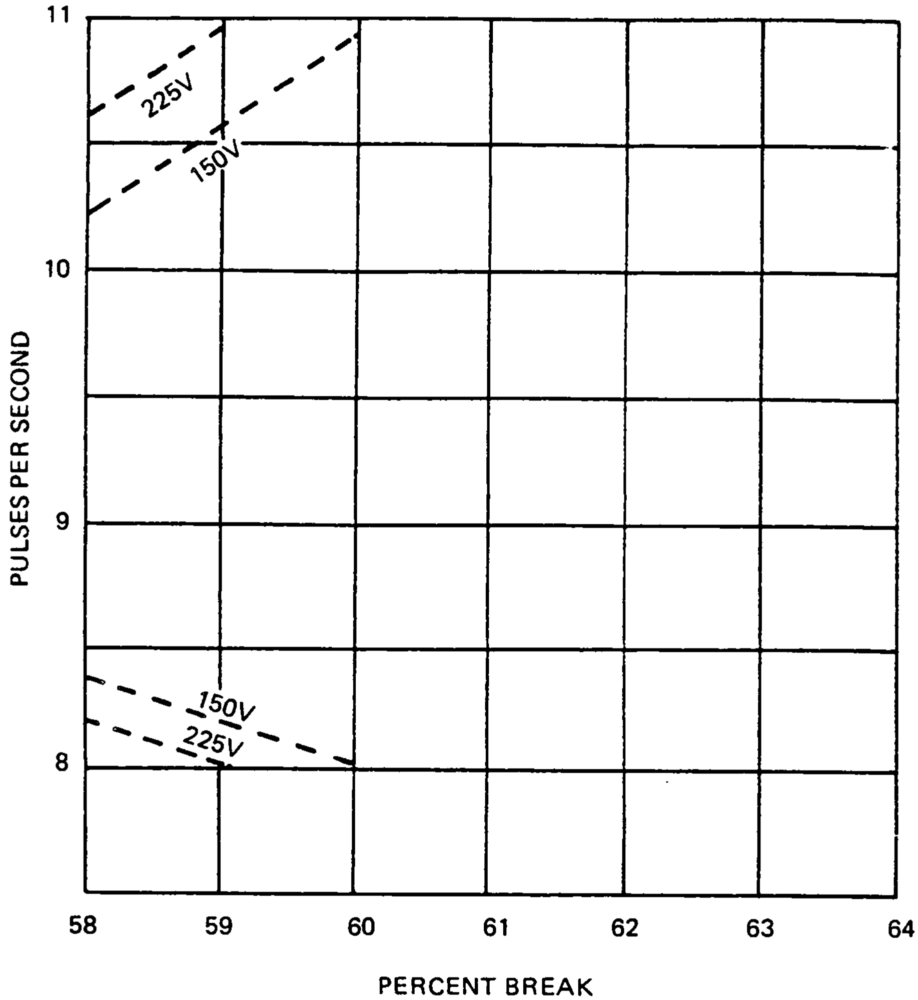
FIGURE 2.1-10



THIS DIAGRAM IS USED TO DETERMINE THE ALLOWED AREA OF OPERATION OF A DIAL FOR A GIVEN CAPACITOR IN ITS PROTECTIVE NETWORK. THUS FOR THE CAPACITANCE OF 1 μF THE PARAMETERS OF THE DIAL PULSES MUST LIE IN THE HEXAGON BOUNDED BY THE TWO SLOPING LINES MARKED 1 μF, THE 58 PERCENT BREAK LINE; THE 8 PPS LINE, THE 11 PPS LINE AND THE 64 PERCENT BREAK LINE.

PERCENT BREAK AND PPS LIMITS AS A FUNCTION OF NETWORK CAPACITANCE FOR DEVICES WHICH GENERATE PULSES

FIGURE 2.3-1

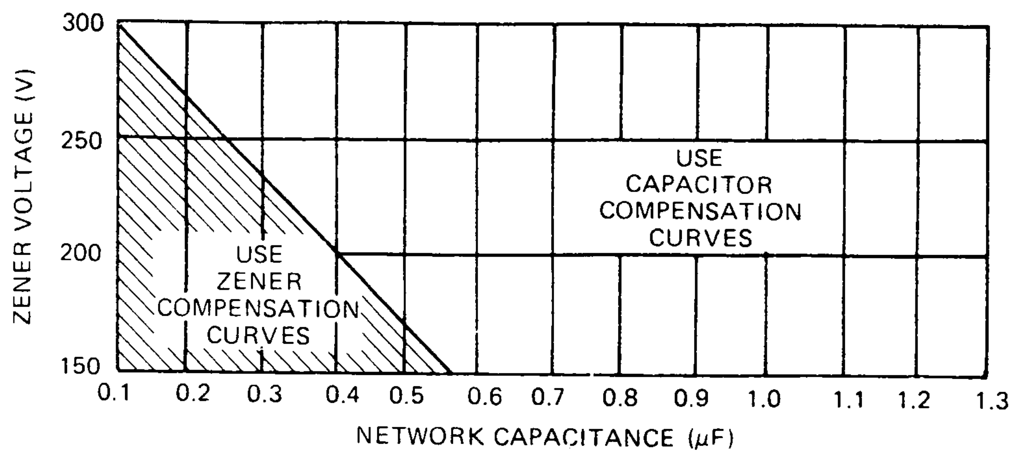


THIS DIAGRAM IS USED TO DETERMINE THE ALLOWED AREA OF OPERATION OF A DIAL FOR A GIVEN ZENER DIODE IN THE PROTECTIVE NETWORK. THUS FOR THE ZENER VOLTAGE OF 225V THE PARAMETERS OF THE DIAL PULSES MUST LIE IN THE HEXAGON BOUNDED BY THE TWO SLOPING LINES MARKED 225V, THE 58 PERCENT BREAK LINE, THE 8 PPS LINE, THE 11 PPS LINE AND THE 64 PERCENT BREAK LINE.

NOTE: IT IS EXPECTED THAT 105 VOLT LINES WILL BE ADDED IN A FUTURE ISSUE.

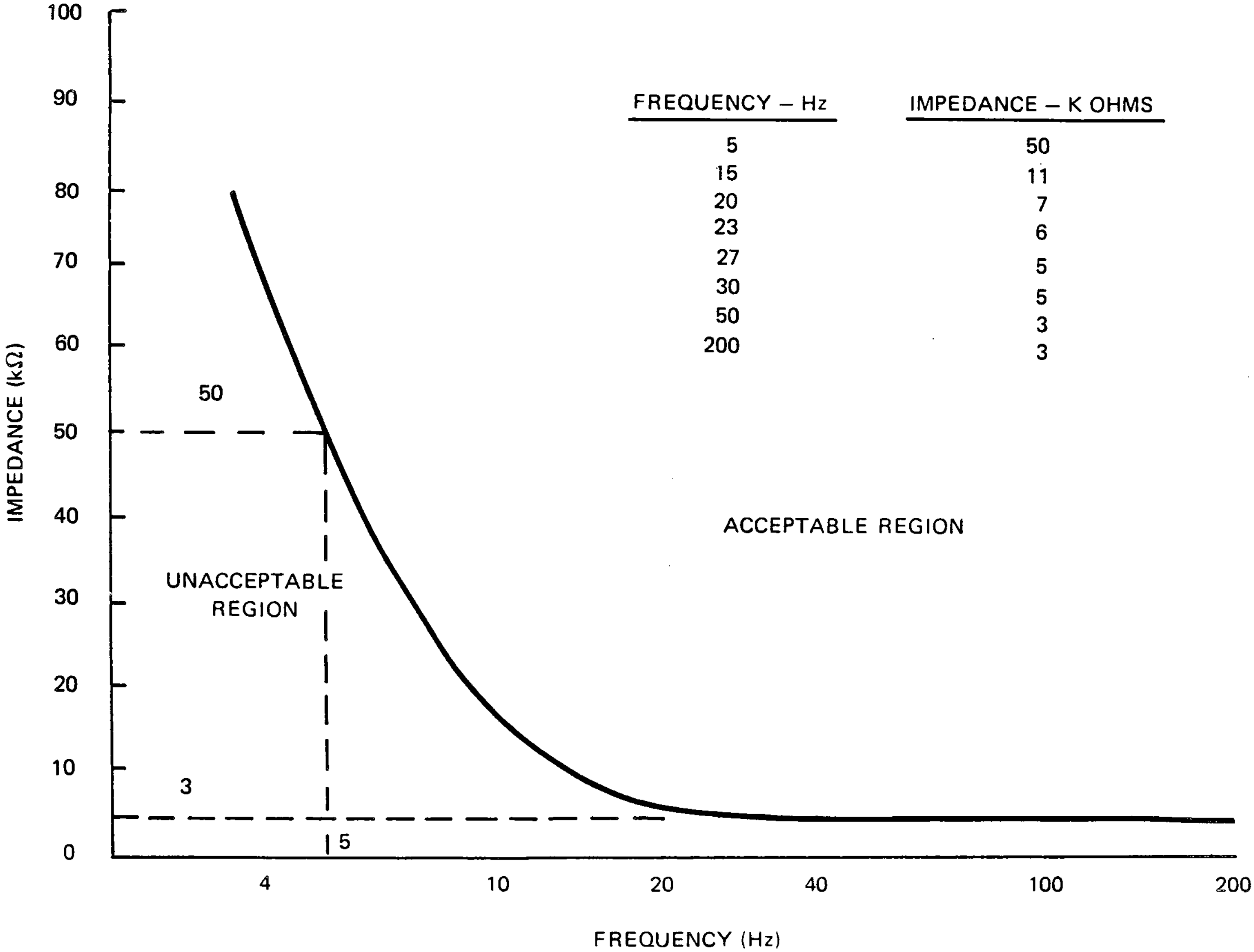
PERCENT BREAK AND PPS LIMITS AS A FUNCTION OF ZENER VOLTAGE FOR DEVICES WHICH GENERATE DIAL PULSES

