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MILITARY STANDARD

COMMON LONG HAUL AND TACTICAL COMMUNICATION SYSTEM TECHNICAL STANDARDS

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

SLHC/TCTS

DEPARTMENT OF DEFENSE
Washington, D. C. 20301

Common Long Haul and Tactical Communication System
Technical Standards

MIL-STD-188-100

1. This Military Standard is approved and mandatory for use by all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be addressed to Director, Defense Communications Agency, ATTN: Code 330, Washington, D.C. 20305 and to the Commanding General, US Army Electronics Command, ATTN: AMSEL-CE-CS, Fort Monmouth, New Jersey 07703.

FOREWORD

1. In the past two decades MIL-STD-188, a Military Standard covering Military Communication System Technical Standards, has evolved from one applicable to all military communications (MIL-STD-188, MIL-STD-188A, and MIL-STD-188B) to one applicable to tactical communications only (MIL-STD-188C).

2. In the past decade, the Defense Communications Agency (DCA) has published DCA Circulars promulgating standards and criteria applicable to the Defense Communications System and to the technical support of the National Military Command System (NMCS).

3. Future standards for all military communications will be published as part of a MIL-STD-188 series of documents. Military Communication System Technical Standards will be subdivided into Common Standards (MIL-STD-188-100 series), Tactical Standards (MIL-STD-188-200 series), and Long Haul Standards (MIL-STD-188-300 series).

4. This document deals with system, subsystem, and equipment standards pertinent to multichannel communications circuits which traverse both long haul and tactical communications systems. The standards contained herein are common to both systems unless stated otherwise.

5. Values appearing herein may differ from those previously published in MIL-STD-188-300, based on later data or errata corrections. In case of conflict, MIL-STD-188-100 shall govern.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

APPENDIX

1. SCOPE

1.1 Purpose. This document provides common standards (except where stated otherwise) for long haul and tactical communication systems. It specifies electrical channel and loop characteristics necessary for the establishment of interconnecting circuits between long haul and tactical users for voice and data service. Parameters are provided for nominal 3-kHz and for nominal 4-kHz voice bandwidth circuits between two-wire and four-wire users. Parameters for a nominal 48-kHz FDM group bandwidth channel are provided for data service between long haul and tactical less maneuverable users.

1.2 Application. This standard is to be used in the design and installation of new communication facilities for both the long haul and tactical systems. In addition, for tactical systems, this standard is to be used for the operation of new communication facilities. These standards are not applicable to commercially leased communications facilities. In a few cases reference is made to other documents which provide standards for specific applications. In cases of conflict between this Military Standard and other long haul or tactical standards documents, the standards herein will prevail.

It is not intended that existing systems be immediately converted to comply with the requirements of this Standard. New systems and those undergoing major modification or rehabilitation must conform to this Standard if economically feasible. Deviations should only be permitted when there is an overriding necessity and only after the adverse effects of the deviation on such factors as interoperation, cost training, and logistics have been considered. The standards shall be adhered to in development of new equipment and facilities, but care should be exercised that the standards do not inhibit advances in communications technology. Revisions of this document and new standards for the future will be generated by such advances in technology.

1.3 Technological Level of Parameter Values. The parameters contained in this document are always Communication System Standards, unless a parameter is specifically identified as a Design Objective (DO).

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2. REFERENCED DOCUMENTS

2.1 Specifications.

UU-P-547G	Paper, Teletypewriter Roll, 12 April 1960
UU-T-120F	Tape, Teletypewriter, Perforator, 31 October 1967
MIL-P-40023D	Paper, Teletypewriter, Continuous Flatfold, 9 September 1969

2.2 Military Standards.

MIL-STD-188C	Military Communication System Technical Standards, 24 November 1969 (to be replaced by MIL-STD-188-200 series)
MIL-STD-188-300	Standards for Long Haul Communications System Design Standards Applicable to the Defense Communications System, 15 July 1971
MIL-STD-188-310	Military Standard, Subsystem Design and Engineering Standards for Technical Control Facilities, 2 August 1971
MIL-STD-188-311	Equipment Technical Design Standards for Multiplexers, 10 December 1971
MIL-STD-188-315	Subsystem Design/Engineering Standards for Wire Systems, 30 July 1971
MIL-STD-188-317	Subsystem Design/Engineering Standards for High Frequency Radio, 30 March 1972
MIL-STD-188-340	Equipment Technical Design Standards for Voice Orderwire Multiplex, 21 May 1971
MIL-STD-188-342	Equipment Technical Design Standards for Voice Frequency Telegraph (FSK), 29 February 1972
MIL-STD-188-344	Modem, Non-Diversity Digital Data, 1200 Bits Per Second, 1 June 1972
MIL-STD-1280	Military Standard Keyboard Arrangements, 28 January 1969

2.3 Military Handbooks.

MIL-HDBK-411	Facility Design Handbook for Long Haul (DCS) Power and Environmental Control for Physical Plant, 21 May 1971
MIL-HDBK-232	Red/Black Engineering-Installation Guidelines, 14 November 1972

2.4 Other Publications.

DCA Circular 330-175-1	Defense Communications System (DCS) Engineering-Installation Standards Manual, 31 July 1963
DCA Circular 370-V165-1	AUTOVON Basic and Special Purpose Telephone Subscriber Equipment, 1 December 1965
DCA Circular 370-D175-1	DCS AUTODIN Interface and Control Criteria, 20 October 1970
DCA Circular 370-V175-6	AUTOVON System Interface Criteria, 1 February 1965
(C) DCA Circular 370-S185-9	AUTOSEVOCOM Network Switching Plan (U), 1 April 1971
DCA Circular 370-V185-7	Overseas AUTOVON Network Switching Plan, 31 October 1967

International Alphabet No. 2, American Version, 24 November 1969.

International Alphabet No. 5, CCITT White Book, Volume VIII, 1969.

Federal Information Processing Standard (FIPS) No 1, Code for Information Interchange, 1 November 1968.

Federal Information Processing Standard (FIPS) No. 2, Perforated Tape Code for Information Interchange, 1 November 1968.

Federal Information Processing Standard (FIPS) No. 3, Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI), 1 November 1968.

Federal Information Processing Standard (FIPS) No 7, Implementation of the Code for Information Interchange and Related Media Standards, 7 March 1969.

Federal Information Processing Standard (FIPS) No 14, Hollerith Punched Card Code, 1 October 1971.

Federal Information Processing Standard (FIPS) No 15, Subsets of the Standard Code for Information Interchange, 1 October 1971.

Federal Information Processing Standard (FIPS) No. 16, Bit Sequencing of the Code for Information Interchange in Serial-by-Bit Data Transmission, 1 October 1971.

Federal Information Processing Standard (FIPS) No 17, Character Structure & Character Parity Sense for Serial-by-Bit Data Communications for Information Interchange, 1 October 1971.

Federal Information Processing Standard (FIPS) No 18, Character Structure & Character Parity Sense for Parallel-by-Bit Data Communication in the Code for Information Exchange, 1 October 1971.

Federal Information Processing Standard (FIPS) No 22, Synchronous Signaling Rates between Data Terminal and Data Communications Equipment, 1 October 1972.

World Meteorological Organization Publication No 9, Volume C, December 1970.

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3. TERMS AND DEFINITIONS

Appendix F consists of a set of Terms and Definitions which have been extracted from Appendix A of MIL-STD-188-300. This appendix is provided as an interim reference pending the development of a comprehensive set of terms and definitions applicable to all facets of communications and electronic technology and practices to be published as MIL-STD-188-120.

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4. SYSTEM STANDARDS AND DESIGN OBJECTIVES

4.1 General. This section deals with overall system standards and design objectives for telecommunications traversing long haul and tactical systems. These overall system standards include those user-to-user requirements and hypothetical reference "building blocks" which are essential for developing overall system plans and subsystem standards. General remarks about the systems and subsystems with which this document is concerned follow. Appendices A and E are provided to explain technical facts which, in the past, have been found to be confusing. Appendix D contains information on standard measuring procedures. All these appendices apply to appropriate paragraphs of this section and will not be referenced further.

4.1.1 Distinction Between Long Haul and Tactical Systems. A precise delineation between long haul and tactical communications cannot be clearly stated because characteristics of each type are sometimes identical. Generally, the long haul system consists of fixed or recoverable assets and is described in greater detail in Section 4 of MIL-STD-188-300. Tactical systems range from highly maneuverable to less maneuverable communications and even some fixed installations used by strategic and tactical forces for support of military operations. Tactical communications are currently further described in Section 3 of MIL-STD-188C (to be replaced by MIL-STD-188-200 series.)

4.1.2 General Description of Long Haul/Tactical Systems.

4.1.2.1 Types of Traffic. The long haul/tactical military communications circuits provide communications service in every essential functional area: command and control, logistics, intelligence, weather, and administration. Traffic in the systems may be in the form of voice, graphics, teletypewriter, and data, and may be transmitted either as analog or quasi-analog signals, or as digital signals. The systems accept traffic from and deliver to individual user stations and other systems and subsystems.

4.1.2.2 Network. An electrical communication network consists of a number of user stations equipped with various end instruments interconnected by transmission facilities, which may be either direct or carried through one or more nodes or centers where such functions as switching, patching, processing, service supervision, and technical control may be provided. The transmission system consists of all the transmission circuits between user stations, between user stations and nodes, and between nodes. It may make use of several means of electrical signaling over metallic or radio media. Extensive use is made of multiplexing to obtain various numbers of channels by providing parallel, simultaneous paths of various bandwidths, or by successively assigning the entire bandwidth of a facility to each of a number of channels in rapid time sequence to give the effect of parallel continuous channels. Transmission circuits may be used in a variety of ways, and may be considered with respect to their functions, the signal modes handled, kind of multiplexing used, and the type of transmission medium over which they are provided.

4.1.2.3 Signal Modes. A transmission circuit may be classified by the signal mode it is designed to handle. Accepted signals may be continuous or discrete signals (frequently called "analog" and "digital" signals respectively). In general, the transmission requirements for these two signal modes vary widely.

4.1.2.3.1 Analog Signals. Transmission circuits for analog signals must be able to transmit, with acceptable fidelity, signals that may take any value within specified ranges of amplitude, frequency, and phase. They cannot be provided with signal regeneration, since there is no physical way to distinguish the desired signal from noise and distortion at intermediate or receiving points. However, their amplitude may be restored by amplification.

4.1.2.3.2 Digital Signals. Transmission circuits for digital signals are only required to transmit signals constrained to two or more defined and discrete states. For example, a binary digital link can only handle signals which alternate between two states, such as marking and spacing, 1 and 0, on and off, etc. The signal which is transmitted between transitions from one state to another is a "signal element". In a binary system a signal element represents one bit, that is, either 1 or 0. In a quaternary digital system, e.g., a four-phase system, four discrete states may be transmitted; therefore, each signal element represents two bits; that is, for the first and second of a pair of adjacent bits in the input, the four available signals are assigned values of "1, 1"; "1, 0"; 0, 1"; and "0, 0". Due to the discrete nature of signals, digital circuits can be provided with signal regeneration because, in general, the receiving device selects the output state which most closely corresponds with the signal state received if the signal is above threshold.

4.1.2.3.3 Quasi-Analog Signals. An analog circuit can be the medium for the transmission of digital signals if they are converted into a form which meets the specifications of an analog circuit. Therefore, a system may be designed to transmit digital signals over an analog circuit, by choosing a suitable frequency, modulation principle, and power level appropriate to the characteristics of the medium providing the analog circuit. For example, physical wire circuits working at audio frequency throughout will allow almost any modulation principle to be used. Analog circuits provided over frequency division multiplexing systems with independent carrier generation may suffer audio frequency displacement; the modulation scheme for the quasi-analog equipment must allow for this. Some radio transmission systems suffer multipath effects which may persist for a number of milliseconds; in such cases, signal element durations longer than the multipath delays offer one method of coping with the problem and, in turn, this may require transmission on a number of parallel frequency channels.

An important consideration in the use of quasi-analog signal transmission is that as long as digital signals remain in the quasi-analog form, no full regeneration (retiming and reshaping) can be performed on them. Should regeneration be required the signal is usually demodulated and restored to digital form. Also, all the anomalies of the analog media such as thermal, impulse, and fading-connected noise, phase jitter, envelope delay distortion, frequency bandwidth reduction, and level variations, tend to accumulate along the circuit. Over a sufficiently long analog circuit, these effects may cause the receiving device to make a large number of errors.

NOTE: Noise impairments of TDM transmission are covered in paragraph 4.4.3.

4.1.2.4 Multiplexing Subsystems. Transmission links may be provided by non-multiplexed or by multiplexed facilities. In general, multiplexed facilities are divided into frequency division multiplexing and time division multiplexing. Each method has distinctive characteristics affecting the objectives and use of circuits so derived.

4.1.2.4.1 Nonmultiplexed Circuits. Multipair cables provide parallel pairs for simultaneous transmission of signals along the route. This is often referred to as space division multiplexing.

4.1.2.4.2 Frequency Division Multiplexing (FDM) Subsystems. FDM is a method of deriving two or more simultaneous, continuous channels from a transmission medium connecting two points by assigning separate portions of the available frequency spectrum to each of the individual channels. The most extensive exploitation of this principle is the transmission plant which provides message quality telephone circuits occupying adjacent nominal 4-kHz slots in wideband media, both metallic and radio, and provides an effective bandwidth from about 300 Hz to 3400 Hz. The procedures for placing many telephone channels in adjacent positions in multiplex basebands extending to 12 MHz and higher have become highly standardized and the practices for utilizing the available spectrum, which are followed by the North American companies and those recommended by the CCITT and CCIR, follow similar principles.

Military practice is characterized by extensive use of modular principles. Common practice is to assemble twelve voice channels by modulation processes in the basic group frequency band 60 kHz to 108 kHz, called "group B" by the CCITT, where they appear as lower sidebands of twelve carrier frequencies. This group is the basic building block of larger subsystems. Five such groups (60 channels) are assembled by further modulation processes to adjacent positions in the basic supergroup frequency band, 312 kHz to 552 kHz. Larger subsystems extend this principle by further higher order groupings, such as mastergroups and supermastergroups, to provide a maximum of 2700 voice channels in a nominal 12-MHz band, and a correspondingly greater number of voice channels in still wider basebands.

4.1.2.4.3 Time Division Multiplexing (TDM) Subsystems. TDM is a method of deriving two or more apparently simultaneous channels from a given frequency spectrum of a transmission medium connecting two points by assigning the entire spectrum to the different channels at different times (usually at regular intervals and by automatic distribution). In general, pulse transmission is used in TDM. The multiplexed pulse train may be considered to be the interleaved pulse trains of the individual channels. The individual channel pulses may be modulated in an analog or a digital manner.

Digital information transmitted over the TDM subsystem on an element for element basis requires that either the contributing individual channels be held in bit synchronism with the TDM subsystem or that some form of buffering be employed.

4.1.2.5 Analog to Digital Conversion Techniques.

4.1.2.5.1 Pulse Modulation (Analog or Non-Discrete). The stream of pulses representing a given channel may be modulated to carry analog information by changing a selected parameter of each pulse over a continuous range of values within specified limits. The pulse rate must be adequate to preserve all essential analog information. This is achieved by using a sampling rate at least twice as high as the highest frequency in the analog channel (Nyquist rate). The selected parameter may be pulse amplitude, duration, or timing. In pulse amplitude modulation (PAM) the amplitude is varied in an analog manner while the duration and timing are constant; in pulse duration modulation (PDM) the amplitude and timing remain constant while the duration varies according to the sampling information; in pulse position modulation (PPM) the amplitude and duration of pulses are constant, while the relative time of arrival of each pulse with respect to a nominal time is varied. Transmissions with analog pulse modulation are not digital; that is, they cannot be regenerated since the receiver has no way to distinguish the desired signal modulation from the effects of distortion and noise, although the unmodulated characteristics of pulses can be restored. An analog pulse modulation scheme may handle both analog signals and quasi-analog signals, the latter representing digital data.

4.1.2.5.2 Pulse Modulation (Digital or Discrete). With digital pulse modulation, a selected parameter of each pulse is varied in a discrete manner; that is, each pulse is constrained to assume one state out of a set of two or more defined and discrete states. Such a signal may be regenerated because the receiving device can be designed so that it is limited to assume a set of output states which correspond to the states of the transmission signal. If noise or distortion, or both, induce the receiver to select an erroneous output state, the analog causes of the digital error are liquidated; the error is "clean." Therefore, the noise and distortion do not have cumulative effects as such; only the errors add up. The same parameters used in analog pulse modulation may also be used for digital modulation. The amplitude may be varied in steps (this includes reversal in polarity or phase), the duration may be varied in steps or the pulse position may be discretely varied. In radio systems, pulses are represented by groups of carrier frequency oscillations; in metallic systems, either carrier or "direct current" pulses may be used.

Analog information may be transmitted over a digital subsystem if it is first placed in digital form. This requires that the analog values be quantized and in some cases coded. In pulse code modulation (PCM) the designation of the quantum level is generally expressed in binary code. Since the stairstep nature of a quantized signal prevents it from perfectly representing a smooth wave, quantizing error or distortion is produced. This is minimized by adopting a relatively large number of quantizing levels. Differential PCM and delta modulation operate on similar principles except that the digital code transmitted is based on the change from the preceding sampling time rather than the total amplitude value.

NOTE: Parameters for differential PCM and for delta modulation are not included in this document since standards for these digital modulation schemes have not yet been established.

Speech transmitted in coded digital form does not suffer directly from analog noise and distortion of the transmission medium. The errors in the received code will have a random noise effect on the recovered speech, as opposed to the progressive analog degradation in bandwidth and speech-to-noise ratio which occurs in very long analog circuits. In addition, loss of synchronization, drop-outs, and similar signal discontinuities in PCM transmission can cause a distinct clicking noise at the telephone receiver.

4.1.2.6 Transmission Media. The transmission facilities for links may be provided by metallic lines or radio. The latter may be divided into relatively stable media such as millimeter and microwave line of sight (LOS) and satellites, varying media such as tropospheric scatter, and those media subject to wide and often prolonged variations, such as high frequency (HF) radio subsystems.

4.1.2.6.1 Metallic Lines. The term metallic lines includes all facilities obtained by use of twisted pair cable, multipair cable, coaxial cable, and waveguides. Characteristics of these lines which affect the parameters of transmission systems designed to operate over them include attenuation, noise, and mutual coupling. Attenuation increases continuously and smoothly with increase of frequency and is also sensitive to temperature. Noise on metallic lines can be induced by electric power systems and crosstalk from other similar parallel circuits, the latter tending to rise with volume of traffic. Impulse noise may also be introduced by natural static, transients from signaling circuits, and switching transients from power systems. In some areas, electric railways, local rail services, and radar equipment may introduce noise. In the case of baseband dc digital transmission over metallic circuits, the cable shunt capacitance is the principal factor which determines the upper bound of the data signaling rate. In the case of quasi-analog data transmission via FDM subsystems, the insertion loss versus frequency characteristic, envelope delay distortion, and noise are the limiting factors of the modulation rate.

4.1.2.6.2 Radio Relay Subsystems. The term radio relay is generally applied to radio subsystems which are suitable for the application of either FDM or TDM and which operate in radio frequency bands where transmission, while varying continually within a restricted range, is relatively stable. The radio spectrum classified as VHF, UHF, and SHF is currently exploited by radio relay subsystems of various types. The channel capacity of these subsystems varies from about twelve to hundreds of channels. The loosely defined term "microwave" is also commonly applied to such subsystems.

Although several types of radio propagation may be present at the same time over a given section, radio paths for radio relay subsystems generally may be classified as line of sight, forward scatter, and satellite relay. In general, an important characteristic of radio relay subsystems is the use of highly directional antenna configurations, which may allow extensive duplication of radio frequency channel assignments in a relatively small geographical area.

4.1.2.6.3 High Frequency (HF) Radio Subsystems. Radio subsystems using frequencies lower than about 30 MHz are subject to wide level changes due to slow and rapid fading. This may affect various frequencies differently even in the same audio channel bandwidth. Offsetting this handicap is their range, made possible by the reflection or refraction properties of the ionosphere, when frequencies appropriate to the time of day, season, and distance are chosen. The range of such HF subsystems makes them useful for maintaining contact with tactical forces with wide operating radii, although such circuits are frequently of low performance. Due to the congested spectrum conditions, telephone channels are limited to a 3-kHz maximum audio input, and single sideband and independent sideband techniques are widely used for spectrum efficiency.

4.1.2.6.4 Radio Subsystems Below HF. Radio subsystems using waves classified as MF, LF, VLF, ILF, and ELF have propagation characteristics which are relatively stable and which may cover long distances. They are used for special purposes such as reaching mobile and fixed elements capable of being located anywhere in the world. Standards for radio subsystems below HF are not included in this document.

4.1.2.7 Basic Communication System Characteristics. The basic long haul/ tactical communication system shall provide analog and digital service to the long haul and tactical users. The basic communication system configuration (Figure 4.1-1a)

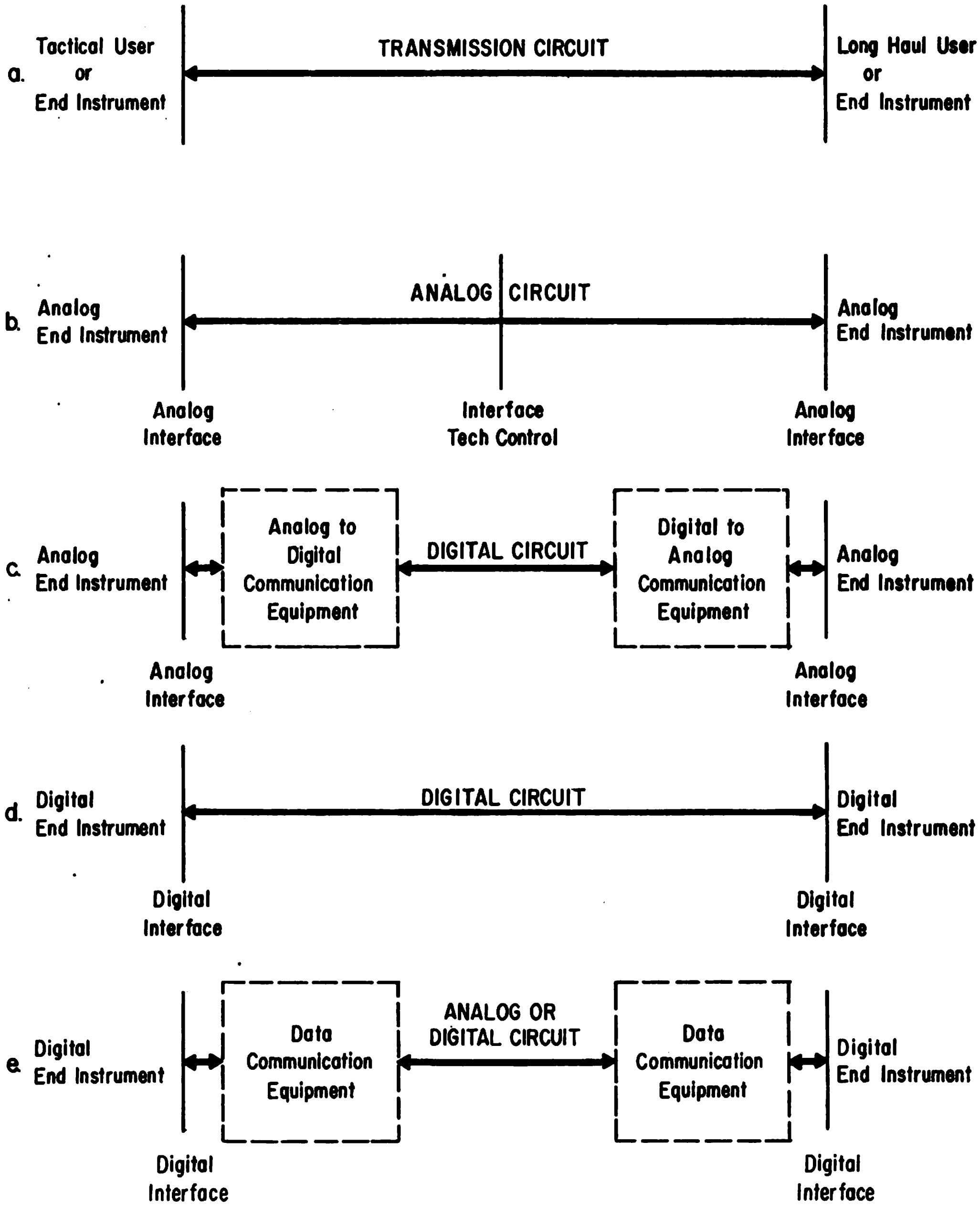


Figure 4.1-1. Basic Communication System Configurations

consists of a long haul user and a tactical user which are interconnected by a transmission circuit transversing both the long haul network and the tactical network (see subparagraph 4.1.2.2). The user or end instrument may be an analog device (see paragraph 5.7) or a digital device (see paragraph 5.8). The transmission circuit may consist of a long haul circuit and a tactical circuit with an interface at a technical control facility. The basic communication system configurations are represented by Figure 4.1-1. Figure 4.1-1b shows two analog end instruments interconnected by an analog transmission circuit. Figure 4.1-1c shows two analog end instruments interconnected by a digital transmission circuit through the use of "analog-to-digital" and "digital-to-analog" communication equipment (see subparagraph 4.1.2.5). Figure 4.1-1d shows two digital end instruments interconnected by a digital transmission circuit (see subparagraph 4.1.2.4.3). Figure 4.1-1e shows two digital end instruments interconnected by an analog or digital transmission circuit through the use of data communication equipment. The data communication equipment is required to interface the digital end instruments with the transmission circuit (see subparagraph 4.1.2.4.3). Where it is desired to interface with an analog circuit, the data communication equipment converts the binary dc signals into a quasi-analog signal (see subparagraph 4.1.2.3.3). The basic system configurations as represented by Figure 4.1-1 are not inclusive of all possible user-transmission circuit variations. However, these system configurations are considered as basic system layouts.

In paragraph 4.1.1, a distinction is made between tactical and long haul communications. Long haul communications are characterized by the global distances traversed; hence, the allocation of electrical characteristics for the different links and sections must inherently be more stringent than those for the relatively short distances traversed by tactical communications. This is valid for any analog FDM or analog/digital (FDM/TDM) transmission subsystem. The requirements for some tactical communication systems are not only different from those for long haul communications but a further distinction must be made between highly maneuverable and less maneuverable tactical system configurations. In a tactical highly maneuverable system the maximum nominal distance over which switched communication is required has been taken as 300 kilometers (km) or 167 nautical miles (nmi); the transmission performance of a hypothetical reference system for such a distance will be published in MIL-STD-188-200 series. When a FDM circuit of a tactical highly maneuverable system is connected in tandem with a long haul circuit nominally 22,000 km (12,000 nmi) long, then the length of the tactical circuit is limited to keep the total circuit noise, user-to-user, at an acceptable level (see Figure 4.7-3, page 103). Examples of hypothetical common long haul/tactical highly maneuverable reference circuits with performance parameters are given in paragraph 4.7. The tactical less maneuverable system would be expected to meet much longer distance requirements than the tactical highly maneuverable system. In a tactical less maneuverable system the maximum nominal distance over which switched communication is required has been taken as 1850 km (1000 nmi); the transmission performance of a hypothetical reference system for such a distance will be published in MIL-STD-188-200 series. Examples of hypothetical tactical less maneuverable reference circuits for nominally 1850 km (1000 nmi) connected in tandem with hypothetical long haul reference circuits are given in paragraph 4.7.

4.2 Parameters for Analog Service.

4.2.1 General. The following subparagraphs 4.2.2.1 through 4.2.3.8 deal with standards and design objectives for voice (subparagraph 4.2.2) and facsimile (subparagraph 4.2.3) transmission over voice bandwidth circuits on a user-to-user basis between the line terminals of the end instruments of a common long haul/tactical circuit. These standards and design objectives are expressed in the form of technical parameters, such as received noise power or transmitted bandwidth, which shall be achieved on all common long haul/tactical voice circuits regardless of user-to-user distances of up to approximately 22,000 km (12,000 nmi), transmission media, and multiplexing scheme used (FDM, TDM, or a mix of FDM and TDM). Part of these parameters are stated as design objectives rather than as standards due to a lack of measured and verified data available at the present time or due to a lack of general consensus in the interpretation of the data.

4.2.2 Parameters for Voice Service.

4.2.2.1 Transmitted Speech Volume. The talker volume distribution at the line terminals of a telephone set has been found to approximate a normal or Gaussian distribution when expressed in Volume Units (VU). Based on the talker volume distribution, the transmitted mean speech volume of a two-wire as well as a four-wire telephone set used in either a long haul or tactical system is assumed to be -10 VU with a standard deviation (sigma) of 5 VU.

4.2.2.2 Received Speech Volume. Subjective tests indicate that received speech volume at the line terminals of the listener telephone set from −21.5 VU to −33.5 VU results in satisfactory service. The mean received speech volume at the line terminals of the listener telephone set should be nominally −28 VU. Table 4.2-1 shows the relationship between received speech volume and the percentage of calls rated good or better when the associated noise level is acceptably low.

Table 4.2-1. Subjective Ratings of Received Speech Volume

Received Speech Volume	VU	Percentage of Calls Rated Good or Better
Maximum	-21.5	95
Mean	-28.0	100
Minimum	-33.5	95

NOTE: The mean received speech volume of −28 VU and the values given in Table 4.2-1 are based on subjective tests made with a commercial type of telephone in a typical office environment. Subjective ratings for military telephones in a field environment are not available at the present time. Experience has shown that mean received speech volumes in a tactical field environment have to be higher than −28 VU for satisfactory service due to a generally higher background noise level and to higher received noise power.

4.2.2.3 Received Noise Power. With a mean received speech volume of −28 VU the value of noise power for acceptable service has been set at 44 dBrnc (DO: 38 dBrnc) at the line terminals of the listener telephone set (see Figure 4.2-1). This is the total noise contribution from all sources.

4.2.2.4 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic referenced to 1000 Hz, over the frequency bandwidth from 400 Hz to 2800 Hz, shall be within the limits of −8 dB to +20 dB, except over the frequency bandwidth from 600 Hz to 2400 Hz it shall be within the limits of −7 dB to +12 dB. The insertion loss below 400 Hz and above 2800 Hz shall be equal to or greater than −8 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.2-2). Insertion loss versus frequency characteristic for data service is given in subparagraphs 4.3.2.5 and 4.3.3.5.

4.2.2.5 Envelope Delay Distortion. No standard or design objective is given for envelope delay distortion with regard to voice service since the human ear is not sensitive to this type of distortion. However, delay distortion plays a significant role in data transmission through audio channels. Envelope delay distortion for data service is given in subparagraphs 4.3.2.6 and 4.3.3.6.

4.2.2.6 Single Tone Interference. No interfering tone of a single frequency shall exceed 30 dBrnc (DO: 24 dBrnc), measured at the line terminals of the listener telephone set.

4.2.2.7 Crosstalk. Subjective listener tests have indicated that intelligible crosstalk is more disturbing than unintelligible crosstalk of the same level. Therefore, a distinction is made between intelligible and unintelligible crosstalk even if no objective measurement technique exists to separate these two crosstalk components. Unintelligible crosstalk is considered noise for which the accepted value is stated in subparagraph 4.2.2.3. Both the near end and far end intelligible crosstalk shall each be at least 55 dB below signal level in the frequency band transmitted.

4.2.2.8 Echo. In a telephone connection, user-to-user, which is completely 4-wire, including the telephone sets but excluding any side-tone circuits, electrical echo need not be considered. However, if there are 2-wire sections or elements at either or both ends of the connection, echo will exist. This is due to lack of perfect electrical balance between the impedances of the "line" and "balancing network" circuits associated with the hybrid circuits at the points where the 2-wire and 4-wire circuits join. While both parties may hear echoes, the talker is the more disturbed by them, so that talker echo considerations govern overall circuit design. Figure 4.2-3 shows the results of subjective tests giving the relationship between echo magnitude and delay. All points above the curve represent combinations of echo path loss and delay considered acceptable to 99 percent or more of all the talkers. Any point corresponding to a specific value of round trip echo loss and a specified value of round trip delay time of any connection shall fall on or above the curve of Figure 4.2-3.

> NOTE: No standard or design objective for round trip echo loss over circuits traversing satellite systems can be provided at the present time. An objective of 30 dB is used by commercial carriers.

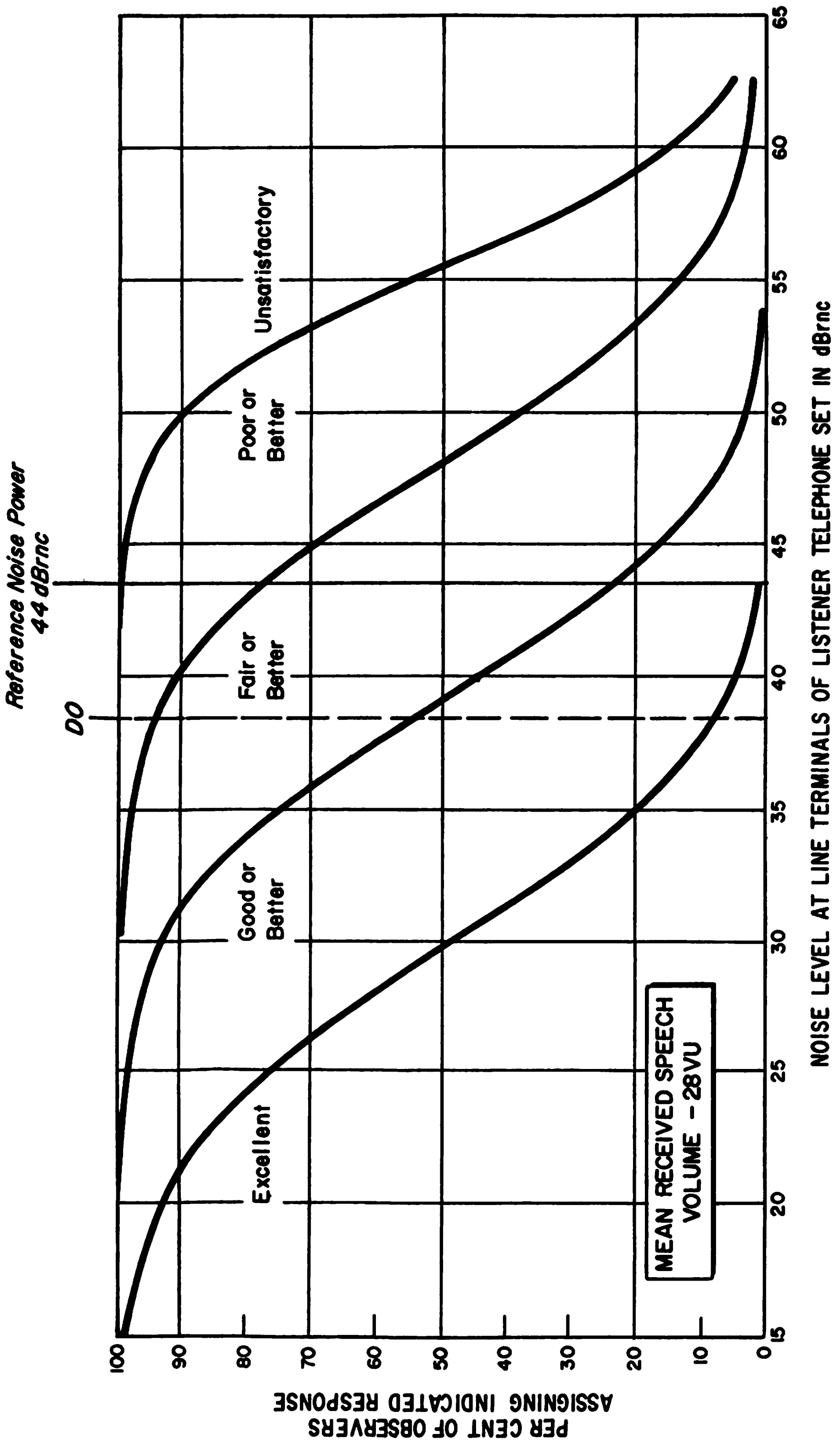
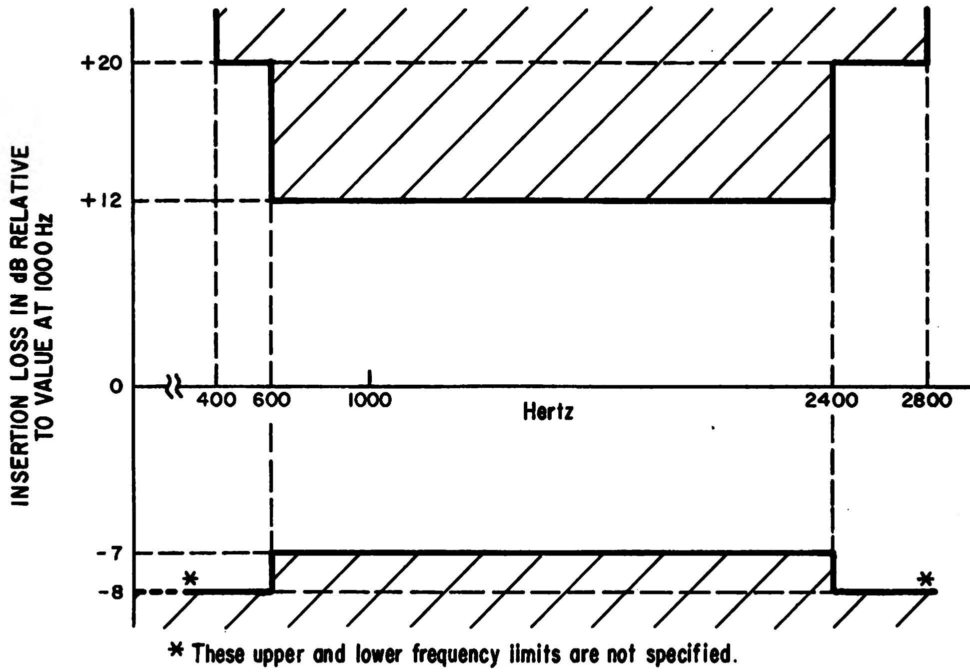
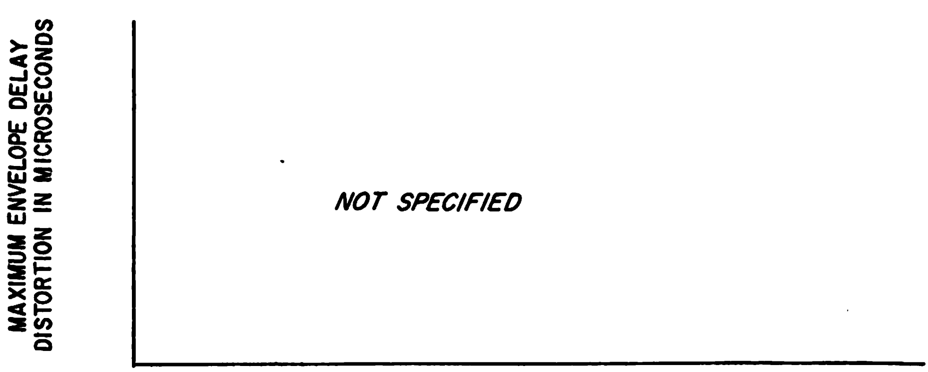


Figure 4.2-1. Subjective Ratings of Received Noise Power



a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.2-2. Parameters for Analog Service Over Voice Bandwidth Circuits (User-to-User)

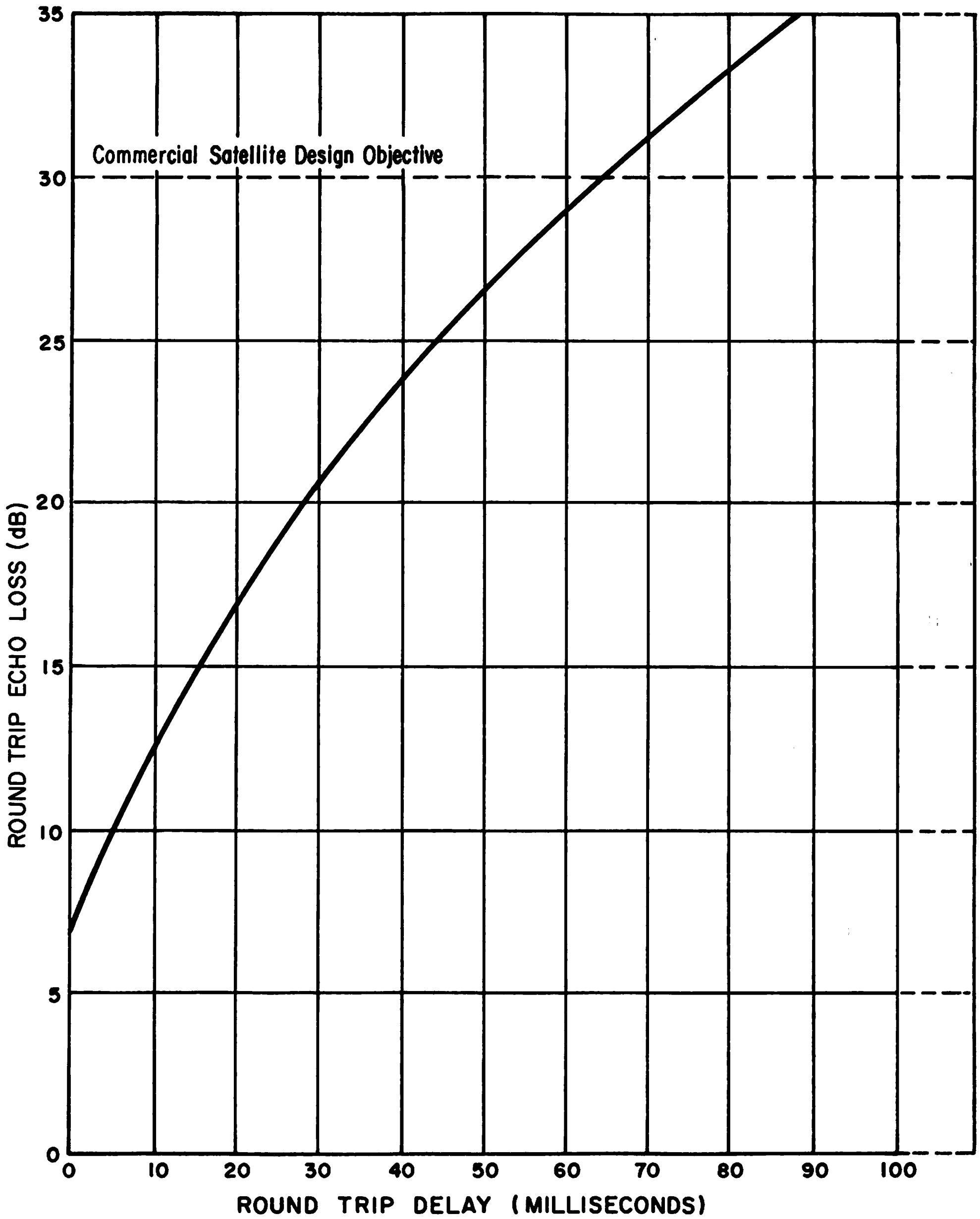


Figure 4. 2-3. Round Trip Echo Loss Vs Round Trip Delay Time

4.2.2.9 Frequency Displacement. No standard or design objective is given for speech since the frequency displacement generally encountered over voice-grade circuits has a negligible effect on intelligibility. Frequency displacement for data service is specified in subparagraph 4.3.2.11.

4.2.2.10 Net Loss Variation. The net loss variation between users shall not exceed ±5 dB over any 30 consecutive days. Net loss variation for data service is the same.

4.2.3 Parameters for Facsimile Service.

4.2.3.1 Transmitted Signal Power. The facsimile transmitter output level corresponding to a high signal contrast shall be adjustable from −10 dBm to +10 dBm. Considering the loop loss, the transmit level shall be −13 dBm at a 0TLP (-13 dBm0) of the long haul or the tactical less maneuverable system and −10 dBm at a −4 TLP of the tactical highly maneuverable system.

4.2.3.2 Received Signal Power. The facsimile receiver input level corresponding to a high signal contrast shall range from −9 dBm to −36 dBm. The average received level should be approximately −20 dBm. The exact value of the received level depends on the insertion loss of the loop.

4.2.3.3 Received Noise Power. The value of noise power for acceptable service has been set at 44 dBrnc (DO: 38 dBrnc) at the line terminals of the facsimile receiver. This is the total noise contribution from all sources.

4.2.3.4 Insertion Loss Versus Frequency Characteristic. Same as subparagraph 4.2.2.4.

4.2.3.5 Envelope Delay Distortion. No standard or design objective is given for envelope delay distortion with regard to voice service on a user-to-user basis. However, delay distortion may play a significant role for analog facsimile transmission and digital transmission requiring the use of data grade circuits. The envelope delay distortion for these data grade circuits are given in subparagraphs 4.3.2.6 and 4.3.3.6.

4.2.3.6 Single Tone Interference. No interfering tone of a single frequency shall exceed 30 dBrnc (DO: 24 dBrnc), measured at the line terminals of the facsimile receiver.

4.2.3.7 Frequency Displacement. No standard or design objective is given for analog facsimile service since the frequency displacement generally encountered over voice grade circuits has a negligible effect on analog facsimile quality.

4.2.3.8 Net Loss Variation. The net loss variation between user end instruments shall not exceed ±5 dB over any 30 consecutive days.

4.3 Parameters for Data Service.

4.3.1 General Digital Parameters. The following subparagraphs 4.3.1.1 through 4.3.3.12 deal with standards and design objectives for single channel and multichannel circuits which provide for transmission of binary dc signals between end instruments. These standards and design objectives are expressed in the form of technical parameters, which shall be achieved on all common long haul/tactical data grade circuits regardless of user-to-user distances of up to approximately 22,000 km (12,000 nmi), transmission media, and multiplexing scheme used (FDM, TDM, or a mix of FDM and TDM). Part of these parameters are stated as design objectives rather than as standards due to a lack of measured and verified data available at the present time or due to a lack of general consensus in the interpretation of the data.

Data transmission is usually accomplished by converting the binary dc signal into a quasi-analog form for transmission over channels which are not capable of transmitting signals in dc digital form. Characteristics of a number of conversion devices (modems) are standardized in order to accommodate the variety of data to be transmitted over the different types of transmission media available. The quasi-analog signal does not have to be in binary form since multi-level (m-ary) modulation schemes also are being utilized for converting the binary dc signal into a quasi-analog form. For wire and cable transmission media, signals may be transmitted in dc digital form without conversion to quasi-analog form over relatively short distances.

The data signaling rate shall be expressed in bits per second (b/s); the modulation rate shall be expressed in Baud (Bd). Data signaling rates in b/s and modulation rates in Bd are the same if, and only if, all pulses are the same length, all pulses occupy the complete unit interval, and binary (rather than m-ary) signaling is used.

(a) Binary Synchronous Serial Systems. In such systems, the signal at the standard digital interface is serial and isochronous, i.e., it is a two-state signal, with all signal elements nominally equal to the unit interval, or multiple thereof. In this case the modulation rate in Bd and the information rate in b/s are numerically equal and either term is correct for a binary isochronous signal.

(b) Quasi-Analog Signals. A modem generates quasi-analog signals suitable for the analog circuit. If the quasi-analog signals are binary in a synchronous system, the nominal time structure of the dc digital signal is not affected by the modem, and the rate of the quasi-analog signal may be expressed in either Bd or b/s. But, in more sophisticated systems, this is generally not true. For instance, a 4-phase modem handling 2400 b/s at the standard digital interface emits a line signal modulated at 1200 Bd. The modulation rate in Bds should be used at the quasi-analog side of the modem and at the transmission equipment as a more meaningful term. Parenthetical additions should be used with the modulation rate where this will help clarify the text, e.g., 2400 Bds (binary), 1200 Bds (4 level).

(c) Start-Stop Systems. In start-stop operation, the stop element may not be a multiple of the unit interval (as in 7.42 unit-per-character interval). Also, the interval between characters in direct keyboard operation is not necessarily a multiple of the unit interval. To express the "instantaneous" modulation rate at which signal elements are transmitted during a character interval (and the required bandwidth is proportional to this), it is necessary to use the unit Bd. In general, the modulation rate in Bd is greater than the information rate in b/s, e.g., ASCII (seven information bits plus one parity bit plus one start bit and one stop bit per character interval) requires a modulation rate of 100 Bds to transmit 80 b/s information.

NOTE: In this example the parity bit has been included as user information.

4.3.1.1 Modulation and Data Signaling Rates. The modulation rates (expressed in Bd) and the data signaling rates (expressed in b/s) at the standard interface (Figure 4.3-1) shall be as follows:

(a) 25×2^{-m} Bds or b/s

(b) 50.0 Bds or b/s

(c) 75×2^{m} Bds or b/s, up to and including 9600 Bds or b/s, where m is a positive integer 0, 1, 2, ... 7.

(d) The modulation rates (expressed in Bds) and the data signaling rates (expressed in b/s) above 9600 Bds or b/s are based on 8000 x N and shall be as follows:

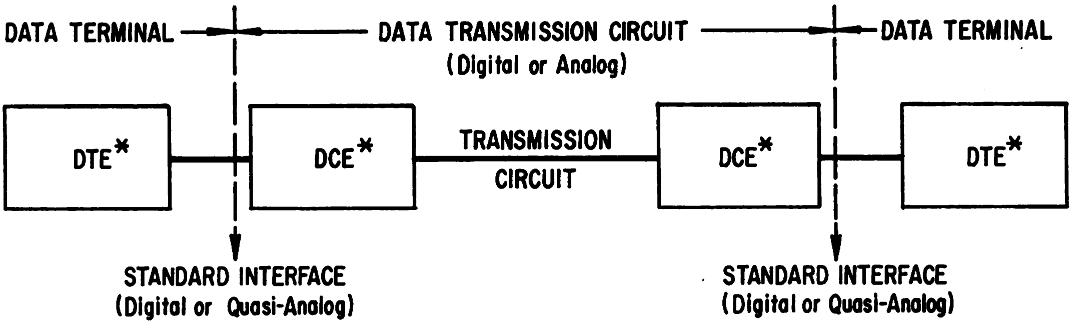
Standard Rates	Recognized Rates Based on Current Inventory
16 kBds or kb/s	50 kBds or kb/s*
32 kBds or kb/s	288 kBds or kb/s
48 kBds or kb/s**	576 kBds or kb/s
56 kBds or kb/s	1152 kBds or kb/s
64 kBds or kb/s	1536 kBds or kb/s
1344 kBds or kb/s	2048 kBds or kb/s
1544 kBds or kb/s	2304 kBds or kb/s
6312 kBds or kb/s***	
6336 kBds or kb/s***	

*This rate is not based on 8000 x N.

**48 kBds or kb/s is an internationally preferred rate for information transfer over 48 kHz group bandwidth channels. It is also recognized as a current military rate for TDM/PCM transmission.

***The selection of this rate will depend on CCITT recommendations.

NOTE: For the transmission over nominal 3-kHz and nominal 4-kHz channels, only the interface rates specified under (a), (b), and (c) shall apply.



LEGEND

DTE - Data Terminal Equipment

DCE - Data Communication Equipment

NOTE - Modulation and Data Signaling Rates at the Standard Interface are Specified in Paragraph 4.3.1.1

* May include Modems, Error Control Devices, Control Units, and Other Equipment as required.

Figure 4.3-1. Standard Interface Between Data Terminal Equipment and Data Communication Equipment

4.3.1.2 Application of Federal Information Processing Standards (FIPS). Federal Information Processing Standards Publications (FIPS PUBS) listed in Section 2 (Referenced Documents) are the official publications within the Federal Government for information relating to standards adopted and promulgated under provisions of Public Law 89-306 and Bureau of the Budget Circular A-86, titled: Standardization of Data Elements and Codes in Data Systems. This series of publications announces the adoption of standards, provides policy, and administrative guidance information for their effective implementation and utilization.

FIPS PUB 1 specifies the standard code for information interchange that will be used in those networks of the Federal Government whose primary function is the transmission of record communications or the transmission of data related to information processing (see Appendix B).

FIPS PUB 7 (Supplement to FIPS PUBS 1, 2, and 3) prescribes the means of implementing the code in media, such as perforated tape, magnetic tape, and punched cards. Other standards which deal with the use of the Standard Code for Information Interchange such as FIPS PUB 15, Subsets of the Standard Code for Information Interchange; FIPS PUB 16, Bit Sequencing of the Code for Information Interchange in Serial-By-Bit Data Transmission; and FIPS PUB 17, Character Structure and Character Parity Sense for Serial-By-Bit Data Communication in the Code for Information Interchange, are presented in Appendix B.

4.3.1.2.1 Standard Code for Information Interchange. The standard code specified in FIPS PUB 1 shall be used for the representation of character coded information in information interchange and files used in data processing, communications, and related equipments by the Departments and Agencies of the Department of Defense. Implementation of the code for information interchange and related media standards shall be applied in accordance with FIPS PUB 7. (Details concerning the applicability and use of these standards are provided in Appendix B.)

4.3.1.2.2 Interim Codes and Alphabets. Supplementary codes and alphabets are currently in use and will be used for an indeterminate period. In such cases the International Telegraph Alphabet No. 2 (ITA No. 2), American version, shall be considered first in meeting the requirements of users where a changeover to the standard code is not advisable or feasible (see Figure 14 of Appendix B).

4.3.1.3 Low Level Digital Interfaces.

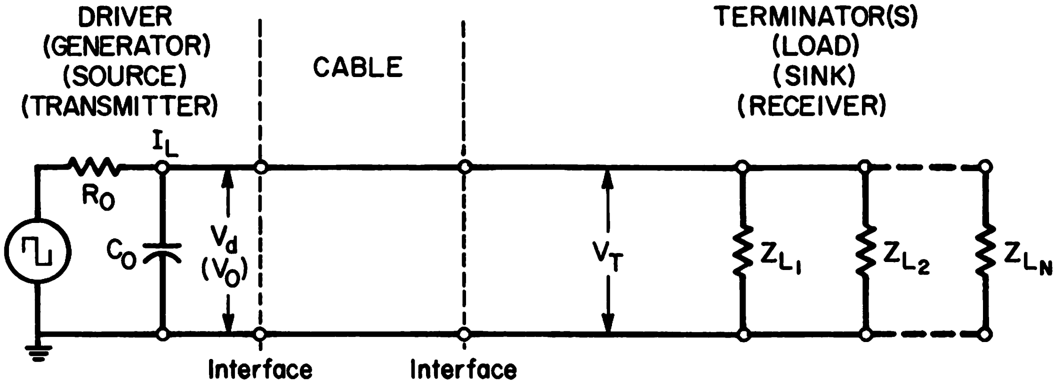
4.3.1.3.1 General. The low level digital interface has two basic configurations, one unbalanced and the other balanced. Both are required. The balanced digital interface allows for longer cable transmission distances than the unbalanced interface. The balanced interface also reduces interference from ground potential differences between source (driver) and sink (terminator). The use of a balanced cable produces a lower level of "near end" crosstalk in the metallic cable plant without a requirement for significant shaping at the source.

In the past, use of low-level balanced dc transmission was not popular due primarily to the unavailability of low-cost solid-state devices for converting unbalanced dc signals to balanced dc signals. With the increased availability of these devices it is likely that the balanced dc interface will experience greater usage. The most likely immediate widespread application of balanced interconnections is between the main or intermediate distribution frame and the cable pairs to the distant frame.

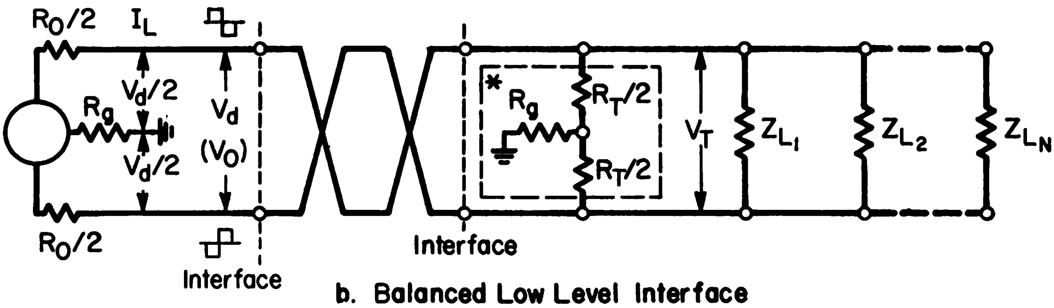
In general, however, the unbalanced interface will still result in lower system cost since two filters, two wires, two jack springs, two cross connects, etc., are required for the balanced interconnections whereas unbalanced interconnections require only one of these (see respective paragraph of MIL-STD-188-300).

Technology in 1972 permits the manufacture of integrated circuits which will switch up to approximately 10 megabaud. Under conditions where the length of the transmission line approaches zero, both the balanced and unbalanced interface will, therefore, function up to about 10 megabaud.

4.3.1.3.2 Applicability. The following characteristics shall be applicable to signal, clock, and control circuits for all digital dc communications where a binary interface appears. The interface standard applies to teletypewriters, data terminals, the dc side of signal conversion (modem) equipment, both terminal and line side of cryptographic or cryptographic control equipment, and remotely operated equipment where the interface is at the dc baseband (see Figure 4.3-2). These standard interfaces are applicable at all data rates regardless of the type of transmission medium used, e.g., a nominal 4-kHz channel, a nominal 48-kHz channel, or a metallic wire or coaxial cable circuit. These interface standards are design objectives for alarm and control circuits which are not directly related to the data or timing.



a. Unbalanced Low Level Interface



b. Balanced Low Level Interface

V_O	Open Circuit Driver Voltage
R_O	Total Effective Driver Resistance
C_O	Total Effective Driver Capacitance (Including Wave Shaper)
V_d	Driver Output Voltage, Loaded
V_T	Terminator Input Voltage
R_T	Cable Terminator Resistance
Z_{L_N}	Effective Impedance of Each Terminator
Z_L	Total Terminator Impedance
I_L	Total Line Driver Current
R_g	Provided for Noise and Current Protection
*	If Required (See Paragraph 4.3.1.3.4.7)

Figure 4.3-2. Low Level Digital Interfaces

These standard interfaces shall apply to all equipment other than an equipment complex connected so as to form a completely functional unit and which does not normally have its internal stages or components connected directly into the communications network. Where this type of equipment complex interfaces with the transmission media, it shall observe the standard.

The choice of the standard interface, either balanced or unbalanced, is left to the designer and depends upon the data rate, the distance between driver and terminator(s) and other factors. For certain applications the unbalanced driver can be connected to the balanced terminator and the balanced driver can be connected to the unbalanced terminator.

4.3.1.3.3 Unbalanced Low Level Digital Interface. An equivalent circuit of the unbalanced low level digital interface is illustrated in Figure 4.3-2a. This interface is represented between a driver and one or more terminators, including an interconnecting cable. The driver is represented by parameters V_o, R_o, C_o, and V_d. The terminator is represented by parameters V_t and Z_{LN}. The cable parameters [Resistance (R), Inductance (L), Capacitance (C), and length] are not standardized but will be determined by application engineering.

4.3.1.3.3.1 Driver Output Resistance (R_o). The total effective driver output resistance (R_o) shall not exceed 50 ohms including the shaping network for driver line current (I_L) with magnitude less than or equal to 0.01 amperes (10 milliamperes). The maximum short circuit current delivered to the interface shall not exceed 0.1 amperes.

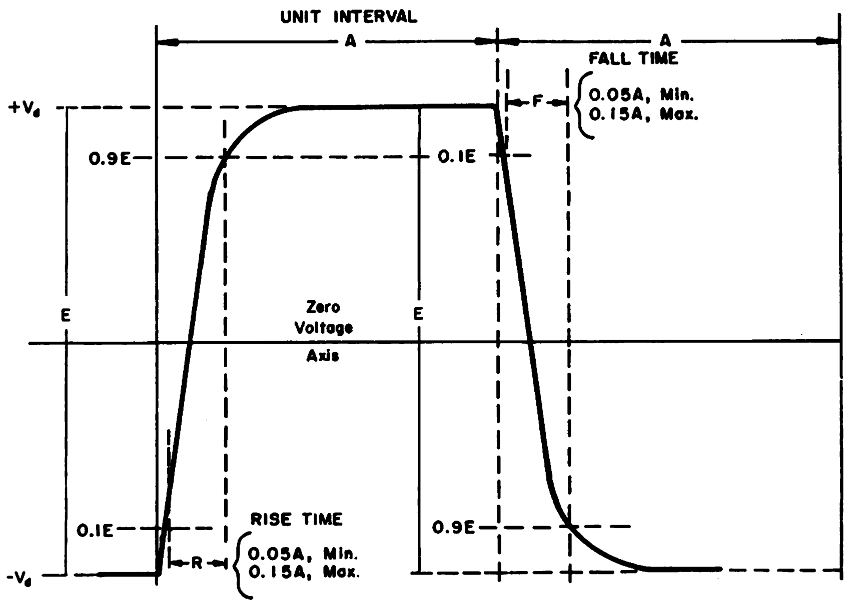
> NOTE: The purpose of the current of 10 milliamperes is to permit the interface with mercury-wetted mechanical relays on low-to-high level digital circuits.

4.3.1.3.3.2 Driver Output Capacitance (C_o). The total effective driver output capacitance includes the internal driver capacitance and any capacitance required to meet wave shape requirements (see subparagraph 4.3.1.3.3.5). The value of C_o is not standardized but must be considered with respect to the ability of the driver to meet the output voltage and wave form requirements.

4.3.1.3.3.3 Driver Output Voltage, Open Circuit (V_o). The open circuit driver voltage (V_o) measured at the unloaded driver output terminals shall be positive or negative 6 ±1 volts.

4.3.1.3.3.4 Driver Output Voltage, Loaded (V_d). The loaded driver output voltage (V_d) measured at the output terminals shall be positive or negative 6 ±1 volts when terminated in a 6000 ohm ±10 percent resistive load. The difference in magnitude between the marking and spacing voltages shall be such that the larger voltage magnitude is within 10 percent of the smaller.

4.3.1.3.3.5 Driver Output Voltage Wave Shape. The voltage wave shape delivered to a 6000 ohm resistive load shall be such that the rise and fall time (defined as the time required for the pulse to go from 10 percent to 90 percent and from 90 percent to 10 percent of its peak-to-peak value, respectively) shall each be within 5 percent to 15 percent of the unit interval at the applicable data signaling rate. Transitions in both directions shall be reasonably equal within the limits specified above and be equally affected by shunt capacitance across the output. Properly shaped wave forms shall exhibit smooth exponential curves and contain no points of inflection prior to obtaining maximum amplitudes (see Figure 4.3-3). For those devices which operate at one specific rate, the wave shaping network shall be selected to meet the 5 percent to 15 percent requirements for that rate. For those devices which may be manually or automatically shifted to different modulation rates, the required wave shaping shall be accomplished at least at the highest modulation rate. The wave shape shall be measured at the output terminals of the wave shaper or the output terminals of the driver if wave shaping is provided internally. If wave shaping is accomplished externally, interconnecting leads between the driver and wave shaping unit shall not exceed 8 inches in length to minimize near end crosstalk.



Rise Time, R, and Fall Time, F, (10% to 90% and 90% to 10% of Peak-to-Peak Voltage E Respectively) shall be within 5% to 15% of the Unit Interval, A, at the Applicable Modulation Rate. The Magnitude of $V_d = E/2$.

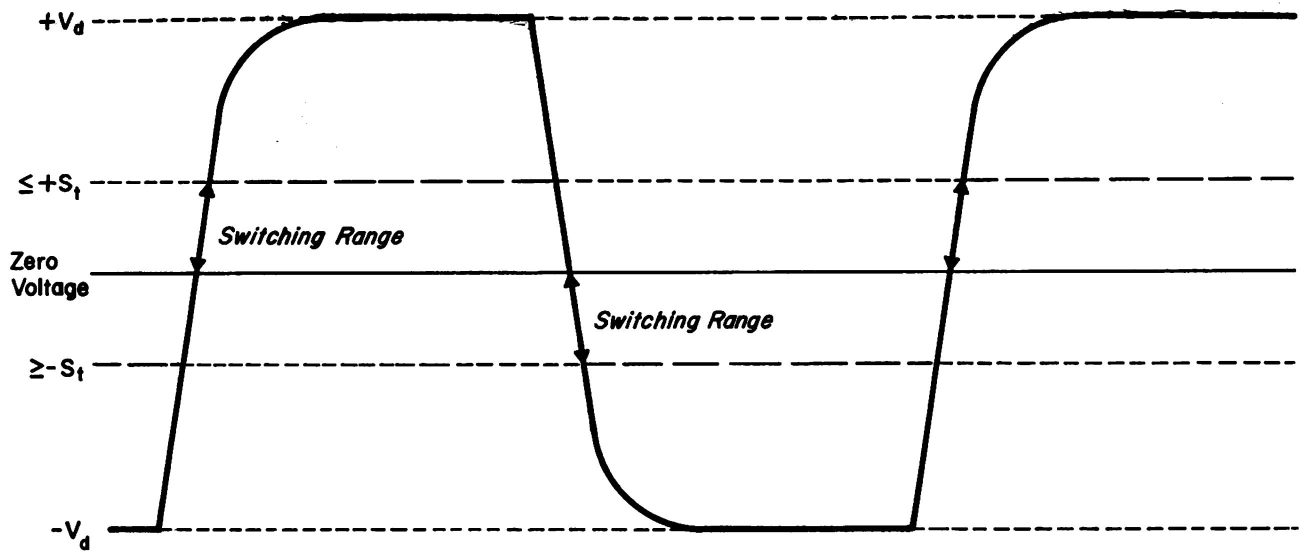
Figure 4.3-3. Driver Output Voltage for Unbalanced Low Level Digital Interface

4.3.1.3.3.6 Terminator Input Impedance (Z_{LN}). The resistive component of each terminator input impedance (Z_{LN}) shall be between 47,000 ohms and 68,000 ohms. The reactive component is not standardized but should not be inductive. Multiple terminators are permitted providing that the combined parallel resistance (Z_L) does not become less than 6000 ohms as presented to the driver. This may include the cable resistance (R).

4.3.1.3.3.7 Cable Termination Resistance (R_t). No cable termination resistance is required or specified.

4.3.1.3.3.8 Terminator Voltages.

4.3.1.3.3.8.1 Input Sensitivity (S_t). A marking voltage magnitude of 0.5 volts or less shall cause the terminator to assume the marking (ONE) state correctly; a spacing voltage magnitude of 0.5 volts or less shall cause the terminator to assume the spacing (ZERO) state correctly (see Figure 4.3-4).



	Low Level Digital Interface	
	UNBALANCED	BALANCED
V_d	5 to 7 Volts	0.4 to 3 Volts
S_t	0.5 Volts	0.05 Volts

Where:

V_d is the Driver Output Voltage, Loaded
S_t is the Terminator Input Sensitivity

Figure 4.3-4. Switching Range of Low Level Digital Interface

4.3.1.3.3.8.2 Operation. The terminator shall operate correctly up to a maximum voltage magnitude of 7 volts.

4.3.1.3.3.9 Protection. Interface circuit protection shall be provided so that any driver or terminator shall not be damaged by occurrence of any of the following contingencies:

(a) Voltage magnitudes of 25 volts on the terminator leads.
(b) Shorting of the input or output leads to ground or to each other.
(c) Crossing of the leads with any other physical leads of the interface.
(d) Opening of either or both of the input or output leads.
(e) Whenever the driver or terminator is connected by a metallic circuit directly to pairs of an outside cable plant, additional protective circuitry shall be provided to protect the driver and terminator against the spurious voltage transients and power surges commonly experienced across a cable pair or between either conductor of a cable pair and ground. The protective circuitry shall be adequate to ensure that the driver or terminator will not be damaged by the appearance across the cable pair or between either conductor and ground, of (1) a voltage transient of up to 1000 volts peak voltage with a 5 microsecond rise time and decaying to 50 percent of peak voltage in 600 microseconds, (2) a voltage transient of up to 350 volts peak with a 10 microsecond rise time and decaying to 50 percent of peak voltage in 2000 microseconds.

4.3.1.3.4 Balanced Low Level Digital Interface. An equivalent circuit of the balanced low level digital interface is illustrated in Figure 4.3-2b. This interface is represented between a driver and one or more terminators, including an interconnecting cable. The driver is represented by parameters V_o, R_o, R_g, and V_d. The terminator is represented by parameters V_t, R_t, R_g, and Z_{LN}. The cable parameters [Resistance (R), Inductance (L), Capacitance (C), and length] are not standardized but will be determined by application engineering.

NOTE: Some of the parameters of the balanced low level digital interface may be subject to modification pending final coordination of a proposed Federal Information Processing Standard (FIPS) which will supersede the standards given in this paragraph. Therefore, before standards of this paragraph are used, the status of the pending FIPS should be checked.

4.3.1.3.4.1 Driver Output Resistance (R_o). The total effective driver output resistance (R_o) shall be 100 ohms ±50 percent balanced to ground for driver line currents (I_L) with magnitudes less than or equal to 0.15 amperes. The resistance balance to ground shall be within 10 percent. The maximum short circuit current delivered to the interface shall not exceed 0.25 amperes.

4.3.1.3.4.2 Driver Output Capacitance (C_o). The total effective driver output capacitance is not standardized.

4.3.1.3.4.3 Driver Output Voltage, Open Circuit (V_o). Not standardized.

4.3.1.3.4.4 Driver Output Voltage, Loaded (V_d). The loaded driver output voltage (V_d) shall be positive or negative 0.8 volts to 6.0 volts peak-to-peak across the terminals and balanced to ground (±0.4 volts to ±3.0 volts, when measured from either terminal to ground). For measuring the loaded driver output voltage (V_d), the driver output shall be terminated in a balanced 100 ohm ±10 percent resistive load. The voltage balance to ground shall be within 10 percent. The difference in magnitude between the marking and spacing voltages shall be such that the larger voltage magnitude is within 10 percent of the smaller.

4.3.1.3.4.5 Driver Output Voltage Wave Shape. The driver output voltage wave shape is not standardized. Wave shaping is not required.

4.3.1.3.4.6 Terminator Input Impedance (Z_{LN}). The resistive component of each terminator input impedance (Z_{LN}) shall be greater than 5000 ohms. The reactive component is not standardized but should not be inductive. Multiple terminators are permitted providing that the combined parallel resistance (Z_L) does not become less than 500 ohms as presented to the driver. This may include the cable resistance (R).

4.3.1.3.4.7 Cable Termination Resistance (R_t). The cable termination resistance (R_t), if required, shall be 100 ohms±10 percent center tapped through a 125 ohms ±10 percent resistor (R_g) to ground. Resistance balance to ground shall be within 10 percent.

4.3.1.3.4.8 Terminator Voltages.

4.3.1.3.4.8.1 Input Sensitivity (S_t). A marking voltage magnitude of 0.05 volts or less shall cause the terminator to assume the marking (ONE) state correctly; a spacing voltage magnitude of 0.05 volts or less shall cause the terminator to assume the spacing (ZERO) state correctly (see Figure 4.3-4).

4.3.1.3.4.8.2 Operation. The terminator shall operate correctly up to a maximum voltage magnitude of 6 volts (3 volts when measured from either terminal to ground).

4.3.1.3.4.9 Protection. Same as subparagraph 4.3.1.3.3.9.

4.3.1.3.4.10 Performance in the Presence of Noise. A driver connected to a terminator shall operate without error in the presence of longitudinal noise or dc common return potential differences (common return offset) as follows:

(a) With ±2 volts (peak) noise present longitudinally, i.e., algebraically added to both terminator input terminals simultaneously with respect to the common return; or

(b) With ±4 volts common return offset;

(c) If common return offset and longitudinal noise are present simultaneously, satisfactory operation shall be achieved when:

$$\frac{\text{Common return offset}}{2} + \text{longitudinal noise (peak)} = 2 \text{ volts or less.}$$

4.3.1.4 High Level Digital Interface. This paragraph describes the high level interface used in some existing facilities. THE FOLLOWING SUBPARAGRAPHS, 4.3.1.4.1 THROUGH 4.3.1.4.6, DESCRIBING THE HIGH LEVEL INTERFACE HAVE BEEN EXTRACTED FROM MIL-STD-188C FOR INFORMATION PURPOSES ONLY, THIS INFORMATION IS NOT TO BE USED AS STANDARD FOR THE DESIGN OF NEW EQUIPMENT OR SYSTEMS. The user cautioned that telegraph systems with different characteristics can be encountered throughout the world. The following is provided for guidance.

In the United States:

Voltages: 24, 48, 60, 75, 130 Vdc.
Current: 20, 60, 65, 75 milliamperes.
Sense: Positive and negative in neutral, polar, and polarential circuits.
Battery Source Impedance: High and low.

In other countries:

	Volts	Milliamperes	Sense (Mark)
United Kingdom	80	20	-
France	48	20	+
Spain	80	20	+
Norway	60	20	-
Germany	60 and 24	20	- and +

International: The standard for international boundary crossing purposes is 48 Vdc polar, 20 mA, positive marking. All normally utilize polar and low impedance battery sources.

4.3.1.4.1 Transmitter Output Current. The interface (high level) shall be a polar signal at 20 mA (±10 percent). A neutral interface (high level) is acceptable and may be either a current of 20 mA (±3 percent) or 60 mA (±3 percent).

4.3.1.4.2 Transmitter Output Magnitude. The standard polar circuit shall be ±60 V (±2 percent) for high performance facilities and ±60 V (±4 percent) for low performance facilities. The standard neutral circuit shall be 130 volts (±2 percent) for high performance facilities and 130 volts (±4 percent) for low performance facilities.

NOTE: Certain US Military electronic telegraph terminal equipment utilize upwards of 300 Vdc (referenced to the signal ground) in their output circuit. Such equipment shall be isolated from the cable plant by suitable relays or other isolation devices to prevent destruction of the cable or hazard to human life.

4.3.1.4.3 Source Impedance. The battery (or equivalent) source impedance at the transmit contacts (or equivalents) should not exceed 150 ohms, essentially resistive.

4.3.1.4.4 Wave Shaper. The standard polar wave shaper for dc telegraph signals with data signaling up to 150 b/s shall be 200 ohm, 10 watt wirewound, ±10 percent resistor connected between the transmitting device and the line (Figure 4.3-5). The line side of the resistor shall be shunted to the signal ground by a 1 microfarad capacitor, 10 percent tolerance, with a capacitor working voltage of 200 volts. Local circumstances may dictate a reduction in the size of the capacitor on long lines (in excess of 10 miles) or on lines exhibiting high capacity. The objective is to provide the maximum wave shaping possible at the transmitting point to reduce or eliminate near end cross-talk and/or to minimize the tendency of the receive relay to bounce. The RC network indicated above has been shown adequate in almost all cases within and outside of the US. The wave shaper for neutral signals is not specified.

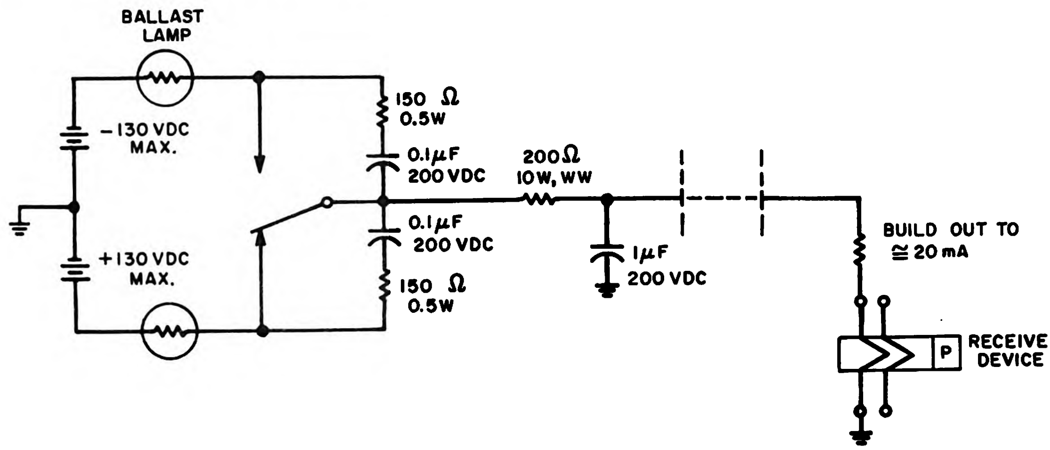


Figure 4.3-5. High Level Digital Interface

4.3.1.4.5 Contact Protection. Transmit contacts (or equivalents) shall be protected by fuses, ballast lamps (such as FSN 5905-335-0644), and/or resistors (not to exceed 150 ohms in each mark and space contact lead).

4.3.1.4.6 Receiver Sensitivity. The input sensitivity of mechanical or electronic, polar-relay driven, printing telegraph equipment shall be in the 2 to 4 mA operating differential region; for example, a change from 32 mA to 28 mA on a 60 mA neutral signal shall cause correct operation of the receiver device or, in the case of a polar signal, a change from +2 mA through 0 to -2 mA shall cause correct operation of the receiver device.

4.3.1.5 Logical and Signal Sense for Binary Signals. For data or timing circuits, the signal voltage with respect to signal ground shall be positive to represent marking, and negative to represent spacing. These and other logical and signal states are tabulated as follows:

Application	Condition	Condition
Voltage to signal ground	Positive (+)	Negative (-)
Conventional term	Marking	Spacing
Binary digit value	One	Zero
Timing signal state	On	Off
Paper tape	Hole	No hole
FSK signal state	Lower frequency	Higher frequency
Neutral system current	On	Off
Tone, single AM system	On	Off
Tone, dual AM system	Lower frequency	Higher frequency

Application	Condition	Condition
Magnetic Tape (See Note 1)		
NRZI (See Note 2)	Change Polarity	No change
Phase Encoding	(See Note 3)	(See Note 4)

NOTE 1: Two methods of recording on magnetic tape have been standardized by the American National Standards Institute. The first is NRZI Recording (see Note 2) standardized for recording densities up to 800 CPI (Character Per Inch). The second is Phase Encoded recording (see Notes 3, 4, and 5) used at 1600 CPI.

NOTE 2: NRZI = Non Return to Zero, change on one. This means change polarity for "1" data bits and make no change in polarity for "0" data bits.

NOTE 3: In Phase Encoded recording a "1" data bit is a flux reversal to the polarity of the interblock gap, when reading in the forward direction (see Note 5).

NOTE 4: In Phase Encoded recording a "0" data bit is a flux reversal to the polarity opposite to that of the interblock gap, when reading in the forward direction (see Note 5).

NOTE 5: A flux reversal shall be written at the nominal mid-point between successive "1" bits or between successive "0" bits to establish proper polarity. This flux reversal shall be called a phase flux reversal.

NOTE 6: An alternative capability to interface with equipment conforming to other standards, e.g., industrial and CCITT, standards, shall be provided to accept signals which may have polarities opposite to those stated in this paragraph.

4.3.1.6 Clock Equipment, Control, and Timing. The clock is the device which provides the time base for controlling operation of digital equipment. An equipment clock provides the peculiar needs of its equipment and in some cases may control the flow of data at its equipment interface. A master or station clock, regardless of its physical location, controls two or more equipments which are linked together as a system. The following subparagraphs, 4.3.1.6.1 through 4.3.1.6.3.1, are primarily concerned with master or station clocks.

4.3.1.6.1 Transmission Modes. All future communication equipment requiring a stable clock or precise character interval control shall make provisions for operating from station clocks in any or all of the following modes, specified in subparagraphs 4.3.1.6.1.1 through 4.3.1.6.1.3.

4.3.1.6.1.1 Bit Synchronous. In bit synchronous operation, clock timing shall be delivered at twice the data modulation rate. (For this purpose "data" includes information bits plus all bits added to the stream for whatever purpose they may serve in the system, i.e., error control, framing...etc.). The device shall release one bit within the duration of one clock cycle. It shall be assumed that, during periods of communication difficulty, a clock signal might be delivered to a send device occasionally or not at all for periods extending to hours. During periods when the sending equipment has no traffic to send, an idle pattern or all "ones" may be transmitted.

4.3.1.6.1.2 Bit-By-Bit Asynchronous. In bit-by-bit asynchronous operation it is assumed that rapid manual, semiautomatic or automatic shifts in the data modulation rate will be accomplished by gating or slewing the clock modulation rate. It is possible that equipment may be operated at 50 b/s one moment and the next moment at 1200 b/s or 2400 b/s, etc. It shall be assumed that, during periods of communication difficulty, a clock signal might be delivered to a send device occasionally or not at all for periods extending to hours. During periods when the sending equipment has no traffic to send, an idle pattern or all "ones" may be transmitted.

4.3.1.6.1.3 Character Interval Synchronous. In character interval synchronized equipment, any character interval from 4 to 16 unit intervals per character interval shall be permitted. It is assumed that, having programmed a given facility for a particular character interval, no other character interval operation would be expected except by reprogramming. An example of such operation would be a 7.0 units per character interval tape reader being stepped at 8.0 units per character interval.

4.3.1.6.2 Clock Characteristics.

4.3.1.6.2.1 Modulation Rates. The standard clock modulation rates for compatibility with modulation or data signaling rates shall be two times the standard rates specified in subparagraph 4.3.1.1.

4.3.1.6.2.2 Modulation Rate Stability. The stability of synchronizing or clock timing supplied in all synchronous digital transmission, switching, terminal, and security equipment shall be sufficient to ensure that synchronism is maintained within ±25 percent of the unit interval between transmitted and received signals for periods of not less than 100,000 consecutive seconds.

4.3.1.6.2.3 Modulation Rate Phase Adjustment. Means shall be provided in all digital transmission, switching, terminal, and security equipment so that, at the applicable modulation rate, a shift in phase of the incoming data stream with relation to the clocking pulse shall be possible over a period of three unit intervals (i.e., a shift of 1.5 unit intervals early or late from theoretical center of the unit interval at the applicable modulation rate).

4.3.1.6.2.4 Output Signal. The output of the clock shall be an alternating symmetrically-shaped wave at the required clock modulation rate. In the case of an unbalanced digital interface, the clock output signal shall comply with the voltage and wave shaping requirement of subparagraphs 4.3.1.3.3.4 and 4.3.1.3.3.5, respectively. In the case of a balanced digital interface, the clock output signal shall comply with the voltage requirements of subparagraph 4.3.1.3.4.4 and shall contain no points of inflection prior to reaching the maximum amplitudes. When the clock is quiescent, the clock signal state shall be negative.

4.3.1.6.2.5 Clock Period. A clock period or cycle is defined as having one half-cycle of positive polarity (sense) and one half-cycle of negative polarity (sense). The duty cycle shall be 50 percent ±1.0 percent. Thus, in the binary sense, each clock period or cycle is composed of two clock unit intervals, and it follows that a clock rate of 50 Hz is a clock modulation rate of 100 Bds.

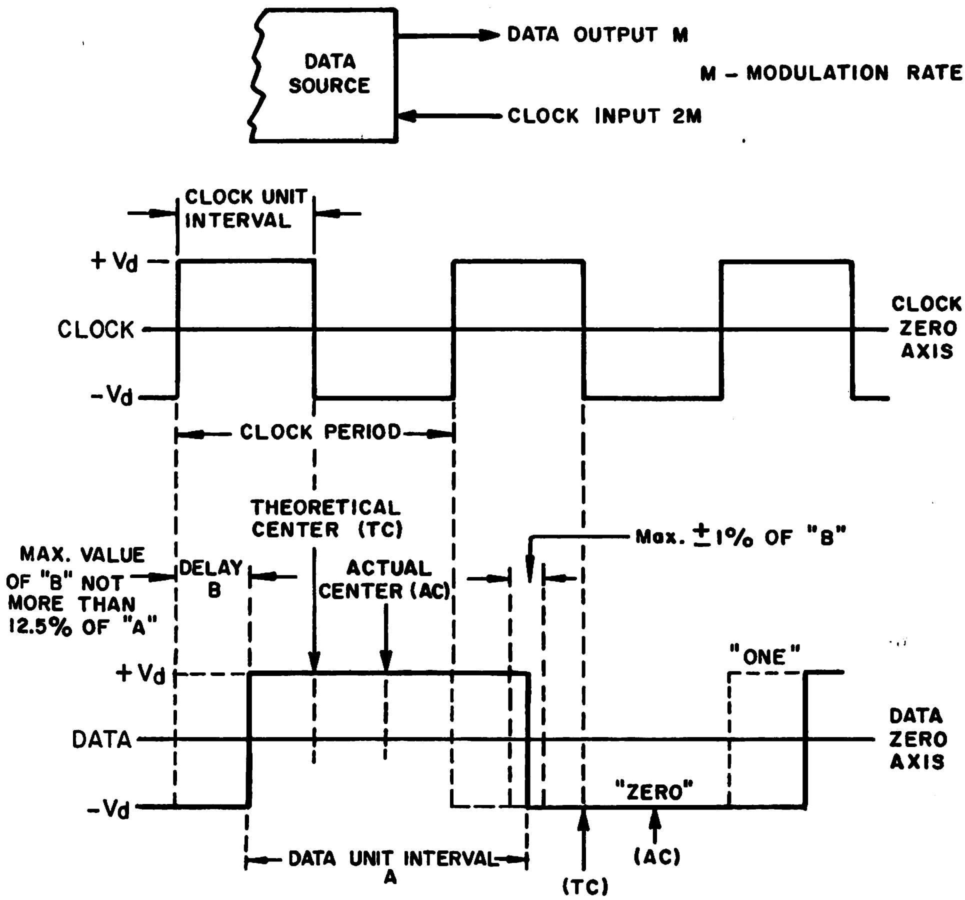
4.3.1.6.3 Clock/Data Phase Relationship. Arrangements which may be used to supply clock pulses to sources and sinks are shown in subparagraph 4.3.1.6.3.1. Typical standard arrangements are shown from which one may be selected to meet a specific application. For those digital devices operated at dc baseband which are interconnected by metallic wire (or other equipment which provides in effect the same function as a metallic wire) the following clock/data phase relationships apply if, and only if, interface circuit lengths permit. It is noted that, due to signal propagation delay time differences over different dc wire circuits or dc equivalent circuits at data modulation rates higher than 2400 Bd, there may be a significant relative clock/data phase shift which must be adjusted in accordance with subparagraph 4.3.1.6.2.3. Practical operating experience indicates that typical multiple pair paper cable or polyvinyl chloride (PVC) insulated exchange grade telephone cable may be expected to function at modulation rates of 4800 Bd data/ 9600 Bd clock at distances up to 3000 cable feet without any need for concern over relative phase shift or noise if the standard low level digital interface is applied to both clock and data signals in accordance with subparagraph 4.3.1.3.

All data transitions emitted by a source under direct control of an external clock shall occur on (be caused by) negative to positive transitions of that clock. The design objective is a minimum delay between the clock transition and the resulting data transition, but in no case shall this delay exceed 12.5 percent of the duration of the data unit interval. For each equipment, once this delay is fixed in hardware, it shall be consistent within ±1 percent of itself for each clock transition. These delay limits shall apply directly at the driver interface (see Figure 4.3-6).

Sampling of the data signal by the external clock at a sink interface shall occur on (be caused by) positive to negative clock transitions (see Figure 4.3-7).

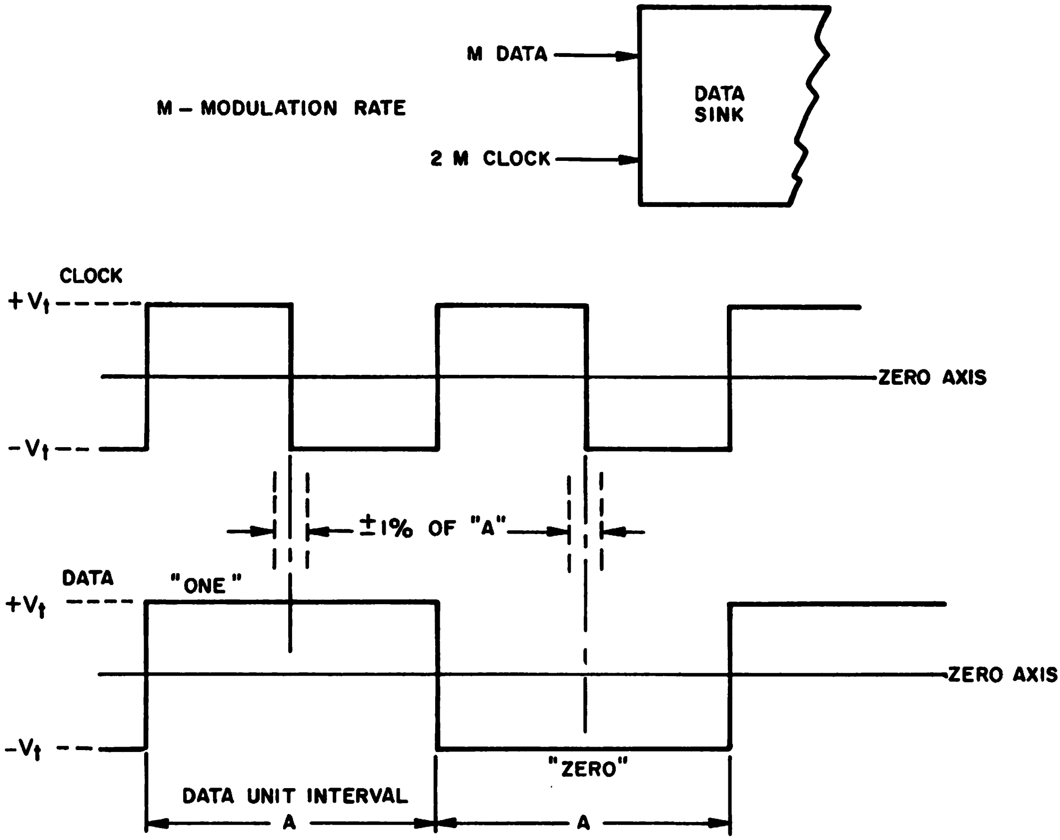
When the clock is used for controlling intermittent data transmission, data may not change state except when requested by a negative to positive clock transition. The quiescent state of the clock shall be at negative voltage. The quiescent state of the data shall be that state resulting from the last negative to positive clock transition (see Figure 4.3-8).

The phase relationship between external clock and data is not specified for devices in which the external clock is related only indirectly to the source data; for example, to maintain synchronism between a data source and a data sink for a signal with a constant modulation rate. However, whatever the phase delay, it shall be consistent to within ±1 percent of the data unit interval at the applicable modulation rate. If the clock at twice the modulation rate of the same data is also supplied as an output, then data transitions shall coincide within ±1 percent of the data unit interval with the negative to positive transitions of the output clock (see Figure 4.3-9). Direct control means control of the data by a clock signal at twice the modulation rate of the data. Indirect control means use of a clock at some higher standard modulation rate, e.g., 4, 8, 128 times the modulation rate.



The source data signal transition shall occur consistently within 12.5 percent of the duration of the data unit interval from the clock input transition from negative to positive. Whatever phase delay is chosen, the equipment design shall insure that data transitions are released with a consistent phase delay not to exceed plus or minus one percent of that delay. Measurements shall be made and these limits apply directly at the source interface.

Figure 4.3-6. External Directly Related Source Clock/ Data Relationship



Positive to negative clock transitions shall be utilized for sampling of the data.

The input data signal to the sink shall be sampled consistently within plus/minus one percent of the duration of the unit interval of the data signal assuming the modulation rate of the clock is twice that of the data.