FIGURE 2.3-2



REQUIRED COMPENSATION FOR COMBINATION ZENER DIODE AND RC NETWORK PROTECTION

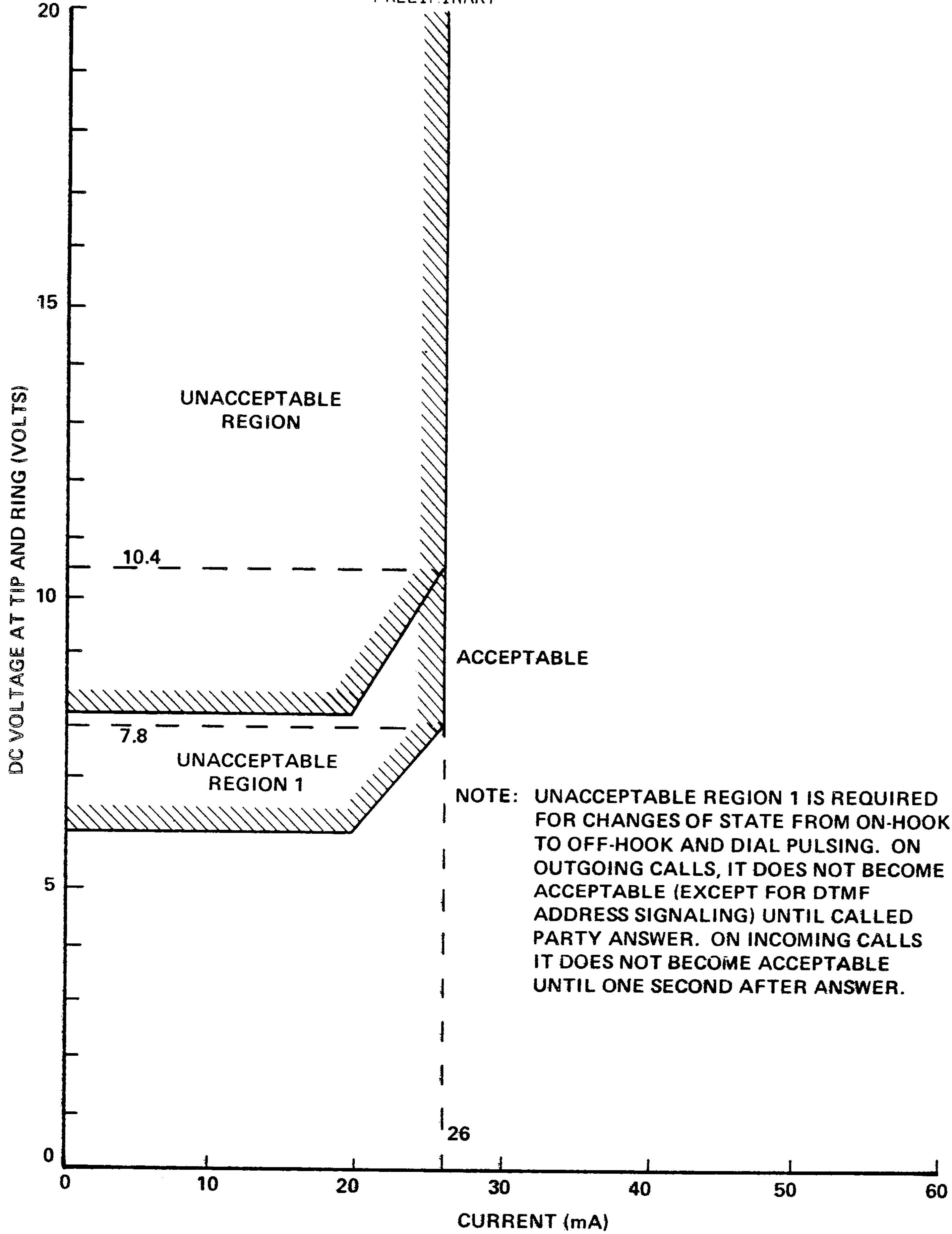
FIGURE 2.3-3



FREQUENCY – Hz	IMPEDANCE – K OHMS
5	50
15	11
20	7
23	6
27	5
30	5
50	3
200	3

MINIMUM IMPEDANCE DURING BREAK INTERVALS
OF DIAL PULSING AND ON-HOOK AC IMPEDANCE
FOR FREQUENCIES BETWEEN 4 AND 200 HERTZ

FIGURE 2.3-4



OFF-HOOK TIP TO RING DC VOLTAGE
VERSUS CURRENT CHARACTERISTICS

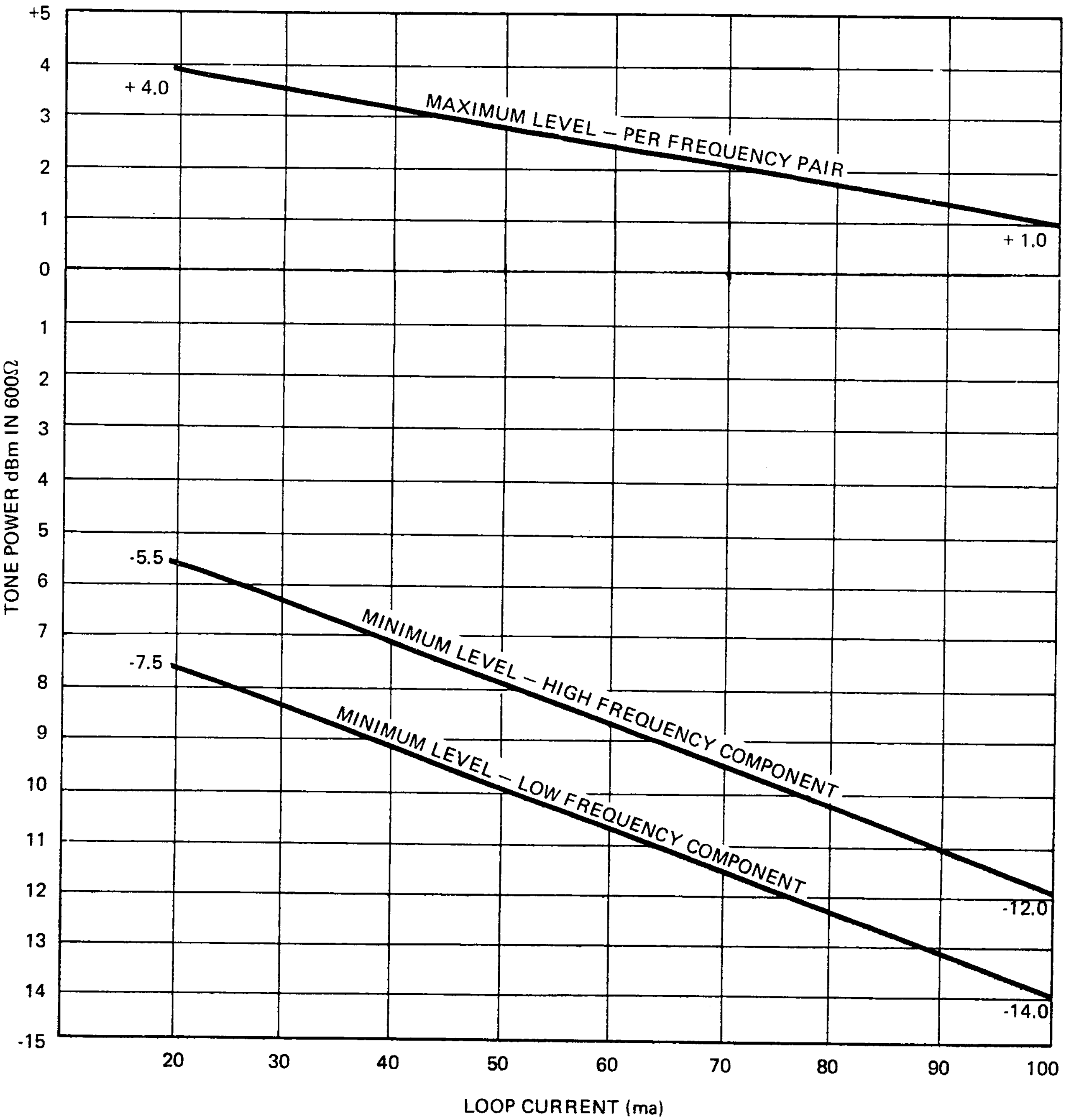
FIGURE 2.3-5

SYMBOL	LETTERS	NUMBER OF PULSES
1		1
2	ABC	2
3	DEF	3
4	GHI	4
5	JKL	5
6	MNO	6
7	PRS	7
8	TUV	8
9	WXY	9
0	OPERATOR OR OPER	10

DIAL PULSE ASSIGNMENTS

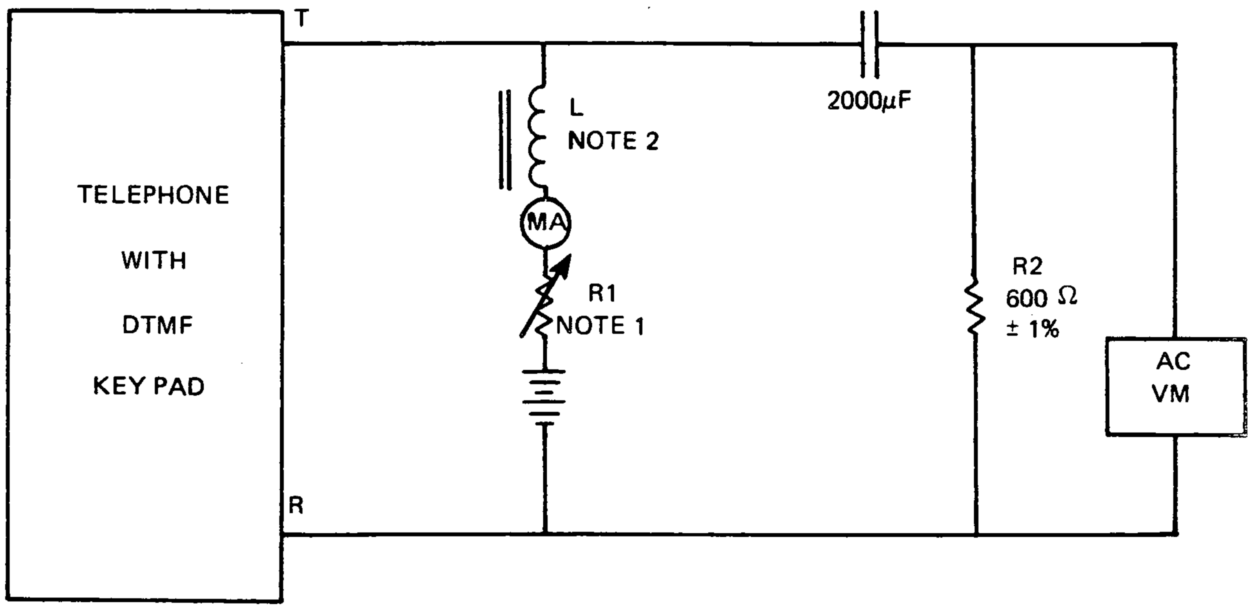
FIGURE 2.3-6

PRELIMINARY



DUAL TONE MULTIFREQUENCY TONE POWER
AT ORIGINATING STATION

FIGURE 2.3-7



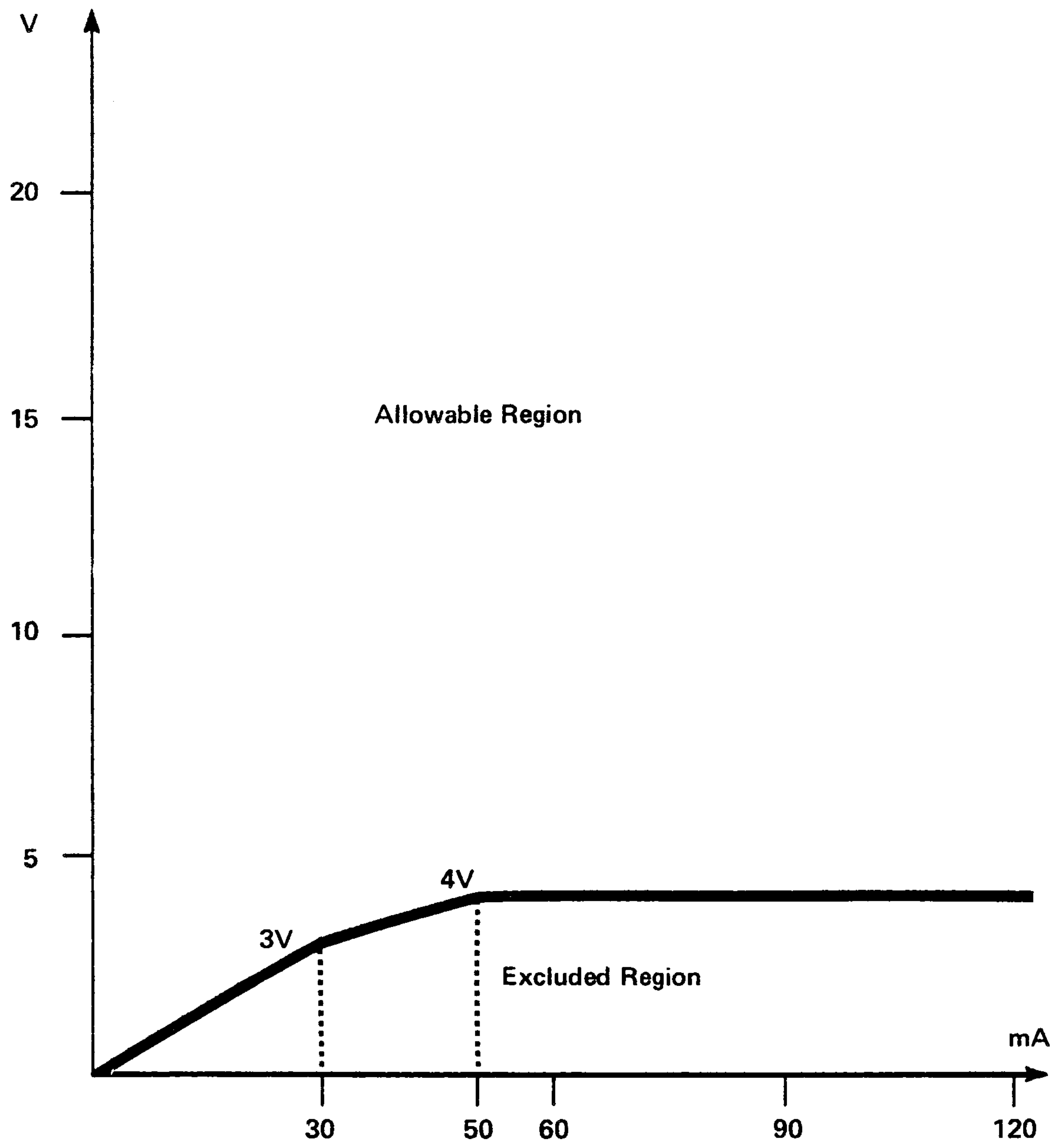
NOTES:

1. ADJUST RESISTOR R1 TO PROVIDE THE RANGE OF DC STATION LOOP CURRENT REQUIRED. SEE FIGURE 2.3-7. USE BATTERY VOLTAGE NECESSARY TO FURNISH REQUIRED CURRENT LEVELS.

2. INDUCTANCE OF BATTERY FEED COIL, L, AT MAXIMUM CURRENT MUST BE AT LEAST 5H. TYPICAL L IS WECO 1011 (RESISTANCE $<$ 400 OHMS).

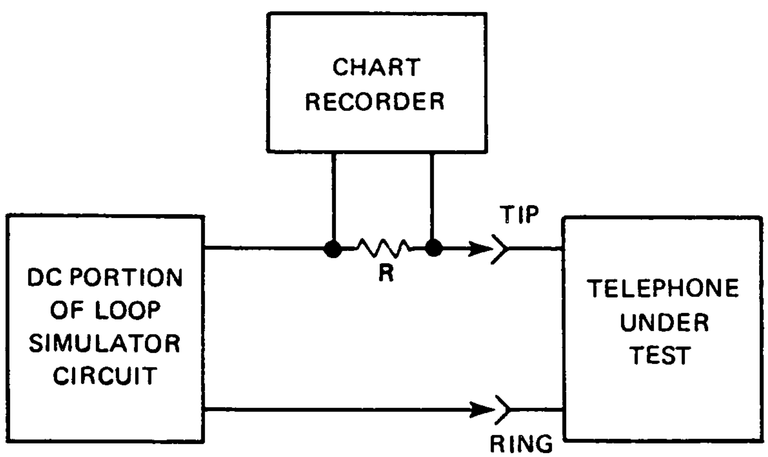
MEASUREMENT OF TELEPHONE DTMF KEY PAD
SIGNAL LEVELS