Figure 4.3-7. External Directly Related Sink Clock/ Data Relationship

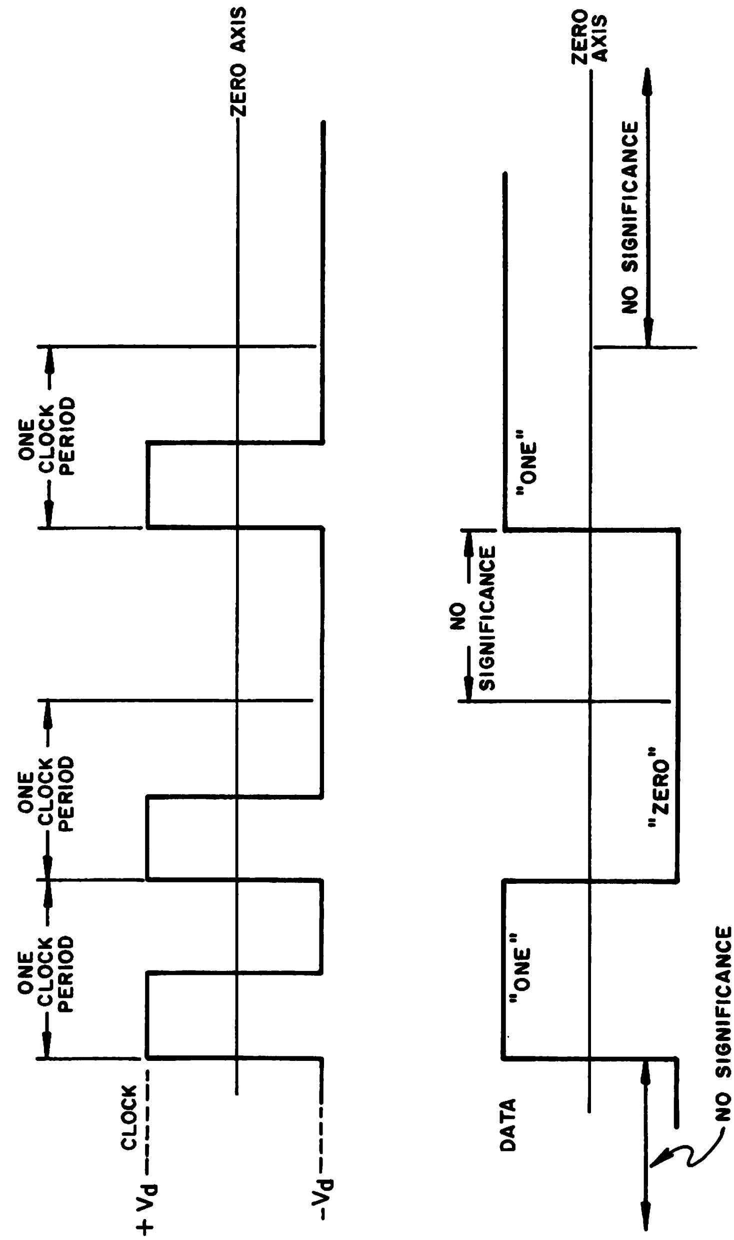
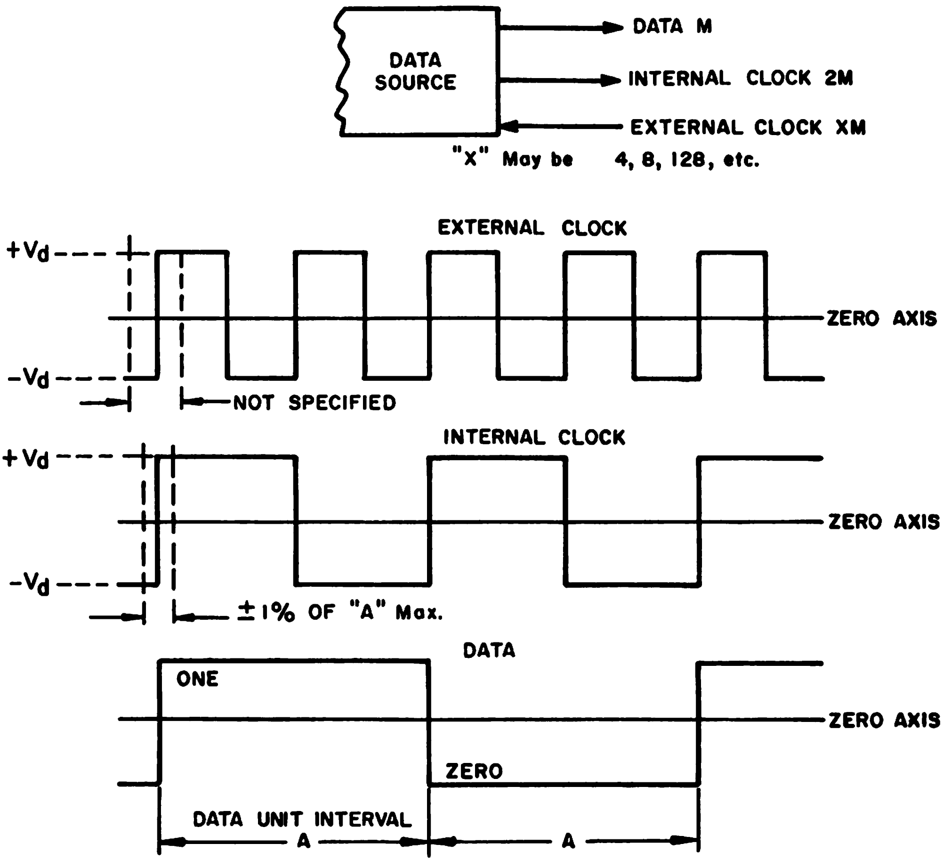


Figure 4.3-8. Standard Interface Clock/Data Phase Relationship



The data transitions shall be coincident within plus/minus one percent with the negative to positive transitions of the internal clock. No phase relationship between data and external clock is specified. The modulation rate and the phase shift of the internal clock shall be constant within plus/minus one percent of the duration of the unit interval of data at the applicable modulation rate.

Figure 4.3-9. External Indirectly Related Internal Clock/Data Relationship

For devices in which input data to the terminator are sampled from a clock not directly related to the data modulation rate, the phase relationship of data to clock shall be maintained in such a way that each data unit interval shall be sampled within ±1 percent of the theoretical center of the data unit interval.

In the case of synchronous devices operating from an external clock directly related to data and outputting start/stop format signals, data transitions shall be coincident with negative to positive clock transitions within ±1 percent of the data unit interval.

For start/stop format devices utilizing internal, low stability sampling sources, it shall be permissible to sample incoming data within ±12.5 percent of the data unit interval away from the actual center. This distortion, however, shall not be passed on to any output interface. Any further transmission of this signal shall be regenerated.

4.3.1.6.3.1 Standard Arrangements for Clock/Data Phase Relationship. The following definitions apply:

(a) Data modulation rate = M.

(b) Clock modulation rate = 2M. (Clock modulation rate is directly related to data modulation rate.)

(c) Clock modulation rate = xM. (Clock modulation rate is indirectly related to data modulation rate.) An external clock, supplied at a higher modulation rate and divided within the equipment to provide a data modulation rate of M, would be defined as some number (x) multiplied by the data modulation rate; e.g., 128M designates that the clock is 128 times the data modulation rate.

There are five typical cases considered in this standard and the user shall relate his case to one of the examples given.

CASE ONE: (See Figure 4.3-10) Source to sink data modulation rate is determined by external clock(s). In some cases the external clock is supplied to the source and sink and in other cases there may be two separate external clocks.

For collocated source and sink driven by the same external clock at rate xM, x may equal 2; clock is directly related to data modulation rate and center sampling, within ±1 percent of the data unit interval, shall be assured.

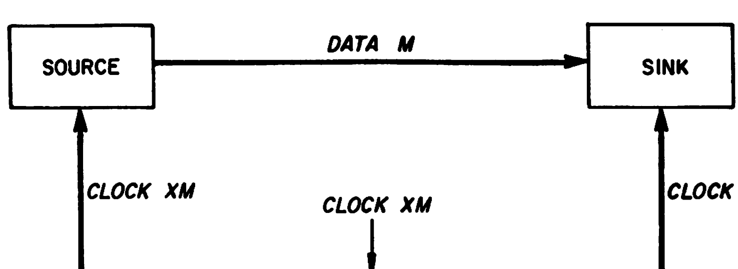


Figure 4.3-10. Case 1: Standard Arrangement for Clock/Data Phase Relationship where $x \geq 2$

For collocated source and sink driven by different clocks, or driven by the same clock when x is greater than 2 or for electrically separated source and sink, phasing techniques shall be employed which permit initial adjustment of sample point to within ±1 percent of the theoretical data unit interval measured from the center of the data unit intervals arriving at the sink.

CASE TWO: (See Figure 4.3-11) External clock is supplied to the source device at xM; divided down to 2M to serve as a directly related clock, and determines the data modulation rate; the 2M clock is released along with the M data to act as an instruction to the sink that the data lead contains data that are to be sensed. The method of gating the 2M clock is considered an equipment design consideration. The phase relationships of M to 2M shall be maintained whether gated or nongated clock is furnished.

There is no specific phase relationship between xM and 2M or between xM and M defined or implied. There is a specific modulation rate relationship which is determined by the ratio xM/2M or xM/M.

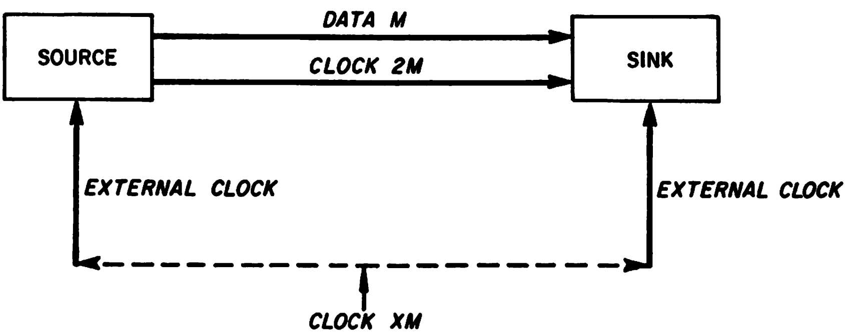


Figure 4.3-11. Case 2: Standard Arrangement for Clock/Data Phase Relationship where x > 2

CASE THREE: (See Figure 4.3-12) Case three is similar to case two except the 2M clock is supplied from the sink toward the source. This clock may be gated or nongated; in effect it requests the source to release data. There is no specific phase relationship between xM and 2M defined or implied. There is a specific phase relationship defined between M and 2M at the source: data transitions can occur only after negative to positive transitions of 2M. The data line shall not again change state until the next negative to positive transition at the 2M lead. The source shall maintain the phase relationship of the data M to clock 2M within ±1 percent. The 2M clock is not permitted to change state except at transitions of a continuous square wave of the same modulation rate. This is intended to preclude data intervals occurring at other than integral multiples of the unit interval.

The duration of the unit interval of the data modulation rate shall be maintained within the accuracy of the external clock to ±1 percent.

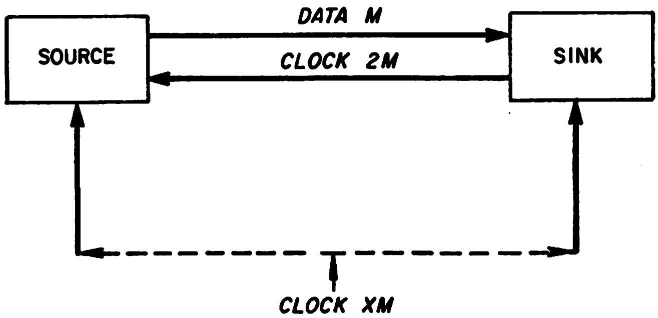


Figure 4.3-12. Case 3: Standard Arrangement for Clock/Data Phase Relationship where x > 2

CASE FOUR: (See Figure 4.3-13) No external clock is required or implied. The control of the data modulation rate is completely under the control of the source. A 2M clock and M data lead are supplied to the sink. The "state" of the clock lead determines the sensing of the data lead at the sink. The 2M clock shall request (cause) changes in the state of the data only on the negative to positive transitions. The receiver shall determine the state of the data lead only on the positive to negative transitions of the 2M clock.

NOTE: For time division multiplexers under development, the exact configuration for the recovery of timing from the received data is under consideration.

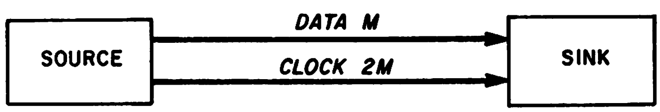


Figure 4.3-13. Case 4: Standard Arrangement for Clock/Data Phase Relationship

CASE FIVE: For start/stop format sinks utilizing internal, low stability, sampling sources or external clock at rate xM, it shall be permissible to sample incoming data within ±12.5 percent of the theoretical data unit interval measured from the actual center of the data unit intervals arriving at the sink. Any data regenerated by this equipment shall be retimed to prevent any interface distortion, caused by this sampling technique, to be passed on to the equipment output.

4.3.1.7 Distortion. As a Design Objective, the maximum total distortion, introduced by the data channel carrying binary dc signals, due to any combination of causes (bias, fortuitous, cyclic, or characteristic) shall not exceed ±25 percent of the unit interval, on a user-to-user basis.

4.3.1.8 Digital Error Rates. As a Design Objective, during 99 percent of the time that a user utilizes the network, the error rate provided by the network to the user shall not exceed 1 erroneous bit in 10^5 information bits at a data signaling rate of 1200 b/s employing FSK modulation. As an additional Design Objective, during 99 percent of the time that a user utilizes the network, the user throughput shall be equal to or greater than 50 percent. The 99 percent time period, as specified in the two above design objectives, may occur in a continuous uninterrupted interval or may occur accumulatively.

NOTE 1: The two above Design Objectives are applicable to system designs utilizing a mathematical model of error probability distributions. For other applications, such as acceptance tests, the unit of time (specified above as a percentage of time) has to be determined based on the special requirements of the system under consideration.

NOTE 2: Automatic-request-repeat (ARQ) systems are generally sensitive to round trip delays. For example, block-by-block data transmission in AUTODIN over a satellite system has throughputs appreciably less than 50 percent. In addition, the throughput as a function of error rate is also a function of block size. These throughput requirements cannot be interpreted as requirements on transmission facilities but rather must be interpreted as requirements on the entire system.

Error control necessary to satisfy special requirements shall be accomplished by ancillary devices or by input/output line units designed for the purpose and shall not be included in the basic communications network design. In cases of special error rate requirements, it shall be the responsibility of the originator of the requirement to supply the means, compatible with the communication system, to meet this requirement.

4.3.1.9 Signal Paths. The standard dc signal path shall be either two-wire with metallic ground or four-wire full metallic for a single full-duplex circuit.

NOTE: The use of earth return is not recommended. It is to be noted that a distinction is implied between ground and earth return. Use of the first term is meant to imply that a single metallic path either insulated or not insulated from the earth is employed for the return path of one or more dc circuits; whereas, use of the term earth return is meant to imply that the signal current literally flows through the earth on a nonmetallic basis.

4.3.1.10 Monitoring. The standard methods of monitoring dc circuits shall be an essentially nonreactive tap with a minimum dc resistance of 10,000 ohms (DO: 47,000 ohms to 68,000 ohms) for polar signaling, and an essentially nonreactive series insertion with a maximum dc resistance of 200 ohms for neutral signaling.

4.3.2 Parameters for Data Service Over Unconditioned Voice Bandwidth Circuits (User-to-User).

4.3.2.1 General. The following subparagraphs 4.3.2.2 through 4.3.2.12 establish standards and design objectives for unconditioned voice bandwidth circuits which are used for transmission of digital information in quasi-analog form. These standards and design objectives are applicable to circuits connecting data reference terminals for transmission of digital information with data signaling rates of up to 1200 b/s. These unconditioned circuits may also be used for satisfactory voice and facsimile service. Such circuits are provided by the use of controlled loop characteristics and by the use of TDM derived channels and of those FDM derived channels which are best suited for quasi-analog data service. FDM CHANNELS 1 AND 2 OF GROUP 1 OF SUPERGROUP 1 AND CHANNELS 11 AND 12 OF GROUP 5 OF SUPERGROUP 3 ARE NOT RECOMMENDED FOR THIS PURPOSE. In general, experience has shown that signal discontinuities, such as phase and amplitude hits, impulse noise, and dropouts as well as the envelope delay distortion and the insertion loss versus frequency characteristic are major causes of unsatisfactory data transmission in the form of excessive digital error rates. If the circuit parameters described herein are achieved, experience has shown that the design objective for the digital error rate stated in subparagraph 4.3.1.8 should also be achievable.

As general guidance for long haul/tactical applications, the data circuit should be equipped with a regeneration capability if the parameters listed in subparagraphs 4.3.2.2 through 4.3.2.12 cannot be achieved. Regeneration is generally not employed on tactical data circuits; however, when tactical data circuits are interconnected with long haul data circuits, regeneration may be necessary at the interface point. In any case, regeneration points have to be determined on an individual basis.

4.3.2.2 Transmitted Level (Quasi-Analog). The quasi-analog transmitted level of the data modem shall be adjustable from −18 dBm to +3 dBm, so as to provide −13 dBm at the 0TLP (−13 dBm0) at the input of the data trunk or switchboard of the long haul or the tactical less maneuverable system and −10 dBm at a −4 TLP of the tactical highly maneuverable system. The power of each data tone, with reference to −13 dBm, shall be equal to -13 dBm -10 log t, where t is the number of tones.

4.3.2.3 Received Level (Quasi-Analog). The quasi-analog received level of the data modem shall range from −35 dBm to −5 dBm. The average received level should be approximately −20 dBm. The exact value of the received level depends on the insertion loss of the loop.

4.3.2.4 Received Noise Power. The nonimpulse type of circuit noise, as measured at the input terminals of the data modem, shall not exceed 50,000 pWp0 (approximately 47 dBrnc0) referenced to the long haul 0TLP during 99 percent or more of the time and shall not exceed 316,000 pWp0 (approximately 55 dBrnc0) referenced to the long haul 0TLP for 1 percent or less of the time. This standard applies to FDM transmission and metallic circuits only.

NOTE 1: The commonly used noise measuring sets will measure total rms noise power including the average impulse noise power. However, the contribution of the average impulse noise, as registered by these meters, is small enough to be neglected.

NOTE 2: The allowable noise specified in this standard for circuits and channels is 50,000 pWp0 (approximately 47 dBrnc0). Circuit engineering must always take the actual loop noise into account, e.g., the channel noise may be allowed to reach the full 50,000 pWp0 if, and only if, the noise of the loops is negligible.

4.3.2.5 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic referenced to 1000 Hz shall not exceed the values given in Table 4.3-1 over the frequency bandwidths indicated. Loss is indicated by a (+) and gain by a (–) sign (see Figure 4.3-14a).

Table 4.3-1. Insertion Loss Versus Frequency Characteristic

Bandwidth in Hz	Insertion Loss in dB
Below 300	Greater than -2
300-2700 (except 1000-2400)	-2 to +6
1000-2400	-1 to +3
2700-3000	-3 to +12
Above 3000	Greater than -3

4.3.2.6 Envelope Delay Distortion. The envelope delay distortion over the frequency bandwidth from 1000 Hz to 2600 Hz shall not exceed 1750 microseconds, except between 1000 Hz and 2400 Hz the envelope delay distortion shall not exceed 1000 microseconds (see Figure 4.3-14b).

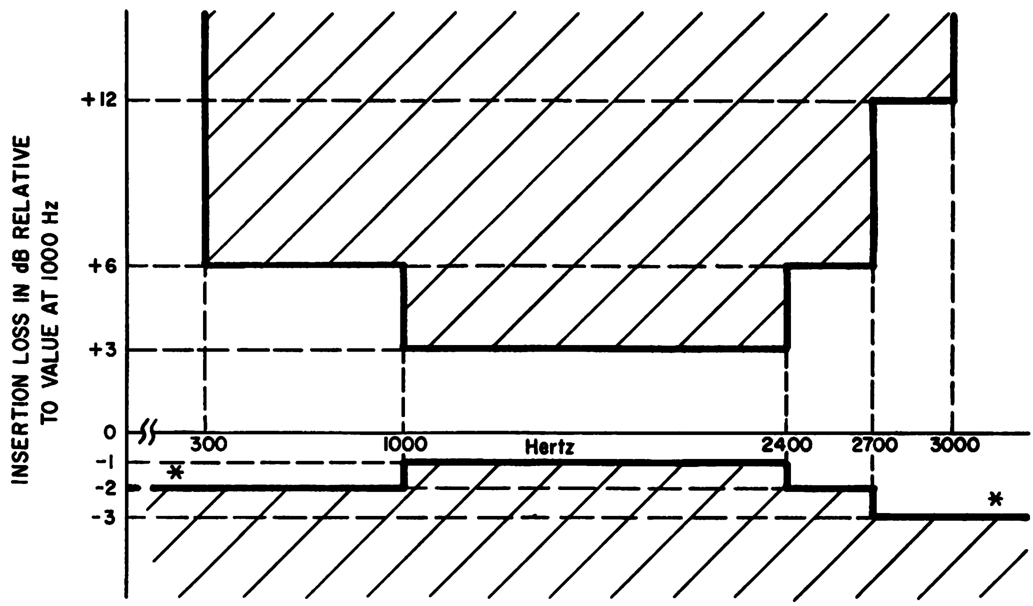
4.3.2.7 Total Harmonic Distortion. As a Design Objective, the total harmonic distortion produced by any single frequency test signal, within the band between 300 Hz and 3000 Hz, shall be at least 40 dB below reference (–40 dBm0). Test signal levels for measuring total harmonic distortion are given in subparagraph 4.4.3.2.7.

4.3.2.8 Intermodulation Distortion. (Under consideration.)

4.3.2.9 Signal Discontinuities.

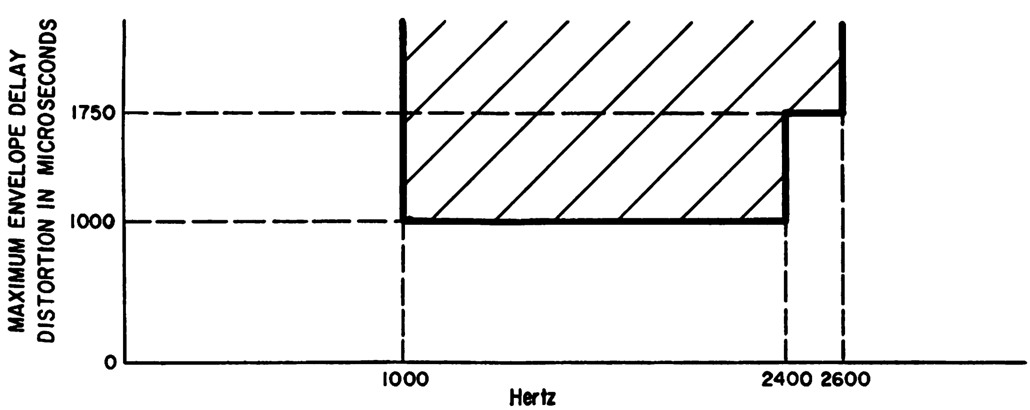
4.3.2.9.1 Impulse Noise. As a Design Objective, the impulse noise shall not exceed 15 counts over any 15 consecutive minutes above a level of 71 dBrnc0. The test instrument shall be capable of counting rates of up to 7.5 counts per second.

NOTE: Impulse noise performance of a connection is most closely related to the type of switching machine and total site complex, in terms of relays, battery charging and filtering, etc. Electronic switching (solid state) subsystems are approximately 10 dB quieter than mechanical relay switchboards.



* These upper and lower frequency limits are not specified.

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.3-14. Parameters for Data Service Over Unconditioned Voice Bandwidth Circuits (User-to-User)

4.3.2.9.2 Signal Level Dropouts. (Under consideration.)

4.3.2.9.3 Signal Level Change. (Under consideration.)

4.3.2.9.4 Phase Jitter. The total peak-to-peak phase jitter imparted to a test tone traversing the circuit at any frequency between 300 Hz and 3000 Hz shall not exceed 15 degrees (DO: 10 degrees).

4.3.2.9.5 Phase Hits. As a Design Objective, the number of phase hits of greater than ±20° occurring in any 15-minute test period shall not exceed 15.

4.3.2.9.6 Amplitude Hits. (Under consideration.)

4.3.2.10 Single Tone Interference. No interfering tone of a single frequency shall exceed 30 dBrnc (DO: 24 dBrnc), measured at the input terminals of the data modem.

4.3.2.11 Frequency Displacement. Any audio frequency transmitted over a FDM derived long haul/tactical circuit shall be reproduced at the data modem (or regeneration point) with a frequency error of not more than ±1 Hz. Frequency displacement for PCM derived circuits is under consideration.

4.3.2.12 Net Loss Variation. The net loss variation from data modem to data modem (or regeneration point) shall not exceed ±5 dB over any 30 consecutive days.

4.3.3 Parameters for Data Service Over Conditioned Voice Bandwidth Circuits (User-to-User).

4.3.3.1 General. The following subparagraphs 4.3.3.2 through 4.3.3.12 establish standards and design objectives for conditioned voice bandwidth circuits (also called data grade circuits) which are used for transmission of digital information in quasi-analog form. These standards and design objectives are applicable to circuits connecting data reference terminals for transmission of digital information with modulation rates of 1200 Bds or 2400 Bds, depending on the modulation technique used. Multilevel or "m-ary" modulators emit a line signal in which each quasi-analog signal element carries information of two or more bits of the dc data signal. Special conditioning devices (which provide equalization for the envelope delay distortion and the insertion loss versus frequency characteristic of a voice bandwidth channel) will be required for higher signaling rates, such as 4800 b/s or 9600 b/s. Standards for these special conditioning devices are not included in this document. Development work continues with the objective of increasing the data signaling rate achievable over voice bandwidth circuits.

Conditioned voice bandwidth circuits are provided by the use of controlled and conditioned loop characteristics and by the use of TDM derived channels and of those FDM derived channels which are best suited for quasi-analog data service. FDM CHANNELS 1 AND 2 OF GROUP 1 OF SUPERGROUP 1 AND CHANNELS 11 AND 12 OF GROUP 5 OF SUPERGROUP 3 ARE NOT RECOMMENDED FOR THIS PURPOSE. In general, experience has shown that signal discontinuities, such as phase and amplitude hits, impulse noise, and dropouts as well as the envelope delay distortion and the insertion loss versus frequency characteristic are major causes of unsatisfactory data transmission in the form of excessive digital error rates. If the circuit parameters described herein are achieved, experience has shown that the design objective for the digital error rate stated in subparagraph 4.3.1.8 should also be achievable.

As general guidance for long haul/tactical applications, the data circuit should be equipped with a regeneration capability if the parameters listed in subparagraphs 4.3.3.2 through 4.3.3.12 cannot be achieved. Regeneration is generally not employed on tactical data circuits; however, when tactical data circuits are interconnected with long haul data circuits, regeneration may be necessary at the interface point. In any case, regeneration points have to be determined on an individual basis.

4.3.3.2 Transmitted Level (Quasi-Analog). Same as subparagraph 4.3.2.2.

4.3.3.3 Received Level (Quasi-Analog). Same as subparagraph 4.3.2.3.

4.3.3.4 Received Noise Power. Same as subparagraph 4.3.2.4.

4.3.3.5 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic referenced to 1000 Hz, over the frequency bandwidth from 300 Hz to 3000 Hz shall be within the limits of −2 dB to +6 dB, except over the frequency bandwidth from 500 Hz to 2800 Hz shall be within the limits of −1 dB to +3 dB. The insertion loss below 300 Hz and above 3000 Hz shall be equal to or greater than −2 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.3-15a).

4.3.3.6 Envelope Delay Distortion. The envelope delay distortion over the frequency bandwidth from 500 Hz to 2800 Hz shall not exceed 3000 microseconds, except from 600 Hz to 2600 Hz the envelope delay distortion shall not exceed 1500 microseconds and between 1000 Hz and 2600 Hz it shall not exceed 500 microseconds (see Figure 4.3-15b).

4.3.3.7 Total Harmonic Distortion. Same as subparagraph 4.3.2.7.

4.3.3.8 Intermodulation Distortion. (Under consideration).

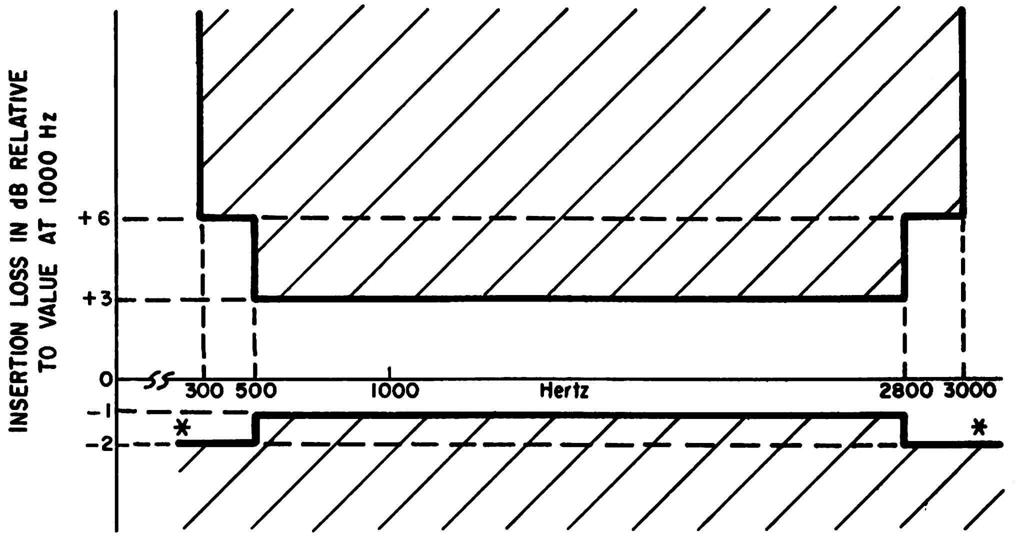
4.3.3.9 Signal Discontinuities. Same as subparagraph 4.3.2.9.

4.3.3.10 Single Tone Interference. Same as subparagraph 4.3.2.10.

4.3.3.11 Frequency Displacement. Same as subparagraph 4.3.2.11.

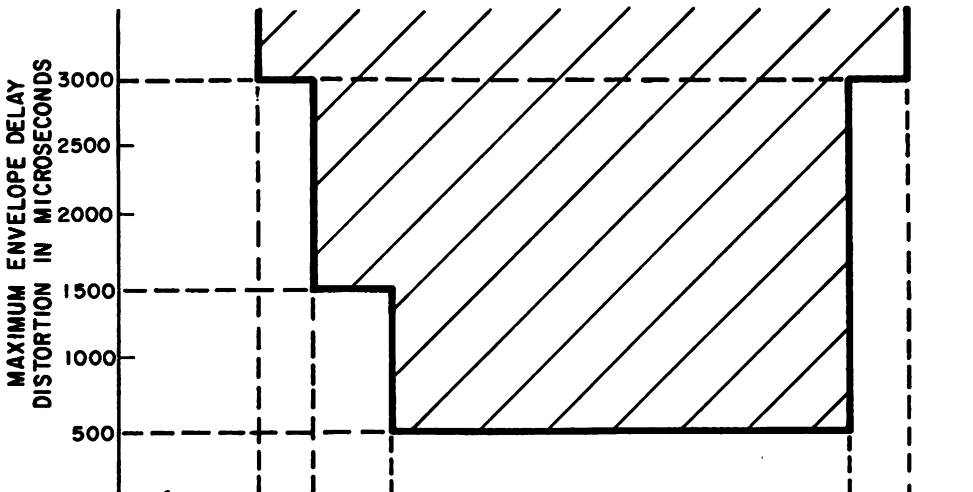
4.3.3.12 Net Loss Variation. Same as subparagraph 4.3.2.12.

4.3.4 Parameters for Data Service Over Nominal 48-kHz FDM Group Bandwidth Circuits (User-to-User). No detailed parameter for data service over FDM derived nominal 48-kHz group bandwidth circuits are provided on a user-to-user basis, since loop characteristics for this service cannot be specified at the present time (see subparagraph 4.4.2.4). Until these loop characteristics are available, the channel parameters stated in subparagraph 4.4.3.3 should be used as a general guidance for data service over FDM derived nominal 48-kHz group bandwidth circuits.



*These upper and lower frequency limits are not specified

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.3-15. Parameters for Data Service Over Conditioned Voice Bandwidth Circuit (User-to-User)

4.3.5 Data Reference Terminals and Circuits.

4.3.5.1 General. The Data Reference Terminals common to long haul and tactical data communications are depicted in Figure 4.3-16. The Data Reference Terminal together with an equivalent termination at the distant end and the transmission circuit constitute the Data Reference Circuit. The purpose of Figure 4.3-16 is to show where standards and design objectives for data service stated in various paragraphs of this document are to be applied and to facilitate interfacing tactical with long haul data communications. As general guidance for long haul applications the data transmission circuit should be equipped with a regeneration capability if the parameters listed herein cannot be achieved. Regeneration is generally not employed on tactical data circuits; however, when tactical data circuits interface with long haul systems, regeneration may be necessary.

4.3.5.2 Characteristics of Data Reference Terminals and Circuits.

4.3.5.2.1 DC Interface Characteristics. The dc interface characteristics at the point labeled "Digital Interface" in Figure 4.3-16 are identical to those specified in subparagraph 4.3.1.3. RED/BLACK requirements are specified in MIL-HDBK-232.

4.3.5.2.2 Quasi-Analog Characteristics. The quasi-analog characteristics at the point labeled "Quasi-Analog Interface" in Figure 4.3-16 are identical to those specified in subparagraphs 4.3.2, 4.3.3, and 4.3.4. Technical control configurations are presented in MIL-STD-188-310, Military Standard, Subsystem Design and Engineering Standards for DCS Technical Controls.

4.3.5.2.3 AUTODIN Interface and Control Criteria. Circuits traversing long haul and tactical transmission subsystems utilizing AUTODIN shall conform to the criteria specified in DCAC 370-D175-1, DCS AUTODIN Interface and Control Criteria.

4.4 Transmission Circuits.

4.4.1 General. The transmission circuit is the complete electrical path between the user's end-terminal instruments (may be either analog or digital) over which two-way telecommunications are provided. The transmission circuit will consist of loops and of a channel (see Figure 4.4-1). Paragraph 4.4 is divided into two parts. The first part, subparagraph 4.4.2, deals with the characteristics of the loops (local line or user's line) which connects a user's end instrument and a trunk or individual message distribution point, or a switching center, or a central office, or a node. The second part, subparagraph 4.4.3, deals with the overall characteristics of the channel which interconnects the two user loops. In general, a channel will consist of a series of links connected in tandem. The links may be either FDM modulation links (see subparagraph 4.5.2) or TDM/PCM voice bandwidth links (see subparagraph 4.5.3). A channel may also consist of a mix of FDM voice bandwidth links and TDM/PCM voice bandwidth links in tandem.

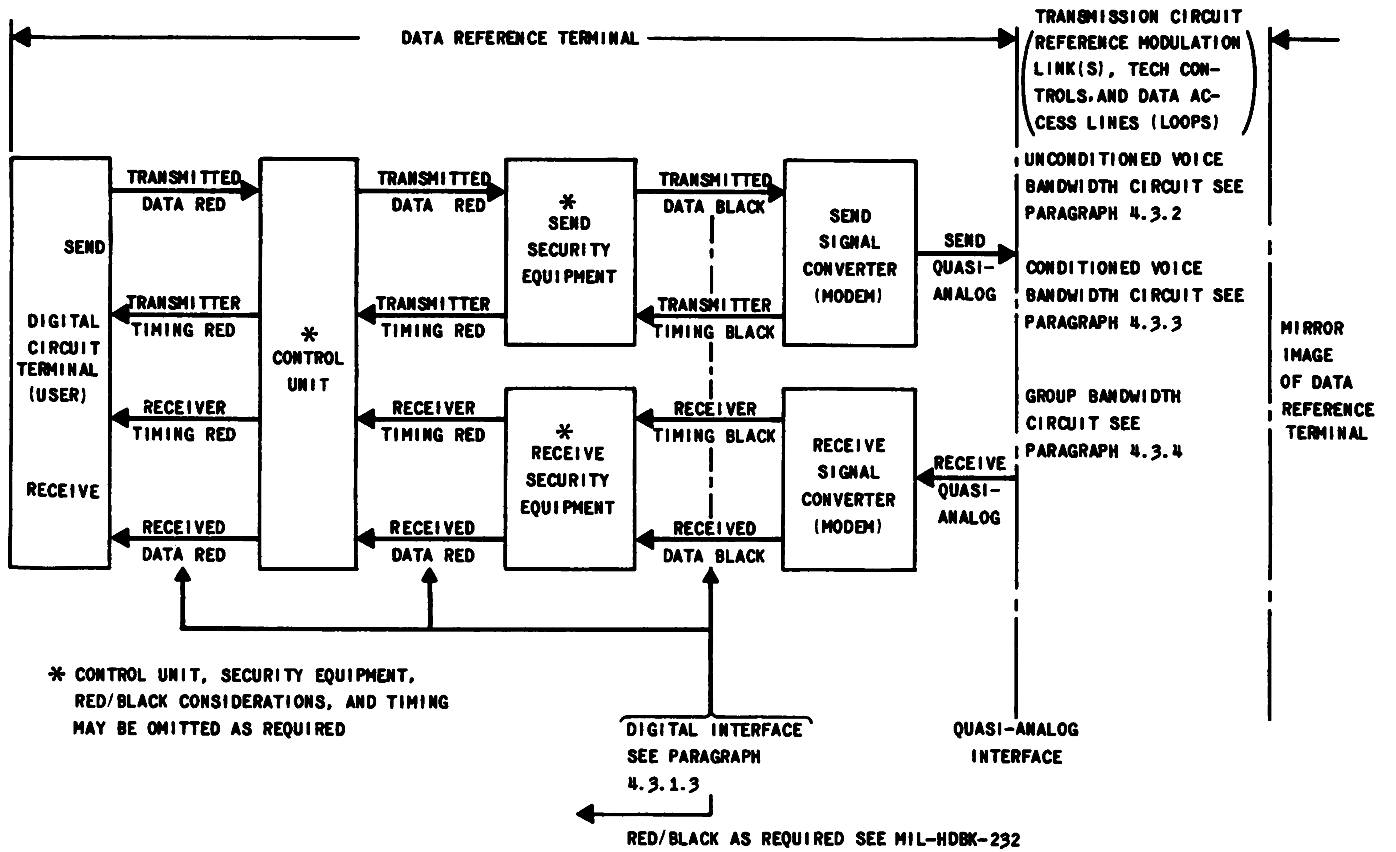


Figure 4.3-16. Data Reference Terminals and Circuit

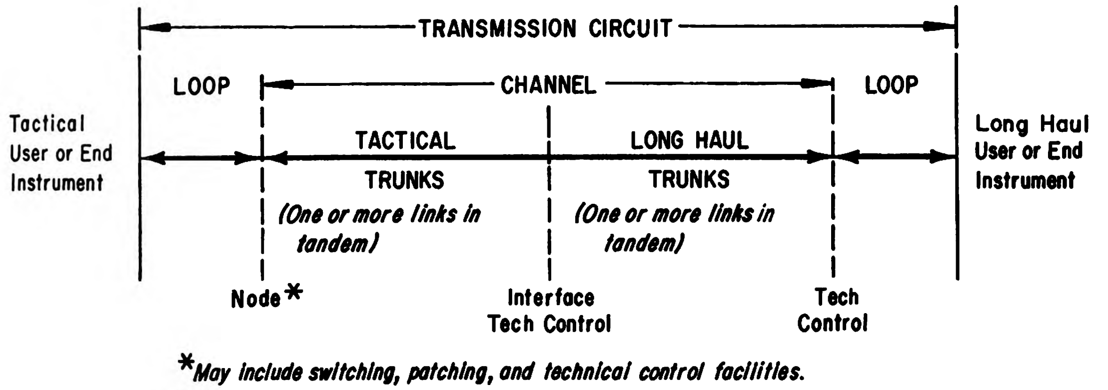


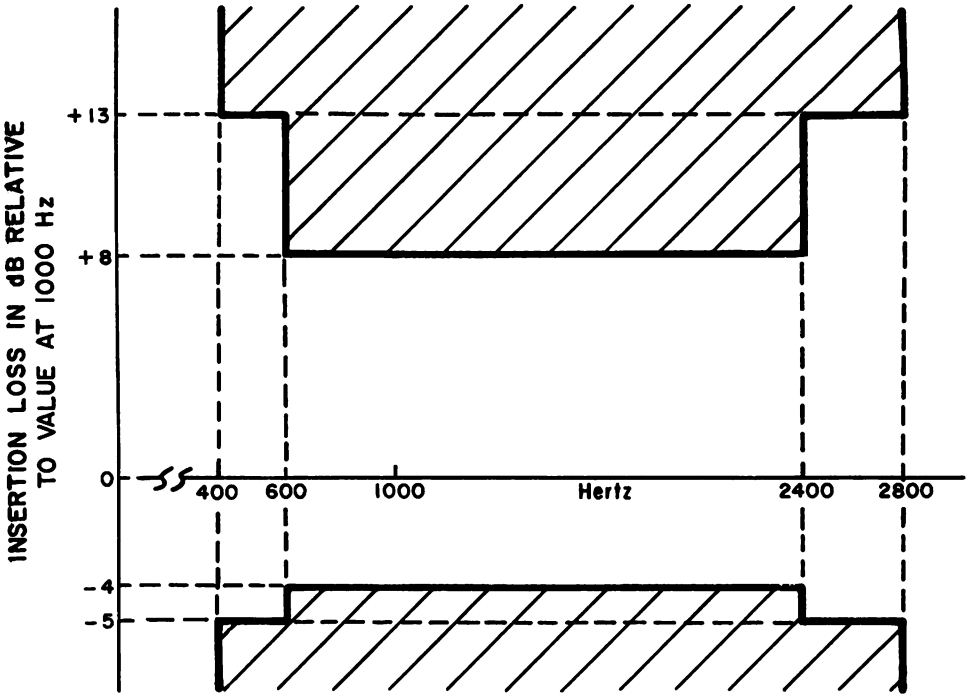
Figure 4.4-1. Basic Transmission Circuit Configuration

4.4.2 Loop Characteristics. The loops may be identified as either an analog loop or a digital loop. The analog loops are used for analog end instruments (see paragraph 5.7) and for digital end instruments when the digital data modems are located at the user's terminals (see paragraph 5.4). The digital loops are used for digital end instruments (see paragraph 5.8) when the transmission circuit is all digital or the digital data modems are located at the (digital) loop/(analog) channel interface. Figure 4.4-7 shows selected parameters at the channel/loop and at the end instrument/loop interface points.

4.4.2.1 Parameters of Single Loop for Analog Service (Voice or Facsimile). The characteristics of analog loops will vary widely among tactical highly maneuverable users, tactical less maneuverable users, and long haul users. In addition to the different types of loops, the actual loops may range from very short loops, consisting entirely of local plant facilities, loaded or nonloaded cable pairs, to very long loops, consisting of one or more facilities of a long haul plant, such as loaded toll grade cable or carrier plus an end section consisting of local plant facilities. As may be expected, the characteristics of the loops will vary widely and are predictable only when the specific makeup of a loop is known. Each loop is a separate problem and each loop must be individually engineered to ensure adequate user-to-user communication service. Each loop will act as a frequency filter-attenuator and will degrade the circuit characteristics (see Figure 4.4-2).

4.4.2.1.1 Insertion Loss of Single Loop.

4.4.2.1.1.1 Long Haul Loop. The insertion loss of long haul loops is controlled at the Technical Control Facility (TCF) and each loop is adjusted on an individual basis. The insertion loss of a four-wire loop shall be 6 dB measured at 1000 Hz ±25 Hz. The insertion loss of a two-wire loop shall be adjusted for an average loss of 3 dB, measured at 1000 Hz ±25 Hz, with a maximum loss of 7 dB, depending on trunk arrangement and loop configuration. When a two-wire loop is connected to a four-wire PBX, an additional 4 dB of loss is allowed for a two-wire/four-wire hybrid transformer resulting in an overall maximum loop loss of 11 dB. For detailed loop configuration see DCA Circular 370-V175-6, AUTOVON Interface Criteria.



a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC

b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.4-2. Parameters of a Single Loop for Analog Service (Voice or Facsimile)

4.4.2.1.1.2 Tactical Highly Maneuverable Loop. The insertion loss of tactical highly maneuverable loops is not controlled and no adjustments are made for loop insertion loss. A statistical distribution of the loop insertion loss is assumed for the purpose of system engineering and circuit design. The loss of one loop (two-wire or four-wire) measured at 1000 Hz ±25 Hz is assumed to be exponential distributed with a mean loss per loop of 3.5 dB and with a standard deviation (sigma) of 3.5 dB.

4.4.2.1.1.3 Tactical Less Maneuverable Loop. The specifications for loop insertion loss are not stated in statistical form; rather, recommended minimum and maximum values are given. The recommended loop loss measured at 1000 Hz ±25 Hz for one four-wire loop is between 6 dB and 8 dB with a mean loop loss of 7 dB. For one two-wire access loop the recommended loop loss measured at 1000 Hz ±25 Hz is between 6 dB and 12 dB with a mean loop loss of 9 dB. These losses include the two-wire/four-wire hybrid transformer insertion loss and the two-wire switchboard insertion loss, if applicable.

Since it is not practical to adjust each individual loop on the basis of loss measurements, loop loss pads shall be provided as part of switching circuits and/or multiplex terminal equipment. When the user is connected to the switch, a means shall be provided to adjust for the length falling within the four distance ranges of approximately 0-300 meters (0-1000 feet), 300 meters - 1500 meters (1000 feet - 5000 feet), 1500 meters - 3000 meters (5000 feet - 10,000 feet), and greater than 3000 meters (10,000 feet).

4.4.2.1.2 Insertion Loss Versus Frequency Characteristic of Single Loop. The insertion loss versus frequency characteristic, referenced to 1000 Hz, over the frequency bandwidth from 400 Hz to 2800 Hz shall be within the limits of −5 dB to +13 dB, except over the frequency bandwidth from 600 Hz to 2400 Hz shall be within the limits of −4 dB to +8 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.4-2a).

4.4.2.1.3 Envelope Delay Distortion of Single Loop. No standard or design objective is given for envelope delay distortion with regard to voice and analog facsimile service (see subparagraphs 4.2.2.5 and 4.2.3.5). However, delay distortion plays a significant role in data transmission through audio channels. Envelope delay distortion of loops for data service is given in subparagraph 4.4.2.2.3.

4.4.2.1.4 Noise of Single Loop. The noise power contributed by a single long haul or tactical less maneuverable loop (two-wire or four-wire) to the total circuit noise is assumed to be 6250 pWp0 (approximately 38 dBrnc0) referenced to the long haul 0TLP.

Noise on field wire and cable loops in the tactical highly maneuverable system is usually so much lower than noise on trunks that its effect on a user-to-user circuit may be neglected. Trouble conditions may, however, produce excessive noise which should be cleared for satisfactory operation.

4.4.2.1.5 Impedance. The impedance of wire and cable loops varies widely with frequency, temperature, moisture, and length and is not specified as a standard. However, the nominal value of the impedance is assumed to be between 600 ohms and 900 ohms, balanced to ground.

4.4.2.1.6 Net Loss Variation of Single Loop. The net loss variation of a single long haul or tactical less maneuverable loop shall not exceed ±1.5 dB over any 30 consecutive days.