FIGURE 2.3-8



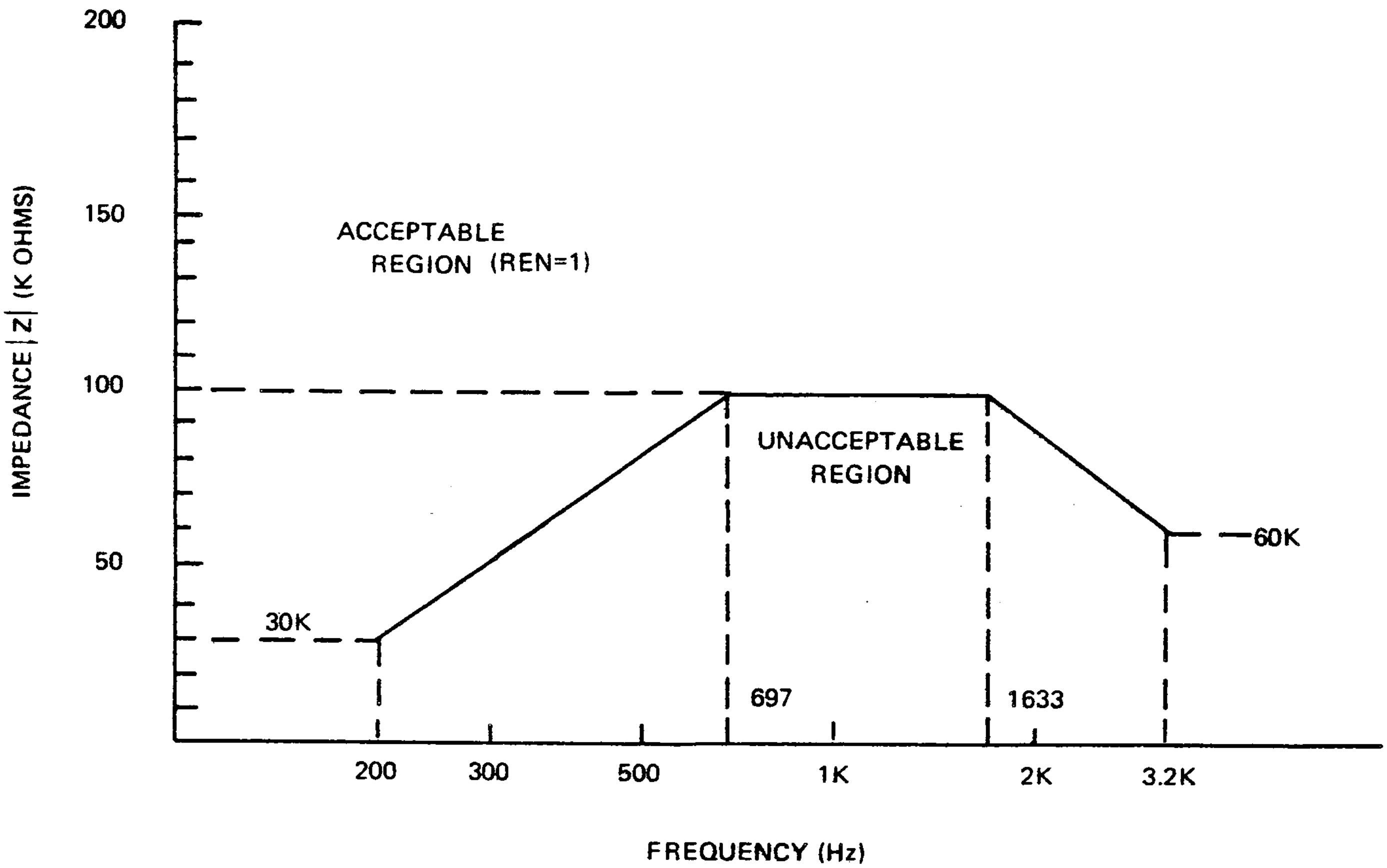
PARALLEL SET DC CHARACTERISTICS

FIGURE 2.4-1



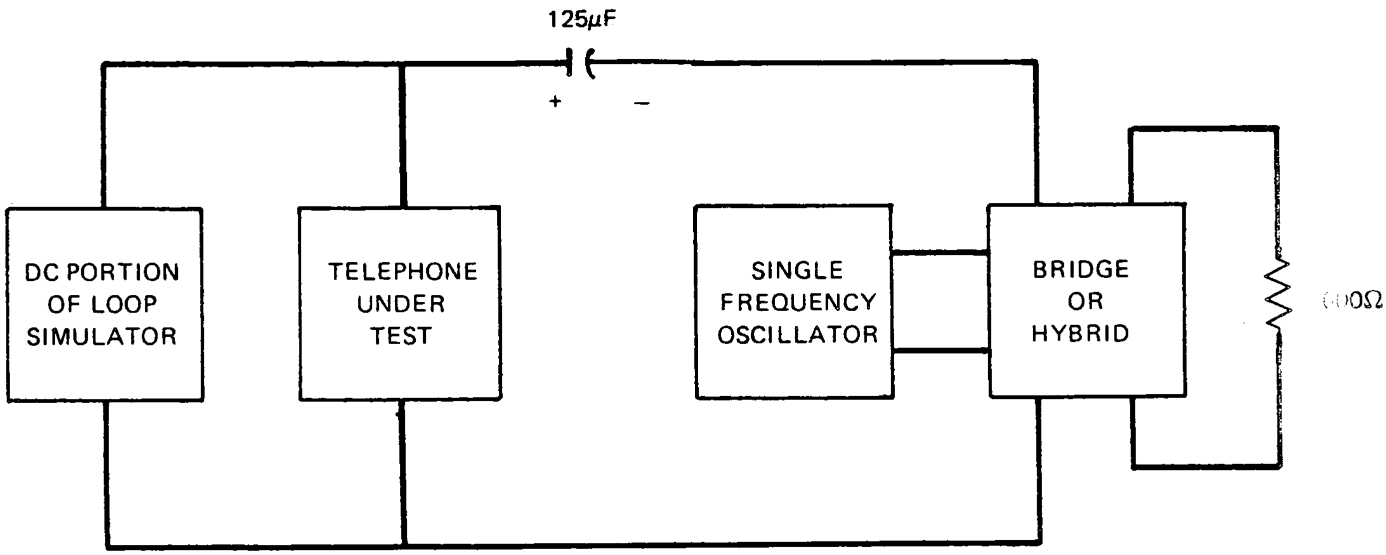
LOOP CURRENT TEST CIRCUIT

FIGURE 2.4-2



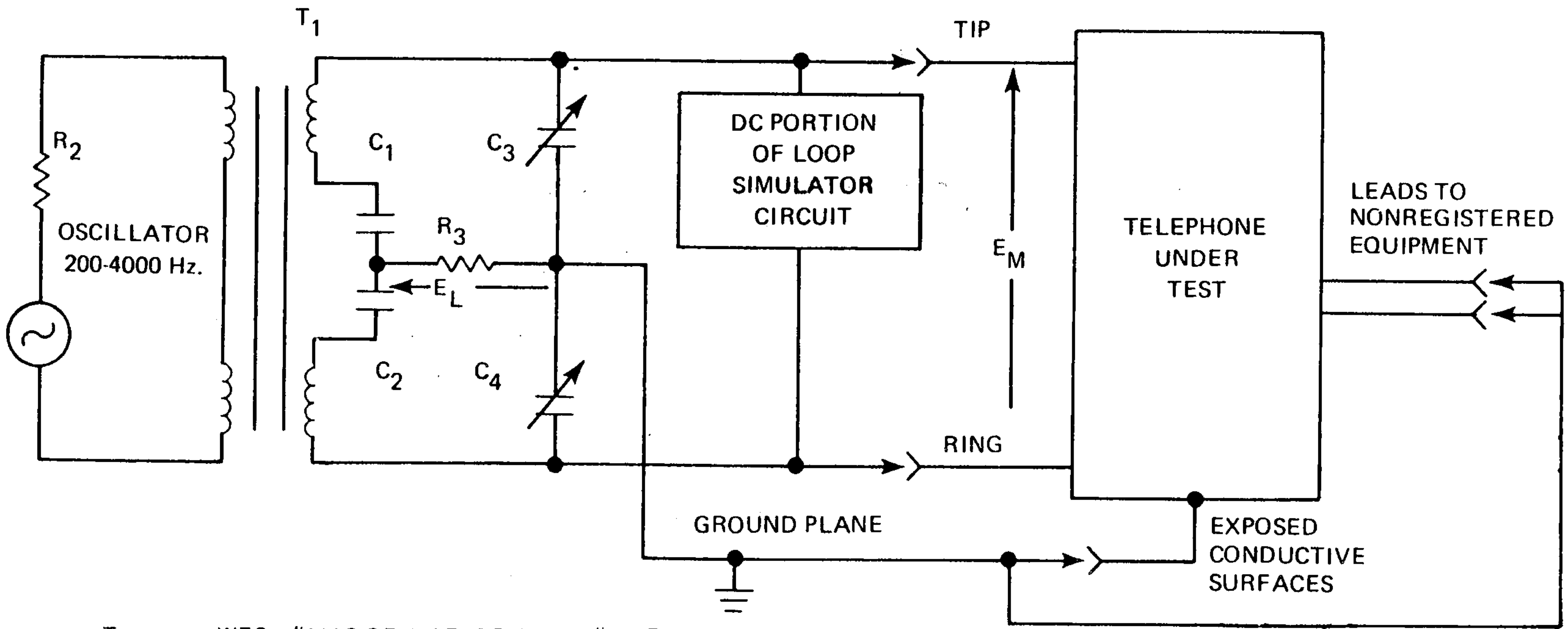
MINIMUM ON-HOOK AC IMPEDANCE – TIP TO RING
FOR FREQUENCIES BETWEEN 200 AND 3200 HERTZ