NOTE: This value of ±1.5 dB does not take into account net loss variations of unprotected loops, such as field wire loops generally installed in the tactical highly maneuverable system. Net losses of unprotected loops may very up to 0.7 dB/km (1.3 dB/nmi) between wet and dry weather conditions.

4.4.2.2 Parameters of Single Loop for Data Service over Unconditioned Voice Bandwidth Circuit. It should be noted that an unconditioned voice bandwidth circuit is unconditioned only in terms of data conditioning. Such unconditioned voice bandwidth circuits may be "conditioned" in terms of voice service by the use of loading coils, etc.

4.4.2.2.1 Insertion Loss of Single Loop. Same as subparagraph 4.4.2.1.1.

4.4.2.2.2 Insertion Loss Versus Frequency Characteristic of Single Loop. The insertion loss versus frequency characteristic referenced to 1000 Hz, over the frequency bandwidth from 300 Hz to 3000 Hz, shall be within the limits of +2 dB to +6 dB, except over the frequency bandwidth from 300 Hz to 2700 Hz it shall be within the limits of +2 dB to +3 dB. Loss is indicated by a (+) sign (see Figure 4.4-3a).

NOTE: No gain is allowed on loops for data service over unconditioned voice bandwidth circuits, as opposed to loops for analog service (voice or facsimile) where the insertion loss versus frequency characteristic given in subparagraph 4.4.2.1 allows loop gain.

4.4.2.2.3 Envelope Delay Distortion of Single Loop. The envelope delay distortion over the frequency bandwidth from 500 Hz to 2800 Hz shall not exceed 3000 microseconds, except between 600 Hz and 2600 Hz the envelope delay distortion shall not exceed 1500 microseconds and between 1000 Hz and 2600 Hz the envelope delay distortion shall not exceed 500 microseconds (see Figure 4.4-3b).

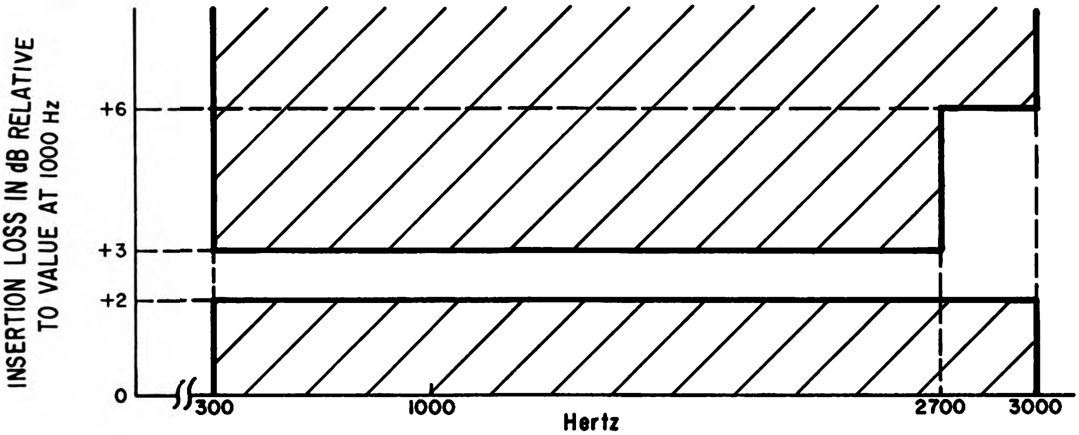
NOTE: Delay distortion parameters on unconditioned loops are based on worst tolerable conditions. They are not intended to "add up" to total allowable delay distortion for unconditioned circuits. Circuit engineering which may include the use of necessary regeneration must take this situation into account.

4.4.2.2.4 Noise of Single Loop. Same as subparagraph 4.4.2.1.4.

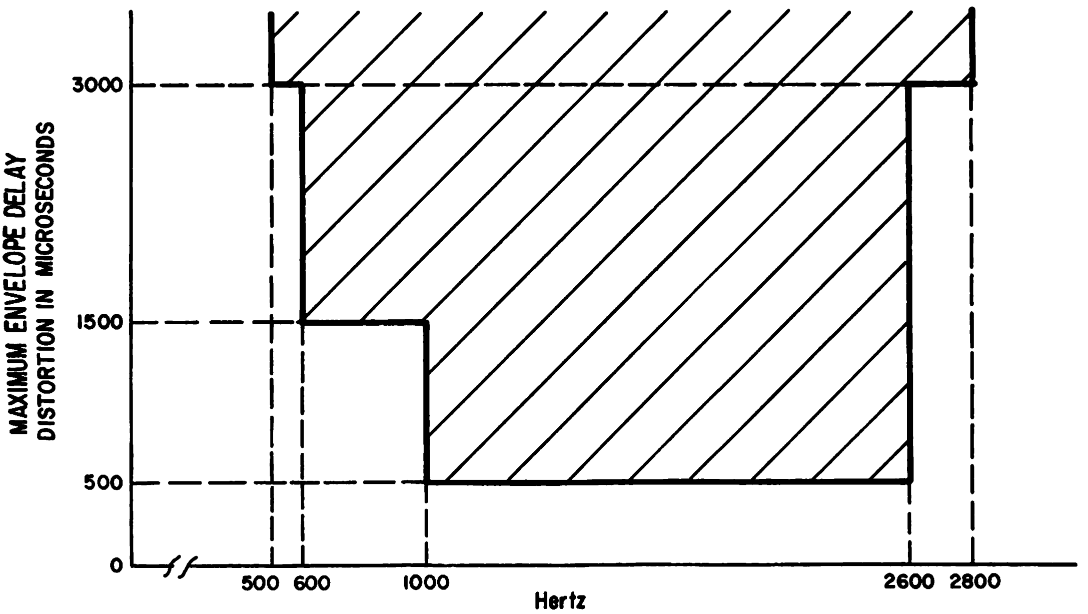
4.4.2.2.5 Impedance. Same as subparagraph 4.4.2.1.5.

4.4.2.2.6 Net Loss Variation of Single Loop. Same as subparagraph 4.4.2.1.6.

4.4.2.3 Parameters of Single Loop for Data Service over Conditioned Voice Bandwidth Circuits.



a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.4-3. **Parameters of Single Loop for Data Service Over Unconditioned Voice Bandwidth Circuits**

4.4.2.3.1 Insertion Loss of Single Loop. Same as subparagraph 4.4.2.1.1.

4.4.2.3.2 Insertion Loss Versus Frequency Characteristic of Single Loop. The insertion loss versus frequency characteristic of a single loop for data service over conditioned voice bandwidth circuits should be equal to or better than the characteristics of a single loop for data service over unconditioned voice bandwidth circuits given in subparagraph 4.4.2.2.2. The use of equalization equipment will be required to meet the user-to-user circuit characteristics (see subparagraph 4.3.3).

4.4.2.3.3 Envelope Delay Distortion of Single Loop. The envelope delay distortion of a single loop for data service over conditioned voice bandwidth circuits should be equal to or better than the characteristics of a single loop for data service over unconditioned voice bandwidth circuits given in subparagraph 4.4.2.2.3. The use of equalization equipment will be required to meet the user-to-user circuit characteristics (see subparagraph 4.3.3).

4.4.2.3.4 Noise of Single Loop. Same as subparagraph 4.4.2.1.4.

4.4.2.3.5 Impedance. Same as subparagraph 4.4.2.1.5.

4.4.2.3.6 Net Loss Variation of Single Loop. Same as subparagraph 4.4.2.1.6.

4.4.2.4 Parameters of Single Loop for Data Service over Nominal 48-kHz FDM Group Bandwidth Circuits. (Under Consideration.)

4.4.2.5 Parameters of Single Loop for Digital Service. The characteristics of a loop for digital service will vary widely among tactical highly maneuverable users, tactical less maneuverable users, and long haul users. In addition to the different types of loops, the cable parameters (impedance, dc resistance, capacitance, and length) are not standardized and will be determined by application engineering. For digital interface parameters see subparagraph 4.3.1.3.

4.4.3 Channel Characteristics. In general, a long haul/tactical channel will be a nominal 4-kHz voice bandwidth channel (see subparagraph 4.4.3.2). There is also within the communication network a nominal 3-kHz voice bandwidth channel (see subparagraph 4.4.3.1), consisting in its basic configuration of nominal 4-kHz links in tandem with nominal 3-kHz links derived from certain submarine cable circuits, HF radio links, etc. Additionally, a nominal 48-kHz group bandwidth channel (see subparagraph 4.4.3.3) may be provided through the use of FDM equipment (see Figure 4.5-1). Figure 4.4-7 (see page 71) shows selected interface parameters of a nominal 48-kHz channel and of a nominal 3-kHz and a nominal 4-kHz channel at the loop/channel interface point.

4.4.3.1 Parameters for Nominal 3-kHz Voice Bandwidth Channel.

4.4.3.1.1 General. A long haul/tactical channel will consist of several links in tandem. The characteristics of the channel will be determined by the summation methods of the transfer characteristics of the individual links in tandem (see paragraphs 4.5 and 4.6). When the channel contains nominal 3-kHz links, such as submarine cable links or HF radio links, the smaller frequency range of the nominal 3-kHz link (as opposed to a nominal 4-kHz link) will determine those channel characteristics depending on frequency parameters. The following subparagraphs 4.4.3.1.2 through 4.4.3.1.12 deal with standards and design objectives of a nominal 3-kHz channel between originating node and terminating node of a long haul/tactical circuit. These channels do not include the loops to and from the user. The standards and design objectives are expressed in the form of technical parameters, such as received noise power or transmitted bandwidth, which shall be achieved on all long haul/tactical voice circuits regardless of channel distances of up to approximately 22,000 km (12,000 nmi), transmission media, and multiplexing scheme used (FDM, TDM, or a mix of FDM and TDM). Part of these parameters are stated as design objectives rather than as standards, due to a lack of measured and verified data available at the present time or due to a lack of general consensus in the interpretation of the data. The characteristics for submarine cable links are being established and will be published in MIL-HDBK-314. Therefore, the characteristics of a nominal 3-kHz channel derived from submarine cable links are not contained in this document (see subparagraph 5.2.2.1). The characteristics of a nominal 3-kHz channel, with an internal HF radio link, are stated in the following subparagraphs 4.4.3.1.2 through 4.4.3.1.12.

4.4.3.1.2 Channel Input Levels. Same as subparagraph 4.4.3.2.2.

4.4.3.1.3 Channel Output Levels.

4.4.3.1.3.1 Speech Volume. Same as subparagraph 4.4.3.2.3.1.

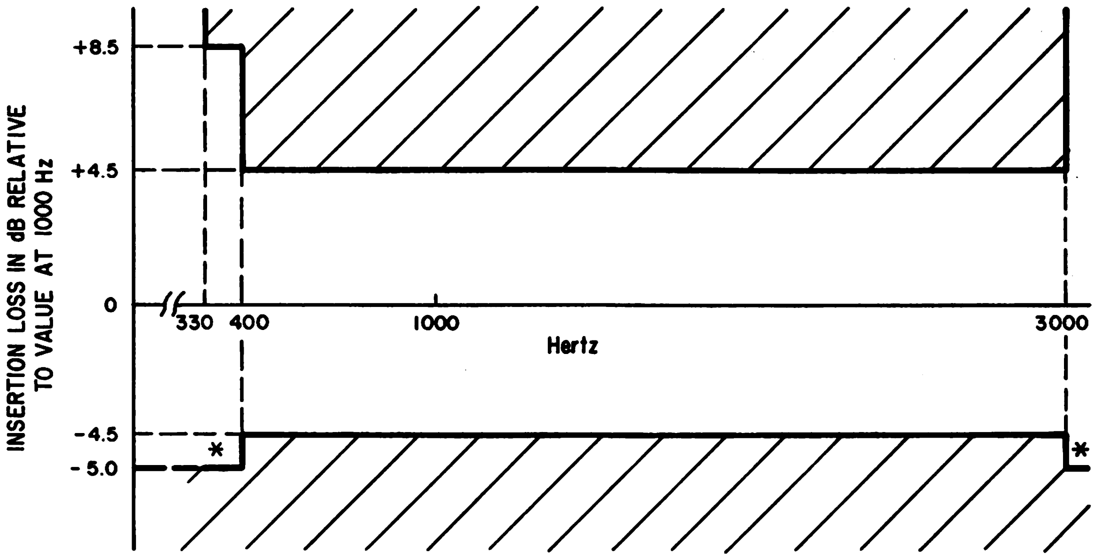
4.4.3.1.3.2 Data Level (Quasi-Analog). Same as subparagraph 4.4.3.2.3.2.

4.4.3.1.3.3 Noise Power. The nonimpulse type of circuit noise shall not exceed 250,000 pWp0 (approximately 54 dBrnc0) referenced to the long haul 0TLP during 99 percent or more of the time and shall not exceed 316,000 pWp0 (approximately 55 dBrnc0) referenced to the long haul 0TLP for 1 percent or less of the time. This standard applies to FDM transmission and metallic circuits only.

> NOTE: The commonly used noise measuring sets will measure total rms noise power including the average impulse noise power. However, the contribution of the average impulse noise, as registered by these meters, is small enough to be neglected.

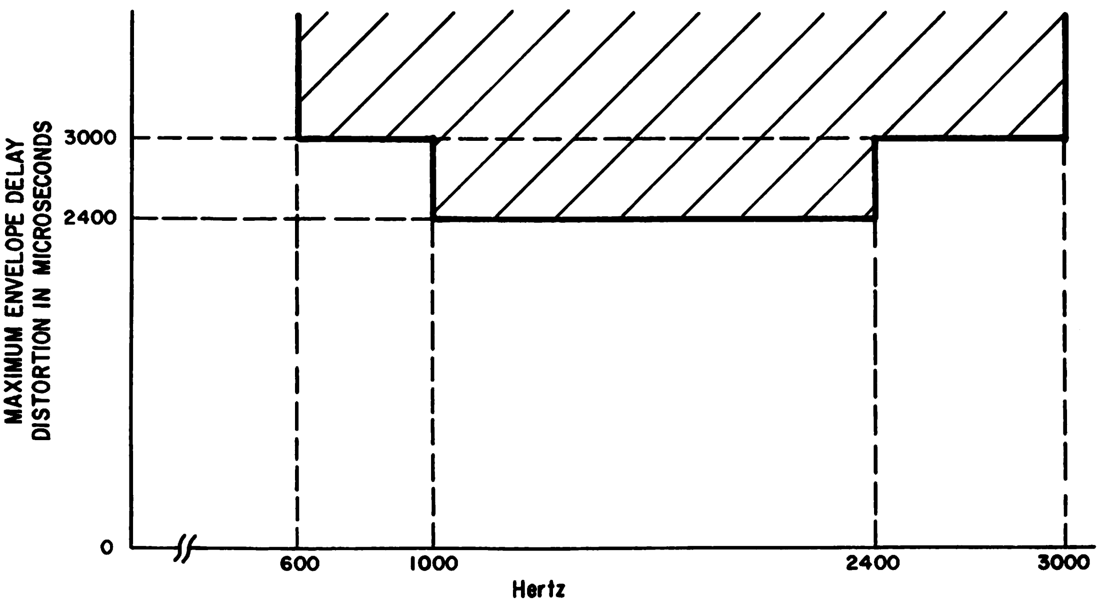
4.4.3.1.4 Channel Input/Output Impedances. The input and output impedances of a nominal 3-kHz channel shall each be 600 ohms, balanced to ground, with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency range from 350 Hz to 3000 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

4.4.3.1.5 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic referenced to 1000 Hz over the frequency bandwidth from 350 Hz to 3000 Hz shall be within the limits of −5 dB to +8.5 dB, except over the frequency bandwidth from 400 Hz to 3000 Hz it shall be within the limits of ±4.5 dB. The insertion loss below 350 Hz and above 3000 Hz shall be equal to or greater than −5 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.4-4a).



*These upper and lower frequency limits are not specified.

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.4-4. Parameters of Nominal 3-kHz Channel

4.4.3.1.6 Envelope Delay Distortion. The envelope delay distortion over the frequency bandwidth from 600 Hz to 3000 Hz shall not exceed 3000 microseconds, except between 1000 Hz and 2400 Hz the envelope delay distortion shall not exceed 2400 microseconds (see Figure 4.4-4b).

4.4.3.1.7 Total Harmonic Distortion. As a Design Objective, the total harmonic distortion produced by any single frequency test signal, within the frequency band between 350 Hz and 3000 Hz, shall be at least 40 dB below reference (−40 dBm0). A standard test signal of 0 dBm shall be introduced into a long haul or tactical less maneuverable channel at the 0TLP and the test signal that appears at the input of all multiplexers shall be 0 dBm0. The test signal level introduced into a tactical highly maneuverable channel at the −4 TLP shall be −4 dBm or 0 dBm0 referenced to a tactical highly maneuverable 0TLP (see subparagraphs 4.4.3.2.2.3 and 4.7.9.1.1).

4.4.3.1.8 Intermodulation Distortion. (Under consideration.)

4.4.3.1.9 Signal Discontinuities. (See subparagraph 4.4.3.2.9.)

4.4.3.1.10 Single Tone Interference. (Same as subparagraph 4.4.3.2.10.)

4.4.3.1.11 Frequency Displacement. (Same as subparagraph 4.4.3.2.11.)

4.4.3.1.12 Net Loss Variation. The net loss variation of a channel shall not exceed ±8 dB over any 30 consecutive days.

4.4.3.2 Parameters for Nominal 4-kHz Voice Bandwidth Channel.

4.4.3.2.1 General. A long haul/tactical channel will consist of several links in tandem. The characteristics of a channel will be determined by the summation methods of the transfer characteristics of the individual links in tandem (see paragraphs 4.5 and 4.6). The following subparagraphs 4.4.3.2.2 through 4.4.3.2.12 deal with standards and design objectives of a nominal 4-kHz channel between originating node and terminating node of a long haul/tactical circuit. These channels do not include the loops to and from the user. The standards and design objectives are expressed in the form of technical parameters, such as received noise power or transmitted bandwidth, which shall be achieved on all long haul/tactical voice circuits regardless of channel distances of up to approximately 22,000 km (12,000 nmi), transmission media, and multiplexing scheme used (FDM, TDM, or a mix of FDM and TDM). Part of these parameters are stated as design objectives rather than as standards, due to a lack of measured and verified data available at the present time or due to a lack of general consensus in the interpretation of the data.

4.4.3.2.2 Channel Input Levels.

4.4.3.2.2.1 Speech Volume. The speech volume at the channel input is a function of the transmitted speech volume given in subparagraph 4.2.2.1 and of the loop insertion loss given in subparagraph 4.4.2.1.1.

4.4.3.2.2.2 Data Level (Quasi-Analog). The quasi-analog data level at the channel input shall be −13 dBm at a 0TLP (−13 dBm0) of a long haul or tactical less maneuverable channel and −10 dBm at a −4 TLP (−6 dBm0) of a tactical highly maneuverable channel. The power of each data tone, with reference to −13 dBm, shall be equal to −13 dBm $-10 \log_{10} t$, where t is the number of tones.

4.4.3.2.2.3 Standard Test Signal. (See Table 4.4-1.) The standard test signal is generally used for testing the peak power transmission capability and for measuring the total harmonic distortion of a channel. In the tactical highly maneuverable system, the standard test signal is also used for level alignment of links in tandem providing that the circuit to be aligned does not include links of the long haul or the tactical less maneuverable system. The standard test signal should not be used in the long haul or the tactical less maneuverable system for level alignment of links in tandem since the test signal may overload FDM derived channels (see subparagraph 4.4.3.2.2.4).

Table 4.4-1. Test Levels

	Long Haul and Tactical Less Maneuverable Systems (dBm0)	Tactical Highly Maneuverable System*(dBm0)
Standard Test Signal	0	0
Standard Test Tone	-10	-3
Monitoring Test Tone	-15	-8**
Intermodulation Distortion Measurements (IMD):		
Composite Two-Tone	-3	-3
Single Tone	-6	-6

*Referenced to a tactical highly maneuverable 0TLP which has to be considered internal to this system and must not be related to a 0TLP of either the long haul or the tactical less maneuverable system (see subparagraph 4.7.9.1.1).
**Normally not used.

The standard test signal shall be 0 dBm0 with a frequency of 1000 Hz, ±25 Hz (1020 Hz preferred for PCM).

The standard test signal of 0 dBm0 shall not be transmitted across a long haul/tactical highly maneuverable interface or across a tactical less maneuverable/tactical highly maneuverable interface in either direction SINCE ANY TLP OF A TACTICAL HIGHLY MANEUVERABLE SYSTEM HAS TO BE CONSIDERED INTERNAL TO THIS SYSTEM AND MUST NOT BE RELATED TO A TLP OF EITHER A LONG HAUL OR A TACTICAL LESS MANEUVERABLE SYSTEM IN TERMS OF SIGNAL LEVELS. For interfacing a tactical less maneuverable circuit see subparagraph 4.7.9.1.

4.4.3.2.2.4 Standard Test Tone. (See Table 4.4-1.) The standard test tone is generally used for level alignment of single links and of links in tandem in the long haul and in the tactical less maneuverable systems. The standard test tone is used in long haul and tactical less maneuverable channels to prevent overloading of those multichannel wideband transmission subsystems which use FDM and radio equipment which have been designed for voice service with an activity factor as low as 25 percent (see subparagraph 4.5.2.1.1).

In addition, the standard test tone shall be used for level alignment of tactical highly maneuverable links if these links interface and form a channel with long haul or tactical less maneuverable links. Details of this level alignment across the interface are provided in subparagraph 4.7.9.1.

In the long haul and in the tactical less maneuverable systems the standard test tone shall be −10 dBm0 with a frequency of 1000 Hz, ±25 Hz (1020 Hz preferred for PCM). In the tactical highly maneuverable system the test tone shall be −3 dBm0 with a frequency of 1000 Hz ±25 Hz (1020 Hz preferred for PCM).

> NOTE: The difference in test tone levels between the tactical highly maneuverable system and the long haul or the tactical less maneuverable system is caused by different traffic signal levels (voice and data) at the respective 0TLP of the system under consideration. The different traffic signal levels are based on different overload characteristics of the communication equipment employed in these systems. THEREFORE, ANY TLP OF A TACTICAL HIGHLY MANEUVERABLE SYSTEM HAS TO BE CONSIDERED INTERNAL TO THIS SYSTEM AND MUST NOT BE RELATED TO A TLP OF EITHER A LONG HAUL OR A TACTICAL LESS MANEUVERABLE SYSTEM IN TERMS OF SIGNAL LEVELS. For interfacing a tactical highly maneuverable circuit with a long haul or a tactical less maneuverable circuit see subparagraph 4.7.9.1.

4.4.3.2.2.5 Monitoring Test Tone. (See Table 4.4-1.) The monitoring test tone is used for testing channels of the long haul and the tactical less maneuverable systems when the test period exceeds approximately 4 hours, e.g., during net loss variation measurements. The monitoring test tone is used because it is comparable to the long term loading of the FDM and radio equipment (see subparagraph 4.5.2.1). The monitoring test tone is not required in the tactical highly maneuverable system since the overload characteristic of the communication equipment employed in this system allows monitoring with the test signal of 0 dBm0 or with the test tone of −3 dBm0 (see Table 4.4-1) stated in subparagraphs 4.4.3.2.2.3 and 4.4.3.2.2.4, respectively.

The monitoring test tone shall be −15 dBm0 with a frequency of 1000 Hz ±25 Hz for use in the long haul and tactical less maneuverable systems.

> NOTE: If the monitoring test tone is transmitted across a long haul/tactical highly maneuverable interface, it will appear at a level of −12 dBm at the −4 TLP (−8 dBm0) of the tactical highly maneuverable system (see subparagraph 4.7.9.1.1).

4.4.3.2.2.6 Intermodulation Distortion (IMD) Measurements. The level of the composite two-tone test signal for IMD measurements of long haul and tactical less maneuverable channels shall be −3 dBm0 (each single tone shall be -6 dBm0). The power level of −3 dBm0, composite, results in a comparable peak power loading of either voice or quasi-analog data signals (see subparagraph 4.5.2.1). The level of the composite two-tone test signal for IMD measurements of a tactical highly maneuverable channel shall be −3 dBm0 (each single tone shall be −6 dBm0) referenced to a tactical highly maneuverable 0TLP, resulting in a composite two-tone signal of −7 dBm or a single tone signal of −10 dBm at a tactical highly maneuverable −4 TLP.

4.4.3.2.2.7 Test Levels. The various test levels described in subparagraphs 4.4.3.2.2.3 through 4.4.3.2.2.6 for the long haul, the tactical less maneuverable, and the tactical highly maneuverable systems are shown in tabular form for ready reference in Table 4.4-1.

4.4.3.2.3 Channel Output Levels.

4.4.3.2.3.1 Speech Volume. The speech volume at the channel output should be the same as the input speech volume if the channel is adjusted for zero dB loss. In order to meet interface requirements, there are transmission circuits where the loss of the channel is different from zero such as long haul/tactical highly maneuverable connections shown in Figures 4.7-8 and 4.7-9. It should also be noted that the loss of the loops is used to attenuate the user transmitted speech volume to the desired user received speech volume (see subparagraphs 4.2.2.1, 4.2.2.2, and Figures 4.7-8 through 4.7-13).

4.4.3.2.3.2 Data Level (Quasi-Analog). With zero loss channels, the quasi-analog data level at the input of the channel should be the same as the quasi-analog data level at the channel output. However, there are cases where the loss of the channel is different from zero to meet interface requirements, such as long haul/tactical highly maneuverable connections shown in Figures 4.7-8 and 4.7-9.

4.4.3.2.3.3 Noise Power. The nonimpulse type of circuit noise shall not exceed 50,000 pWp0 (approximately 47 dBrnc0) referenced to the long haul 0TLP during 99 percent or more of the time and shall not exceed 316,000 pWp0 (approximately 55 dBrnc0) referenced to the long haul 0TLP for 1 percent or less of the time. This standard applies to FDM transmission and metallic circuits only.

NOTE 1: The commonly used noise measuring sets will measure total rms noise power including the average impulse noise power. However the contribution of the average impulse noise, as registered by these meters, is small enough to be neglected.

NOTE 2: The allowable noise specified in this standard for circuits and channels is 50,000 pWp0 (approximately 47 dBrnc0). Circuit engineering must always take the actual loop noise into account, e.g., the channel noise may be allowed to reach the full 50,000 pWp0 if, and only if, the noise of the loops is negligible.

4.4.3.2.4 Channel Input/Output Impedances. The input and output impedances of a nominal 4-kHz channel shall each be 600 ohms, balanced to ground, with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency range from 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

4.4.3.2.5 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic referenced to 1000 Hz, over the frequency bandwidth from 300 Hz to 3400 Hz, shall be within the limits of −4 dB to +8 dB, except over the frequency bandwidth from 400 Hz to 3000 Hz it shall be within the limits of ±4 dB. The insertion loss below 300 Hz and above 3400 Hz shall be equal to or greater than −4 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.4-5a).

4.4.3.2.6 Envelope Delay Distortion. The envelope delay distortion over the frequency bandwidth from 600 Hz to 3200 Hz shall not exceed 2500 microseconds, except between 1000 Hz and 3000 Hz the envelope delay distortion shall not exceed 1750 microseconds (see Figure 4.4-5b).

4.4.3.2.7 Total Harmonic Distortion. As a Design Objective, the total harmonic distortion produced by any single frequency test signal, within the frequency band between 300 Hz and 3400 Hz, shall be at least 40 dB below reference (−40 dBm0). A standard test signal of 0 dBm shall be introduced into a long haul or tactical less maneuverable channel at the 0TLP and the test signal that appears at the input of all multiplexers shall be 0 dBm0. The test signal level introduced into a tactical highly maneuverable channel at the −4 TLP shall be −4 dBm or 0 dBm0 referenced to a tactical highly maneuverable 0TLP (see subparagraphs 4.4.3.2.2.3 and 4.7.9.1.1).

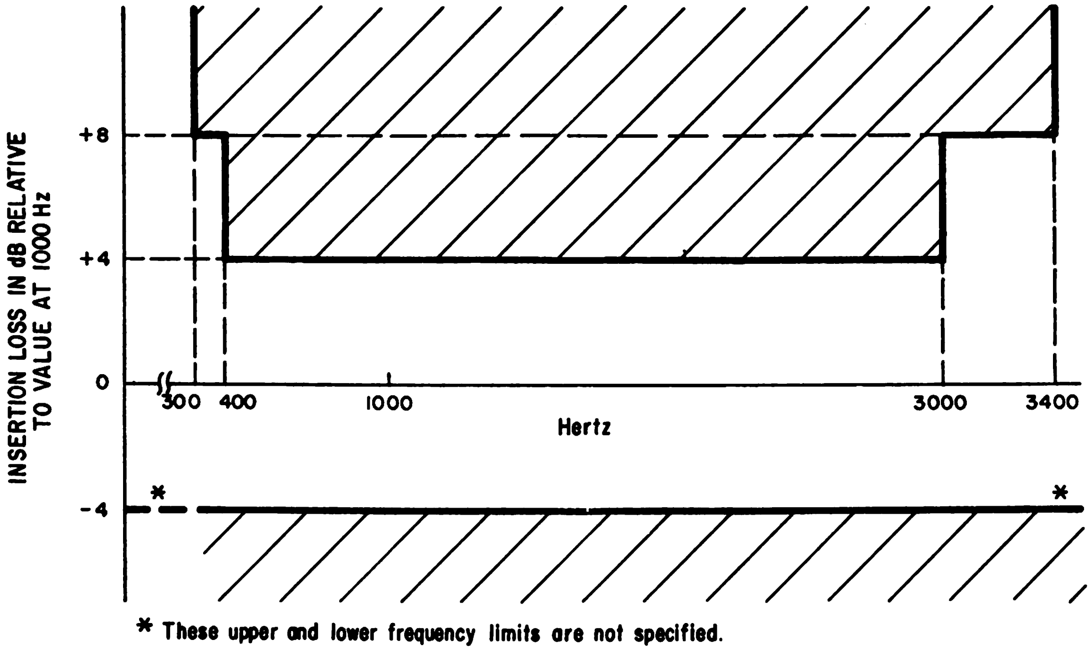
4.4.3.2.8 Intermodulation Distortion. (Under consideration.)

4.4.3.2.9 Signal Discontinuities. The statistical characteristics of the various signal discontinuities are not well enough known to establish prorating or summation methods at the present time. The wide variability of the loop characteristics further complicates the prorating problem (see paragraph 4.4.2). However, experience has shown that, on a user-to-user basis, a single modulation link or, in some cases, a loop will normally be the major source of signal discontinuities. Further, the signal discontinuities may often be traceable to excessive drive levels in the transmission circuit, to propagation anomalies, or to maintenance procedures. It is recommended that the signal discontinuity characteristics given on a user-to-user basis in subparagraph 4.3.2.9 be used as general guidance for the channel signal discontinuities.

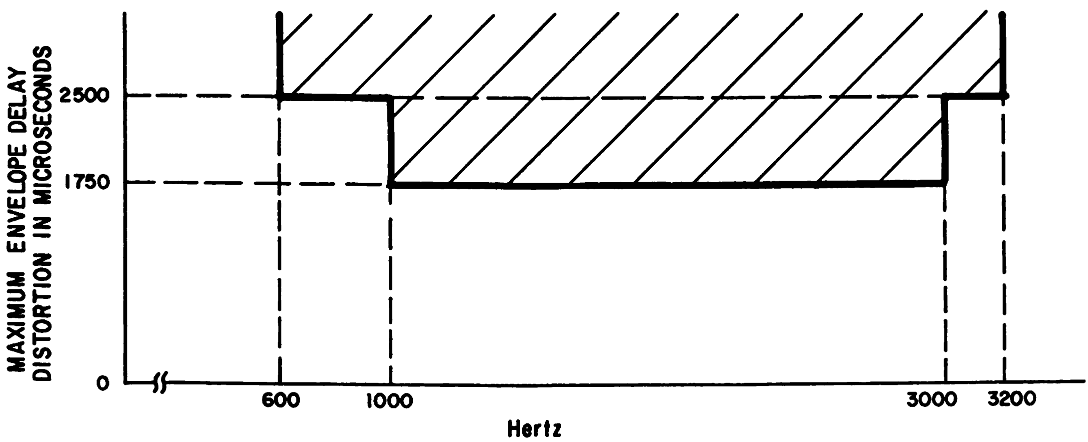
4.4.3.2.10 Single Tone Interference. No interfering tone of a single frequency shall exceed 30 dBrnc0, measured at the output terminals of a channel.

4.4.3.2.11 Frequency Displacement. Any audio frequency transmitted over a FDM derived long haul/tactical channel shall be reproduced at the channel output with a frequency error of not more than ±1 Hz. Frequency displacement for PCM derived channels is under consideration.

4.4.3.2.12 Net Loss Variation. The net loss variation of a channel shall not exceed ±4.5 dB over any 30 consecutive days.



a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.4-5. Parameters of Nominal 4-kHz Channel

4.4.3.3 Parameters for Nominal 48-kHz FDM Group Bandwidth Channel.

4.4.3.3.1 General. This paragraph establishes standards and design objectives for analog group bandwidth channels which are used for the transmission of high speed digital data signals. Such channels are provided over those FDM groups which are best suited for high speed digital service. GROUP A (12 kHz to 60 kHz), GROUP 1 OF SUPERGROUP 1, AND GROUP 5 OF SUPERGROUP 3 ARE NOT RECOMMENDED FOR THIS PURPOSE. The group channel normally terminates at each end of the group distribution frame (GDF) or equivalent points. Its nominal bandwidth extends from 60 kHz to 108 kHz; however, the standard group pilot for system regulation and alarm appears at 104.08 kHz, which effectively prevents the use of the 104-kHz to 108-kHz portion of this bandwidth for high speed data. This portion can be used for a voice or medium speed data circuit for coordination and control of the high speed data channel. The remaining bandwidth is suitable for high speed data transmission. In systems having pilots at frequencies other than 104.08 kHz, such pilots must be disabled and the filters associated with them removed from the group channel before this channel may be used for high speed data. Loop characteristics are not included herein but must be carefully considered and engineered for user-to-user service. The common standards which follow supplement paragraph 4.3.1, General Digital Parameters, in describing those parameters which are essential for quality high speed digital data service. Experience has shown that it may be necessary for the data to be regenerated after 3 tandem data trunks to provide satisfactory data service.

4.4.3.3.2 Channel Input Levels.

4.4.3.3.2.1 Data Level (Quasi-Analog). The power of the high speed modulated data carrier signal when handling traffic shall not exceed 5 dB below standard test signal level (−5 dBm0). The power of any single frequency component of the data signal shall not exceed 13 dB below standard test signal level (−13 dBm0).

4.4.3.3.2.2 Test Signal. The test signal level at a group channel input, measured at the group distribution frame (GDF), shall be −34.5 dBm.

4.4.3.3.3 Channel Output Levels.

4.4.3.3.3.1 Test Signal. The test signal level at a group channel output, measured at the group distribution frame (GDF), shall be −12 dBm ±0.5 dBm.

4.4.3.3.3.2 Noise Power. The long term median circuit noise shall not exceed −30 dBm0 (DO: −40 dBm0) of unweighted noise over the nominal 48-kHz bandwidth.

4.4.3.3.4 Channel Input/Output Impedances. The input and output impedances of a nominal 48-kHz channel shall each be 135 ohms, balanced to ground, with a minimum return loss of 20 dB (DO: 26 dB) against a 135-ohm resistance over the frequency band of interest. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. For the purpose of interfacing with other equipment, a strapping option for 150-ohm impedance termination, balanced to ground, shall be provided.

NOTE: If this strapping option is used, the multiplexer gain may have to be adjusted to meet the test signal level at the group channel output given in subparagraph 4.4.3.3.3.1.

4.4.3.3.5 Insertion Loss Versus Frequency Characteristic. The insertion loss versus frequency characteristic of an unconditioned nominal 48-kHz FDM group bandwidth channel, referenced to 83 kHz over the frequency bandwidth from 60.6 kHz to 107.7 kHz, shall be within the limits of ±8dB (see Figure 4.4-6a). Conditioning of the channel, if required, will be provided externally to the group equipment on a case-by-case basis.

4.4.3.3.6 Envelope Delay Distortion. The envelope delay distortion of an unconditioned nominal 48-kHz FDM group bandwidth channel, over the frequency bandwidth from 64 kHz to 104 kHz, shall not exceed 800 microseconds, except between 68 kHz and 100 kHz the envelope delay distortion shall not exceed 500 microseconds (see Figure 4.4-6b). This standard assumes that suitable delay equalizers, if required, will be part of the group data modem.

4.4.3.3.7 Impulse Noise. The unweighted impulse noise at a group channel output, measured at the group distribution frame (GDF), shall not exceed 45 counts over any 30 consecutive minutes above a level which is 5 dB below the total signal power level.

4.4.3.3.8 Net Loss Variation. The net loss variation, measured between group distribution frames (GDFs) or equivalent points, shall not exceed ±2.5 dB over any 30 consecutive days.

4.4.3.4 Parameters for Digital Channel. (Under consideration.)

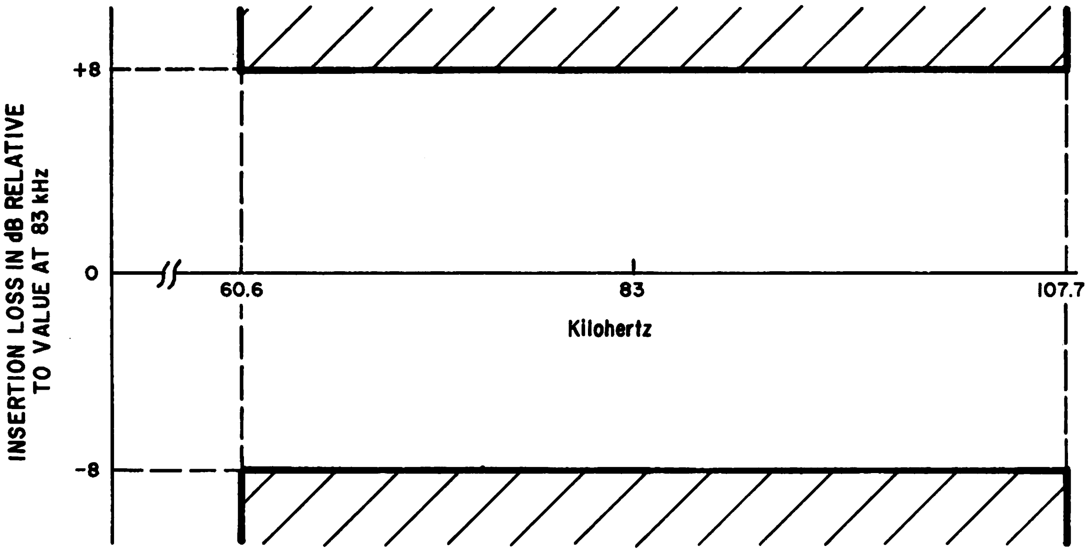
4.5 Reference Modulation Links.

4.5.1 General. The reference modulation links discussed herein deal with "building block" configurations of transmission and modulation. Historically, these configurations were developed for analog speech service and as such they did not deal with technical control configurations, nor with switched subsystems or networks. However, with the advent of quasi-analog data service and AUTOVON and AUTODIN switched network applications, additional conditioning and regeneration equipment must be introduced to the basic configurations to ensure satisfactory performance. Hypothetical configurations for voice, data, AUTOVON and AUTODIN service are included in this document. Additional detailed information about these and other possible configurations is contained in the following documents. In case of conflict, MIL-STD-188-100 shall govern.

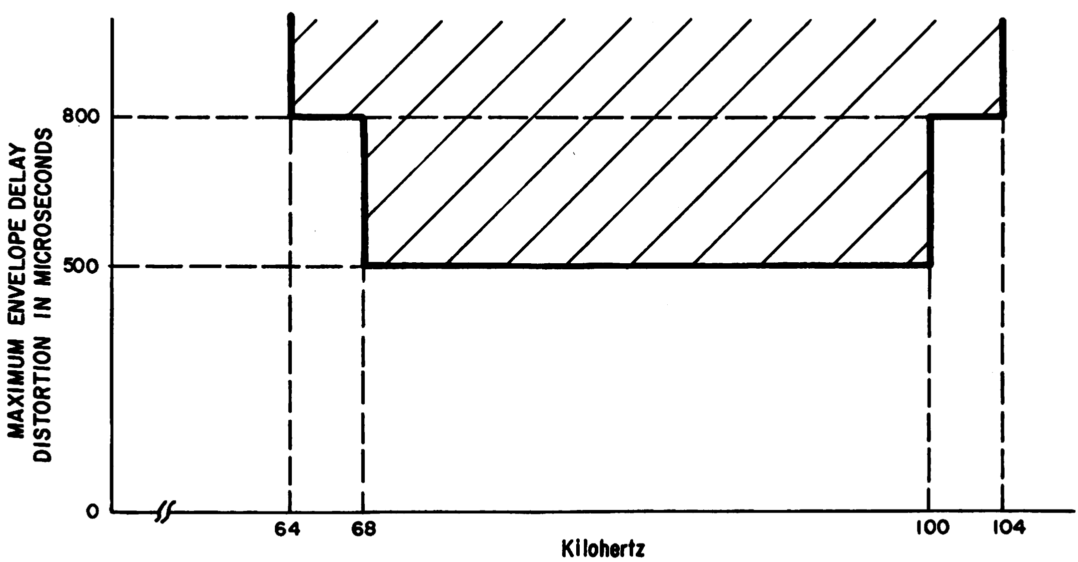
(a) MIL-STD-188C, Military Standard, Military Communication System Technical Standards, 24 November 1969 (to be replaced by MIL-STD-188-200 series).

(b) MIL-STD-188-300, Military Standard, Standards for Long Haul Communications, System Design Standards Applicable to the Defense Communications System, 15 July 1971.

(c) MIL-STD-188-310, Military Standard, Subsystem Design and Engineering Standards for Technical Control.



a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.4-6. Parameters for Data Service Over Unconditioned Nominal 48 kHz FDM Group Channel

(d) DCAC 370-V175-6, AUTOVON System Interface Criteria.

(e) DCAC 370-V185-7, Overseas AUTOVON Network Switching Plan.

(f) DCAC 370-D175-1, DCS AUTODIN Interface and Control Criteria.

(g) DCAC 370-S185-9, AUTOSEVOCOM Network Switching Plan.

In the hypothetical reference circuit examples covered in paragraph 4.7, some of the considerations from the documents noted above will be introduced to illustrate where the reference voice bandwidth links fit into the overall user-to-user connection.

4.5.2 Characteristics of Single FDM Reference Modulation Links. The configuration of a common long haul/tactical less maneuverable FDM reference modulation link is shown in Figure 4.5-1. This link, called a Type I link, has no multiplex translations between the initiating and the terminating HFDFs and the transmission medium may consist of LOS radio relay, troposcatter satellite relay, or submarine cable and each medium may cover different nominal distances. In the long haul system, the Type I link is either a nominal 617 km (333 nmi) radio or cable link or a nominal 5556 km (3000 nmi) submarine cable or satellite relay link. In the tactical less maneuverable system, the Type I FDM reference modulation link can be assumed to comprise six LOS radio repeater links of average length of about 51 km (28 nmi), properly sited, resulting in a nominal length of 308 km (167 nmi) of the reference modulation link. Regardless of the nominal distance, Figure 4.5-1 shows the basic configuration of a Type I link. The FDM reference voice bandwidth link begins at the left of Figure 4.5-1 at audio frequency (A), is modulated in successive stages to basic group frequency band (G) and basic supergroup frequency band (S) and then, as required, to either baseband frequency (B) for radio transmission or to line frequency band (L) for metallic line transmission, over the appropriate medium. At the receiving end of the link, corresponding demodulation stages return to audio frequency (A). The FDM reference group bandwidth line (Type I) begins at the left of Figure 4.5-1 at group frequency band (G), is modulated and demodulated in a similar manner, and terminates at (G) on the right. Figure 4.5-1 shows only one direction of transmission; the other direction is identical.

Special requirements for the tactical highly maneuverable system have led to the development of FDM equipment with channel groupings different from the configuration shown in Figure 4.5-1. This type of FDM equipment cannot meet all of the standards of the long haul or the tactical less maneuverable FDM reference modulation link given in paragraph 4.5.2. Therefore, standards and design objectives for the tactical highly maneuverable FDM reference voice bandwidth link are stated in separate subparagraphs, whenever they are different from the corresponding parameters of the long haul or tactical less maneuverable FDM reference voice bandwidth link. However, all FDM derived channels of the tactical highly maneuverable system shall meet the channel characteristics given in MIL-STD-188C (to be replaced by the MIL-STD-188-200 series).