FIGURE 2.5-1



RETURN LOSS TEST CIRCUIT

FIGURE 2.5-2

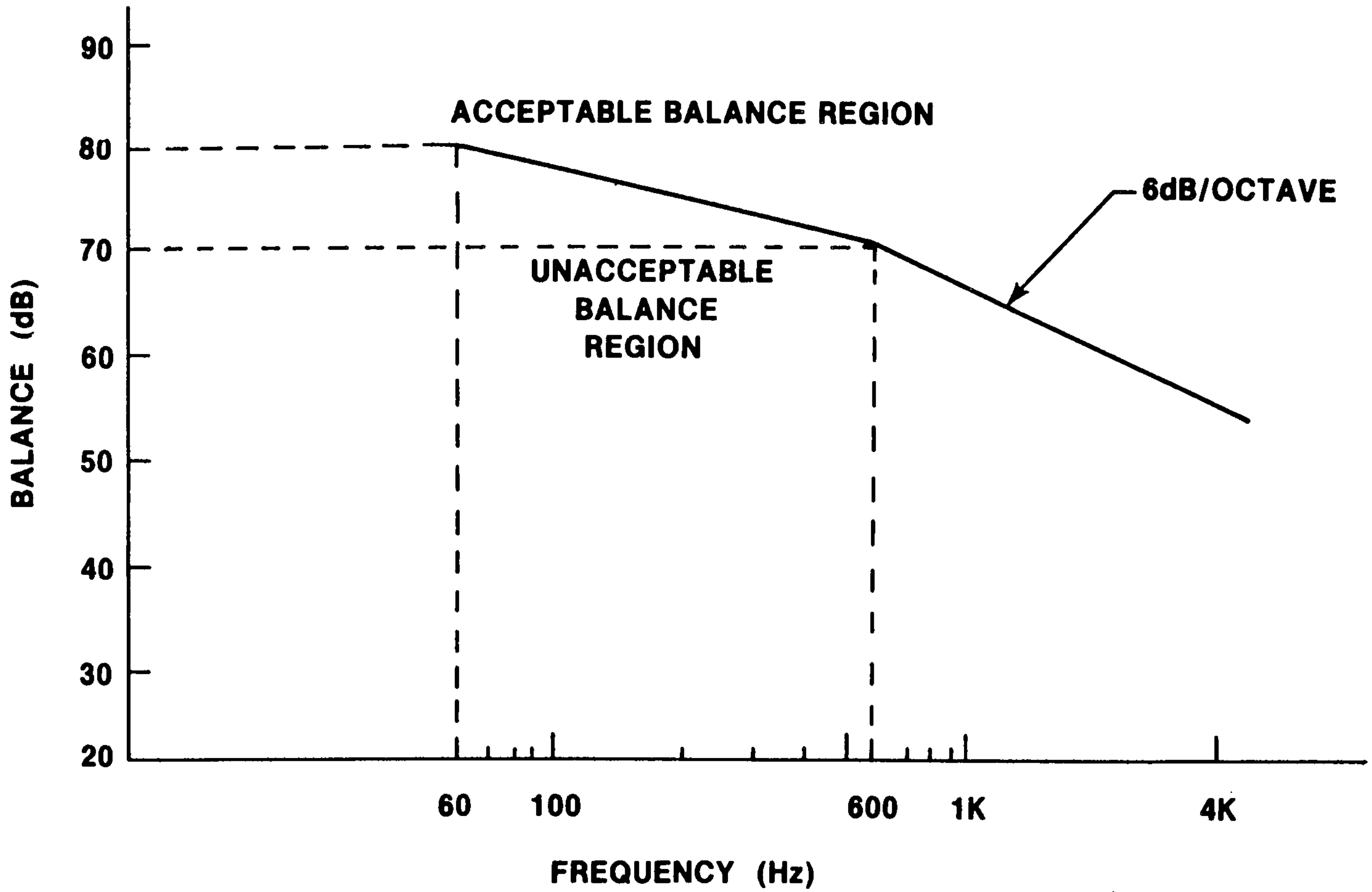


T_1 – WECo #111C OR 119E, OR A.D.C. #118F, OR EQUIVALENT.
C_1, C_2 – 8 MICROFARAD, 400 WVDC, MATCHED TO WITHIN 0.1%.
C_3, C_4 – 100 TO 500 PICOFARAD ADJUSTABLE TRIMMER CAPACITORS.
OSC. – AUDIO OSCILLATOR WITH SOURCE RESISTANCE, $R_1 \leqslant 600$ OHMS.
R_2 – SELECTED SUCH THAT $R_1 + R_2 = 600$ OHMS.
R_3 – 500 OHMS.

USE TRIMMER CAPACITORS C_3 AND C_4 TO BALANCE THE TEST CIRCUIT TO A 20 dB GREATER BALANCE THAN THE REQUIREMENT FOR ALL FREQUENCIES SPECIFIED WITH A 600-OHM METALLIC AND A PRECISELY BALANCED LONGITUDINAL TERMINATION SUBSTITUTED FOR THE EQUIPMENT UNDER TEST. THE LONGITUDINAL TERMINATION HAS A LONGITUDINAL IMPEDANCE TO GROUND WHICH IS SIMILAR TO THAT OF THE EQUIPMENT UNDER TEST.

METALLIC – TO – LONGITUDINAL BALANCE TEST CIRCUIT

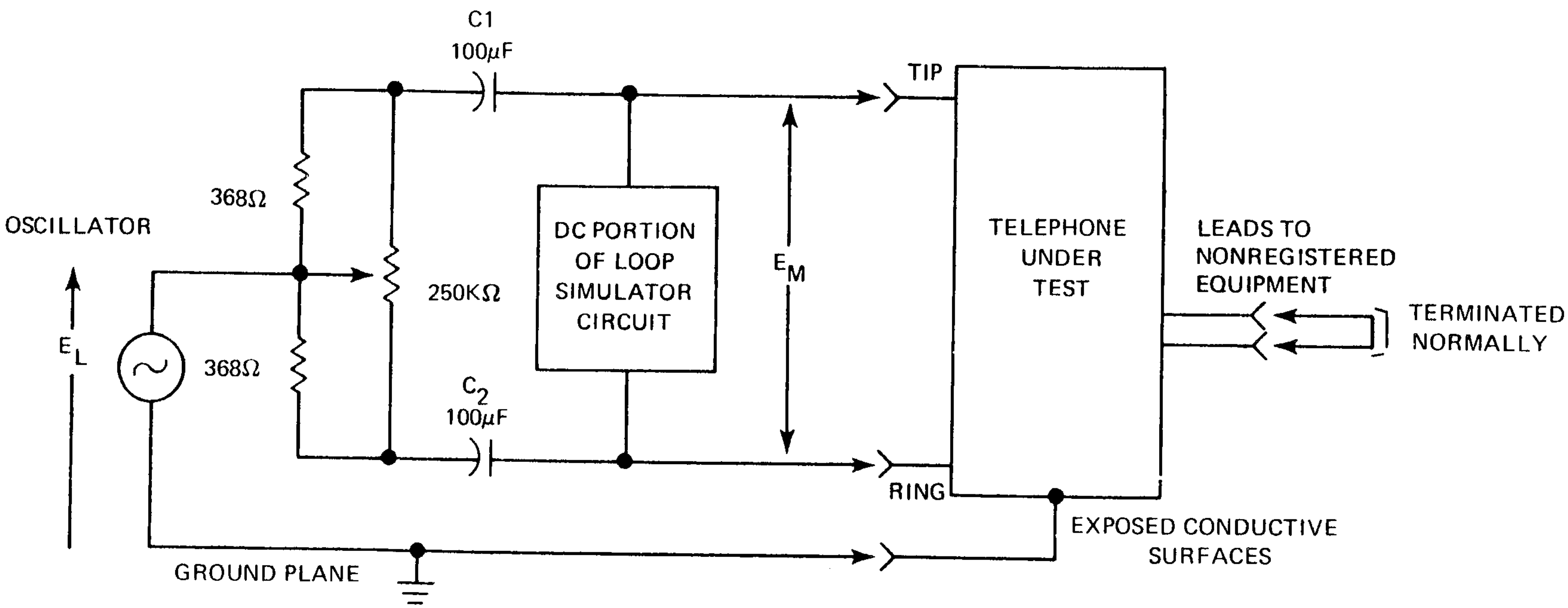
FIGURE 2.5-3



LONGITUDINAL–TO–METALLIC BALANCE REQUIREMENT

FIGURE 2.5-4

PRELIMINARY



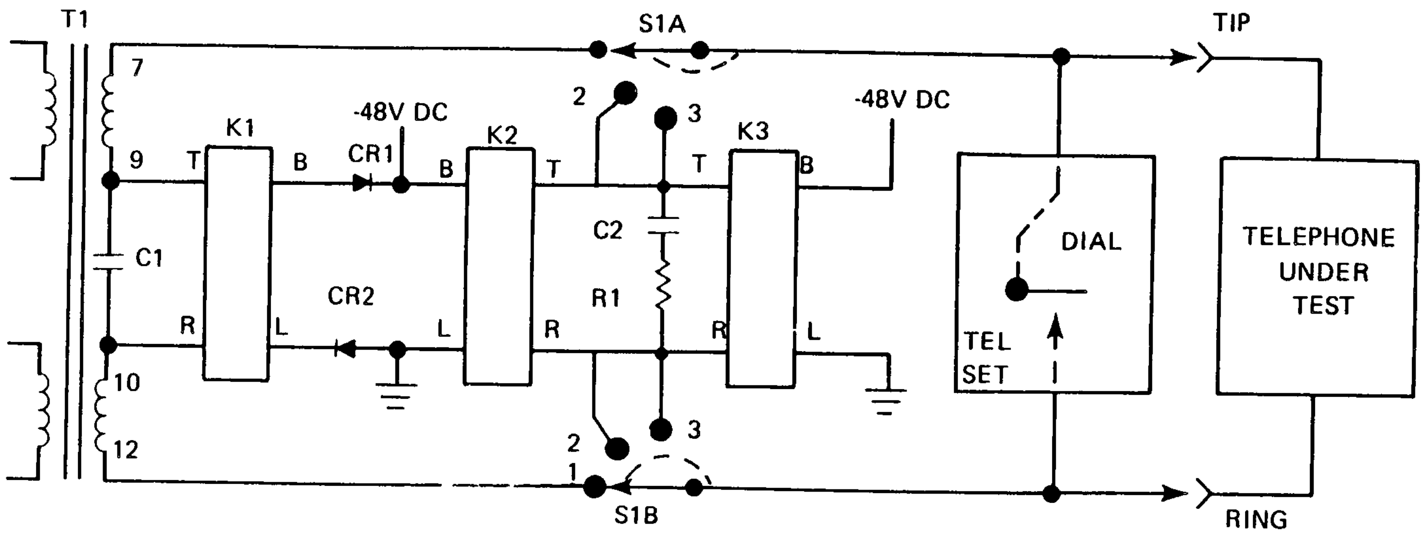
PRELIMINARY

NOTES:

1. THE CAPACITANCE OF C_1 IS MAINTAINED WITHIN 0.2μF OF C_2.
2. THE OSCILLATOR PROVIDES 0 TO 10 VOLTS RMS OVER THE FREQUENCY RANGE 60 TO 400 Hz.

LONGITUDINAL–TO–METALLIC BALANCE TEST CIRCUIT

FIGURE 2.5-5



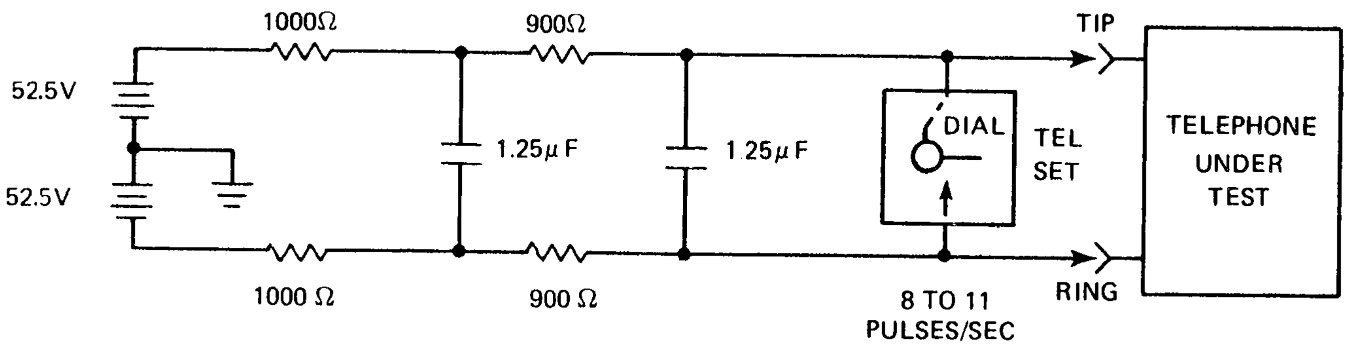
C1	–	4μF, 250V DC
K1	–	WECo 221FAE RELAY OR EQUIV.
T1	–	WECo 120P REPEAT COIL OR EQUIV.
CR1, CR2	–	600V, 1 AMP
K2	–	WECo 221A RELAY OR EQUIV.
K3	–	WECo 221FAC RELAY OR EQUIV.
C2	–	1μF
R1	–	300Ω OR 1100Ω

DC DIAL PULSING OR LINE SWITCH OPERATION FROM THE TEL SET SHALL NOT CAUSE THE TELEPHONE UNDER TEST TO RESPOND WITH S1 IN POSITION 1, 2 OR 3 AND WITH R1 OF EITHER VALUE SPECIFIED.

SHORT LOOP FALSE RINGING DETECTION CIRCUIT

FIGURE 2.5-6

PRELIMINARY



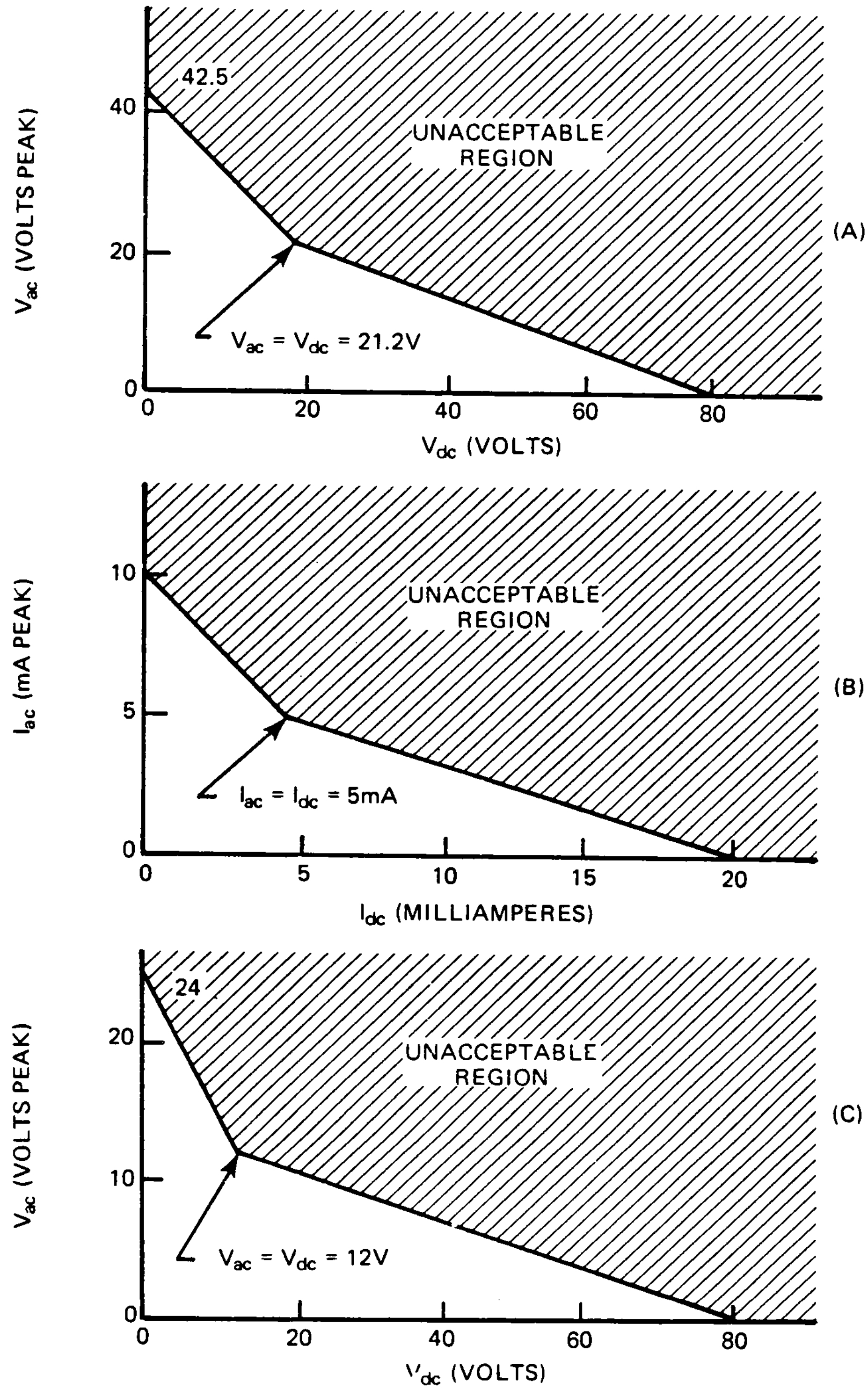
RINGER OR RING DETECTOR OF TELEPHONE UNDER TEST SHALL NOT RESPOND WHEN DIAL OR SWITCHHOOK OF TEL SET IS OPERATED..