Figure 4.5-2 depicts a typical configuration of a long haul FDM reference modulation link with a nominal length of 1850 km (1000 nmi). This link, called a Type II link as opposed to a Type I link shown in Figure 4.5-1, contains additional multiplex translations between the initiating and the terminating audio frequency terminals (A). The translations are accomplished by employing through supergroup equipment and through

FROM

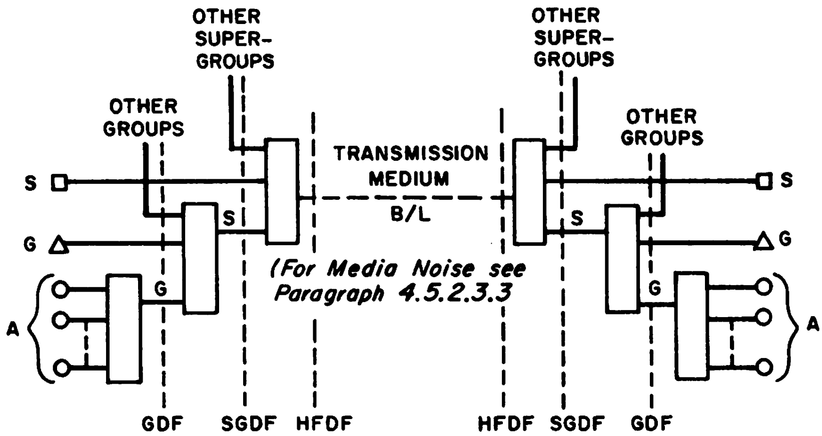
TACTICAL/LONG HAUL — TRUNKS/LINKS (up to 12,000 nmi) — GROUP — GROUP — CHANNEL — INTERFACE — LOOP[4] — INTERFACE — USER - RECEIVE/END INSTRUMENT[5]

Item	48-kHz Channel[1] (see para. 4.4.3.3)	3-kHz Channel[2,3] (see para. 4.4.3.1)	4-kHz Channel[3] (see para. 4.4.3.2)	For loop characteristics see para. 4.4.2	Conditioned[6,9] Voice Bandwidth Circuit (see para. 4.3.3)	Unconditioned[7,9] Voice Bandwidth Circuit (see para. 4.3.2)	Analog[8] Voice Bandwidth Circuit (see para. 4.2.2)
Received Noise Power	-30 dBm0[10]	54 dBrnc0[10]	47 dBrnc0[10]		47 dBrnc0[10]	47 dBrnc0[10]	44 dBrnc
Insertion Loss vs Frequency Characteristics	60.6 kHz-107.7 kHz ±8 dB	0.35 kHz-3.0 kHz (except 0.4 kHz-3.0 kHz) -5 dB to +8.5 dB 0.4 kHz-3.0 kHz ±4.5 dB For data service, regenerative repeaters may be required to meet the user-to-user (modem-to-modem) requirements of para. 4.3.2 & 4.3.3.	0.3 kHz-3.4 kHz (except 0.4 kHz-3.0 kHz) -4 dB to 8 dB 0.4 kHz-3.0 kHz ±4 dB		0.3 kHz-3.0 kHz (except 0.5 kHz-2.8 kHz) -2 dB to +6 dB 0.5 kHz-2.8 kHz -1 dB to +3 dB	0.3 kHz-3.0 kHz (except 0.3 kHz-2.7 kHz) -3 dB to +12 dB 0.3 kHz-2.7 kHz (except 1.0 kHz-2.4 kHz) -2 dB to +6 dB 1.0 kHz-2.4 kHz -1 dB to +3 dB	0.4 kHz-2.8 kHz (except 0.6 kHz-2.4 kHz) -8 dB to 20 dB 0.6 kHz-2.4 kHz -7 dB to +12 dB
Envelope Delay Distortion	64 kHz-104 kHz (except 68 kHz-100 kHz) 800 μs 68 kHz-100 kHz 500 μs	0.6 kHz-3.0 kHz (except 1.0 kHz-2.9 kHz) 3000 μs 1.0 kHz-2.4 kHz 2400 μs For data service, regenerative repeaters may be required to meet the user-to-user (modem-to-modem) requirements of para. 4.3.2 & 4.3.3.	0.6 kHz-3.2 kHz (except 1.0 kHz-3.0 kHz) 2500 μs 1.0 kHz-3.0 kHz 1750 μs		0.5 kHz-2.8 kHz (except 0.6 kHz-2.6 kHz) 3000 μs 0.6 kHz-2.6 kHz (except 1.0 kHz-2.6 kHz) 1500 μs 1.0 kHz-2.6 kHz 500 μs	1.0 kHz-2.6 kHz (except 1.0 kHz-2.4 kHz) 1750 μs 1.0 kHz-2.4 kHz 1000 μs	NOT SPECIFIED
Net Loss Variation Over 30-day Period	±2.5 dB	±8.0 dB	±4.5 dB		±5.0 dB	±5.0 dB	±5.0 dB

NOTES

1. Unconditioned 48-kHz group channel.
2. Basically a 4-kHz channel which has internal 3-kHz links, i.e., submarine cable or HF radio.
3. Unconditioned channel output.
4. The loop will act as a frequency filter-attenuator and will degrade channel characteristics.
5. The user end instrument may be either analog or digital.
6. Conditioned 4-kHz channel used for 2400 b/s data stream.
7. Unconditioned 4-kHz channel used for 1200 b/s or less data stream or analog instruments.
8. Analog channel, used for analog instruments; i.e., telephone or facsimile equipment.
9. Modems may also be located at trunk/loop interface.
10. Reference Long Haul OTLP.

Figure 4.4-7. Loop - Channel - Circuit Interface Parameters



Legend

A – Audio Frequency 4-Wire Nominal 4 kHz Circuit

G – Basic Group Frequency Band, 60 kHz – 108 kHz

S – Basic Supergroup Frequency Band, 312 kHz – 552 kHz

B – Baseband Frequency for Radio Relay Transmission

L – Line Frequency Band for Cable Transmission

△ – Access Point, Nominal 48 kHz Circuit (Through Group or High Speed Data Modem)

□ – Access Point, Nominal 240 kHz Circuit

AO to AO – Reference Voice Bandwidth Link

G△ to G△ – Reference Group Bandwidth Link

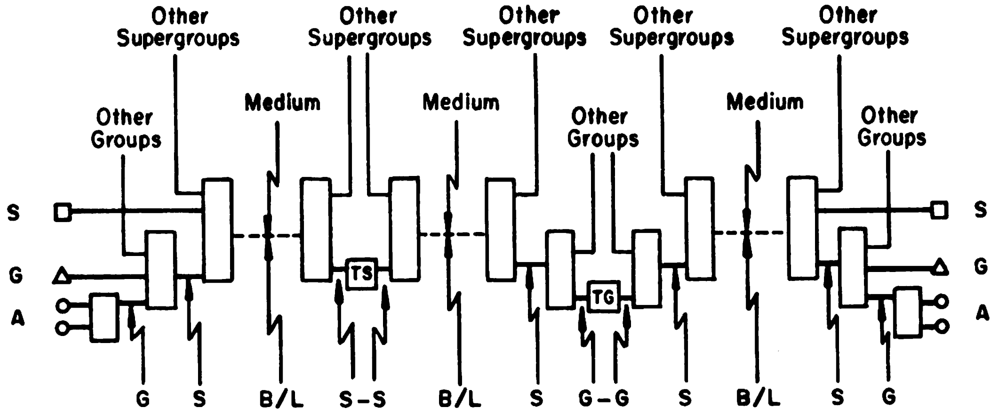
O – Access Point, Nominal 4 kHz Circuit

GDF – Group Distribution Frame

SGDF – Supergroup Distribution Frame

HFDF – High Frequency Distribution Frame

Figure 4.5-1. Common Long Haul/Tactical Less Maneuverable FDM Reference Modulation Link (Type I) group equipment at the Technical Control Facilities. Figure 4.5-2 is shown in order to illustrate the configurations of common long haul/tactical reference circuit examples given in paragraph 4.7.



(For Media Noise see paragraph 4.5.2.3.3)

LEGEND

A - Audio Frequency 4-Wire Nominal 4 kHz Circuit
G - Basic Group Frequency Band, 60 kHz - 108 kHz
S - Basic Supergroup Frequency Band, 312 kHz - 552 kHz
B - Baseband Frequency for Radio Relay Transmission
L - Line Frequency Band for Cable Transmission
○ - Access Point, Nominal 4 kHz Circuit
△ - Access Point, Nominal 48 kHz Circuit (Through Group or High Speed Data Modem)
□ - Access Point, Nominal 240 kHz Circuit
TG - Through Group Equipment
TS - Through Supergroup Equipment

Figure 4.5-2. Nominal 1850 km (1000 nmi) Long Haul Modulation Link (Type II)

Parameters for both types of FDM reference modulation links (Type I shown in Figure 4.5-1 and Type II shown in Figure 4.5-2) are given in the following subparagraphs 4.5.2.1 through 4.5.2.7. Some of the values appearing in these subparagraphs are based on recent multiplex tests and are different from the values appearing in MIL-STD-188-300 which will be revised accordingly.

4.5.2.1 Loading.

4.5.2.1.1 Voice Loading (Analog). The total load applied to a multichannel amplifier is the sum of the loads in the individual channels. There are certain factors about speech transmission that tend to reduce and stabilize the total load as the number of channels increases. These factors are:

(a) The number and distribution of channels actively transmitting speech.

(b) The volumes of speech in the individual channels.

In determining the channel loading of a multichannel voice system, considerable advantage may be taken of the statistical distribution of the speech signals. For example, the activity factor for a channel or the percentage of time in the busiest traffic hour a channel might be active in multichannel systems is about 25 percent.

For smaller groups of channels this percentage may be larger, but it is highly unlikely that any increase in group size would change it appreciably. Utilization of this activity factor results in a decrease of the mean power (–10 dBm0) of a voice channel (short term average of active channel) to a mean power of –16 dBm0 for a voice channel (long term average).

The volumes of speech in active voice channels will also affect the total load. Speech volumes are not constant in a channel, but vary considerably, depending on the characteristics of the talker's speech and the loudness of his voice.

The changes in active channels and in speech volumes concern only the maximum rms load on a multichannel amplifier, causing more and more gradual variations as the number of channels increases.

However, it is the total input voltage applied to the amplifier, and not just the rms portion, that determines whether the amplifier will overload. This total voltage is the vector sum of the instantaneous voltages in the separate channels and is a function of both the phase and amplitude of each speech signal.

In consideration of the above statistical aspects of voice and the associated probabilities, loading formulas were established by Holbrook and Dixon and are recommended by CCIR. These formulas give the mean absolute power (P_m) of the distributed speech signals that the system must be capable of carrying. The signal power depends on the number of channels involved, and is calculated from one of the two formulas (see Figure 4.5-3):

$$P_m = -1 + 4 \log N, \quad (12 \leq N < 240 \text{ channels}) \text{ dBm0}$$

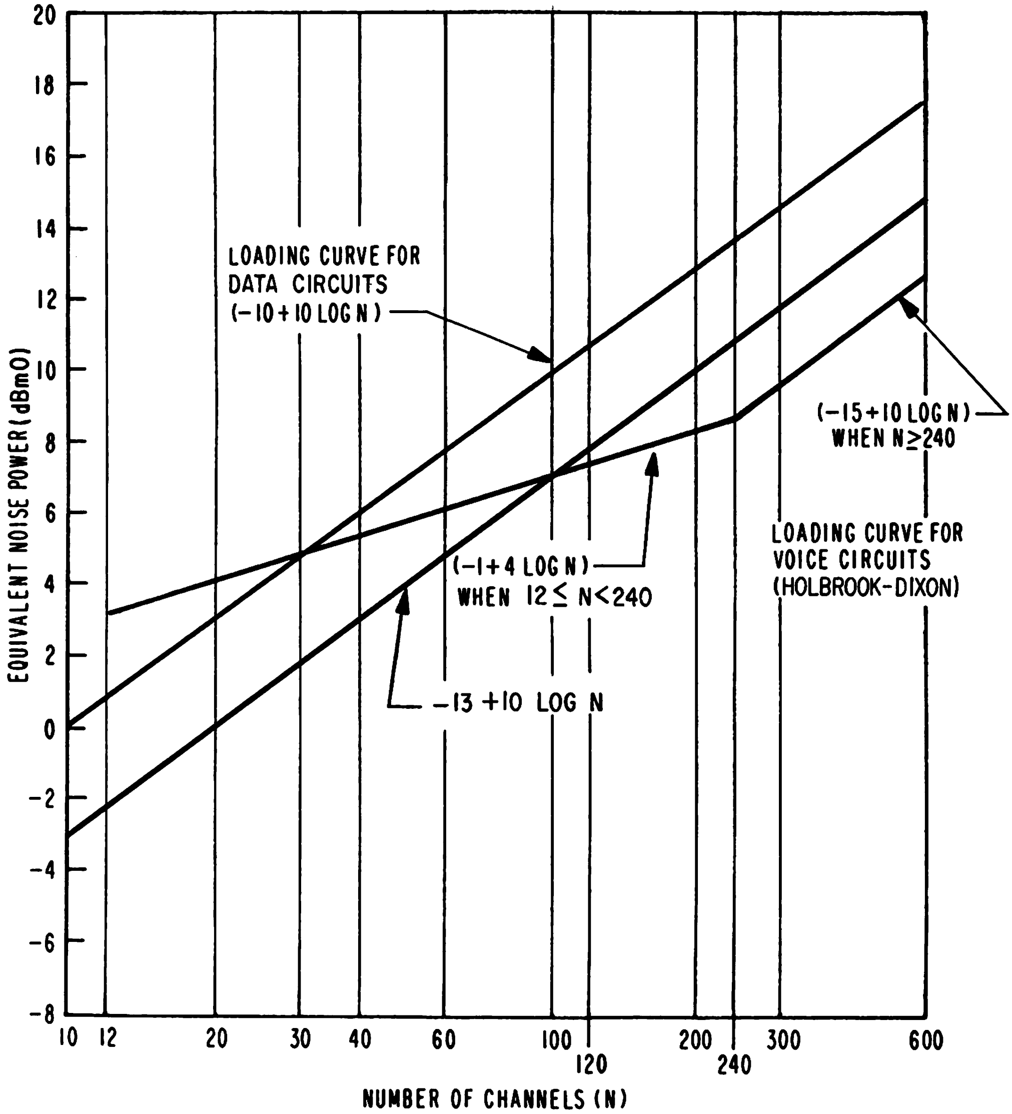
or

$$P_m = -15 + 10 \log N, \quad (N \geq 240 \text{ channels}) \text{ dBm0}$$

The formulas include a small margin for loads caused by signaling tones, pilot signals, and carrier leak.

4.5.2.1.2 Data Loading (Quasi-Analog). Data signals are, more or less, of constant amplitude in contrast to the wide variations of speech. Thus, the average power of a data signal is continuous and imposes greater loads on the multichannel amplifier than that of a voice signal which is present only part of the time. The loading imposed by telegraph and data signals is calculated from the following formula (see Figure 4.5-3):

$$P_m = P_C + 10 \log N$$



Equivalent Gaussian Noise test signal for simulating load provided by various numbers of channels. Lower values for simulating voice channels result from lower activity factor. Values shown may be used directly for noise load ratio when converting NPR to S/N dBrnc (see Notes 1 and 2, subparagraph 4.5.2.1.2).

Figure 4.5-3. FDM Channels Loading Curves where

P_m = rms power of the multichannel signal (dBm0)

P_C = rms power of the input telegraph or data signal

N = number of channels carrying telegraph or data signals.

NOTE 1: In contemporary switched multichannel systems, the combination of voice, teletype, and data loading (with a data loading of −10 dBm0 mean power per channel) produces a resultant composite loading level that is reasonably compatible with the specific overload characteristics of FDM equipment based on Holbrook and Dixon and on CCIR criteria.

NOTE 2: When all or nearly all of the FDM channels are devoted to data, telegraph, or digital facsimile, the resultant loading (−10 +10 log N) dBm0 is approximately 3.2 times higher than the CCIR loading. Thus, if there were a need for 300 data channels, and only voice type FDM and radio equipment (not designed for continuous data loading of (−10 +10 log N) dBm0 are available, then the system engineering loading must be the same as if a 960-channel voice loaded system were deployed. In actual system practice, where both types of FDM and radio equipment (designed for voice service only or for voice and data service) may be found, the data loading is reduced from −10 dBm0 to −13 dBm0 mean power per channel in order to prevent overloading the system.

As a Design Objective, all multichannel communication equipment shall be designed for 100 percent data loading.

4.5.2.2 Standard Test Signal Levels. The test signal levels of a long haul or of a tactical FDM reference modulation link shall be as shown in Table 4.5-1. Figure 4.5-4 summarizes test and traffic levels for long haul and for tactical (highly and less maneuverable) FDM reference voice bandwidth links.

4.5.2.3 Noise. This parameter is divided into multiplex noise (idle and loaded) and noise due to the transmission media. Noise values for voice bandwidth links are psophometrically weighted (pWp0) and noise values for group bandwidth links are flat weighted (pW0) over the nominal 48-kHz bandwidth. For the highly maneuverable tactical system, media noise and multiplex noise for FDM transmission are not separated but the total noise (multiplex plus media) is allocated on a per link basis as shown in subparagraph 4.5.2.3.4.

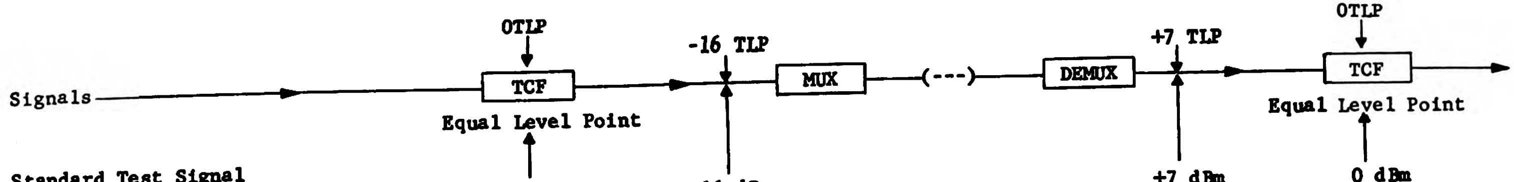
4.5.2.3.1 Multiplex Noise of Voice Bandwidth Links. The multiplex idle channel noise and the loaded noise of a long haul or of a tactical less maneuverable FDM reference voice bandwidth link when referenced to a 0TLP shall not exceed the values given in Table 4.5-2.

Table 4.5-1. Standard Test Signal Levels of FDM Reference Modulation Link

Test Point	System	Standard Test Signal Levels (dBm)*
Channel Modulator In (Input to channel translating equipment)	Long Haul/Tactical, less manueverable	-16
	Tactical, highly maneuverable	-4
Channel Demodulator Out (Output from channel translating equipment)	Long Haul/Tactical, less maneuverable	+7
	Tactical, highly maneuverable, 4-wire termination	-4
	Tactical, highly maneuverable, 2-wire termination	+1
Transmit Group Distribution Frame	Long Haul/Tactical	-34.5
Receive Group Distribution Frame	Long Haul/Tactical	-12
Transmit Supergroup Distribution Frame	Long Haul/Tactical	-18
Receive Supergroup Distribution Frame	Long Haul/Tactical	-28
Transmit High Frequency Distribution Frame	Long Haul/Tactical	-45
Receive High Frequency Distribution Frame	Long Haul/Tactical	-15

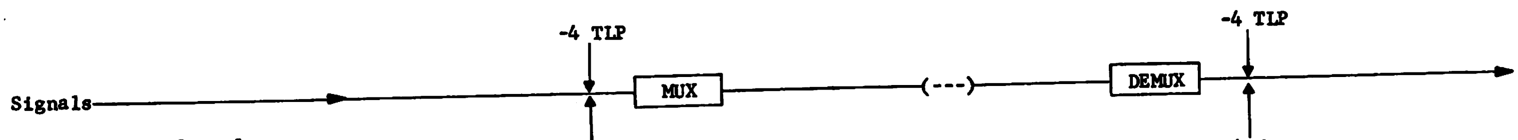
*These values equate to a 1000 Hz ±25 Hz test signal level of 0 dBm (1 mW across 600 ohms) at the 0TLP (0 dBm0) (see subparagraph 4.4.3.2.2.3), and should not be confused with the standard test tone of -10 dBm0 for the long haul and tactical less maneuverable systems and of -3 dBm0 for the tactical highly maneuverable system (see subparagraph 4.4.3.2.2.4).

LONG HAUL AND TACTICAL LESS MANEUVERABLE LINK



Signals	TCF (OTLP, Equal Level Point)	-16 TLP	+7 TLP	TCF (OTLP, Equal Level Point)
Standard Test Signal (1000 Hz ±25 Hz, 0 dBm0)	0 dBm	-16 dBm	+7 dBm	0 dBm
Standard Test Tone (1000 Hz ±25 Hz, -10 dBm0)	-10 dBm	-26 dBm	-3 dBm	-10 dBm
Monitoring Test Tone (-15 dBm0)	-15 dBm	-31 dBm	-8 dBm	-15 dBm
Two-Tone IMD Signal Composite	-3 dBm	-19 dBm	+4 dBm	-3 dBm
Single Tone	-6 dBm	-22 dBm	+1 dBm	-6 dBm
Traffic Data	-13 dBm	-29 dBm	-6 dBm	-13 dBm
Voice (Assumed Loop Loss of 6 dB)	-16 VU	-32 VU	-9 VU	-16 VU

TACTICAL HIGHLY MANEUVERABLE LINK



Signals	-4 TLP (MUX)	-4 TLP (DEMUX)
Standard Test Signal (1000 Hz ±25 Hz, 0 dBm0)	-4 dBm	-4 dBm
Standard Test Tone (1000 Hz ±25, 3 dBm0)	-7 dBm	-7 dBm
Two-Tone IMD Signal Composite	-7 dBm	-7 dBm
Single Tone	-10 dBm	-10 dBm
Traffic Data	-10 dBm	-10 dBm
Voice (Assumed Loop Loss of 3.5 dB)	-13.5 VU	-13.5 VU

Figure 4.5-4. Interface and Test Levels of FDM Reference Voice Bandwidth Links

Table 4.5-2. Multiplex Idle Channel and Loaded Noise of FDM Reference Voice Bandwidth Links

Configuration	FDM Noise Allocation	
	Idle Noise (pWp0)	Loaded Noise (pWp0)
Pair, channel translation sets	10	31
Pair, group translation sets	40	50
Pair, supergroup translation sets	25	50
Through group equipment	N/A	10
Through supergroup equipment	25	50
Multiplex Noise of FDM Reference Voice Bandwidth Link (Type I)	75	131
Multiplex Noise of FDM Reference Voice Bandwidth Link (Type II)	245	341

4.5.2.3.2 Multiplex Noise of Group Bandwidth Links. The multiplex idle channel noise and the loaded noise of a long haul or of a tactical less maneuverable FDM reference group bandwidth link when referenced to a 0TLP shall not exceed the values given in Table 4.5-3.

Table 4.5-3. Multiplex Idle Channel and Loaded Noise of FDM Reference Group Bandwidth Links

Configuration	FDM Noise Allocation	
	Idle Noise (pW0)	Loaded Noise (pW0)
Pair, group translation sets	1,140	1,425
Pair, supergroup translation sets	710	1,425
Through group equipment	N/A	284
Through supergroup equipment	710	1,425
Multiplex Noise of FDM Reference Group Bandwidth Link (Type I)	1,850	2,850
Multiplex Noise of FDM Reference Group Bandwidth Link (Type II)	5,120	8,834

4.5.2.3.3 Media Noise. The allocation of noise due to the transmission media (see Figures 4.5-1 and 4.5-2) depends on the type of medium and on the type of communication system. The media noise when referenced to a 0TLP shall not exceed the values given in Table 4.5-4. Media noise for a tactical highly maneuverable system is given in subparagraph 4.5.2.3.4.

Table 4.5-4. Noise Allocation of Transmission Media

Media	System	4 kHz Media Noise	48 kHz Media Noise
Land metallic or radio relay	Long Haul	3-1/3 pWp0/nmi	100 pW0/nmi
Radio relay	Tactical, less maneuverable	6-2/3 pWp0/nmi	200 pW0/nmi
Submarine cable	Long Haul	1.5 pWp0/nmi	50 pW0/nmi
Communication satellite	Long Haul	10,000 pWp0/hop	310,000 pW0/hop

NOTE: The reference circuits addressed in this standard do not include short links. Noise for short LOS links (with the exception of the highly maneuverable tactical system) can be calculated as follows:

Section Length (Nautical Miles)	Allowable Noise
$27 < L < 151$ nm	$2.76\ L$ pWp0 + 85.5 pWp0
$L \leq 27$ nm	160 pWp0

where L is the distance of the hop of subsystem in nautical miles.

4.5.2.3.4 Total Noise for Tactical Highly Maneuverable System. The total noise (multiplex plus media noise) of a tactical highly maneuverable FDM reference voice bandwidth link when referenced to a tactical highly maneuverable 0TLP shall not exceed 25,000 pWp0 (approximately 44 dBrnc0) per link during 99 percent or more of the time.

4.5.2.4 Link Input/Output Impedances.

4.5.2.4.1 Voice Bandwidth Link. The audio input and output impedances of a nominal 4-kHz channel of a long haul or of a tactical FDM reference voice bandwidth link shall each be 600 ohms, balanced to ground, with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency range of 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

4.5.2.4.2 Group Bandwidth Link. The input and output impedances of a nominal 48-kHz channel of a long haul or of a tactical FDM reference group bandwidth link shall each be 135 ohms, balanced to ground, with a minimum return loss of 20 dB (DO: 26 dB) against a 135-ohm resistance over the frequency band of interest. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level. For the purpose of interfacing with other equipment, a strapping option for 150-ohm impedance termination, balanced to ground, shall be provided.

NOTE: If this strapping option is used, the multiplexer gain may have to be adjusted to meet the standard test signal level at the group channel output given in subparagraph 4.5.2.2.

4.5.2.4.3 Multiplex Baseband. The input and output impedances at the multiplex baseband of a long haul or of a tactical FDM reference modulation link shall each be 75 ohms, one side grounded, with a minimum return loss of 20 dB (DO: 26 dB) against a 75-ohm resistance over the frequency band of interest.

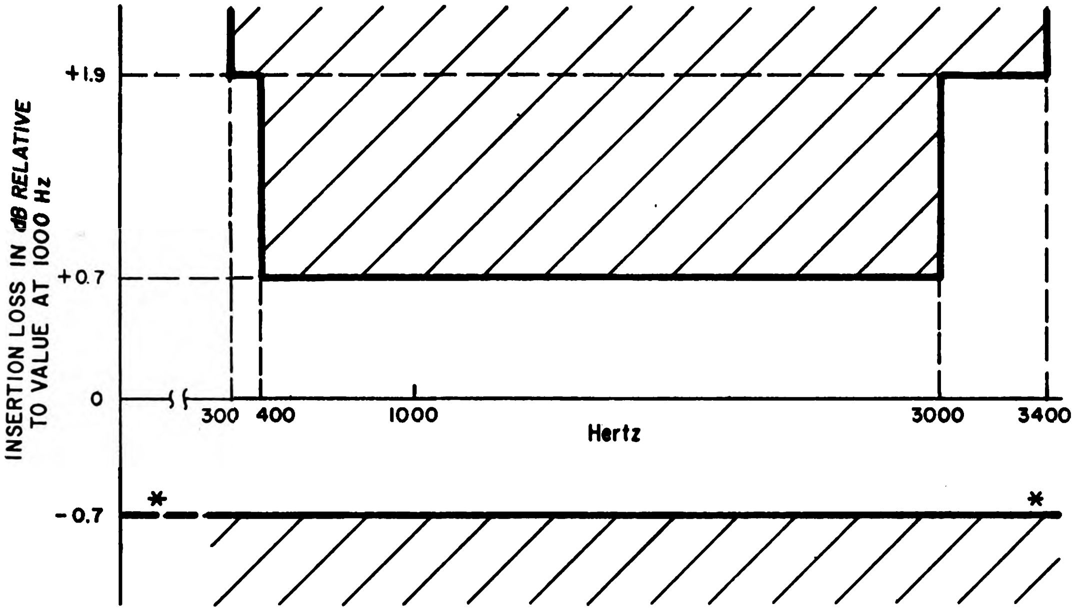
4.5.2.5 Insertion Loss Versus Frequency Characteristic.

4.5.2.5.1 Voice Bandwidth Link of Long Haul or Tactical Less Maneuverable System. The insertion loss versus frequency characteristic referenced to 1000 Hz of a long haul or a tactical less maneuverable FDM reference voice bandwidth link shall not exceed the values given in Table 4.5-5. Loss is indicated by a (+) and gain by a (−) sign. The contributions to the insertion loss versus frequency characteristic of wideband transmission subsystems are considered negligible for stable media (see Figures 4.5-5a and 4.5-6a).

Table 4.5-5. Insertion Loss Versus Frequency Characteristics of FDM Reference Voice Bandwidth Links

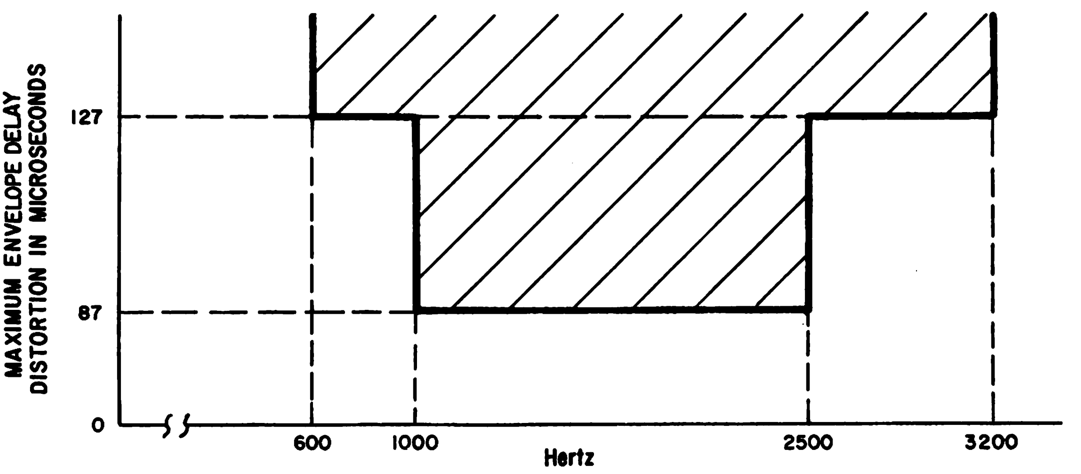
Configuration	Loss in dB referenced to 1000 Hz		Below 300 Hz and above 3400 Hz
	300 Hz-3400 Hz (except 400 Hz-3000 Hz)	400 Hz-3000 Hz	
Pair, channel translation sets	-0.3, +1.5	±0.3	-0.3
Pair, group translation sets	±0.3	±0.3	-0.3
Pair, supergroup translation sets	±0.5	±0.5	-0.5
Through group equipment	±0.5	±0.5	-0.5
Through supergroup equipment	±0.5	±0.5	-0.5
FDM Reference Voice Bandwidth Link (Type I)	-0.7, +1.9	±0.7	-0.7
FDM Reference Voice Bandwidth Link (Type II)	-1.1, +2.2	±1.1	-1.1

4.5.2.5.2 Voice Bandwidth Link of Tactical Highly Maneuverable System. The insertion loss versus frequency characteristic referenced to 1000 Hz of a tactical highly maneuverable FDM reference voice bandwidth link, over the frequency bandwidth from 300 Hz to 3400 Hz, shall be within the limits of −1 dB to +2 dB, except over the frequency bandwidth from 400 Hz to 3000 Hz it shall be within the limits of ±1 dB. The insertion loss below 300 Hz and above 3400 Hz shall be equal to or greater than −1 dB. Loss is indicated by a (+) and gain by a (−) sign (see Figure 4.5-7a).



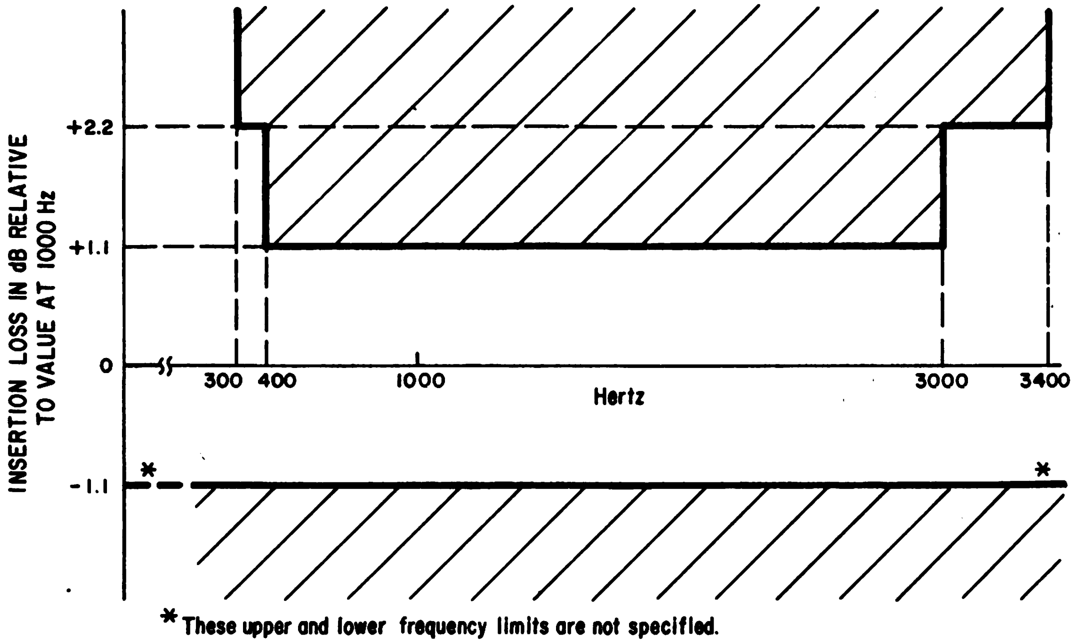
* These upper and lower frequency limits are not specified.

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC

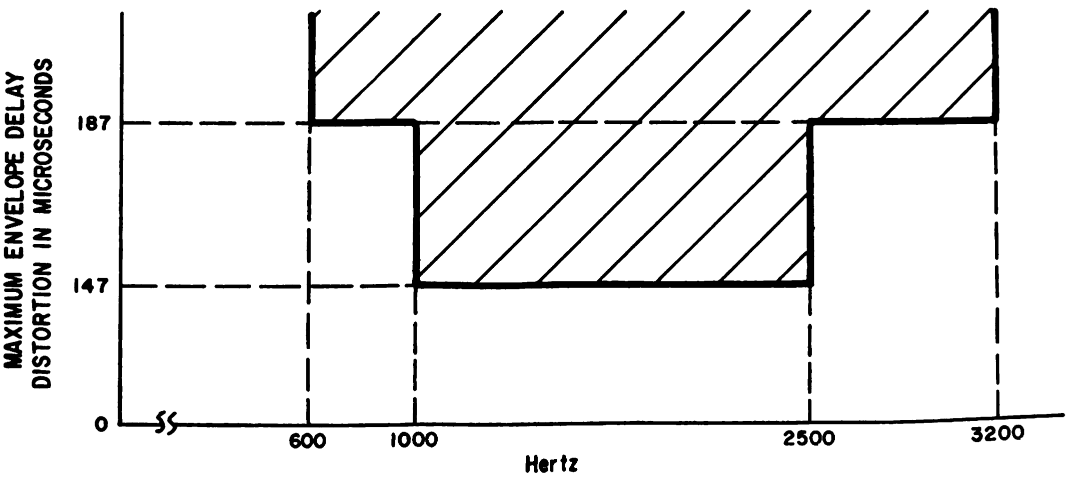


b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.5-5. Parameters for Single Long Haul or Tactical Less Maneuverable FDM Reference Voice Bandwidth Link (Type I)

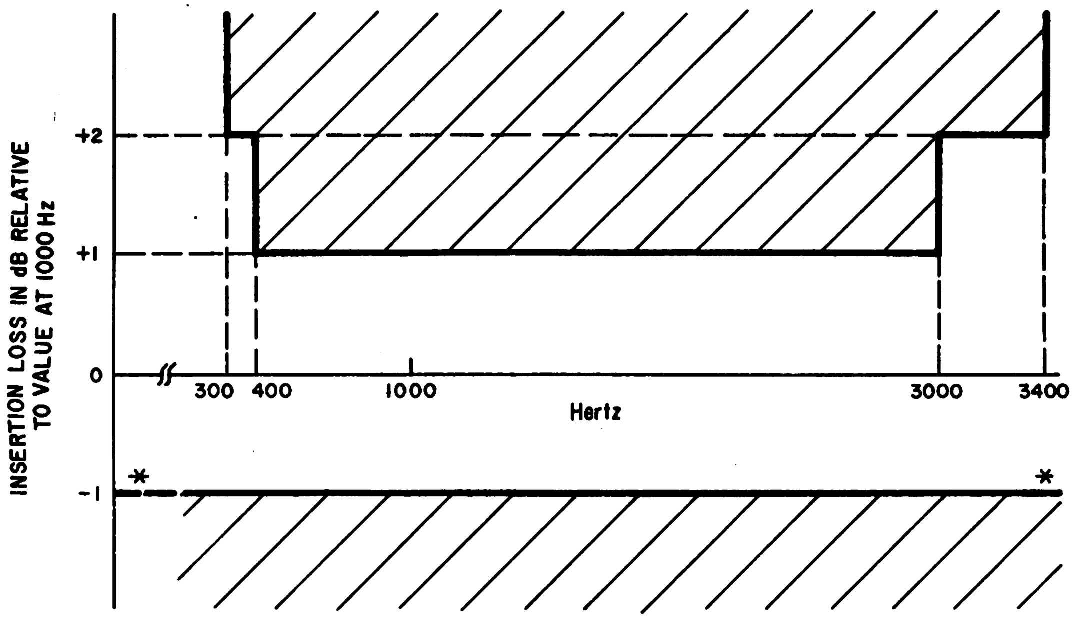


a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



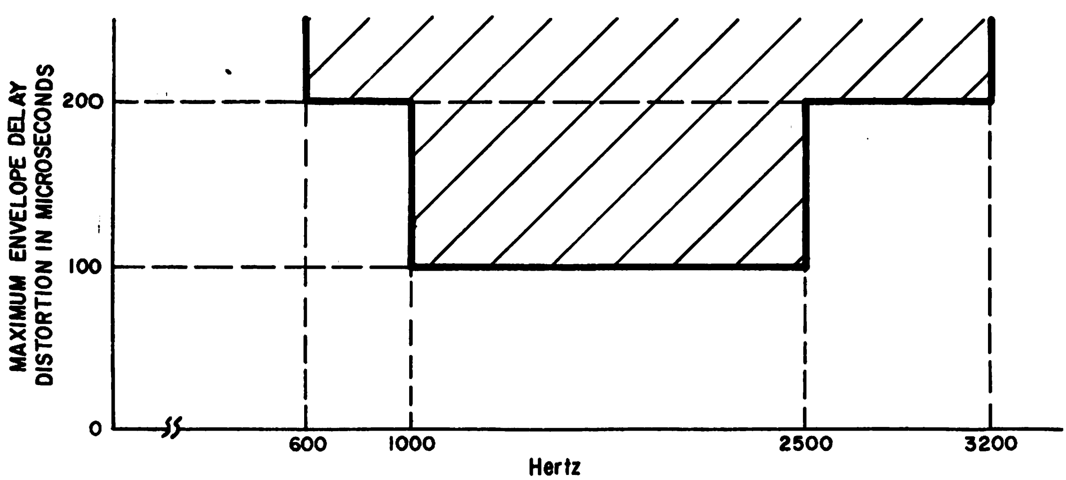
b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.5-6. Parameters for Single Long Haul FDM Reference Voice Bandwidth Link (Type II)



* These upper and lower frequency limits are not specified.

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.5-7. Parameters for Single Tactical Highly Maneuverable FDM Reference Voice Bandwidth Link

4.5.2.5.3 Group Bandwidth Link of Long Haul or Tactical Less Maneuverable System. The spread of the insertion loss versus frequency characteristic of a long haul or a tactical less maneuverable FDM reference group bandwidth link shall not exceed the values given in Table 4.5-6. Loss is indicated by a (+) and gain by a (—) sign. The contributions to the insertion loss of wideband transmission subsystems are considered negligible for stable media.

Table 4.5-6. Insertion Loss Versus Frequency Characteristic for FDM Group Bandwidth Links

Configuration	Loss in dB 60.6 kHz-107.7 kHz
Pair, group translation sets	±0.6
Pair, supergroup translation sets	±2.0
Through group equipment	±1.0
Through supergroup equipment	±1.4
FDM Reference Group Bandwidth Link (Type I)	±2.1
FDM Reference Group Bandwidth Link (Type II)	±4.0

4.5.2.6 Envelope Delay Distortion.

4.5.2.6.1 Voice Bandwidth Link of Long Haul or Tactical Less Maneuverable System. The envelope delay distortion of a long haul or a tactical less maneuverable FDM voice bandwidth link shall not exceed the values given in Table 4.5-7. The contributions to the envelope delay distortion of wideband transmission subsystems are considered negligible for stable media (see Figures 4.5-5b and 4.5-6b).

4.5.2.6.2 Voice Bandwidth Link of Tactical Highly Maneuverable System. The envelope delay distortion of a tactical highly maneuverable FDM reference voice bandwidth link over the frequency bandwidth from 600 Hz to 3200 Hz shall not exceed 200 microseconds (DO: 150 microseconds), except between 1000 Hz and 2500 Hz the envelope delay distortion shall not exceed 100 microseconds (see Figure 4.5-7b).

4.5.2.6.3 Group Bandwidth Link. The envelope delay distortion of a long haul or a tactical less maneuverable FDM group bandwidth link shall not exceed the values given in Table 4.5-8. The contributions to the envelope delay distortion of wideband transmission subsystems are considered negligible for stable media.

4.5.2.7 Net Loss Variation.

4.5.2.7.1 Modulation Link of Long Haul or Tactical Less Maneuverable System. The net loss variation of a long haul or a tactical less maneuverable FDM reference modulation link over any 30 consecutive days shall not exceed the values given in Table 4.5-9.

Table 4.5-7. Envelope Delay Distortion of FDM Reference Voice Bandwidth Links

Configuration	Envelope Delay Distortion in Microseconds (μs)	
	600 Hz-3200 Hz (except 1000 Hz-2500 Hz)	1000 Hz-2500 Hz
Pair, channel translation sets	120	80
Pair, group translation sets	(4 μs in any 4-kHz channel slot, 60 kHz-108-kHz band)	
Pair, supergroup translation sets	(3 μs in any 4-kHz channel slot, except channels 1 and 2, group 1, supergroup 1 and channels 11, and 12, group 5, supergroup 3)	
Through group equipment	20	20
Through supergroup equipment	30	30
FDM Reference Voice Bandwidth Link (Type I)	127	87
FDM Reference Voice Bandwidth Link (Type II)	187	147

Table 4.5-8. Envelope Delay Distortion of FDM Reference Group Bandwidth Links

Configuration	Envelope Delay Distortion in Microseconds (μs)	
	64 kHz-104 kHz (except 68 kHz-100 kHz)	68 kHz-100 kHz
Pair, group translation sets	12	12
Pair, supergroup translation sets	10* 56**	10* 20**
Through group equipment	120	40
Through supergroup equipment	70	70
FDM Reference Group Bandwidth Link (Type I)	22* 68**	22* 32**
FDM Reference Group Bandwidth Link (Type II)	244* 382**	164* 194**

NOTES

* Only for Supergroup 2, and 4 through 10.
** For Supergroup 1 and 3, except Group 1 of Supergroup 1 and Group 5 of Supergroup 3.

Table 4.5-9. Net Loss Variation of FDM Reference Modulation Links

Configuration	Net Loss Variation (dB)
Pair, channel translation sets	±0.5
Pair, group translation sets	±0.5
Pair, supergroup translation sets	±0.5
Through group equipment	±0.2
Through supergroup equipment	±0.2
FDM Reference Voice Bandwidth Link (Type I)	±1.0*
FDM Reference Voice Bandwidth Link (Type II)	±1.4*
FDM Reference Group Bandwidth Link (Type I)	±0.9*
FDM Reference Group Bandwidth Link (Type II)	±1.3*

*These values include an estimate of ±0.5 dB due to the medium and are based on the Root-Sum-Square Law specified in subparagraph 4.6.5.

4.5.2.7.2 Voice Bandwidth Link of Tactical Highly Maneuverable System. As a Design Objective, the net loss variation of a tactical highly maneuverable FDM reference voice bandwidth link shall not exceed ±2 dB over any 30 consecutive days.

4.5.3 Characteristics of Single TDM/PCM Reference Voice Bandwidth Link. Basic features of PCM have been outlined in subparagraph 4.1.2.5.2. Due to the advantages of digital transmission in general and of PCM in particular, this modulation scheme is gaining wide acceptance not only in military but also in commercial communications. Since PCM transmission is compatible with the audio channel described in subparagraphs 4.4.3.1 and 4.4.3.2, TDM/PCM reference voice bandwidth links can be connected in tandem with FDM reference voice bandwidth links on an audio channel-by-channel basis. Thus, a hybrid communication system can be engineered employing digital (TDM/PCM) and analog (FDM) transmissions. An example of such a hybrid system is the planned introduction of TDM/PCM satellite transmission links into the DCS. This satellite subsystem will employ 8-bit PCM with a sampling rate of 8000 samples per second resulting in a digital bit stream of 64 kb/s for each audio channel. On the other hand, the tactical highly maneuverable communication system uses a 6-bit PCM scheme with 48 kb/s for each audio channel, resulting in less bandwidth requirement of the radio spectrum and in lower voice quality as compared with the DCS satellite subsystem.

The TDM/PCM reference voice bandwidth link for long haul and tactical communications is shown in Figure 4.5-8. The voice bandwidth link starts with a group of audio channels at the multiplexer input. Each audio channel has a nominal bandwidth of 4 kHz and is capable of transmitting voice or, under certain conditions, data in quasi-analog form. The amplitudes of the analog signal carried in each audio channel are periodically sampled in time and converted into a time division multiplexed PAM signal. Each PAM sample is then coded into a n-bit code word and this PCM signal, together with framing and synchronization pulses, appears at the multiplexer output where it is fed into a cable interface converter or a radio for transmission.

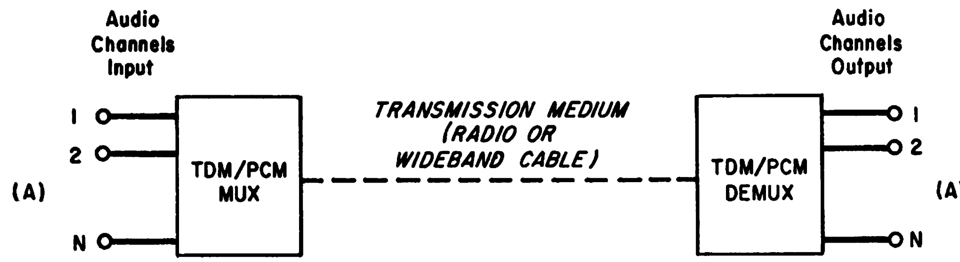


Figure 4.5-8. TDM/PCM Reference Voice Bandwidth Link

The coding process of PCM approximates the infinite number of possible sampled amplitudes of the analog signal by a discrete and therefore finite number of digital code words (quantization). Due to this quantization process, a certain amount of approximation error is inherently introduced. This type of error is called quantizing noise which is an important parameter for describing and measuring the quality of digitized voice transmission. Once the analog information is converted into a quantized digital signal it can be transmitted over tactical and global distances by using regenerative repeaters with little or no additional degradation if the signal is above threshold. Noise can cause errors which regeneration including error control may not be able to correct. Thus, the consideration of media noise specified in subparagraph 4.5.2.3.3 is not applicable to PCM transmission. However, demodulating the digital signal to analog baseband for analog processing (switching, patching, etc.) and modulating it back into a digital form for further transmission will introduce additional quantizing noise and thus degrade the voice quality. Therefore, in such systems, the number of analog/digital-digital/analog conversions has to be limited in order to keep the received quantizing noise sufficiently low.