LONG LOOP FALSE RINGING DETECTION CIRCUIT

FIGURE 2.5-7

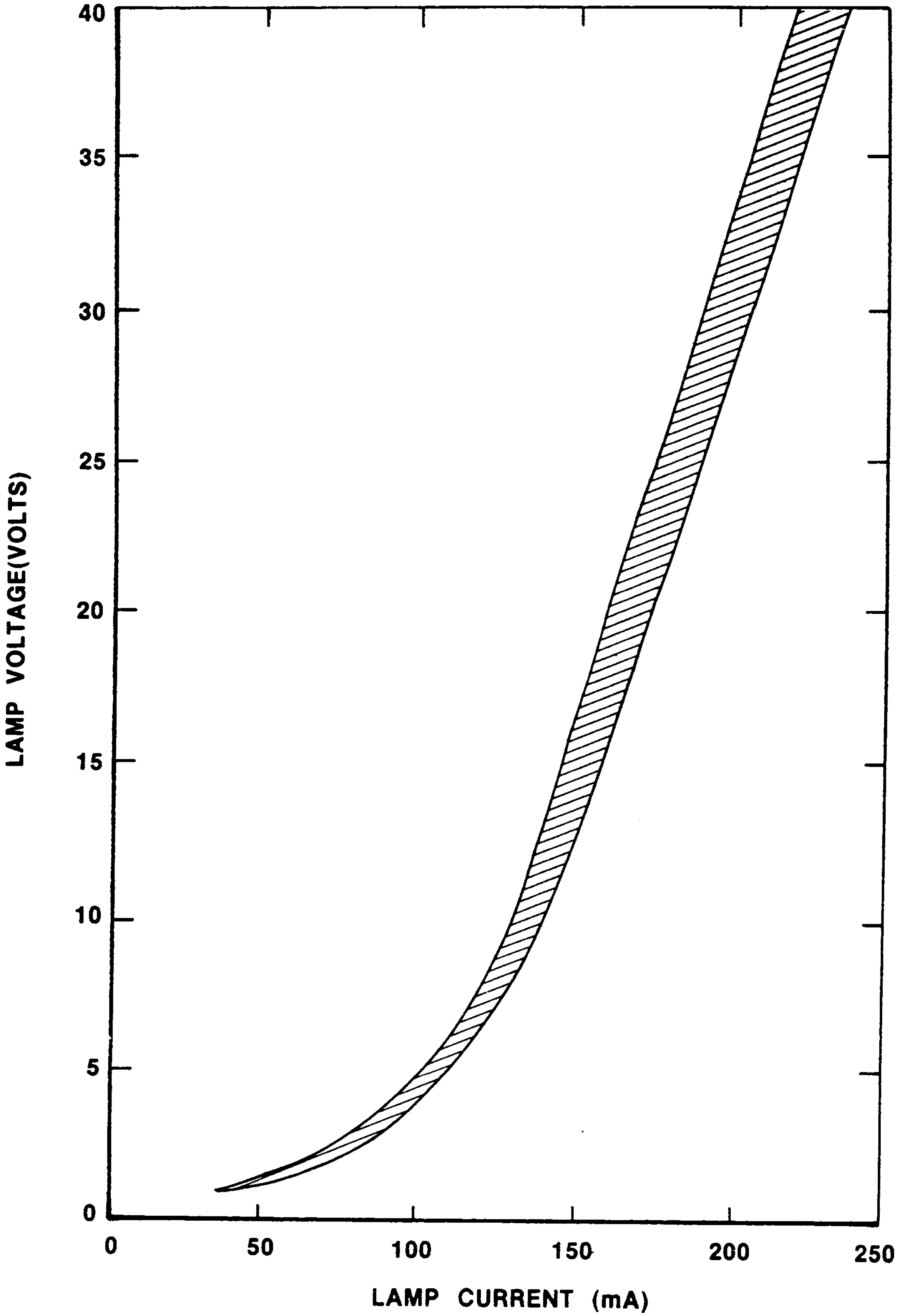
PRELIMINARY

PRELIMINARY



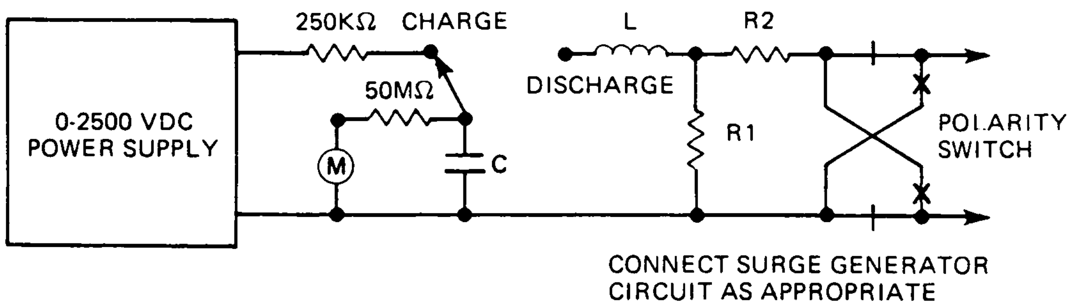
COMBINED AC & DC VOLTAGE & CURRENT LIMITS

FIGURE 4.2



11B RESISTANCE LAMP CHARACTERISTIC

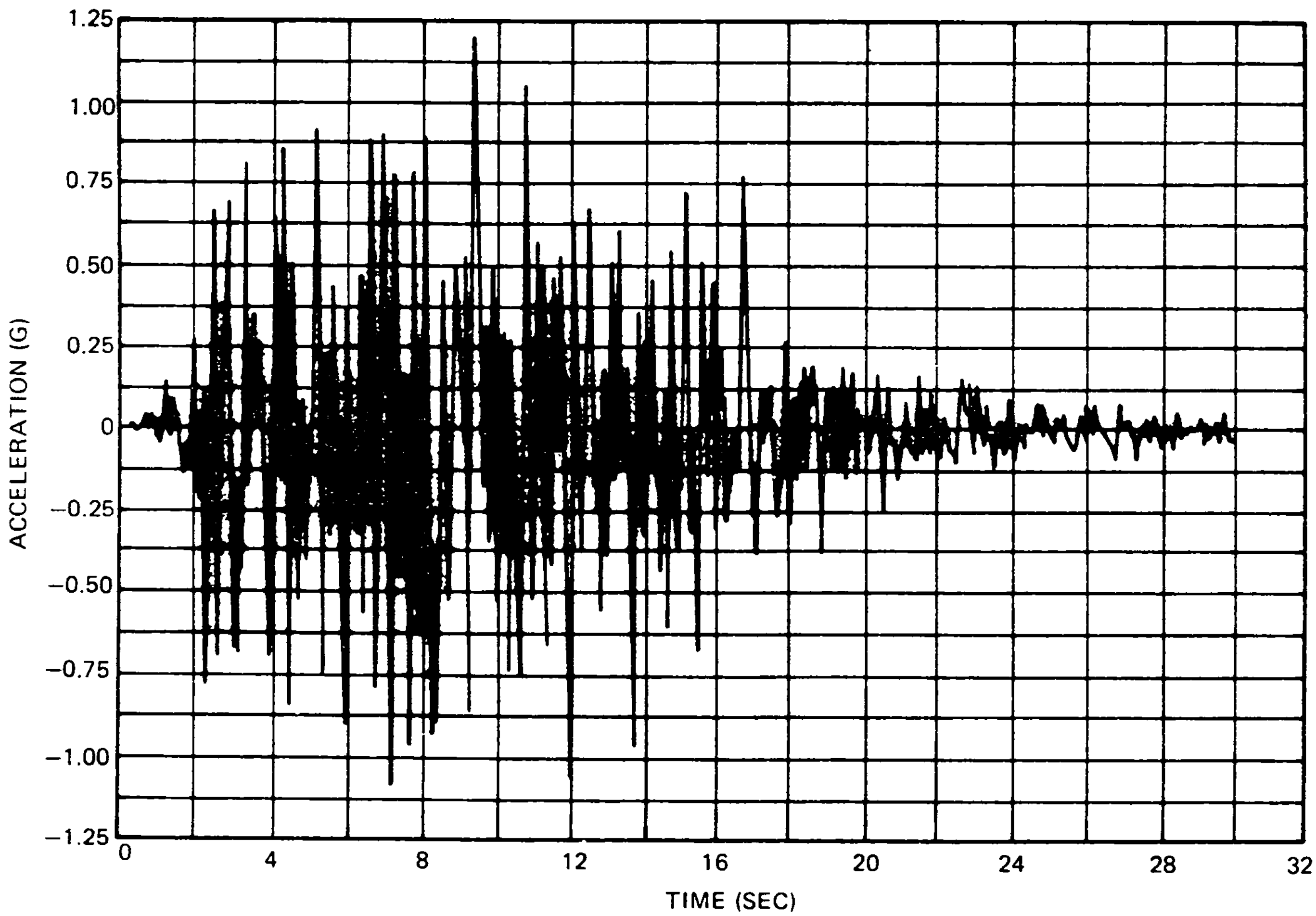
FIGURE 5.1



CIRCUIT ELEMENT	800 VOLT METALLIC SURGE	1500 VOLT LONGITUDINAL SURGE	2500 VOLT LONGITUDINAL SURGE
C	40μF	20μF	20μF
L	5μH	5μH	0
R1	24Ω	16Ω	1Ω
R2	5.6Ω	5.6Ω	2.3Ω
M	0.50μA DC MICROAMMETER		