At the receiving end the pulse stream is decoded, demultiplexed, and the PAM samples are demodulated to analog baseband. PCM quantizing noise is not present per se when the audio channel is idle but appears together with the analog signal at the receiver and varies with the instantaneous amplitude of the analog signal. However, PCM idle channel noise is present whenever information is not transmitted (see subparagraph 4.5.3.4.1). Therefore, quantizing noise influences intelligibility in a different way than thermal noise does. One method of determining the influence of quantizing noise on intelligibility is by comparing subjective listener tests of speech received through two parallel audio channels. In one channel the speech is transmitted in digitized form derived from PCM; in the other channel the same speech is transmitted in analog (non-digitized) form. For this comparison, the thermal noise in the non-digitized speech channel is simulated by a noise generator which has an adjustable noise power output. An amount of thermal noise power in the non-digitized speech channel can be determined such that the thermal noise has a similar effect on the speech quality as the quantizing noise which is generated in the PCM channel. The amount of thermal noise power determined by this comparison is called the equivalent PCM noise. For the purpose of this standard, the equivalent PCM noise is used to determine the contributions by TDM/PCM links to the total circuit noise when FDM and TDM/PCM links are connected in tandem for voice service (see subparagraph 4.5.3.4.3).

The following parameters given in subparagraphs 4.5.3.2 through 4.5.3.12 are for a single link when properly terminated. A single link in this context comprises a channel which joins two points and wherein the analog signal is coded into digital form at the originating end of the channel, for transmission over the entire channel under consideration, and decoded into analog at the terminating end of the channel. The characteristics of this nominal 4-kHz channel are specified for the four-wire analog input and output terminals of the link (see Figure 4.5-8). The characteristics of the TDM/PCM reference voice bandwidth link are based on the characteristics of the multiplex signal of the TDM/PCM equipment described in subparagraph 4.5.3.1.

4.5.3.1 Characteristics of the Multiplex Signal.

4.5.3.1.1 Sampling Rate. Each nominal 4-kHz channel of a long haul or of a tactical TDM/PCM reference voice bandwidth link shall be sampled at a nominal rate of 8000 samples per second.

4.5.3.1.2 Number of Digits per Sample.

4.5.3.1.2.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. Each sample from a nominal 4-kHz audio channel shall be encoded into an 8-bit folded binary code word with the most significant bit transmitted first.

4.5.3.1.2.2 Tactical TDM/PCM Reference Voice Bandwidth Link. Each sample from a nominal 4-kHz audio channel shall be encoded into a 6-bit binary code word with the most significant bit transmitted first.

4.5.3.1.3 Compandor Characteristics.

4.5.3.1.3.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. An instantaneous compandor shall be used. As a Design Objective, the compressor shall have a 15-segment characteristic with the input step size on each segment twice that of the segment next closest to the center of the range. The expandor shall have the complementary transfer characteristic of the compressor.

4.5.3.1.3.2 Tactical TDM/PCM Reference Voice Bandwidth Link. An instantaneous compandor shall be used. The compressor shall have a 3-segment, straight-line transfer characteristic. The expandor shall have the complementary transfer characteristic of the compressor. The compression ratio, defined as the initial to average slope, shall be 20 dB, ±1 dB. For details see MIL-STD-188C (to be replaced by the MIL-STD-188-200 series).

4.5.3.1.4 Frame Synchronization.

4.5.3.1.4.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. There presently is no standard PCM frame synchronization technique used in long haul communications. Currently two methods are applicable and will remain in effect until such time that a technique has been standardized. The two methods presently applicable on a subsystem-by-subsystem basis are described below:

(a) The framing information shall be generated at the transmit portions of the PCM multiplexer and added to the PCM output. The framing information shall be submultiplexed into the PCM output using the least significant bit of the 8-bit code word of each channel in one out of every twelve frames. Detectors at the PCM input to the demultiplexer shall extract this information for synchronizing the receive circuits with the incoming PCM bit stream.

(b) Framing information shall be generated at the transmit portion of the PCM multiplexer and added to the PCM output. The framing information shall be obtained by adding an additional bit (193'rd bit) after each twenty-four 8-bit channels (192 bits). Detectors at the PCM input to the demultiplexer shall extract this information for synchronizing receive circuits with the incoming PCM bit stream.

4.5.3.1.4.2 Tactical TDM/PCM Reference Voice Bandwidth Link. Frame synchronization information shall be added to the PCM output of the multiplexer. This information shall consist of one frame bit substituted for the least significant bit of the binary code word in the last channel of the channel group. The frame bit shall have the same shape and amplitude characteristics as the remaining code word bits.

4.5.3.2 Standard Test Signal Levels.

4.5.3.2.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. The test signal level at the four-wire input of the long haul TDM/PCM reference voice bandwidth link shall be −16 dBm. The test signal level at the four-wire output of the long haul TDM/PCM reference voice bandwidth link shall be +7 dBm.

4.5.3.2.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The test signal levels at the four-wire input and at the four-wire output of the tactical TDM/PCM reference voice bandwidth link shall be −4 dBm. In tactical TDM/PCM reference voice bandwidth links with two-wire terminations (hybrids), the test signal levels at the four-wire point of a connection to the hybrid shall be −4 dBm transmitting into the reference voice bandwidth link and +1 dBm receiving from the reference voice bandwidth link.

4.5.3.3 Standard Test Signal Frequency. The signal used for transmission testing on long haul and tactical TDM/PCM reference voice bandwidth links shall have a frequency of 1000 Hz ±25 Hz, preferably 1020 Hz.

NOTE: PCM signal processing can generate unique forms of nonlinear distortion which have no direct counterpart in analog transmission. The sources of these types of nonlinear PCM distortion are sampling, quantizing, mistracking of the instantaneous compandor, and filtering methods used to limit the demultiplexed PAM samples to audio bandwidth signals. Test signal frequencies which are exactly rational fractions of the 8000-Hz PCM sampling rate, such as 800-Hz, 1000-Hz, 1600-Hz, etc., can cause nonlinear PCM distortion and therefore should not be used. This nonlinear PCM distortion results in fluctuating meter readings which can be avoided by changing the 1000-Hz test signal frequency by a few hertz. Changing the 1000-Hz test signal frequency could have an impact on current test equipment.

4.5.3.4 Noise.

4.5.3.4.1 Idle Channel Noise. PCM idle channel noise of a single voice bandwidth link and of several links in tandem is generally much lower than FDM idle channel noise. Therefore, to the operation/maintenance personnel and to the user, the PCM channel may appear out of service when information is not transmitted. One method of avoiding this misjudgment is employing a noise generator in the PCM multiplexer which inserts a small amount of thermal noise into the TDM/PAM signal common to an audio channel group before the PAM signal is coded into a PCM signal. The noise generator is adjusted at a mean noise level which will cause a variation of one coder level. This random change of a coder level will create the subjective impression of an FDM idle channel noise level at each PCM audio channel output.

4.5.3.4.1.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the noise measured at the receiving end of any idle audio channel of a long haul TDM/PCM reference voice bandwidth link, when referenced to the Zero Transmission Level Point (0TLP), shall not exceed 400 pWp0 (approximately 26 dBrnc0).

4.5.3.4.1.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The noise measured at the receiving end of any idle audio channel of a tactical TDM/PCM reference voice bandwidth link, when referenced to the tactical, highly maneuverable 0TLP, shall not exceed 4000 pWp0 (approximately 36 dBrnc0).

4.5.3.4.2 Test Signal-to-Quantizing Noise Ratio.

4.5.3.4.2.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, a sine wave signal with a frequency of 1000 Hz ±25 Hz, preferably 1020 Hz, at the input of any audio channel of a long haul TDM/PCM reference voice bandwidth link shall produce at the output of the same audio channel a minimum test signal-to-quantizing noise ratio, C-message weighted, as follows:

Input Signal in dBm0	Input Signal in dBm at -16 TLP	Minimum Test Signal-to-Quantizing Noise Ratio in dB
0 to -25	-16 to -41	34
-26 to -30	-42 to -46	33
-31 to -40	-47 to -56	27
-41 to -45	-57 to -61	22

4.5.3.4.2.2 Tactical TDM/PCM Reference Voice Bandwidth Link. A sine wave signal with a frequency of 1000 Hz ±25 Hz, preferably 1020 Hz, at the input of any audio channel of a tactical TDM/PCM reference voice bandwidth link shall produce at the output of the same audio channel a minimum test signal-to-quantizing noise ratio as stated below. The quantizing noise shall be measured with flat weighting over the frequency bandwidth from 300 Hz to 3400 Hz of a nominal 4-kHz channel.

Input Signal in dBm0	Input Signal in dBm at -4 TLP	Minimum Test Signal-to-Quantizing Noise Ratio in dB	
		DO	Standard
0	-4		30
-1 to -16	-5 to -20	30	17
-17 to -26	-21 to -30	25	15
-27 to -36	-31 to -40	16	14

4.5.3.4.3 Equivalent PCM Noise.

4.5.3.4.3.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the equivalent PCM noise of a long haul TDM/PCM reference voice bandwidth link when referenced to a 0TLP shall not exceed 160 pWp0 (approximately 22 dBrnc0).

4.5.3.4.3.2 Tactical TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the equivalent PCM noise of a tactical TDM/PCM reference voice bandwidth link when referenced to a tactical highly maneuverable 0TLP shall not exceed 12,500 pWp0 (approximately 41 dBrnc0).

4.5.3.5 Link Input/Output Impedances. The audio input and output impedances of a nominal 4-kHz channel of a long haul or of a tactical TDM/PCM reference voice bandwidth link shall each be 600 ohms, balanced to ground, with a minimum return loss of 26 dB against a 600-ohm resistance over the frequency bandwidth from 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

4.5.3.6 Link Input/Output Linearity.

4.5.3.6.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the input/output level characteristic of a nominal 4-kHz channel of a long haul TDM/PCM reference voice bandwidth link shall be linear within ±0.5 dB for input signals from −16 dBm to −53 dBm; ±1.0 dB for input signals between −53 dBm and −67 dBm; and ±3.0 dB for input signals between −67 dBm and −70 dBm; at an input level of −11 dBm, the output level shall not be greater than +11.2 dBm.

4.5.3.6.2 Tactical TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the input/output level characteristic of a nominal 4-kHz four-wire channel of a tactical TDM/PCM reference voice bandwidth link shall be linear within ±0.5 dB (with a mean of zero) for input signal levels from −4 dBm to −40 dBm.

4.5.3.7 Insertion Loss Versus Frequency Characteristic.

4.5.3.7.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the insertion loss versus frequency characteristic referenced to 1000 Hz of a long haul TDM/PCM reference voice bandwidth link shall not exceed the values given in Table 4.5-10. Loss is indicated by a (+) and gain by a (—) sign (see Figure 4.5-9a).

Table 4.5-10. Insertion Loss Versus Frequency Characteristic of Long Haul TDM/PCM Reference Voice Bandwidth Link

Frequency in Hz	Insertion Loss in dB
Below 200	Greater than 0
200-300	Greater than -0.7
300-400	-0.7 to +3.0
400-600	-0.7 to +1.5
600-2400	-0.7 to +0.7
2400-3000	-0.7 to +1.5
3000-3400	-0.7 to +3.0
3400-4600	Greater than -0.7
Above 4600	Greater than +40.0

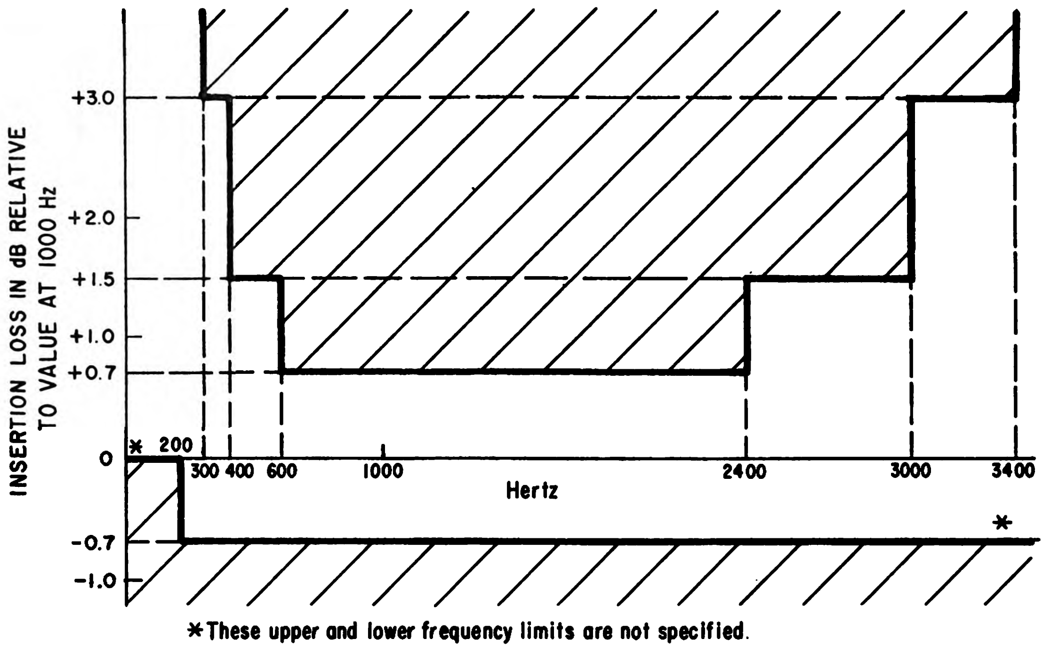
4.5.3.7.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The insertion loss versus frequency characteristic, referenced to 1000 Hz of a tactical TDM/PCM reference voice bandwidth link over the frequency bandwidth from 300 Hz to 3400 Hz, shall be within the limits of —1 dB to +2 dB, except over the frequency bandwidth from 400 Hz to 3000 Hz it shall be within the limits of ±1 dB. Loss is indicated by a (+) and gain by a (—) sign (see Figure 4.5-10a).

4.5.3.8 Envelope Delay Distortion.

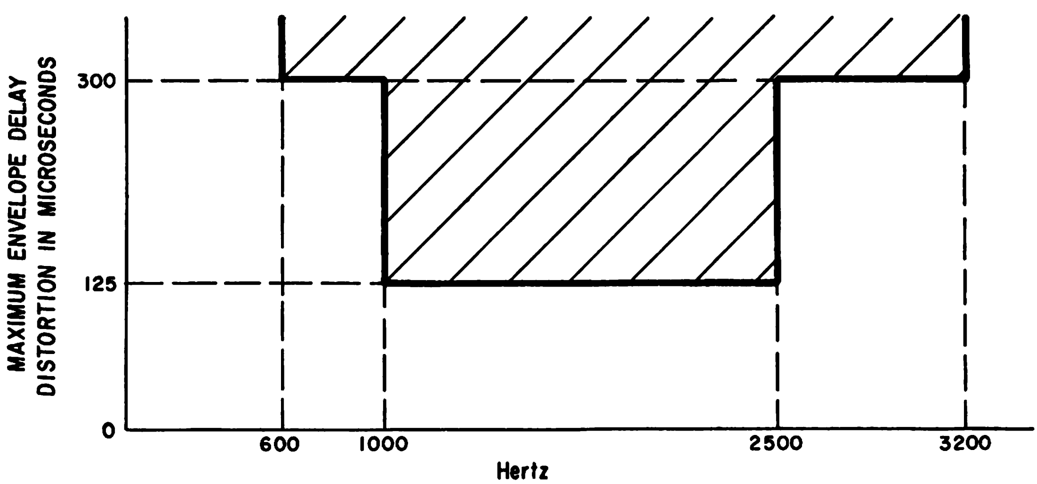
4.5.3.8.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the envelope delay distortion of a long haul TDM/PCM reference voice bandwidth link over the frequency bandwidth from 600 Hz to 3200 Hz shall not exceed 300 microseconds, except between 1000 Hz and 2500 Hz the envelope delay distortion shall not exceed 125 microseconds (see Figure 4.5-9b).

NOTE: The rather large value of this parameter as compared to the envelope delay distortion of a tactical (6-bit) TDM/PCM reference voice bandwidth link is due to other characteristics of the 8-bit PCM multiplexer equipment.

4.5.3.8.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The envelope delay distortion of a tactical TDM/PCM reference voice bandwidth link over the frequency bandwidth from 600 Hz to 3200 Hz shall not exceed 200 microseconds (DO: 150 microseconds), except between 1000 Hz and 2500 Hz the envelope delay distortion shall not exceed 100 microseconds (see Figure 4.5-10b).

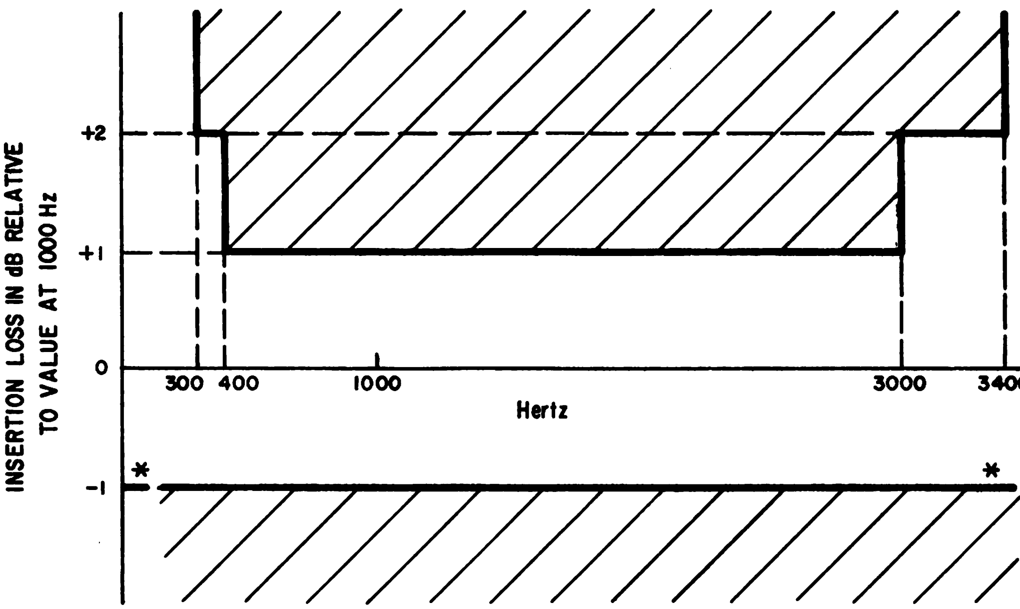


a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



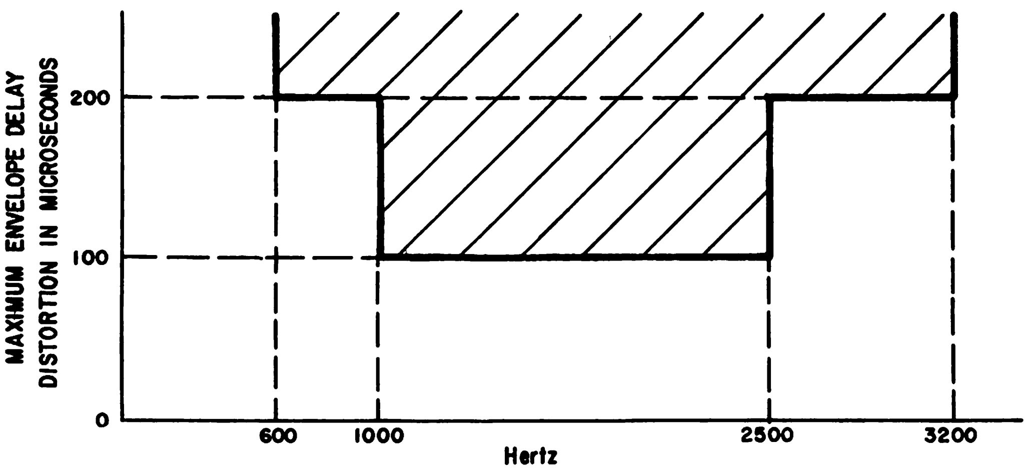
b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.5-9. Parameters for Single Long Haul TDM/PCM Reference Voice Bandwidth Link



* These upper and lower frequency limits are not specified

a. INSERTION LOSS VERSUS FREQUENCY CHARACTERISTIC



b. MAXIMUM ENVELOPE DELAY DISTORTION

Figure 4.5-10. Parameters for Single Tactical TDM/PCM Reference Voice Bandwidth Link

4.5.3.9 Total Harmonic Distortion.

4.5.3.9.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the total harmonic distortion of any audio channel of a long haul TDM/PCM reference voice bandwidth link produced by any single frequency test signal within the frequency band between 300 Hz and 3400 Hz shall be at least 34 dB below the demultiplexer output signal level. The test signal shall be introduced into the link at a level of 0 dBm0, that is, −16 dBm at the −16 TLP (see subparagraph 4.4.3.2.2.3).

4.5.3.9.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The total harmonic distortion of any audio channel of a tactical TDM/PCM reference voice bandwidth link produced by any single frequency test signal within the frequency band between 300 Hz and 3400 Hz shall be at least 30 dB (DO: 40 dB) below the demultiplexer output signal level. The test signal shall be introduced into the four-wire link at a level of 0 dBm0, that is, −4 dBm at the −4 TLP (see subparagraph 4.4.3.2.2.3).

4.5.3.10 Intermodulation Distortion.

4.5.3.10.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective, the individual intermodulation distortion products of any audio channel of a long haul TDM/PCM reference voice bandwidth link produced by any two equal level single frequency tones within the frequency band between 300 Hz and 3400 Hz shall be at least 38 dB below the demultiplexer output signal level. Each single frequency tone shall be introduced into the reference voice bandwidth link at a level of −6 dBm0, that is, −22 dBm at the −16 TLP.

> NOTE: The nominal input level of the long haul 8-bit PCM multiplexer is −16 dBm (−16 TLP). The power level of each single frequency tone has been chosen so that the sum of the powers of the two equal level tones is −19 dBm which is 3 dB below the nominal input level of the multiplexer. This power level of −19 dBm results in a peak power identical with the nominal −16 dBm input level of the multiplexer.

4.5.3.10.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The individual intermodulation distortion products of any audio channel of a tactical TDM/PCM reference voice bandwidth link produced by any two equal level single frequency tones within the frequency band between 300 Hz and 3400 Hz shall be at least 38 dB (DO: 45 dB) below the demultiplexer output signal level. Each single frequency tone shall be introduced into the reference voice bandwidth link at a level of −6 dBm0, that is, −10 dBm at the −4 TLP.

> NOTE: The nominal input level of the tactical 6-bit PCM multiplexer is −4 dBm (−4 TLP). The power level of each single frequency tone has been chosen so that the sum of the powers of the two equal level tones is −7 dBm which is 3 dB below the nominal input level of the multiplexer. This power level of −7 dBm results in a peak power identical with the nominal −4 dBm input level of the multiplexer.

4.5.3.11 Crosstalk.

4.5.3.11.1 Long Haul TDM/PCM Reference Voice Bandwidth Link. As a Design Objective the near end or the far end test-signal-to-noise plus crosstalk ratio in any idle audio channel of a long haul TDM/PCM reference voice bandwidth link, due to full test signal modulation of −16 dBm at the −16 TLP of any other audio channel, shall be at least 65 dB, C-message weighted, below the demultiplexer output signal level.

4.5.3.11.2 Tactical TDM/PCM Reference Voice Bandwidth Link. The near end or the far end test-signal-to-noise plus crosstalk ratio in any idle audio channel of a tactical TDM/PCM reference voice bandwidth link due to full test signal modulation of −4 dBm at the −4 TLP of any other audio channel shall be at least 53 dB F1A weighted below the demultiplexer output signal level.

4.5.3.12 Net Loss Variation. As a Design Objective, the net loss variation of a long haul or of a tactical TDM/PCM reference voice bandwidth link shall not exceed ±0.25 dB over any 24 consecutive hours (short term variation) and shall not exceed ±1.0 dB over any 30 consecutive days (long term variation).

4.6 Transfer Characteristics of Reference Links in Tandem.

4.6.1 General. Assumed methods for summation of the individual link transfer characteristics to obtain the corresponding tandem characteristic are given in the following subparagraphs 4.6.2 through 4.6.5. In general, these assumed methods should only be used if the parameters contributed by the single links are specified over identical frequency ranges. However, if the parameters are specified over different frequency ranges, then the smaller frequency range will govern the overall frequency response and the summation rule should only be applied to the smaller frequency range. For example, when the insertion loss versus frequency characteristic of loops and links in tandem are combined to obtain the reference circuit characteristics of paragraph 4.7, the summation rules have been applied with respect to the frequency bandwidth assumed for the loops.

These summation methods are applicable to analog service (voice and facsimile) on a user-to-user basis by considering loop and channel characteristics in tandem. These methods are also applicable to data service from the transmitting quasi-analog modem output to the receiving quasi-analog modem input, providing there is no regeneration employed between the modems. If regeneration is employed then each regeneration point acts as a data sink/data source combination and the summation methods will only be applicable from regeneration point to regeneration point and not on a circuit basis from user-to-user.

4.6.2 Noise. It is assumed that the total noise power in picowatts of FDM or TDM/PCM reference links in tandem is the sum of the noise powers in picowatts contributed by the single links, provided the noise powers are referenced to the same transmission level point (TLP) and represent the same type of noise, e.g., worst hour median noise or all year median noise. If the noise powers are not referenced to the same TLP then they have to be converted to a common TLP before they can be summed. Noise powers expressed in units of dB cannot be added algebraically but must be converted first to units of picowatts. When FDM and TDM/PCM links are connected in tandem for voice service, the equivalent PCM noise is used to determine the contributions by TDM/PCM links to the total circuit noise (see subparagraphs 4.5.3 and 4.5.3.4.3).

NOTE: For the purpose of this standard, the following approximate relationship between y units of dBrnc and x units of pWp is used: $y = 10 \log_{10} x$.

4.6.3 Insertion Loss Versus Frequency Characteristic. It is assumed that the insertion loss versus frequency characteristic (in dB) over the band of interest of FDM or TDM/PCM reference links in tandem is obtained by summing the squares of the insertion loss (in dB) contributed by the single links and taking the square root of this sum (Root-Sum-Square Law).

4.6.4 Envelope Delay Distortion. It is assumed that the envelope delay distortion of FDM or TDM/PCM reference links in tandem is the sum of the envelope delay distortion contributed by the single links.

4.6.5 Net Loss Variation. It is assumed that the net loss variation (in dB) of FDM or TDM/PCM reference links in tandem is obtained by summing the squares of the variations (in dB) contributed by the single links and taking the square root of this sum (Root-Sum-Square Law).

4.7 Hypothetical Reference Circuit Examples.

4.7.1 General. Common long haul/tactical hypothetical reference circuits consist of combinations of the previously defined reference voice bandwidth links connected in tandem. Because of the large number of hypothetical combinations which are possible, only a selected number of examples of hypothetical connections are discussed in the following subparagraphs.

The first four examples depict the use of noise proration or allocation in tandem trunks and do not include the effects of loops.

The parameters of Examples 1 through 4, such as noise and envelope delay distortion shown in subparagraphs 4.7.2 through 4.7.5, are only applicable to analog service (voice and facsimile) and to quasi-analog data service without regeneration between the end terminals of a channel. See subparagraph 4.6.1 for calculating the transfer characteristics of data links in tandem with regeneration employed.

Examples 1 and 3 depict worst case examples where the long haul TDM/PCM links are not available. Example 1 considers a hypothetical connection including tactical less maneuverable assets while Example 3 considers one including tactical highly maneuverable assets.

Examples 2 and 4 show what is hypothetically possible utilizing the long haul TDM/PCM links. Examples 5, 6, and 7 address AUTOVON and AUTODIN service.

Example 8 extends Examples 1 through 4 to include the hypothetical effects of loop characteristics on the overall user-to-user circuit.

Examples 9 through 12 show signal level diagrams for a user-to-user circuit traversing long haul and tactical trunks and loops.

4.7.2 Example 1: Long Haul/Tactical Less Maneuverable FDM Connection. Figure 4.7-1 shows an example of a hypothetical connection over long haul/tactical less maneuverable channels utilizing FDM techniques exclusively. At the left of the figure is a line diagram to facilitate visualization, but it is not drawn to scale. The circles in the line diagram represent nodes which may include technical control facilities and switches. The first column from the left shows the nominal length of the reference links between the nodes. The Roman numeral I indicates a reference voice bandwidth link Type I with no multiplex translations between the end multiplexers of the link (see Figure 4.5-1), whereas Roman numeral II indicates a reference voice bandwidth link Type II with multiplex translations between the end multiplexers of the link (see Figure 4.5-2).

4.7.2.1 Noise. For Example 1, addition of the noise allocated to the medium and multiplex equipment for each reference link indicates that an overall connection with a noise performance of about 35,000 pWp0 (approximately 45.5 dBrnc0) is possible. This addition utilizes the summation method defined in subparagraph 4.6.2.

4.7.2.2 Insertion Loss Versus Frequency Characteristic. By applying the summation method defined in subparagraph 4.6.3, the following are the expected values of the insertion loss versus frequency characteristic referenced to 1000 Hz for the connection of Example 1:

300 Hz to 3400 Hz (Except 400 Hz to 3000 Hz)	400 Hz to 3000 Hz
−3.3 dB, +8.1 dB	±3.3 dB

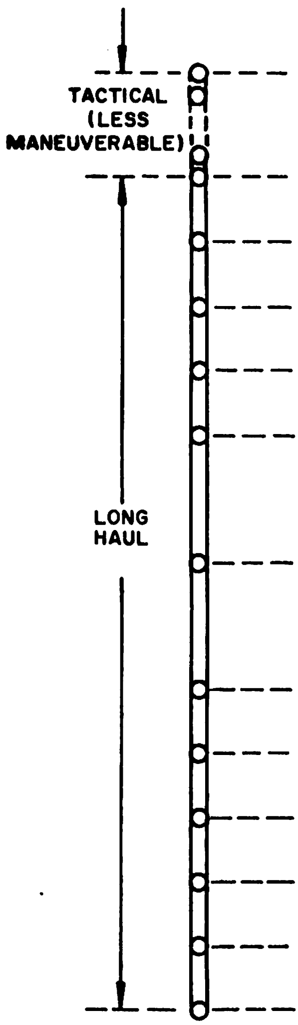
4.7.2.3 Envelope Delay Distortion. By utilizing the summation method defined in subparagraph 4.6.4, the following are the expected values of envelope delay distortion over the range of frequencies indicated:

600 Hz to 3200 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
2,339 microseconds	1,659 microseconds

4.7.2.4 Net Loss Variation. By utilizing the summation method defined in subparagraph 4.6.5, the expected value of net loss variation is ±4.5 dB.

4.7.3 Example 2: Long Haul/Tactical Less Maneuverable FDM-TDM/PCM Connection. Figure 4.7-2 shows an example utilizing TDM/PCM techniques on a long haul satellite system and FDM techniques on other links. The general layout is the same as described in Example 1.

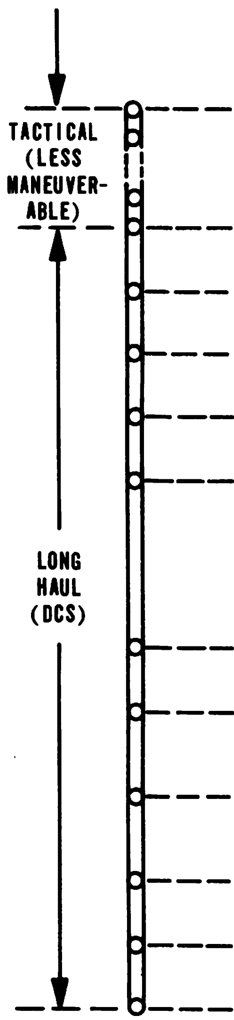
4.7.3.1 Noise. The results indicate that a connection with a noise performance of about 26,000 pWp0 (approximately 44.2 dBrnc0) is hypothetically attainable, following the summation method defined in subparagraph 4.6.2.



NOMINAL DISTANCE	VOICE BAND-WIDTH LINK (FDM)	MEDIA (Example)	MAX. MEDIA NOISE pWpO	MAX. MUX NOISE pWpO
1850 km (1000 nmi)	I (6 IN TANDEM)	RADIO	6,667	786
617 km (333 nmi)	I	RADIO	1,111	131
617 km (333 nmi)	I	RADIO	1,111	131
1850 km (1000 nmi)	II	RADIO	3,333	341
617 km (333 nmi)	I	RADIO	1,111	131
5556 km (3000 nmi)	I	SUBMARINE CABLE	4,500	131
5556 km (3000 nmi)	I	SUBMARINE CABLE	4,500	131
617 km (333 nmi)	I	RADIO	1,111	131
1850 km (1000 nmi)	II	RADIO	3,333	341
1850 km (1000 nmi)	II	RADIO	3,333	341
617 km (333 nmi)	I	RADIO	1,111	131
617 km (333 nmi)	I	RADIO	1,111	131
22,214 km (12,000 nmi)	TOTAL NOISE		32,332	2857

TOTAL NOISE	35,189 pWpO (APPROX. 45.5 dBrncO)

Figure 4.7-1. Reference Channel Example 1: Long Haul/Tactical Less Maneuverable FDM Connection Excluding Loops



NOMINAL DISTANCE	VOICE BANDWIDTH LINK (FDM or PCM)	MEDIA (Example)	TOTAL MAX. NOISE (MUX and Media) pWp0
1850. km (1000 nmi)	I (6 in tandem)	Radio	7,453
617 km (333 nmi)	I	Radio	1,242
617 km (333 nmi)	I	Radio	1,242
1850 km (1000 nmi)	II	Radio	3,674
617 km (333 nmi)	I	Radio	1,242
11,112 km (6000 nmi)	PCM	Satellite	160 (Equivalent PCM Noise)
617 km (333 nmi)	I	Radio	1,242
1850 km (1000 nmi)	II	Radio	3,674
1850 km (1000 nmi)	II	Radio	3,674
617 km (333 nmi)	I	Radio	1,242
617 km (333 nmi)	I	Radio	1,242
22,214 km (12,000 nmi)	TOTAL NOISE	26,087 pWp0 (Approx. 44.2 dBrnc0)	

Figure 4.7-2. Reference Channel Example 2: Long Haul/Tactical Less Maneuverable FDM-TDM/PCM Connection Excluding Loops

4.7.3.2 Insertion Loss Versus Frequency Characteristic. By applying the summation method defined in subparagraph 4.6.3, the following are the expected values of the insertion loss versus frequency characteristic referenced to 1000 Hz for the connection of Example 2:

300 Hz to 3400 Hz (Except 400 Hz to 3000 Hz)	400 Hz to 3000 Hz
−3.2 dB, +8.2 dB	−3.2 dB, +3.4 dB

4.7.3.3 Envelope Delay Distortion. By utilizing the summation method defined in subparagraph 4.6.4, the following are the expected values of envelope delay distortion over the range of frequencies indicated:

600 Hz to 3200 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
2,385 microseconds	1,610 microseconds

4.7.3.4 Net Loss Variation. By utilizing the summation method defined in subparagraph 4.6.5, the expected value of net loss variation is ±4.4 dB.

4.7.4 Example 3: Long Haul/Tactical Highly Maneuverable FDM Connection. Figure 4.7-3 (Example 3) shows a connection of long haul FDM voice bandwidth links in tandem with tactical highly maneuverable FDM voice bandwidth links. The general layout is the same as described in Example 1.

4.7.4.1 Noise. In Figure 4.7-3, the total maximum noise of 15,000 pWp0 of three tactical highly maneuverable FDM links in tandem is referenced to the 0TLP of the long haul circuit for both directions of transmission. Using the summation method defined in subparagraph 4.6.2, the result indicates that a noise performance of about 46,000 pWp0 (approximately 46.6 dBrnc0) is hypothetically attainable, provided that the tactical portion of the connection is limited to three tandem links.

> NOTE: According to subparagraph 4.5.2.3.4, each tactical highly maneuverable FDM link contributes a maximum noise of 25,000 pWp0 at the 0TLP or 10,000 pWp at the −4 TLP of a tactical highly maneuverable circuit. The total maximum noise of three tactical highly maneuverable FDM links in tandem is 30,000 pWp at the −4 TLP. Since the −4 TLP of a tactical highly maneuverable circuit is connected to the 0TLP of a long haul circuit either by a 3 dB amplifier or a 3 dB attenuator (see Figure 4.7-8), the total maximum noise of three tactical FDM tandem links is 15,000 pWp0 referenced to the long haul 0TLP for both transmission directions of the common connection shown in Figure 4.7-3.

4.7.4.2 Insertion Loss Versus Frequency Characteristic. By applying the summation method defined in subparagraph 4.6.3, the following are the expected values of the insertion loss versus frequency characteristic referenced to 1000 Hz for the connection of Example 3:

NOTE: Tactical (highly maneuverable) channel is limited to three links

TACTICAL (HIGHLY MANEUVER-ABLE)

LONG HAUL (DCS)

NOMINAL DISTANCE	VOICE BANDWIDTH LINK (FDM)	MEDIA (Example)	TOTAL MAX. NOISE (MUX and Media) pWp0
150 km (84 nmi)	1 (3 in tandem)	Radio	25,000
309 km (167 nmi)	I	Radio	686
617 km (333 nmi)	I	Radio	1,242
1850 km (1000 nmi)	II	Radio	3,674
1850 km (1000 nmi)	II	Radio	3,674
617 km (333 nmi)	I	Radio	1,242
5556 km (3000 nmi)	I	Sub Cable	4,631
5556 km (3000 nmi)	I	Sub Cable	4,631
617 km (333 nmi)	I	Radio	1,242
1850 km (1000 nmi)	II	Radio	3,674
1850 km (1000 nmi)	II	Radio	3,674
617 km (333 nmi)	I	Radio	1,242
617 km (333 nmi)	I	Radio	1,242
22,056 km (11,916 nmi)	TOTAL NOISE	45,854 pWp0 (Approx. 46.6 dBrnc0)	

Figure 4.7-3. Reference Channel Example 3: Long Haul/Tactical Highly Manueverable FDM Connection Excluding Loops

300 Hz to 3400 Hz (Except 400 Hz to 3000 Hz)	400 Hz to 3000 Hz
−3.4 dB, +7.8 dB	±3.4 dB

4.7.4.3 Envelope Delay Distortion. By utilizing the summation method defined in subparagraph 4.6.4, the following are the expected values of envelope delay distortion over the range of frequencies indicated.

600 Hz to 3200 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
2,364 microseconds	1,584 microseconds

4.7.4.4 Net Loss Variation. By utilizing the summation method defined in subparagraph 4.6.5, the expected value of net loss variation is ±4.3 dB.

4.7.5 Example 4: Long Haul/Tactical Highly Maneuverable FDM-TDM/PCM Connection. Figure 4.7-4 (Example 4) shows a connection of long haul FDM voice bandwidth links including a TDM/PCM satellite link in tandem with tactical highly maneuverable TDM/PCM voice bandwidth links. The general layout of the connection is the same as described in Example 1.

4.7.5.1 Noise. In Figure 4.7-4, the total maximum noise of 15,000 pWp0 (equivalent PCM noise) of six tactical highly maneuverable TDM/PCM links in tandem is referenced to the 0TLP of the long haul circuit for both directions of transmission. Using the summation method defined in subparagraph 4.6.2, the result indicates that a noise performance of about 37,000 pWp0 (approximately 45.7 dBrnc0) is hypothetically attainable for the connection shown in Example 4.

> NOTE: According to subparagraph 4.5.3.4.3.2, each tactical highly maneuverable TDM/PCM link contributes a maximum equivalent PCM noise of 12,500 pWp0 at the 0TLP or 5,000 pWp at the −4 TLP of a tactical highly maneuverable circuit. The total maximum equivalent PCM noise of six tactical highly maneuverable TDM/PCM links in tandem is 30,000 pWp at the −4 TLP. Since the −4 TLP of a tactical highly maneuverable circuit is connected to the 0TLP of a long haul circuit either by a 3-dB amplifier or a 3-dB attenuator (see Figure 4.7-8), the total maximum equivalent PCM noise of six tactical TDM/PCM tandem links is 15,000 pWp0 referenced to the long haul 0TLP for both transmission directions of the common connection shown in Figure 4.7-4.

4.7.5.2 Insertion Loss Versus Frequency Characteristic. By applying the summation method defined in subparagraph 4.6.3, the following are the expected values of the insertion loss versus frequency characteristic referenced to 1000 Hz for the connection of Example 4:

300 Hz to 3400 Hz (Except 400 Hz to 3000 Hz)	400 Hz to 3000 Hz
−3.8 dB, +8.6 dB	−3.8 dB, +4.0 dB

*Equivalent PCM Noise

	NOMINAL DISTANCE	VOICE BANDWIDTH LINK (FDM OR PCM)	MEDIA (Example)	TOTAL MAX. NOISE (MUX and Media) pWp0
TACTICAL (HIGHLY MANEUVER-ABLE)	300 km (162 nmi)	PCM (6 in Tandem)	Radio	15,000 *
LONG HAUL	309 km (167 nmi)	I	Radio	686
	617 km (333 nmi)	I	Radio	1,242
	1850 km (1000 nmi)	II	Radio	3,674
	1850 km (1000 nmi)	II	Radio	3,674
	617 km (333 nmi)	I	Radio	1,242
	11,112 km (6000 nmi)	PCM	Satellite	160 *
	617 km (333 nmi)	I	Radio	1,242
	1850 km (1000 nmi)	II	Radio	3,674
	1850 km (1000 nmi)	II	Radio	3,674
	617 km (333 nmi)	I	Radio	1,242
	617 km (333 nmi)	I	Radio	1,242
	22,206 km (12,000 nmi)	TOTAL NOISE		36,752 pWp0 (Approx. 45.7 dBrnc0)

Figure 4.7-4. Reference Channel Example 4: Long Haul/Tactical Highly Maneuverable FDM-TDM/PCM Hybrid Connection Excluding Loops

4.7.5.3 Envelope Delay Distortion. By utilizing the summation method defined in subparagraph 4.6.4, the following are the expected values of envelope delay distortion over the range of frequencies indicated:

600 Hz to 3200 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
3,010 microseconds	1,835 microseconds

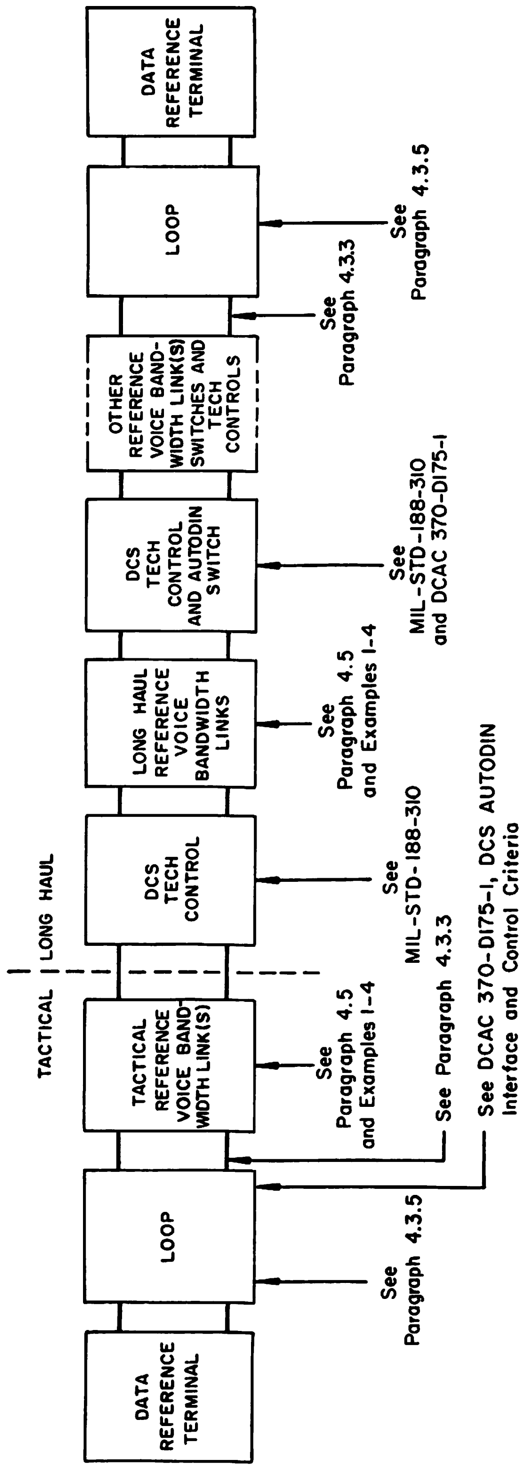
4.7.5.4 Net Loss Variation. By utilizing the summation method defined in subparagraph 4.6.5, the expected value of net loss variation is ±4.6 dB.

4.7.6 Example 5: AUTODIN Long Haul/Tactical Connection. Figure 4.7-5 (Example 5) illustrates how and where the reference voice bandwidth links and the data reference terminations are applicable in an AUTODIN long haul/tactical connection. In this example, applicable standards and criteria other than standards cited herein are introduced to illustrate the location where they are applicable. Otherwise, the figure is self-explanatory.

4.7.7 Example 6: AUTOVON Long Haul/Tactical Connection with AUTOVON 4-Wire Instrument in Tactical Area. Figure 4.7-6 (Example 6) illustrates the applicability of the reference voice bandwidth links in an AUTOVON connection with a 4-wire AUTOVON instrument in the tactical area. The figure also indicates other standards and criteria in addition to those cited herein which are applicable.

4.7.8 Example 7: AUTOVON Long Haul/Tactical Connection with 2-Wire Switches at Both Terminations (Worst Allowable Configuration). Figure 4.7-7 (Example 7) shows a worst case example of an AUTOVON connection with 2-wire switches in tandem at each termination; two of the switches are in the tactical area. Applicable standards and criteria are also shown in the figure. The 2-wire switch (in the tactical area) connecting the tactical circuit with the long haul circuit must have AUTOVON compatible signaling specified in DCAC 370-V185-7, Overseas AUTOVON Network Switching Plan.