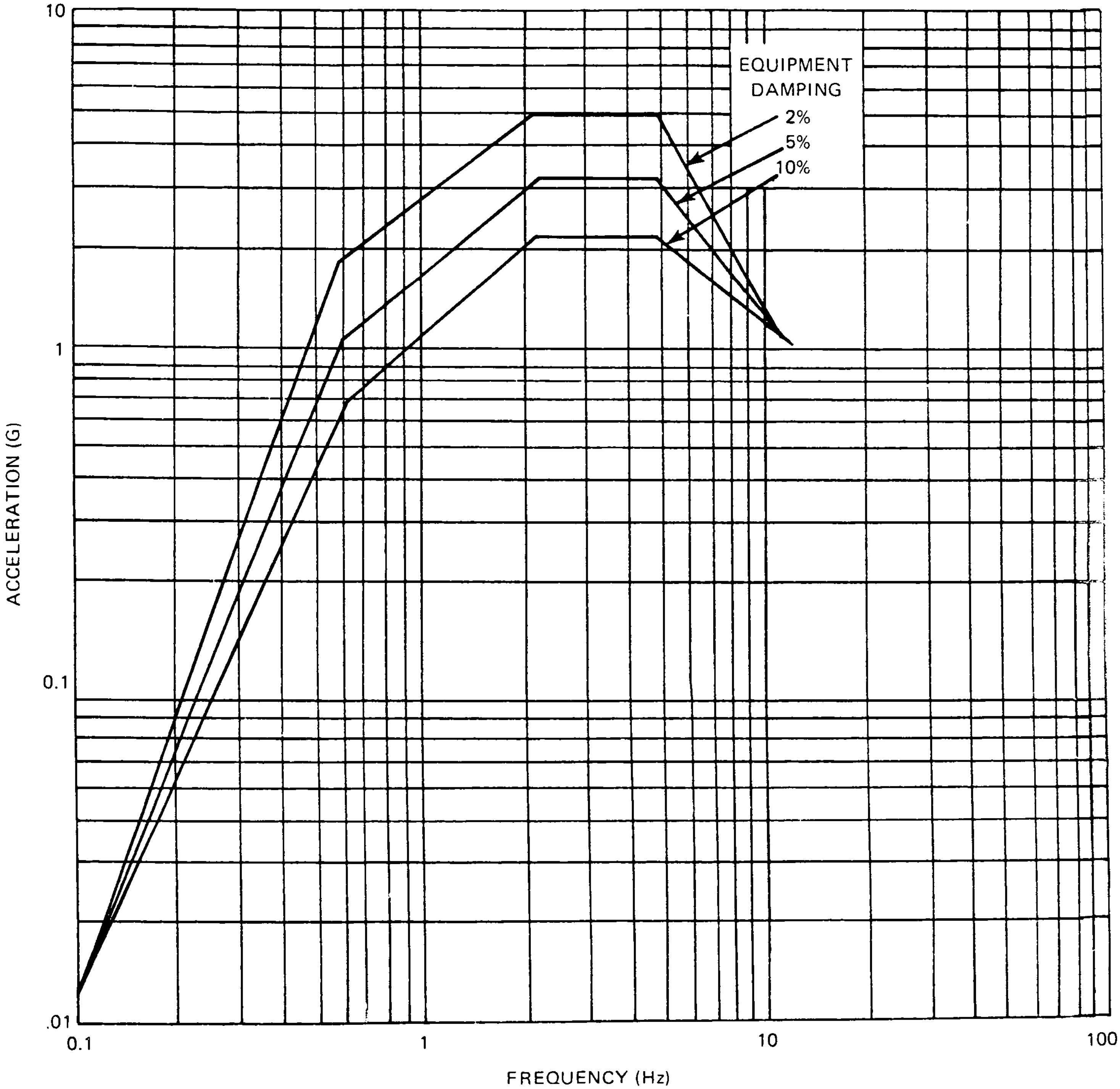
SURGE GENERATOR CIRCUIT

FIGURE 5.2



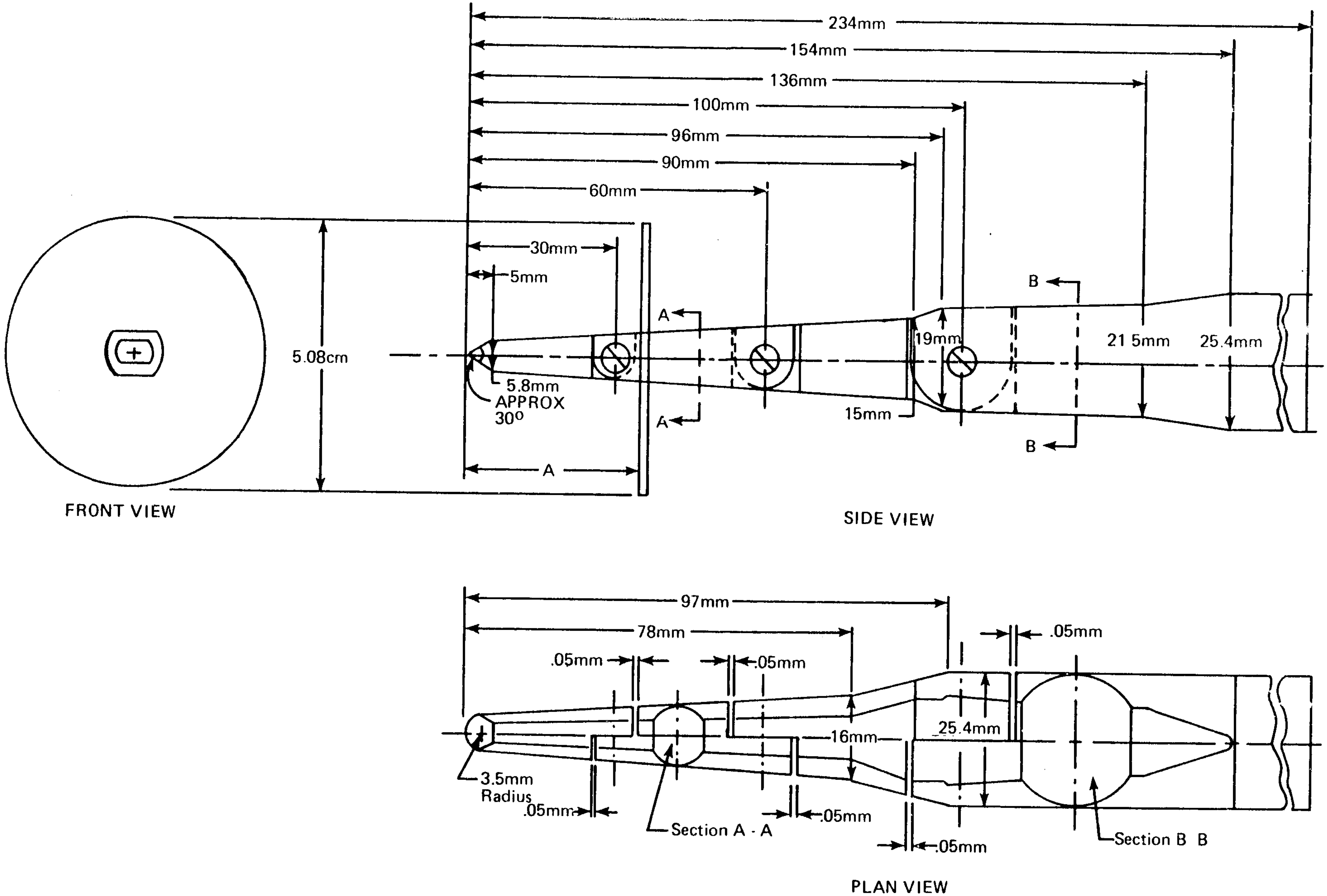
TYPICAL EARTHQUAKE SYNTHESIZED WAVEFORM
(TIME HISTORY)

FIGURE 6.4—1



EARTHQUAKE SPECTRA CRITERIA

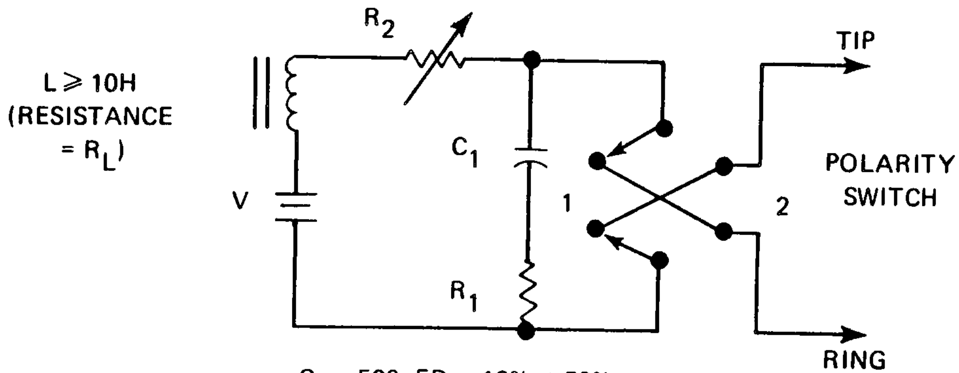
FIGURE 6.4–2



PRELIMINARY

ACCESSIBILITY PROBE

FIGURE G1



C_1 = 500μFD, −10%, + 50%
R_1 = 600Ω± 1%

CONDITION	V, VOLTS		SWITCH POSITION FOR TEST	$R_2 + R_L$
1	MIN 42.5	MAX 52.5	BOTH	CONTINUOUSLY VARIABLE OVER 400 TO 1740 Ω
2	105		2	2000 Ω

PRELIMINARY

NOTES:

1. MEANS SHALL BE USED TO GENERATE, AT THE POINT OF TIP AND RING CONNECTIONS TO THE TERMINAL EQUIPMENT THE PARAMETERS OF DC LINE CURRENT AND AC IMPEDANCE WHICH ARE GENERATED BY THE ILLUSTRATIVE CIRCUIT DEPICTED ABOVE.
2. WHEN THE "DC PORTION OF THE LOOP SIMULATOR CIRCUIT" IS SPECIFIED, COMPONENTS R_1 AND C_1 ABOVE ARE REMOVED.

LOOP SIMULATOR CIRCUIT

FIGURE G2