4.7.9 Example 8: User-to-User Characteristics Based on Examples 1 through 4. The user-to-user characteristics may be determined by combining the characteristics of a hypothetical reference circuit (Examples 1 through 4) with the characteristics of the loops, which connect the users to the reference circuit. The characteristics of loops will vary widely among tactical highly maneuverable users, tactical less maneuverable users, and long haul users. In addition to the different types of loops, the length may range from very short loops consisting entirely of local plant facilities or loaded/nonloaded cable pairs, to very long loops consisting of one or more sections of a long haul plant, such as a loaded toll grade cable or a carrier plus an end section consisting of local plant facilities. As may be expected, the inherent characteristics of the loops will vary widely and are predictable only when the specific makeup of a loop is known. Each loop is a separate problem and each loop must be individually engineered. Thus, for purposes of demonstrating the calculation of hypothetical user-to-user characteristics (for Examples 1 through 4), it is necessary to assume characteristics for the loop. The reader is cautioned that these assumed characteristics are not real values and are not to be used literally for the calculation of actual user-to-user characteristics.



NOTE: The requirements of DCAC 370-DI75-I apply to AUTODIN service and do not necessarily apply to data service through a different network or through a non-switched channel.

Figure 4.7-5. Example 5: AUTODIN Long Haul/Tactical Connection

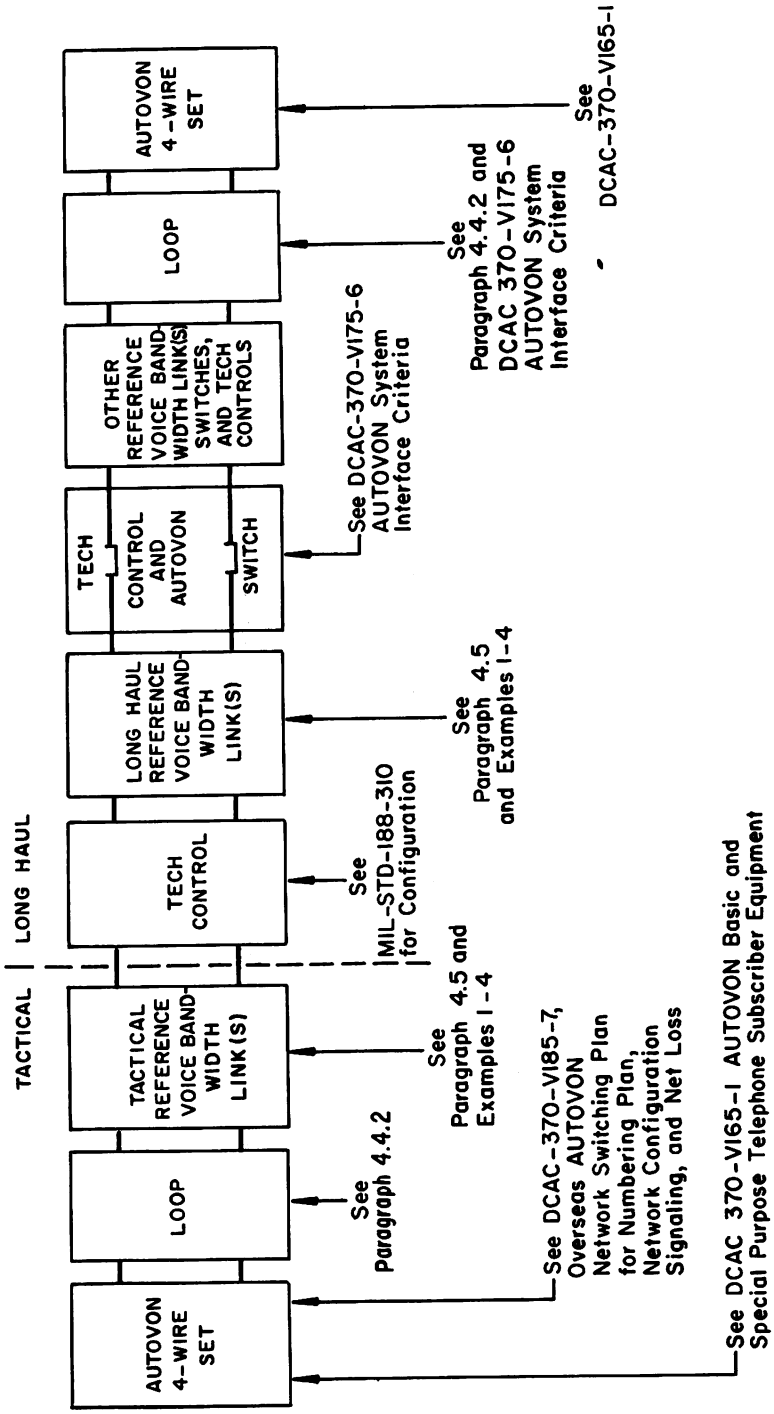


Figure 4.7-6. Example 6: AUTOVON Long Haul/Tactical Connection with AUTOVON 4-Wire Instrument in Tactical Area

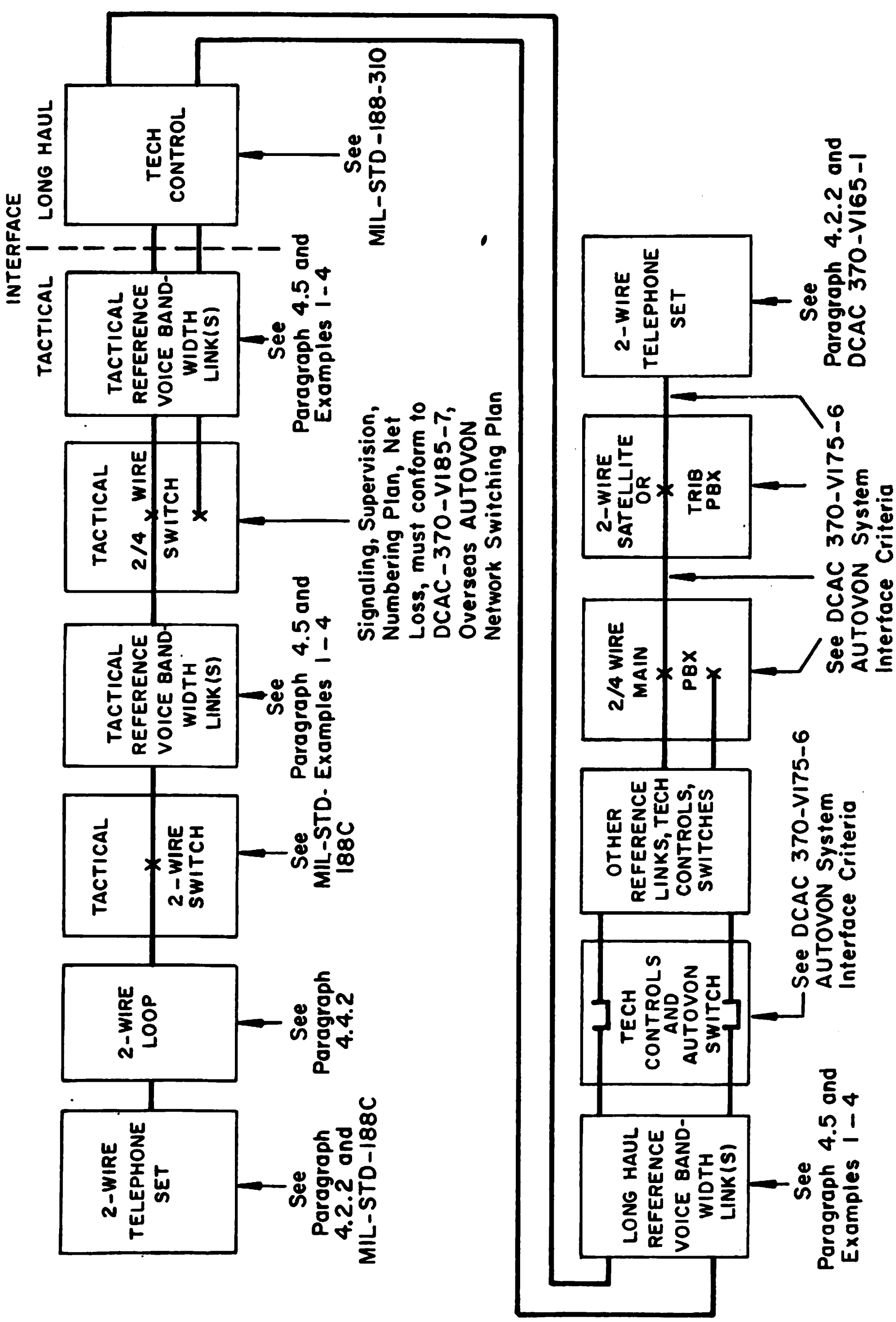


Figure 4.7-7. Example 7: AUTOVON Long Haul/Tactical Connection with 2-Wire Switches at Both Terminations (Worst Allowable Configuration)

4.7.9.1 Signal Level and Interface Diagrams of Long Haul and Tactical Reference Circuits (User-to-User). Figures 4.7-8 through 4.7-13 show examples of circuits consisting of long haul and tactical (highly and less maneuverable) links based on Examples 1 through 4, and of two-wire or four-wire loops extending to the terminal equipment. The insertion loss of the loops are identical with the values given in subparagraph 4.4.2.1.1. Figures 4.7-8 through 4.7-13 show test levels and traffic signal levels for voice and data and the interface levels between any of the three systems, long haul, tactical highly maneuverable, and tactical less maneuverable.

4.7.9.1.1 Long Haul/Tactical Highly Maneuverable Four-Wire Reference Circuit. Different requirements for the long haul and the tactical highly maneuverable systems have led to the development of equipment, such as multiplexers and radios, with significantly different traffic signal levels (voice and data) and overload characteristics. THEREFORE, SPECIAL METHODS HAVE TO BE USED FOR INTERFACING LONG HAUL WITH TACTICAL HIGHLY MANEUVERABLE LINKS.

Figure 4.7-8 (Example 8a) shows a signal level and interface diagram of a long haul/tactical highly maneuverable four-wire reference circuit. The interface shall be accomplished on the basis of the standard test tone defined in subparagraph 4.4.3.2.2.4 as −10 dBm0 for the long haul and −3 dBm0 for the tactical highly maneuverable system. It should be emphasized that the standard test tone of −10 dBm0 for the long haul system is referenced to the long haul 0TLP, whereas the test tone of −3 dBm0 for the tactical highly maneuverable system is referenced to the tactical highly maneuverable 0TLP and not to the long haul 0TLP.

The method of interfacing on the basis of the standard test tone results in a 3 dB gain at the interface point for signals traversing from the long haul to the tactical highly maneuverable portion of a circuit and in a 3 dB attenuation at the interface point for signals traversing from the tactical highly maneuverable to the long haul portion of a circuit. THE TLPS OF THE TACTICAL HIGHLY MANEUVERABLE SYSTEM CANNOT BE DIRECTLY EQUATED TO THE TLPS OF THE LONG HAUL SYSTEM, SAVE IN TERMS OF ACTUAL POWER LEVELS (dBm). THEREFORE, THESE TLPS SHALL BE CONSIDERED AS INTERNAL REFERENCES FOR EACH SYSTEM ONLY, AND MUST NOT BE TRANSFERRED ACROSS THE INTERFACE. For this reason, the standard test signal and the signal for intermodulation distortion measurements (IMD) shall not be transmitted across a long haul/tactical highly maneuverable interface, as indicated in Figure 4.7-8. The monitoring test tone is not used in the tactical highly maneuverable system (see subparagraph 4.4.3.2.2.5). However, the monitoring test tone may be transmitted across the interface, if required, and would appear at a level of -12 dBm at a -4 TLP of a tactical highly maneuverable circuit.

In Figure 4.7-8, the transmitted speech volumes at the telephones have been assumed as −10 VU for both the long haul and the tactical highly maneuverable users in accordance with subparagraph 4.2.2.1. The received speech volume of −16.5 VU at the tactical highly maneuverable telephone is higher than the nominal value of −28 VU stated in subparagraph 4.2.2.2 but the higher value is considered desirable for satisfactory service in a tactical highly maneuverable environment. The received speech volume of −22.5 VU at the long haul telephone is within the range of volume units given in subparagraph 4.2.2.2 indicating that more than 95 percent of calls would be rated good or better. The data levels shown in Figure 4.7-8 are identical with the values stated in subparagraphs 4.3.2.2 and 4.4.3.2.2.2.

NOTE: The following items have been considered for the development of an interface standard between the tactical highly maneuverable system and the long haul or the tactical less maneuverable systems:

(a) The level difference across the interface is caused by the current inventory which cannot be changed significantly in the foreseeable future based on economic factors, such as equipment life cycles.

(b) Any solution of the interface problem should have a minimum impact on existing procedures and practices used in all systems to be interfaced.

(c) The introduction of a new definition into the tactical highly maneuverable system, namely the standard test tone of −3 dBm0, is considered less confusing to communications personnel than a change of established procedures and methods employed within a system, such as the TLP concept.

(d) The method of interfacing on the basis of the standard test tone will affect only circuits traversing the long haul/tactical highly maneuverable system or the tactical less maneuverable/tactical highly maneuverable system and will not change established test or alignment procedures within any of these systems.

4.7.9.1.2 Long Haul/Tactical Highly Maneuverable Two-Wire Reference Circuit. Figure 4.7-9 depicts an example of a long haul/tactical highly maneuverable two-wire reference circuit showing signal levels for testing and aligning of links and traffic signal levels (voice and data) from user-to-user. The interface method is the same as shown in Figure 4.7-8 and described in subparagraph 4.7.9.1.1. The TLPs and the corresponding test levels and speech volumes are the same as shown in Figure 4.7-8, except the two-wire termination in the receiving direction of the tactical highly maneuverable links has a +1 TLP in accordance with subparagraphs 4.5.2.2 and 4.5.3.2.2. The transmitted speech volumes at the telephones have been assumed as −10 VU for both the long haul and the tactical highly maneuverable users in accordance with subparagraph 4.2.2.1. The received speech volume of −20.5 VU at the tactical highly maneuverable telephone is higher than the nominal value of −28 VU stated in subparagraph 4.2.2.2 but the higher value is considered desirable for satisfactory service in a tactical highly maneuverable environment. The received speech volume of −31.5 VU at the long haul telephone is within the range of volume units given in subparagraph 4.2.2.2 indicating that more than 95 percent of calls would be rated good or better. The data levels shown in Figure 4.7-9 are identical with the values stated in subparagraphs 4.3.2.2 and 4.4.3.2.2.2.

4.7.9.1.3 Long Haul/Tactical Less Maneuverable Four-Wire Reference Circuit. A signal level and interface diagram for a long haul/tactical less maneuverable four-wire circuit is shown in Figure 4.7-10 (Example 8c). An interface connection between these two types of systems is relatively simple, inasmuch as both systems employ a

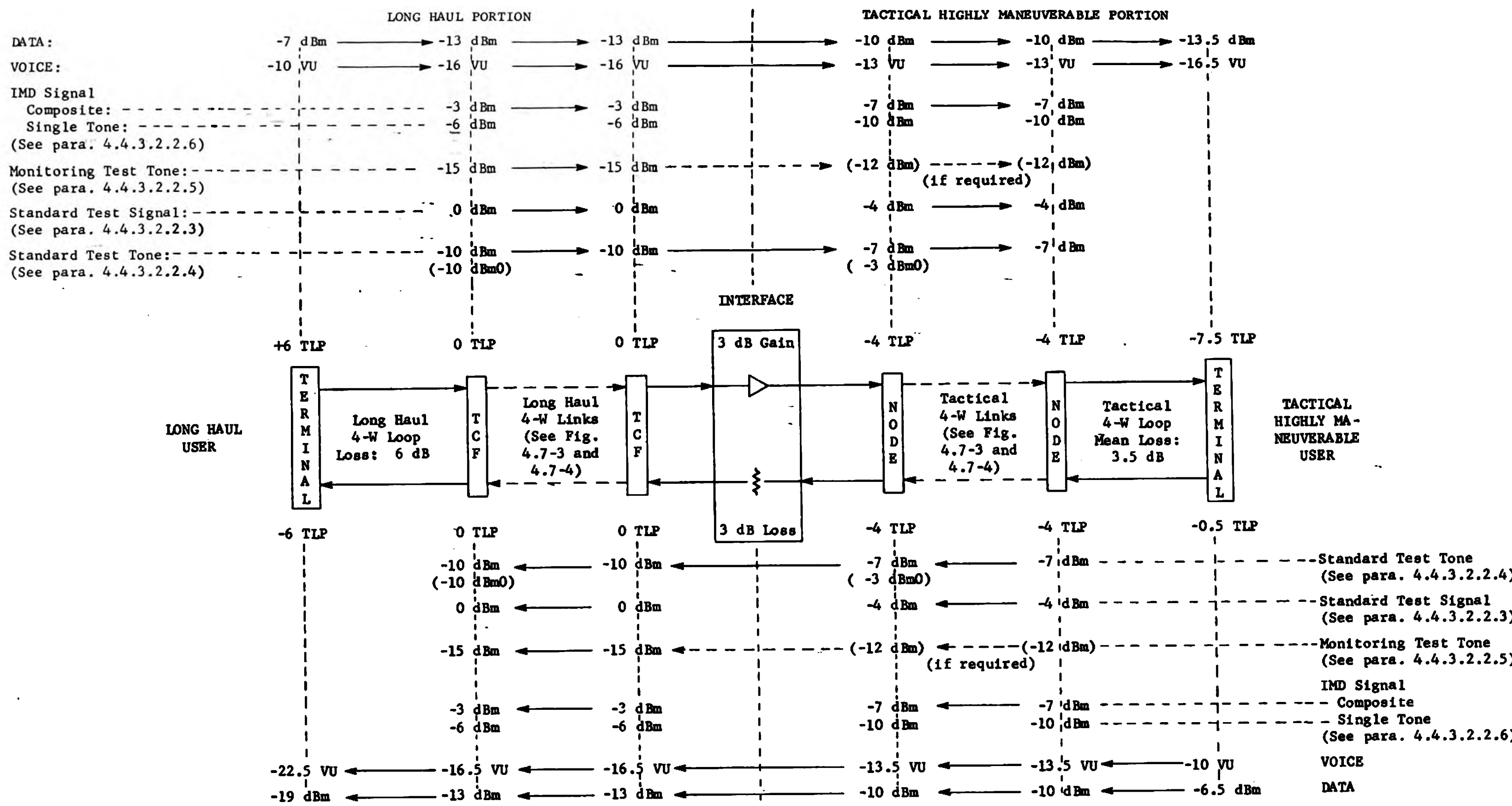
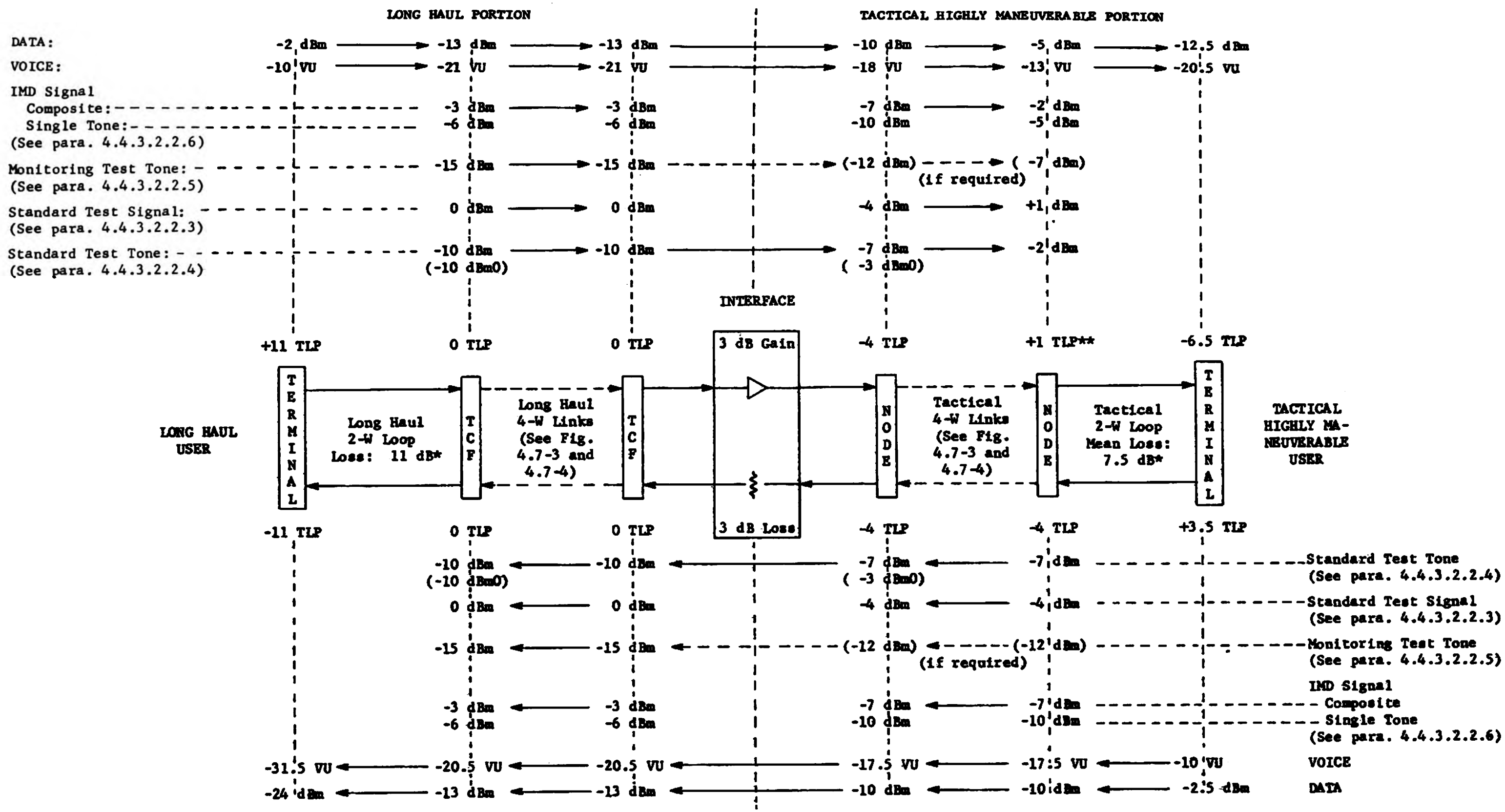


Figure 4.7-8. Example 8a: Signal Level and Interface Diagram of Long Haul/Tactical Highly Maneuverable Four-Wire Reference Circuit



*This value includes a 2-wire/4-wire hybrid transformer insertion loss of 4 dB.
**See paragraph 4.5.2.2 and 4.5.3.2.2.

Figure 4.7-9. Example 8b: Signal Level and Interface Diagram of Long Haul/Tactical Highly Maneuverable Two-Wire Reference Circuit

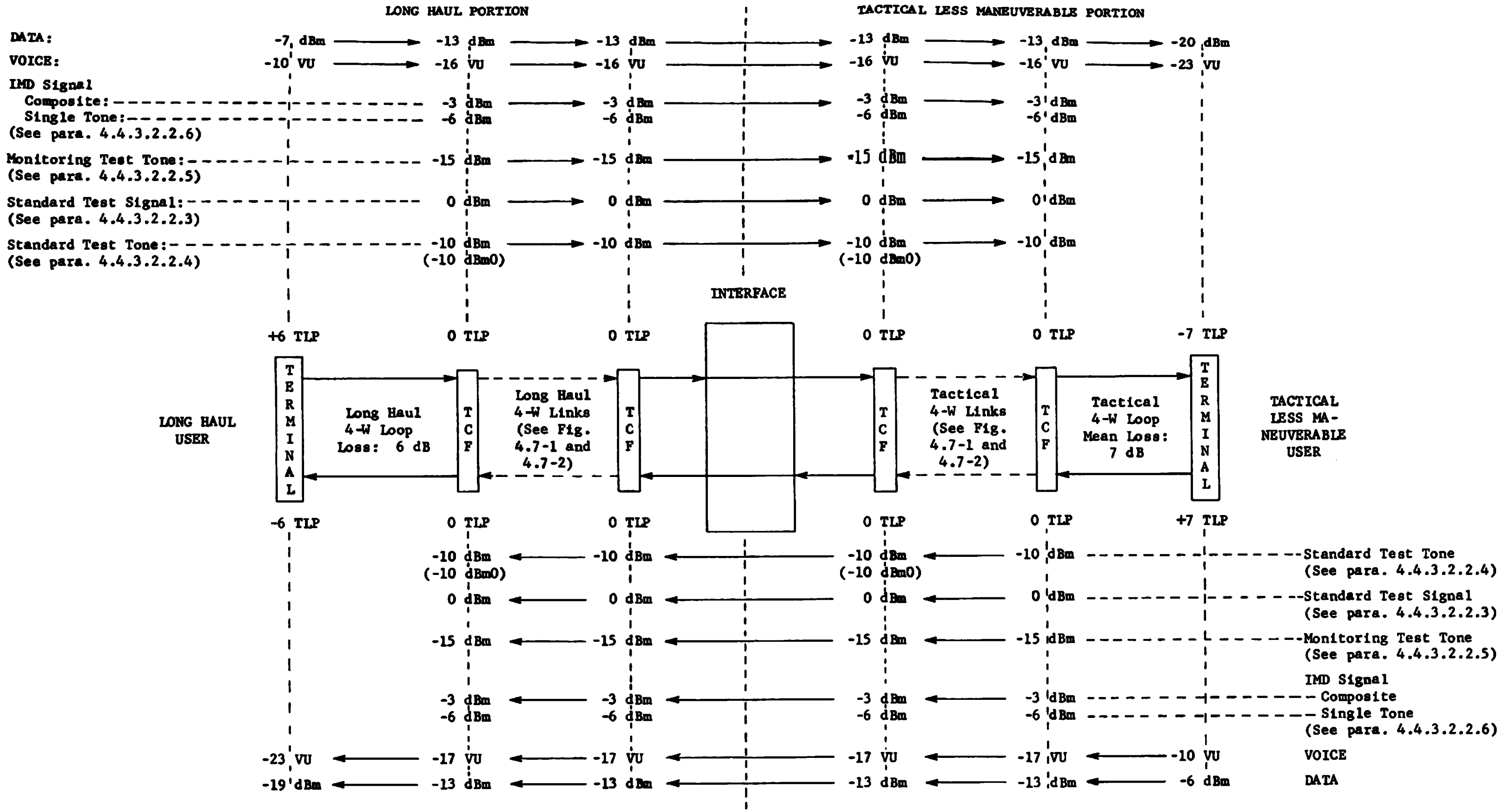


Figure 4.7-10. Example 8c: Signal Level and Interface Diagram of Long Haul/Tactical Less Maneuverable Four-Wire Reference Circuit

0TLP at their respective Technical Control Facilities. The difference between the two systems is in the area of loops. Long haul four-wire reference circuits maintain a 6 dB loss in the loop. The less maneuverable tactical four-wire reference circuits have loops with a mean loss of 7 dB. This difference causes the transmitted and received levels of speech and data to differ slightly as shown in Figure 4.7-10.

4.7.9.1.4 Long Haul/Tactical Less Maneuverable Two-Wire Reference Circuit. Figure 4.7-11 (Example 8d) provides a signal level and interface diagram for a long haul/tactical less maneuverable two-wire reference circuit. This is very similar to Figure 4.7-10 which addresses a long haul/less maneuverable tactical four-wire reference circuit, the major difference between them being the additional loop loss shown for both the long haul two-wire reference circuits (11 dB including a 4-dB two-wire to four-wire hybrid loss) and the tactical less maneuverable two-wire reference circuits (9 dB including two-wire to four-wire hybrid loss). As a result of these additional loop losses, the values of data and voice signal levels change accordingly from the values shown on Figure 4.7-10 (Example 8c). The major impact is in the received speech volume (−30 VU) at both the long haul and the tactical less maneuverable telephone instrument. However, this level of −30 VU is within the range of received speech volume required for satisfactory voice service (see subparagraph 4.2.2.2).

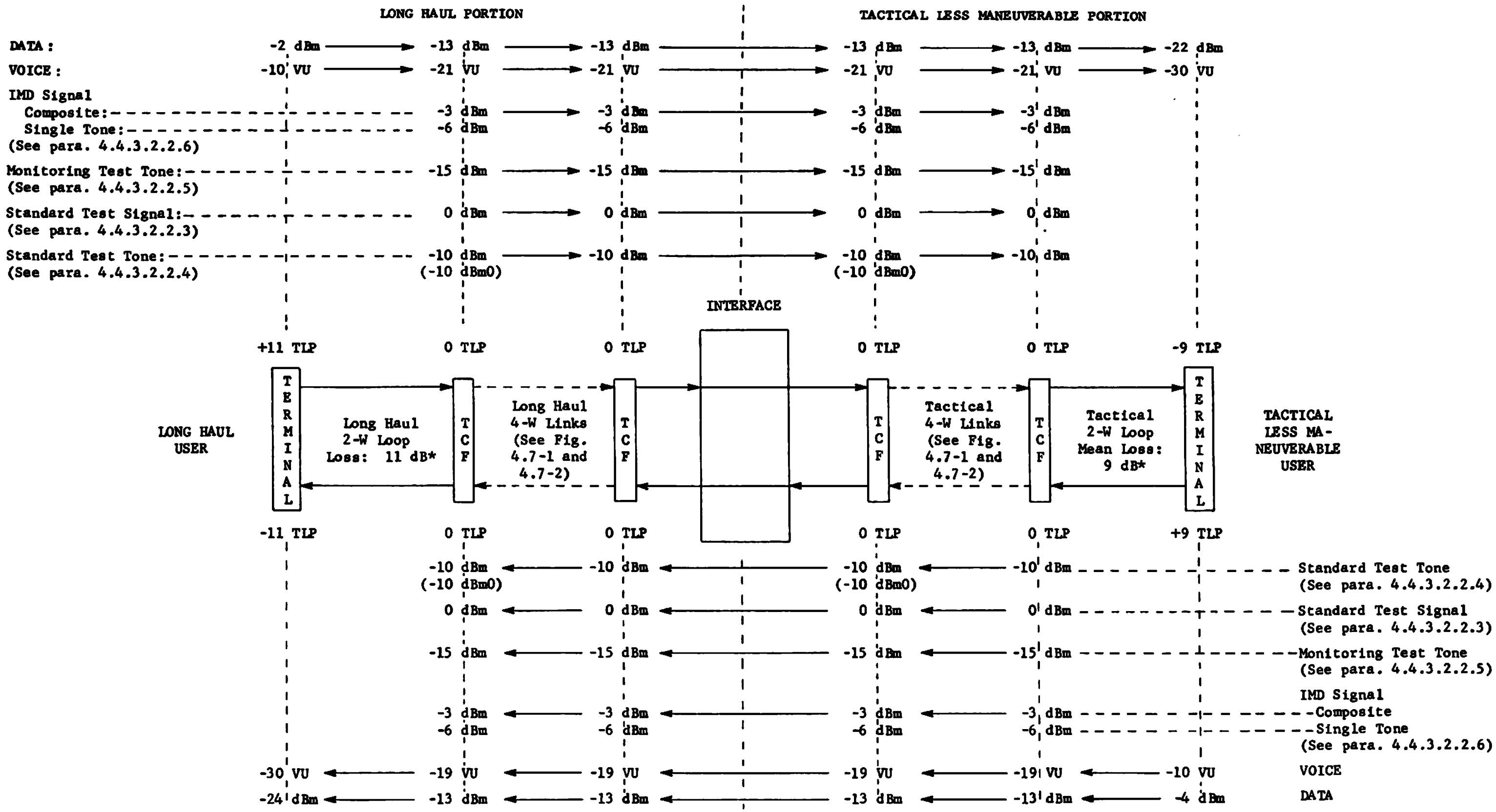
4.7.9.1.5 Tactical Less Maneuverable/Tactical Highly Maneuverable Four-Wire Reference Circuit. Figure 4.7-12 (Example 8e) provides a signal level and interface diagram of a tactical less maneuverable/tactical highly maneuverable four-wire reference circuit. This diagram is almost identical to the long haul/tactical highly maneuverable four-wire circuit shown in Figure 4.7-8 (Example 8a). The differences in signal level values shown on the diagram are due to the 7-dB loop loss on the tactical less maneuverable system as compared to the 6-dB loop loss shown on the long haul system illustrated in Figure 4.7-8.

4.7.9.1.6 Tactical Less Maneuverable/Tactical Highly Maneuverable Two-Wire Reference Circuit. Figure 4.7-13 (Example 8f) provides a signal level and interface diagram for a tactical less maneuverable/tactical highly maneuverable two-wire circuit. The interface arrangement shown is identical to the interface arrangement provided in Figure 4.7-9 (Example 8b) and is described in subparagraph 4.7.9.1.2. The only change between the level and interface diagram shown in Figure 4.7-13 and Figure 4.7-9 is the difference in voice and data levels due to a difference in loop loss in the tactical less maneuverable two-wire reference circuit (9 dB) and the long haul two-wire reference circuit (11 dB).

4.7.9.2 Calculation of Hypothetical Noise Power at User Terminals. The total received noise at the user terminals will consist of channel noise plus the noise contributed by the two loops, attenuated by the one-way insertion loss of the loop connecting the user terminals to the channel (see Figure 4.4-1). It is accepted practice in circuit engineering to reference each noise power value, contributed by the different portions of a circuit, to the 0TLP of the circuit under consideration and thus arrive at the total circuit noise power expressed in units of pWp0 or dBrnc0. The total circuit noise power referenced to the 0TLP can be transferred from the 0TLP to any other TLP of the circuit by considering the transmission level difference between the 0TLP and the other TLP (see Appendix F, Terms and Definitions, under: Transmission Level).

Table 4.7-1 shows the noise power contributed by a channel and the loops, and the total received circuit noise power at the long haul or tactical user terminals based on the reference circuit Examples 1 through 4.

The parameters of Examples 1 through 4, such as noise and envelope delay distortion shown in subparagraphs 4.7.2 through 4.7.5, are only applicable to analog service (voice and facsimile) and to quasi-analog data service without regeneration between the end terminals of a channel. See subparagraph 4.6.1 for calculating the transfer characteristics of data links in tandem with regeneration employed. In the first column of Table 4.7-1, the numbers of the reference circuit examples are listed which correspond to Figures 4.7-1 through 4.7-4. The second column of Table 4.7-1 shows the channel noise power referenced to the long haul or the tactical less maneuverable 0TLP. The values of channel noise power listed in Table 4.7-1 are identical with the values shown in Figures 4.7-1 through 4.7-4. The noise contributed by one loop (see subparagraph 4.4.2.1.4) is listed in the third column of Table 4.7-1. It should be noted that in the tactical highly maneuverable system the loop noise is generally so much lower than the noise contributed by trunks and links that the effect of loop noise on a user-to-user circuit is considered negligible. Consequently, the total circuit noise of Examples 3 and 4 consists of channel noise plus noise of one long haul loop, whereas the total circuit noise of Examples 1 and 2 is the sum of channel noise plus the noise contributed by one long haul loop and one tactical less maneuverable loop. The fifth column of Table 4.7-1 shows a −6 TLP assumed at a long haul end instrument and a −7 TLP assumed at a tactical less maneuverable end instrument, based on the four-wire loop insertion loss stated in subparagraphs 4.4.2.1.1.1 and 4.4.2.1.1.3, respectively. Examples 3 and 4 also show a −6 TLP assumed at a long haul end instrument and a −7.5 TLP assumed at a tactical highly maneuverable end instrument in accordance with Figure 4.7-8. The last column of Table 4.7-1 shows the total received circuit noise power at the assumed TLPs of long haul or tactical end instruments. For Examples 1 and 2, the total noise at the user TLP is calculated by subtracting from the circuit noise (expressed in dBrnc0) 6 dB for a long haul user or 7 dB for a tactical highly maneuverable user in accordance with the corresponding assumed TLPs. Since the TLP of a tactical highly maneuverable circuit is not related to the long haul 0TLP in terms of transmission power levels, the calculation of total circuit noise at the tactical highly maneuverable end instrument (Examples 3 and 4 of Table 4.7-1) must not be performed by the conventional method used for Examples 1 and 2 but has to be based on the interface diagram shown in Figure 4.7-8. According to Figure 4.7-8, a signal traversing the interface from the long haul 0TLP to the tactical highly maneuverable −4 TLP is amplified by 3 dB. Likewise, circuit noise power referenced to the long haul 0TLP, as shown in the fourth column of Table 4.7-1, will be 3 dB higher at the tactical highly maneuverable −4 TLP. This amount of noise power at the −4 TLP is attenuated by the loop loss of 3.5 dB at the tactical highly maneuverable user terminal. For instance, reference circuit Example 3 of Table 4.7-1 has a total circuit noise of 47.2 dBrnc0 (referenced to the long haul 0TLP) plus 3 dB (gain at the long haul/tactical interface) minus 3.5 dB (of tactical loop insertion loss) resulting in 46.7 dBrnc of total circuit noise power at the tactical (highly maneuverable) user terminals. The total circuit noise shown in the last column of Figure 4.7-1 is within the limits of received noise power for voice, analog facsimile and data service given in subparagraphs 4.2.2.3, 4.2.3.3, and 4.3.2.4 respectively. The permissible noise of 44 dBrnc shown in subparagraph 4.2.2.3 is based on a mean received speech volume of −28 VU. The tactical highly maneuverable system has a higher received speech volume (see Figure 4.7-8) and therefore can tolerate more noise power at the user terminals than stated in subparagraph 4.2.2.3.



*This value includes a 2-wire/4-wire hybrid transformer insertion loss of 4 dB.

Figure 4.7-11. Example 8d: Signal Level and Interface Diagram of Long Haul/Tactical Less Maneuverable Two-Wire Reference Circuit

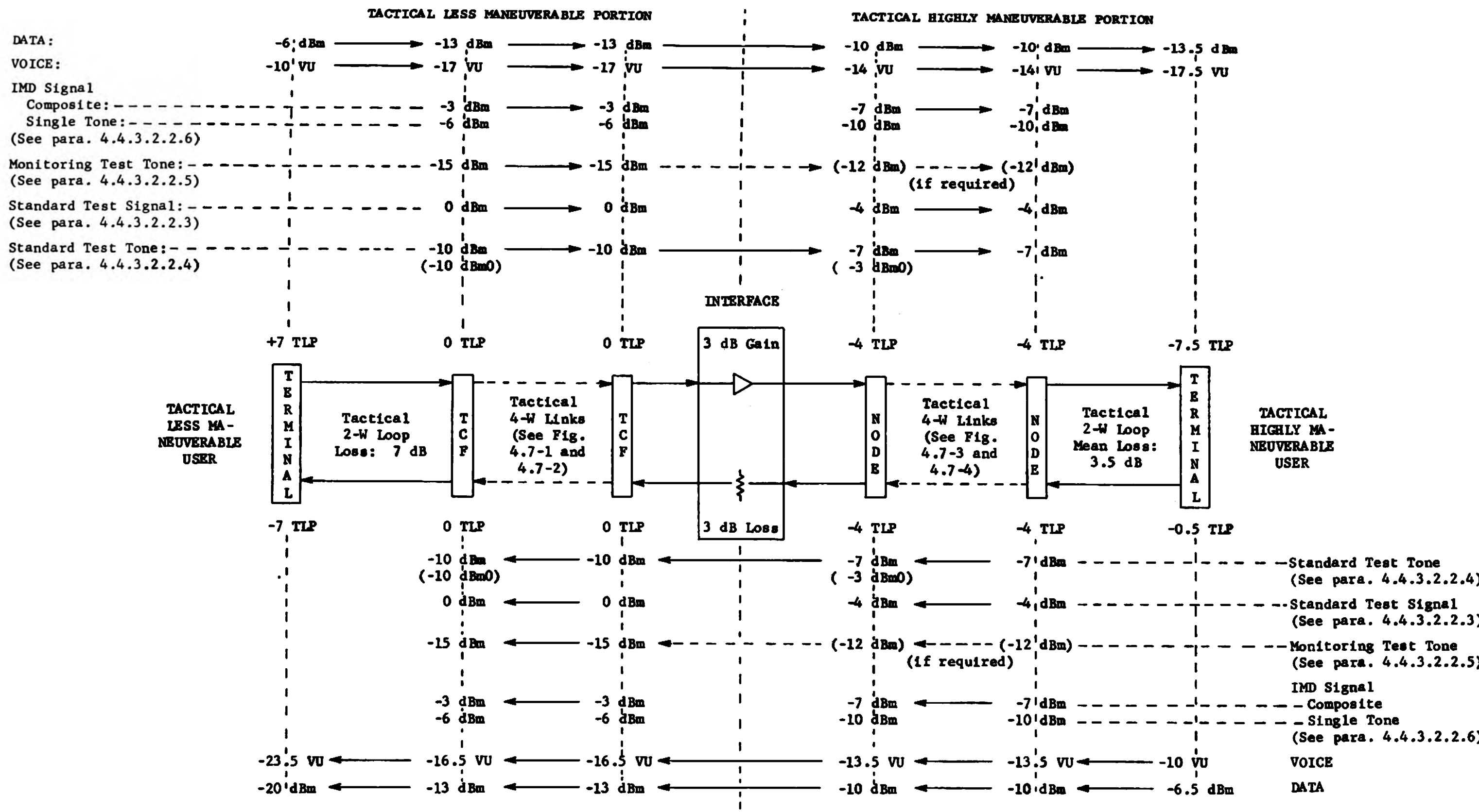
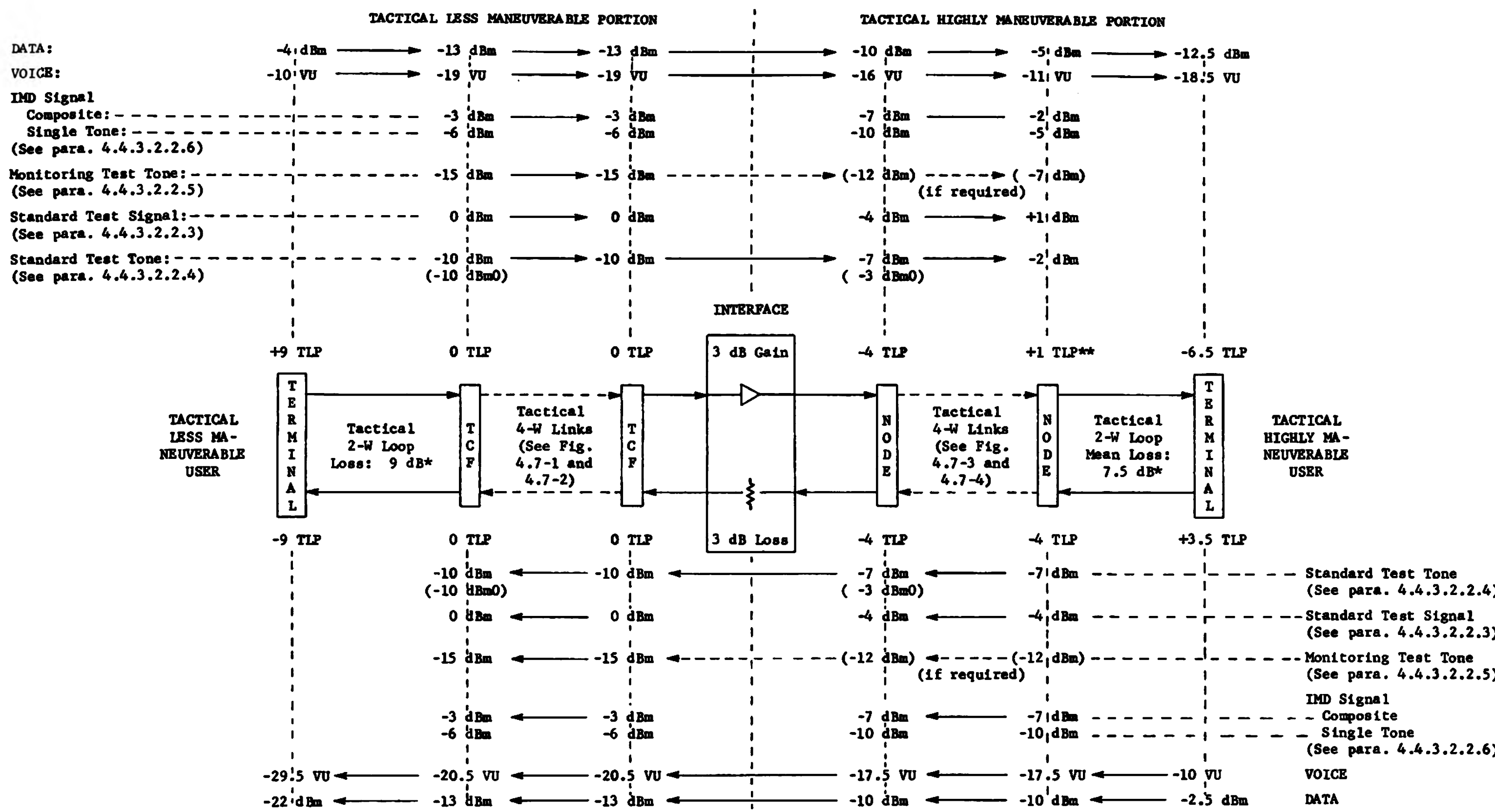


Figure 4.7-12. Example 8e: Signal Level and Interface Diagram of Tactical Less Maneuverable/ Tactical Highly Maneuverable Four-Wire Reference Circuit



*This value includes a 2-wire/4-wire hybrid transformer insertion loss of 4 dB.
**See paragraphs 4.5.2.2 and 4.5.3.2.2.

Figure 4.7-13. Example 8f: Signal Level and Interface Diagram of Tactical Less Maneuverable/ Tactical Highly Maneuverable Two-Wire Reference Circuit

Table 4.7-1. Noise Contributions and Circuit Noise for Reference Circuit Examples 1 through 4

Reference Circuit Examples (see Figures 4.7-1 through 4.7-4)		Reference Circuit Noise (Channel Noise) at Long Haul OTLP		Noise of One Long Haul or Tactical Loop at Long Haul OTLP		Total Circuit Noise (Channel Noise Plus Noise of Long Haul and Tactical Loop) at Long Haul OTLP		Assumed TLP of User Terminals	Total Circuit Noise Received at TLP of User Terminals	
		pWp0	Appr. dBrnc0	pWp0	Appr. dBrnc0	pWp0	Appr. dBrnc0		pWp	Appr. dBrnc
1	Long Haul	35,189	45.5	6,250	38.0	47,689	46.8	-6 TLP	12,000	40.8
	Tactical Less Maneuverable			6,250	38.0			-7 TLP	9,550	39.8
2	Long Haul	26,087	44.2	6,250	38.0	38,587	45.9	-6 TLP	9,770	39.9
	Tactical Less Maneuverable			6,250	38.0			-7 TLP	7,760	38.9
3	Long Haul	45,854	46.6	6,250	38.0	52,104	47.2	-6 TLP	13,180	41.2
	Tactical Highly Maneuverable			0*	0*			-7.5 TLP**	46,770**	46.7**
4	Long Haul	36,752	45.7	6,250	38.0	43,002	46.3	-6 TLP	10,720	40.3
	Tactical Highly Maneuverable			0*	0*			-7.5 TLP**	38,020**	45.8**

*Noise of tactical highly maneuverable loops is assumed to be negligible (see subparagraph 4.4.2.1.4)

**The TLP of a tactical highly maneuverable circuit is not related to the TLP of a long haul circuit in terms of transmission levels. See subparagraph 4.7.9.2 for details to calculate the noise of a common long haul/tactical highly maneuverable circuit.

NOTE: Reference circuits 3 and 4 seemingly exceed the 44 dBrnc standard stated in subparagraph 4.2.2.3. One must remember, however, that the 44 dBrnc in subparagraph 4.2.2.3 is tied to a −28 VU speech volume. In the reference circuits, the speech level at the tactical highly maneuverable user terminals is considerably higher (−17 VU).

In real circuits there will be some attenuation at all switch and interconnect points which will amount to several dB effective attenuation of the signals arriving at either user terminals, thus dropping the noise power within the standard limit of 44 dBrnc while the speech volume will stay above −28 VU.

4.7.9.3 Calculation of Hypothetical Insertion Loss Versus Frequency Characteristic at User Terminals. By applying the summation method defined in subparagraph 4.6.3 the total resultant hypothetical insertion loss versus frequency characteristic at the user terminals may be obtained. This involves the summarizing of the insertion loss versus frequency characteristic for the hypothetical reference links Examples 1 through 4 described in subparagraph 4.7.2 and the loop characteristics given in subparagraph 4.4.2.2.2 considering the contributions of two loops. The following examples are for unconditioned data loops and unconditioned data circuits only. The same method of summarizing would apply to other types of loops and circuits.

(a) Example 1

300 Hz to 3000 Hz (Except 300 Hz to 2700 Hz)	300 Hz to 2700 Hz
−1.7 dB, +11.7 dB	−1.7 dB, +5.4 dB

(b) Example 2

300 Hz to 3000 Hz (Except 300 Hz to 2700 Hz)	300 Hz to 2700 Hz
−1.5 dB, +11.8 dB	−1.5 dB, +5.4 dB

(c) Example 3

300 Hz to 3000 Hz (Except 300 Hz to 2700 Hz)	300 Hz to 2700 Hz
−1.9 dB, +11.5 dB	−1.9 dB, +5.4 dB

(d) Example 4

300 Hz to 3000 Hz (Except 400 Hz to 2700 Hz)	400 Hz to 2700 Hz
−2.5 dB, +12.1 dB	−2.5 dB, +5.8 dB

4.7.9.4 Calculation of Hypothetical Envelope Delay Distortion at the User Terminals. By applying the summation method defined in subparagraph 4.6.4, the total resultant hypothetical envelope delay distortion at the user terminals may be obtained.

This involves the summarizing of the envelope delay distortion for the hypothetical reference links Examples 1 through 4 described in subparagraph 4.7.2 and the loop characteristics given in subparagraph 4.4.2.2.3 considering the contributions of two loops. The following examples are for unconditioned data loops and unconditioned data circuits only. The same method of summarizing would apply to other types of loops and circuits. The summed values exceed the limits established for unconditioned data circuits. Hence regeneration, at intermediate points, may be required (see subparagraphs 4.3.2.1 and 4.3.2.5).

(a) Example 1

600 Hz to 2800 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
8,339 microseconds	2,659 microseconds

(b) Example 2

600 Hz to 2800 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
8,385 microseconds	2,610 microseconds

(c) Example 3

600 Hz to 2800 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
8,364 microseconds	2,584 microseconds

(d) Example 4

600 Hz to 2800 Hz (Except 1000 Hz to 2500 Hz)	1000 Hz to 2500 Hz
9,010 microseconds	2,835 microseconds

4.7.9.5 Calculation of Hypothetical Net Loss Variation at the User Terminals. By applying the summation method defined in subparagraph 4.6.5, the total resultant hypothetical net loss variation at the user terminals may be obtained. This involves the summarizing of the net loss variation for the hypothetical reference links Example 1 through 4 described in subparagraph 4.7.2 and the loop characteristics given in subparagraph 4.4.2.2.6 considering the contributions of two loops. The results are shown below:

(a) Example 1: 5.0 dB
(b) Example 2: 4.9 dB
(c) Example 3: 4.8 dB
(d) Example 4: 5.1 dB

4.8 Voice Channel Network Standards.

4.8.1 General. This paragraph deals with network aspects of voice channels. In other paragraphs, parameters for transmission links such as insertion loss versus frequency characteristic, envelope delay distortion, noise, etc., are given, based upon their contribution to the parameters for the appropriate hypothetical reference circuit. However, circuit net loss and signaling are not covered. These are the subject of the following subparagraphs 4.8.2 and 4.8.3.

4.8.2 Net Loss Design. Net loss is the nominal insertion loss at test tone frequency of any transmission link, measured between points at which they interconnect with another link at a switching equipment, or to the line terminals of a telephone. This includes trunks, subscriber or switch access lines, switch tie lines, and user loops. The sum of the net losses of all links in tandem between the line terminals of the two interconnected telephones is the net loss of the connection. The overall net loss allowable takes into account the user-to-user requirements and, if there are any 2-wire links or 2-wire telephones which may form part of the connection, echo control must be considered (see subparagraph 4.2.2.8).

Although the net loss design of the tactical systems and the long haul system do not entirely agree, the net loss of a 4-wire trunk, between switching points, shall be 0 dB and the net loss of a 2-wire trunk, between switching points, shall be 3 dB.

4.8.3 Signaling.

4.8.3.1 Dual Tone Multi-Frequency Signaling. In general, signaling in tactical systems and in the long haul (AUTOVON) systems is quite different in most details. However, both make some use of telephones with Dual Tone Multi-Frequency (DTMF) signaling. The numbers 1 - 0 and the four precedence signals are identical. The DTMF signals shown in Table 4.8-1 below are common.

Table 4.8-1. Dual Tone Multi-Frequency Signals

DTMF Key	Tone Group Frequencies (Hz)	
	Lower	Upper
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
0	941	1336
Precedence 0: (FO) Flash Override	697	1633
Precedence 1: (F) Flash	770	1633
Precedence 2: (I) Immediate	852	1633
Precedence 3: (P) Priority	941	1633
End of Signaling	941	1477

4.8.3.2 Dial Pulse Signaling. For telephone sets requiring dial pulsing for operating with switching equipment, the following standards apply. Two categories of dial pulsing are recognized: low speed (for step-by-step systems), and high speed (or common control systems, e.g., crossbar systems).

		Low Speed	High Speed
(a)	Break period: percent of combined make and break period	60% to 67%	60% to 67%
(b)	Speed, pulses per second	9.5 to 10.5	17 to 19
(c)	Minimum interdigital period	0.6 sec ±5%	0.35 sec ±5%

5. SUBSYSTEM STANDARDS AND DESIGN OBJECTIVES.

5.1 General. In paragraph 4 overall system standards having general application to both long haul and tactical systems are given, with application to circuits up to approximately 22,000 km (12,000 nmi). Paragraph 5 is devoted to standards and design objectives for multiplexing, transmission, and end instrument subsystems or equipments which may be employed to implement an overall system. In particular, this paragraph is divided into the following:

Paragraph	Subject
5.2	FDM Subsystems
5.3	TDM/PCM Subsystems
5.4	Digital Data Modem Subsystems
5.5	Radio Transmission Subsystems
5.6	Wire Transmission Subsystems
5.7	End Instruments, Analog
5.8	End Instruments, Digital

Some of the paragraphs listed above cannot be supported at this time by a substantial number of common standard parameters. Therefore, several of these subject headings are included only for completeness and foresight as revisions and expansions to the document become appropriate.

5.2 Frequency Division Multiplexed (FDM) Subsystems.

5.2.1 General. Frequency division multiplexed subsystems can be categorized according to type of multiplex channel used. In this regard 3-kHz FDM, 4-kHz FDM, and voice frequency carrier telegraph (VFCT) subsystems are of general interest.

5 2.2 Frequency Division Multiplex Equipment (3 kHz).

5.2.2.1 Wideband Applications. This type of 3-kHz channel multiplexing is used on many wideband underseas cable transmission subsystems. Most DoD underseas cable subsystems are leased. Military Standards for this application, therefore, are limited and a common standard is not included at this time (see subparagraph 4.4.3.1.1).

5.2.2.2 HF Radio Applications. See subparagraphs 4.4.3.1.1 and 5.5.2.

5.2.3 Frequency Division Multiplex Equipment (4 kHz). Subparagraph 4.5.2 of this document lists numerous characteristics of 4-kHz FDM equipment which are applicable to the development of the long haul/tactical reference circuit examples of paragraph 4.7. For further information, reference should be made to MIL-STD-188-311 and MIL-STD-188C (to be replaced by MIL-STD-188-200 series) for the respective long haul and tactical standards. Reason: Technical completeness.

5.2.4 Voice Frequency Carrier Telegraph (VFCT). The standard VFCT subsystem is configured for 16 duplex telegraph circuits. Frequency shift modulation shall be employed. The mark signal shall be at the center frequency minus 42.5 Hz and the space frequency shall be at the center frequency plus 42.5 Hz. Table 5.2-1 lists the center, mark, and space frequencies for each of the 16 channels.

Table 5.2-1. 16-Channel System Center, Mark, and Space Frequencies

Channel Designation	Mark Frequency (Hz)	Center Frequency (Hz)	Space Frequency (Hz)
1	382.5	425	467.5
2	552.5	595	637.5
3	722.5	765	807.5
4	892.5	935	977.5
5	1062.5	1105	1147.5
6	1232.5	1275	1317.5
7	1402.5	1445	1487.5
8	1572.5	1615	1657.5
9	1742.5	1785	1827.5
10	1912.5	1955	1997.5
11	2082.5	2125	2167.5
12	2252.5	2295	2337.5
13	2422.5	2465	2507.5
14	2592.5	2635	2677.5
15	2762.5	2805	2847.5
16	2932.5	2975	3017.5

5.2.4.1 Frequency Tolerance. The tolerance allowed on the "mark" and "space" frequencies, as generated, shall be ±4 Hz.

5.2.4.2 Audio Input/Output Impedance. The output impedance of the telegraph channel multiplexer and the input impedance of the demultiplexer shall be nominally 600 ohms over the voice frequency band. The minimum return loss shall be 26 dB measured against a resistance of 600 ohms. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

5.2.4.3 Crosstalk. The crosstalk coupling loss between telegraph channels, with equipment connected on a looped basis, shall be numerically greater than 55 dB, when referred to equal level points.

5.2.4.4 Distortion. With the transmit and receive terminals connected back to back, with sending and receiving loops properly terminated, with all transmit tones activated at proper levels, and with random undistorted signals keyed simultaneously into each sending loop at the maximum modulation rate of the terminal design, the maximum peak telegraph distortion, as measured in the receiving loops, shall not exceed 4 percent. (DO: 2 percent).

5.2 4.5 Low Level Interface for Loop Circuits. It is the usual practice to terminate the individual telegraph channels in a digital loop circuit. The standard low level interface described in subparagraph 4.3.1.3 shall be provided for these loops.

5.3 TDM/PCM Subsystems. Paragraph 4.5.3 of this document compares the respective long haul and tactical standards for TDM/PCM subsystems. This comparison readily indicates that there are very few subsystem commonalities in this area. Reference is made to MIL-STD-188C for further information on tactical TDM/PCM subsystems.

5.4 Digital Data Modem Subsystems. Digital data modems are devices which allow digital information to be transmitted over analog facilities. The sending portion of the modem converts dc pulses into analog tones suitable for transmission over analog circuits; the receiving portion of the modem accepts analog tones from the transmission facility and converts them into dc pulses for use by the end instrument. Included herein are standards which are common to modems used for tactical applications and those used on the long-haul system. The standards regarding interface and timing criteria, although applicable to digital modems, are relevant to a wide variety of other subsystems as well; therefore the discussion herein references the reader to subparagraphs 4.3.1.3 and 4.3.1.6 for a detailed description of these parameters.

5.4.1 Common Parameters for Low, Medium, and High-Speed Modems. Included herein are standards common to low, medium, and high-speed tactical and long-haul modems. This paragraph has been formatted to allow for future expansion; at the present time, however, the only parameters exhibiting the required degree of commonality are those falling within the standard digital interface criteria.

5.4.1.1 Low Level Digital Interface. All modems shall conform to the low level digital interface criteria described in 4.3.1.3. Those existing modems which are equipped for high level operation shall be used in conjunction with dc level converters to provide a low level interface; the interim high level digital interface criteria described in 4.3.1.4 shall apply to these modems.

5.4.1.2 Additional Parameters Common to All Modems. (Under consideration).

5.4.2 Digital Data Modems for 150 b/s to 9600 b/s.

5.4.2.1 DPSK Data Modems. The following subparagraphs, 5.4.2.1.1 through 5.4.2.1.13, establish standards and design objectives for 2400 b/s modems for those applications where differential phase shift keying (DPSK) is used on nominal 4-kHz voice channels.

5.4.2.1.1 Modulator Input Signal Characteristics. The modulator shall accept as a modulating signal synchronous serial digital data at data signaling rates of 1200 b/s or 2400 b/s. This signal shall be presented to the modulator input as a binary dc signal in polar form with nominal significant states of plus and minus 6 volts ±1 volt. These states are representative of a mark or space, binary 1 or 0 condition, respectively, of the input digital signal. The modulator shall be equipped with a means of reversing the sense of the received digital data.

5.4.2.1.2 Isochronous Distortion of Input Data. The modem shall operate in accordance with the performance requirements specified herein when the isochronous distortion of the input data is less than or equal to 10 percent measured at the data signaling rate of the modem.

5.4.2.1.3 Binary Encoder. Prior to translation into a phase shift line signal, the digital input signal, described in subparagraph 5.4.2.1.1, shall be subjected to an encoding process utilizing a binary encoder. This encoder shall consist of a modulo 2 adder and a 2-bit shift register arranged as illustrated in Figure 5.4-1. Encoding shall be accomplished at a data signaling rate of 2400 b/s for the two input data signal rates. The encoder shall be an integral part of the modem but capable of being inserted or bypassed on an optional basis.

5.4.2.1.4 Modulator Output Signal Characteristics. The information signal at the output of the modulator shall be a synchronous differentially coherent quaternary phase shift keyed signal. For a data signaling rate of 1200 b/s or 2400 b/s at the modulator input, the line signal shall always be 1200 baud. This line signal shall be obtained by grouping the serial stream of binary digital signals from the binary encoder (or, if the encoder is bypassed, the data source) into dibits. Upon determining which of four possible bit sequences are contained in the dibit under consideration, i.e., 00, 01, 10, or 11, the phase of an 1800-Hz carrier shall be shifted by +45, +135, -45, or -135 degrees respectively from the phase position of the carrier at the beginning of the immediately preceding dibit interval (see Figure 5.4-2). The left hand digit of the dibit is the one occurring first in the data stream. Figure 5.4-3 is an example of the phase shifts of the 1800-Hz carrier, prior to filtering, which would result from eight random bits at the 2400 b/s input data rate.

5.4.2.1.5 Modulator Output Level. The output level of the modulator shall be adjustable from -18 dBm to +3 dBm in steps no greater than 1.0 dB.

5.4.2.1.6 Modulator Carrier. The carrier frequency of the modulator shall be 1800 Hz and shall be manually adjustable to within ±0.5 Hz of the required carrier frequency. The long term frequency stability of the carrier shall be better than 1 part in 10^5 per day.

5.4.2.1.7 Modulator Output Impedance, Return Loss, and Balance. The output impedance of the modulator, over the frequency band 370 Hz to 3400 Hz, shall be 600 ohms balanced to ground with a minimum return loss of 26 dB against a nonreactive 600-ohm resistance. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

5.4.2.1.8 Demodulator Input Impedance, Return Loss, and Balance. The input impedance of the demodulator, over the frequency band 370 Hz to 3400 Hz, shall be 600 ohms balanced to ground with a minimum return loss of 26 dB against a nonreactive 600-ohm resistance. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB below the reference signal level.

5.4.2.1.9 Demodulator Input Signal Characteristics. The demodulator input signal shall be the synchronous quaternary phase shift keyed signal cited in 5.4.2.1.4, as modified by passage through the transmission channel. The demodulator shall accept

IF SIGNAL STATE AT POINT "C" IS	AND SIGNAL STATE AT POINT "A" IS	THE SIGNAL STATE AT POINT "B" SHALL BE
1	0	1
0	0	0
1	1	0
0	1	1

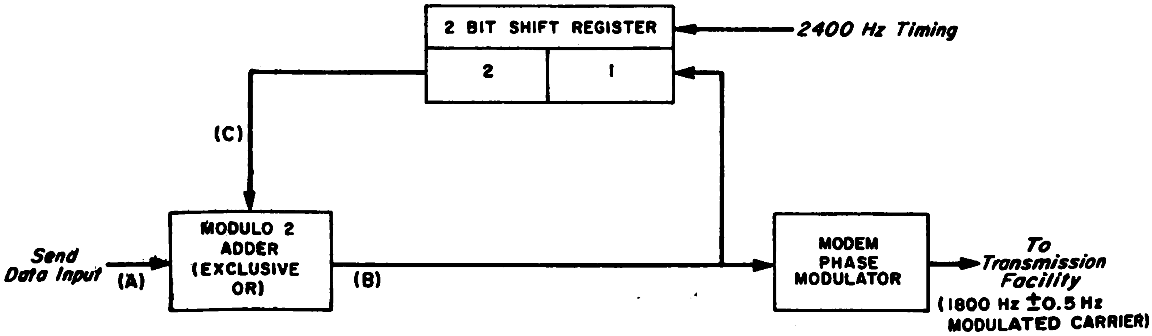


Figure 5.4-1. Binary Encoder

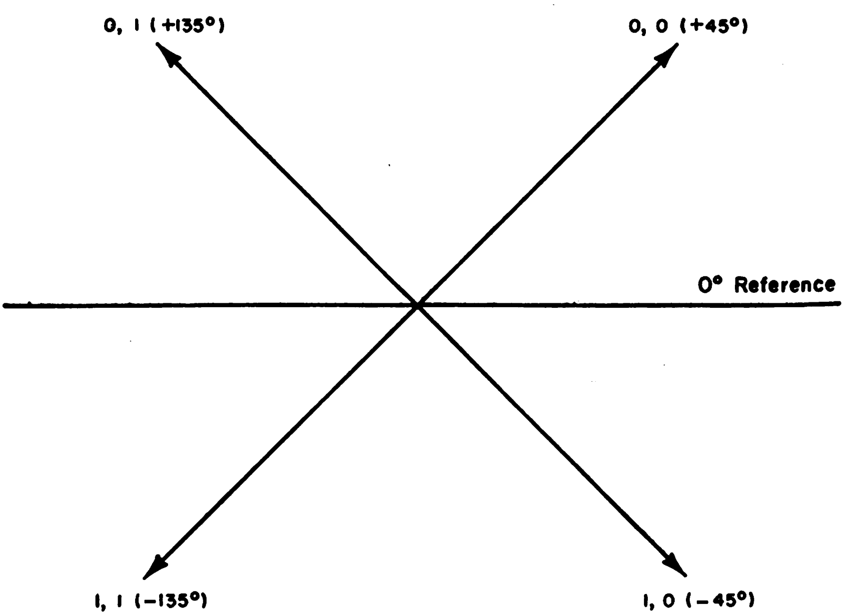
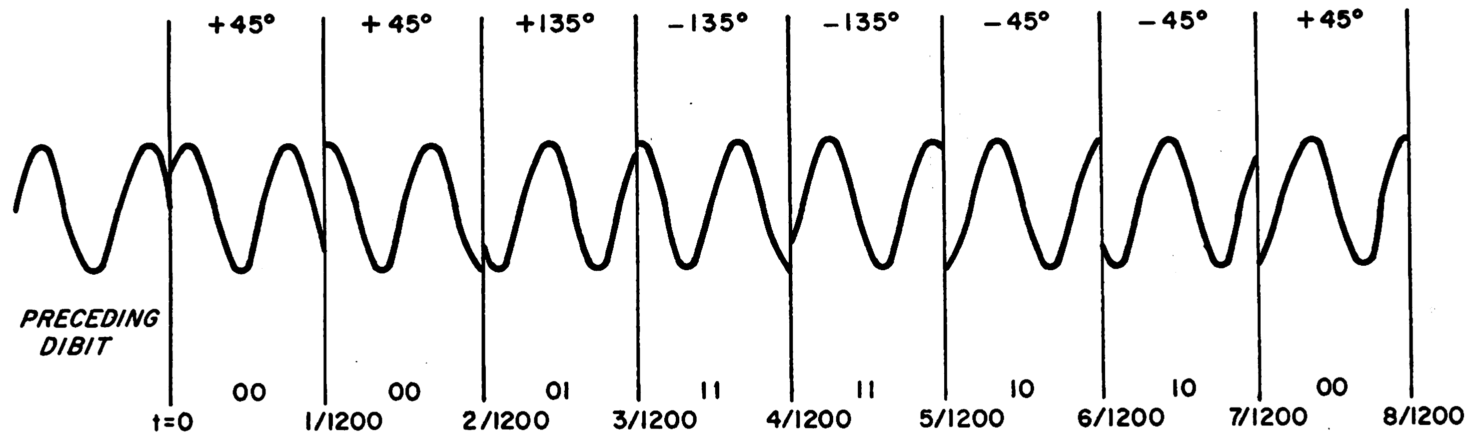


Figure 5.4-2. Vector Diagram



NOTE:

The phase shift shown is referenced to the beginning phase position of the preceding dibit interval. In actual practice, the transition is a smoothed phase change, rather than an abrupt phase change as shown in this figure.

Figure 5.4-3. Waveform Phase Relationships of Eight Random Bits this signal, synchronize the timing output signal to the received digital signal, and produce regenerated and retimed digital signals at 1200 b/s or 2400 b/s respectively, corresponding to the signals applied to the distant complementary modulator.

5.4.2.1.10 Demodulator Dynamic Range. The demodulator shall have a dynamic range of 30 dB, sufficient to accept and process, without degradation of performance, input signal levels from -35 dBm to -5 dBm.

5.4.2.1.11 Binary Decoder. Following demodulation of the signal described in subparagraph 5.4.2.1.9 and prior to the application of the demodulated signal to the demodulator output terminals, the demodulator shall subject the signal to a decoding process using a binary decoder. This decoder shall consist of a modulo 2 adder and 2-bit shift register as illustrated in Figure 5.4-4. Decoding shall be accomplished at a data signaling rate of 2400 b/s for the two data rates. The decoder complements the encoder discussed in 5.4.2.1.3 and, like the encoder, shall be capable of being inserted or bypassed on an optional basis.

IF SIGNAL STATE AT POINT "C" IS	AND SIGNAL STATE AT POINT "A" IS	THE SIGNAL STATE AT POINT "B" SHALL BE
1	0	1
0	0	0
1	1	0
0	1	1

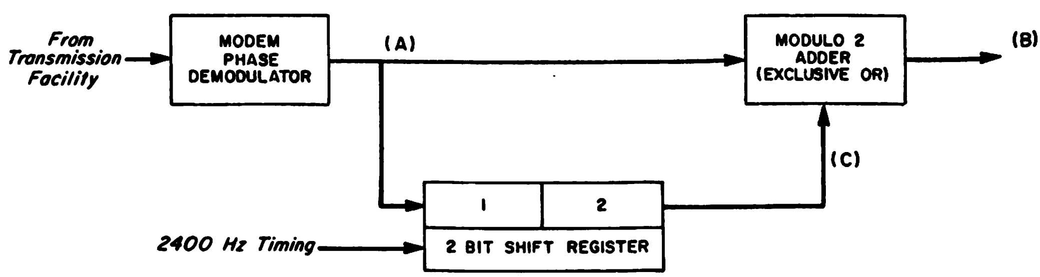


Figure 5.4-4. Binary Decoder

5.4.2.1.12 Isochronous Distortion of Demodulator Output. The isochronous distortion of the output data signal when measured at the operating data signaling rate shall be less than 4 percent (DO: 1 percent).

5.4.2.1.13 Timing Requirements. The modem shall be equipped with an internal clock which shall provide all necessary timing for generation of the multiplex line signals and data signal regeneration, as well as timing for other modem components and associated terminal equipment. In addition, the modem modulator and demodulator shall be capable of operation from an external station clock. The characteristics of the timing signals shall be as described in 4.3.1.6.

5.5 Radio Transmission Subsystems.

5.5.1 General. Radio transmission subsystems can be developed to utilize almost the entire frequency spectrum through various modes of propagation. For purposes of this document, these subsystems are presently limited to the areas listed in subparagraphs 5.5.2 through 5.5.5. These subsystems provide a suitable medium over which multiplexed channels can be passed.

5.5.2 High Frequency (HF) Radio Subsystems. Until common standards become available, reference shall be made to MIL-STD-188C and MIL-STD-188-317 for the respective tactical and long haul standards.

5.5.3 Line-of-Sight (LOS) Radio Subsystems. The long haul standards for LOS are currently being revised and updated (MIL-STD-188-313). Pending publication of MIL-STD-188-313, reference shall be made to DCAC 330-175-1 for long haul LOS standards. Tactical LOS standards are covered in MIL-STD-188C (to be replaced by MIL-STD-188-200 series). Until common LOS standards become available, reference shall be made to the respective long haul and tactical LOS standards.

5.5.4 Tropospheric Scatter (Tropo) Radio Subsystems. The long haul standards for tropo are currently being revised and updated and will be included as a part of MIL-STD-188-313. Pending publication of MIL-STD-188-313, reference shall be made to DCAC 330-175-1 for long haul tropo standards. Tactical tropo standards are covered in MIL-STD-188C (to be replaced by MIL-STD-188-200 series). Until common tropo standards become available, reference shall be made to the respective long haul and tactical tropo standards.

5.5.5 Communication Satellite Radio Relay Subsystems. Common standards for satellite service have not yet been developed.

5.6 Wire Transmission Subsystems. (Under Consideration)

5.7 End Instruments - Analog.

5.7.1 General. The following paragraphs deal with standards which are common to long-haul and tactical end instruments which transmit or receive an analog signal over a nominal voice bandwidth channel. Specifically, telephone instruments (both 2-wire and 4-wire) and facsimile instruments (both meteorological and general purpose) are discussed.

5.7.2 Telephone Instruments.

5.7.2.1 General. This section discusses those parameters which are common to long-haul and tactical telephone instruments. The instruments discussed herein are categorized as either 2-wire or 4-wire instruments. When 4-wire instrument standards are identical to 2-wire instrument standards, the discussion of the parameter appears under the 2-wire paragraph heading.

5.7.2.2 Two-Wire Instruments.

5.7.2.2.1 Impedance. The terminal impedance of a 2-wire telephone subset without automatic regulator features shall be 600 ohms ±20% at 1000 Hz. The reactive portion of this impedance shall be inductive and shall not exceed 300 ohms at 1000 Hz. The longitudinal terminal balance for telephone instruments shall be at least 40 dB.

5.7.2.2.2 Acoustical/Electrical Conversion.

5.7.2.2.2.1 Transmit Direction. A 1000-Hz signal with an rms sound pressure of 20 dynes per square centimeter at the grid of the transmitter shall produce -6 dBm ±2 dB at the 2-wire output of the telephone set (see Figure 5.7-1a).

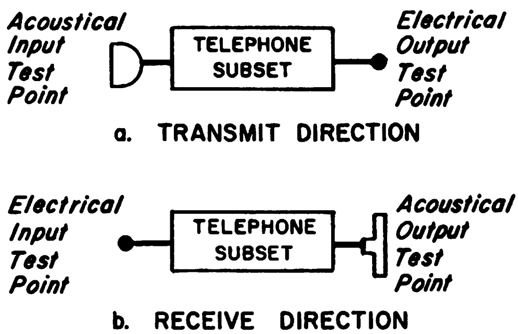


Figure 5.7-1. Test Points for Measurement of Amplitude Versus Frequency Characteristics

5.7.2.2.2.2 Receive Direction. A 1000-Hz signal of -22 dBm at the input of the telephone set shall produce an rms sound pressure of not less than 3.6 dynes per square centimeter at the receiver output (see Figure 5.7-1b). (DO: -32 dBm at the 2-wire input shall produce 2 dynes per square centimeter at the receiver output.)

5.7.2.2.2.3 Sidetone. A design objective for sidetone coupling loss between the transmitter input and the receiver output shall be between 15 dB and 40 dB and shall be determined by the formula:

$$\text{Sidetone (dB)} = 20 \log_{10} \frac{\text{Transmit rms Sound Pressure}}{\text{Receiver rms Sound Pressure}}$$

The actual value is not critical, but sidetone should not result in sound levels greatly in excess of those being received from the distant end nor should they be below audibility.

5.7.2.2.3 Amplitude vs. Frequency Characteristics.

5.7.2.2.3.1 Transmit Direction. Figure 5.7-1a shows the test points for measuring the amplitude versus frequency characteristics of the complete telephone transmitter. Standards for this parameter are under consideration.

5.7.2.2.3.2 Receive Direction. Figure 5.7-1b shows the test points for measuring the amplitude versus frequency characteristics of the complete telephone receiver. Standards for this parameter are under consideration.

5.7.2.2.4 Level Regulation. Telephones which employ automatic level regulation equipment shall incorporate passive nonlinear devices to automatically adjust the transmission loss in the subset to deliver a relatively constant level at the local switchboard or automatic switching center when connected to a short or long loop circuit. The level adjustment shall be controlled by the local loop resistance and local battery current that decreases as the length of the loop and its resistance is increased. Receiver level regulation shall be within the limits shown in Figure 5.7-2 when connected to typical 26 gauge nonloaded exchange cable, and the transmitter level regulation shall be within the limits shown in Figure 5.7-3. The above characteristics are based on the commercial type 500 subset. On older type instruments, many of which are currently in use, the loop resistance should not exceed 850 ohms to provide suitable levels. The limits shown in Figures 5.7-2 and 5.7-3 may be exceeded by 4 dB at the 10,000-ft. length (830 ohms approximately) where older instruments are in use. Although this standard does not cover exchange cable, it is necessary to consider the loop characteristics in the design of the telephone instrument.

5.7.2.2.5 Control and Supervision.

5.7.2.2.5.1 Local Battery. For the local battery mode of operation, microphone power shall be integral with the telephone set. Signaling to the other end of the line (magneto switchboard or other telephone) shall be achieved by a hand driven 20-Hz generator integral to the telephone set or other means.

5.7.2.2.5.2 Common Battery Supervision. In the common battery supervision mode of operation, microphone power shall be integral with the telephone set. Signaling to the other end of the line (switchboard only) shall be achieved by dc closure.

5.7.2.2.5.3 Common Battery. In the common battery mode of operation, microphone power shall be provided by the switchboard over the line. Signaling to the switchboard shall be by dc closure.

5.7.2.2.6 Ringing. Telephone instruments used in tactical and long-haul systems shall have an integral ringer with an arrangement to manually adjust the acoustic level. Provision shall also be made for connection of remote ringing units and visual signals when required. The ringer shall have the following characteristics:

(a) Impedance. The ringer shall have at least 6000 ohms impedance bridged across the line throughout the frequency range of 200 Hz to 3000 Hz.

(b) Frequency. The ringer shall operate on any frequency between 15 Hz and 25 Hz, and shall not respond to frequencies in the 200 Hz to 4000 Hz voice range.

(c) Current. Nominal ringing current shall be 0.04 amperes at 16 Hz to 20 Hz supplied by the switchboard.

(d) Voltage. The nominal ringing voltage shall be 90 volts.

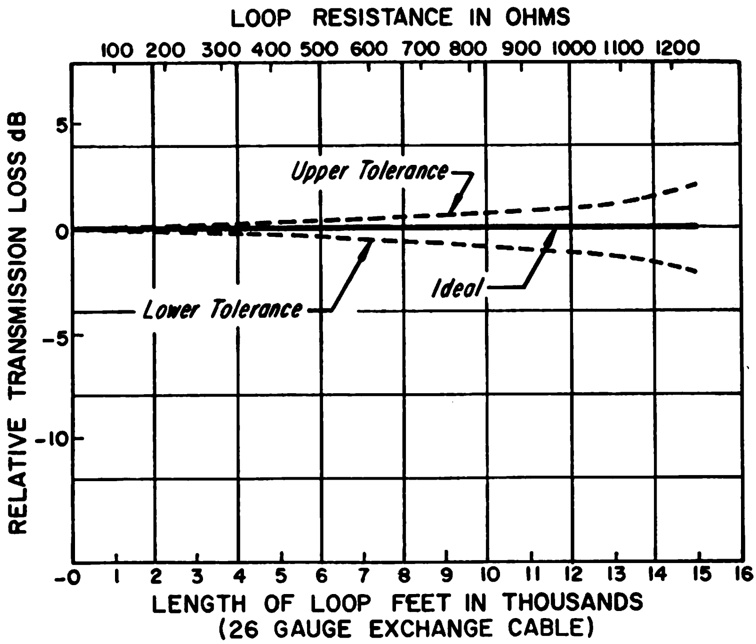


Figure 5.7-2. Subset Receiving Level Compensation Versus Loop Length

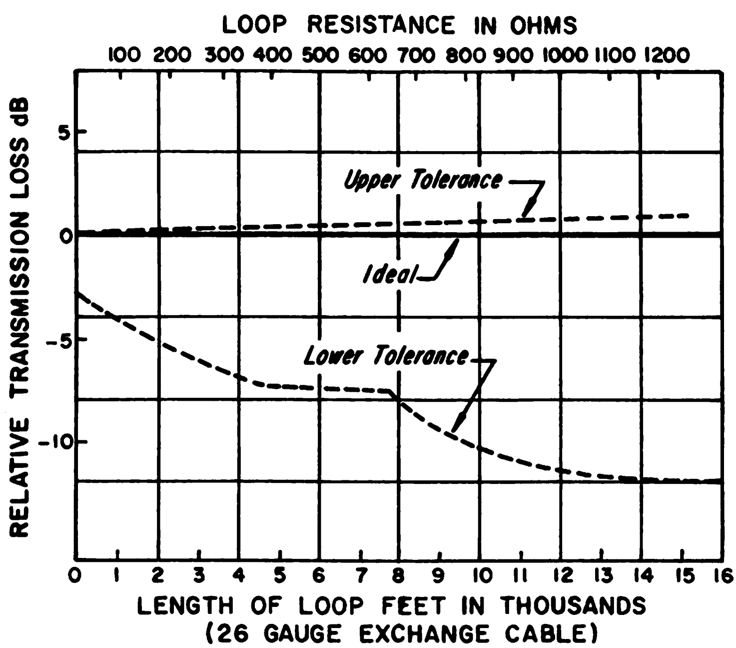


Figure 5.7-3. Subset Transmission Level Compensation Versus Loop Length

5.7.2.2.7 Dial Pulse Signaling. See subparagraph 4.8.3.2 for common standards.

5.7.2.2.8 Harmonic Distortion. The total harmonic distortion in the receiver direction shall be less than 5 percent for all input signals within the band 300 Hz to 3500 Hz with input level at 0 dBm.

5.7.2.3 Four-Wire Instruments.

5.7.2.3.1 Impedance. The terminal impedance on the transmit and receive sides of a 4-wire telephone subset shall be 600 ohms ±20% at 1000 Hz. When level regulation features are employed in the transmit section of the set, the above standard applies for a transmitter loop current of 50 mA. The longitudinal terminal balance for the input and output of 4-wire telephone instruments shall be at least 40 dB.

5.7.2.3.2 Acoustical/Electrical Conversion. See subparagraph 5.7.2.2.2 for common standard.

5.7.2.3.3 Amplitude vs. Frequency Characteristics. See subparagraph 5.7.2.2.3 for common standard.

5.7.2.3.4 Level Regulation. See subparagraph 5.7.2.2.4 for common standard.

5.7.2.3.5 Control and Supervision. See subparagraph 5.7.2.2.5 for common standard.

5.7.2.3.6 Ringing.

5.7.2.3.6.1 20-Hz Ringing. See subparagraph 5.7.2.2.6 for common standard.

5.7.2.3.6.2 Tone-Ringing. For telephone sets equipped with an integral tone ringer, the following standards apply:

(a) The tone ringer shall operate from a signaling battery supplied on the receive pair. A grille shall be provided as an audible outlet for tones generated by the ringer.

(b) The tone ringer shall consist of an oscillator and a transducer. On an incoming call signal, the oscillator and transducer shall produce a 2000 Hz ±400 Hz acoustic tone, interrupted 12 ±4 times per second. The output tone level shall be manually adjustable from the outside of the instrument. The adjustment, however, shall not completely disable the tone.

(c) The acoustic power output of the tone ringer, when measured in a free field perpendicular to the telephone face plate at a distance of two feet, with the ringer volume control in the maximum output position, shall be greater than +70 dB, referred to 2×10^{-4} dynes/cm^2.

5.7.2.3.7 Dual Tone Multi-Frequency (DTMF) Signaling. For present common standard see subparagraph 4.8.3.1. Other areas of commonality are under consideration due to the need for a higher degree of commonality in DTMF techniques.

5.7.2.3.8 Harmonic Distortion. See subparagraph 5.7.2.2.8 for common standard.

5.7.3 Facsimile Equipment.

5.7.3.1 Meteorological Facsimile Equipment. Facsimile is extensively employed throughout the world for meteorological communications. The majority of the systems in use are scheduled broadcasts employing wire or radio facilities. When employing wire, amplitude modulation is employed. When employing radio, either amplitude modulation or frequency modulation (FSK) is employed. When frequency modulation is employed, an ancillary device to convert amplitude to/from frequency modulation is required. It is expected that the use of digitized facsimile will be expanded in the future. There are two general types of facsimile equipment in use in the long haul/tactical environment. They are meteorological and general purpose types.

5.7.3.1.1 Meteorological Facsimile Transmitter.

5.7.3.1.1.1 Original Copy Size.

5.7.3.1.1.1.1 Drum Scanners. The scanning system of the transmitter shall be configured to accept an original copy 18-5/8 inches (473 mm) wide with tolerances not to exceed +1/16 inch (1.6 mm) to -3/32 inch (2.4 mm) and either 12 inches (305 mm) in length or an integral multiple thereof and of thickness not greater than 0.010 inch (0.25 mm).

> NOTE: The World Meteorological Organization Standards specify a drum length of 550 mm, which will suitably accommodate this size original copy.

5.7.3.1.1.1.2 Continuous Scanners. A continuous (flat bed) scanner shall accept and properly scan an original copy 18-5/8 inches (473 mm) wide. At least 2 inches (50.8 mm) of paper will be provided in the direction of feed to accommodate the paper feed mechanism. The copy need not be precisely sized or have square edges.

> NOTE: It is desirable that flat bed scanning devices accept originals of greater width than 18-5/8 inches (473 mm) and of indefinite length.

5.7.3.1.1.2 Original Copy Characteristics. The facsimile scanner shall be designed to accept any original copy normally used for meteorological charts and shall have a spectral sensitivity corresponding to the RMA S-4 photo-surface. It shall transmit marks on the copy made by any visible color used for printing.

> NOTE: The inclusion of an automatic level control system capable of compensating for variations in the background density or color of the original copy is desirable to eliminate manual adjustments between copies.

5.7.3.1.1.3 Scanning Line Length. The total length of the scanning line shall be 18.85 inches (478 mm).

NOTE: The total scanning line length includes the length of the dead sector, which is not optically scanned in the transmission process (see subparagraph 5.7.3.1.1.5 for dead sector length).

5.7.3.1.1.4 Scanning Direction. The scanning direction shall be normal (corresponding to a left-hand helix).

5.7.3.1.1.5 Dead Sector. A sector at the end of the scanning line which is 3 percent to 5 percent ±0.5 percent of the scanning line length shall be provided. This dead sector shall coincide with the time position of the phasing signal (see subparagraph 5.7.3.1.1.13.2) when the phasing signal is transmitted. The signal transmitted by the transmitter during the dead sector shall be the equivalent of scanning 50 percent of full black and then 50 percent of full white.

NOTE: This characteristic signal is specified to permit manually phasing a facsimile recorder under adverse transmission conditions and to provide information for an automatic control system for the recorder.

5.7.3.1.1.6 Scanning Speeds. The scanning speed shall be 60, 90, and 120 strokes per minute. The selection of the scanning speed shall be by means of a suitable control on the device and rapidly made by the machine operator.

5.7.3.1.1.7 Line Advance. The line advance shall be 1/96 inch (0.26 mm).

5.7.3.1.1.8 Scanning Spot Size. The scanning spot size shall be 0.0104 inch (0.26 mm) x 0.0104 inch (0.26 mm), and be constant along the scanning line.

5.7.3.1.1.9 Index of Cooperation. The index of cooperation shall be 576.

NOTE: The World Meteorological Organization Standards also permit an Index of Cooperation of 288 (or an index of 576 with alternate line scanning).

5.7.3.1.1.10 Scanning Linearity. To protect the dimensional fidelity of the system, the physical position of the scanning spot shall not depart from the theoretical position thereof by more than 1/96 inch (0.26 mm) per inch (25.4 mm) of scanned copy. This relation applies in the direction of the scanning line as well as perpendicular to it.

5.7.3.1.1.11 Signal Characteristics.

5.7.3.1.1.11.1 Signal Output Chracteristics. The signal output of the facsimile transmitter corresponding to a high signal contrast shall be adjustable between +10 dBm and -10 dBm. The output impedance shall be 600 ohms, balanced to ground, with a minimum return loss of 20 dB against a 600-ohm resistance over the frequency range of 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB. No signal shall be transmitted when the transmitter is in standby or idle condition. A suitable output signal level monitor will be provided. The carrier frequency shall be maintained at an accuracy of at least 3 parts per 10^6.

5.7.3.1.1.11.2 Signal Contrast. The signal contrast shall be 20 dB ±2 dB. Both black and white transmission shall be provided on a selectable basis (see also subparagraph 5.7.3.1.2.11).

5.7.3.1.1.11.3 Halftone Chracteristic. The voltage output/copy density relation of the transmitted signal shall be nominally linear.

5.7.3.1.1.12 Synchronization. The scanning rates of the transmitter shall be controlled by a self-contained frequency standard maintained at the assigned frequency within 3 parts per million. The frequency driving the synchronous drive system of the scanner shall be 300 Hz or an integral multiple thereof.

> NOTE: The World Meteorological Organization Standards specify a frequency standard maintained at only 5 parts per million for synchronization purposes.

5.7.3.1.1.13 Control Functions. To effect automatic operation, it is necessary to transmit to a facsimile recorder a start command, a signal to permit recorder phasing, and a stop command. The transmitter operating cycle shall conform to this cycle as follows.

5.7.3.1.1.13.1 Start Signal. When activated, the transmitter shall transmit alternate black and white levels (corresponding to high and low signal levels) modulated at a rate of 300 ±0.1 times per second for a period of five seconds.

> NOTE 1: If an index of 288 (or index of 576 with alternate line scanning) is employed, the transmitter shall transmit alternate black and white levels modulated at a rate of 675 times per second for a period of five seconds.

> NOTE 2: If the index selection signals described in this paragraph are not employed, transmission of the phasing signal described in subparagraph 5.7.3.1.1.13.2 shall be sufficient to start the facsimile recorder.

5.7.3.1.1.13.2 Phasing Signal (Accepted as an interim measure). A 30-second transmission of alternating white and black signals of the following frequencies:

1.0 Hz for speed of 60 strokes per minute
1.5 Hz for speed of 90 strokes per minute
2.0 Hz for speed of 120 strokes per minute

The waveform may be either symmetrical, i.e. white and black, each lasting half the line of scanning, or asymmetrical provided that in such event the white will last for 5 percent and the black for 95 percent of the line of scanning.

Published data of facsimile transmissions shall include details of the phasing signal transmitted, e.g., 50 percent or 5 percent white phasing. Phasing is actuated by the leading edge of the signal. This leading edge must correspond in phase with the entry of the scanning-beam into the dead sector of the subsequent transmission. The envelopes of the signals transmitted will be roughly rectangular.

5.7.3.1.1.13.3 Stop Signal. Upon completion of the scanning, the transmitter shall automatically transmit an alternate black and white signal interrupted at a rate of 450 ±0.1 times per second for a period of five seconds followed by 10 seconds of signals corresponding to continuous black. The envelopes of the 450-Hz signals will be roughly rectangular.

5.7.3.1.1.13.4 Manual Operation. Controls shall be provided on the transmitter to permit the operator to start or stop the transmitter, or transmit phasing signals manually. Provisions shall also be included within the transmitter to permit the operator to transmit unmodulated black or white signals indefinitely for circuit adjustment purposes.

5.7.3.1.1.14 Power Requirements. No power requirements are stipulated in these standards; however, no information or frequency obtained from the power source shall be used to derive any frequency or timing rates within the transmitter.

5.7.3.1.1.15 Modulation Characteristics.

(a) Amplitude modulation (AM):
The maximum amplitude of the carrying frequency should correspond to the transmission of signal black. Value of the carrier frequency shall be 1800 Hz or 2400 Hz.

NOTE: When vestigial sideband transmission is used over a nominal 4-kHz voice bandwidth circuit, a carrier frequency of 2400 Hz will be employed. The upper sideband will be completely attenuated. Also 1800 Hz is normally used for scanning speeds of 60 strokes per minute and 2400 Hz for 90 or 120 strokes per minute.

(b) Modulation by frequency deviation (FM):
Value of the central frequency - 1900 Hz
Value of the frequency for black - 1500 Hz
Value of the frequency for white - 2300 Hz

The frequencies for black and white should not vary by more than 8 Hz over a period of 30 seconds and by more than 16 Hz over a period of 15 minutes.

5.7.3.1.2. Meteorological Facsimile Receiver (Large Format).

5.7.3.1.2.1 Recorded Copy Size.

5.7.3.1.2.1.1 Drum Recorders. The drum of these recorders shall accept recording media 18-5/8 inches (473 mm) wide with tolerances not to exceed +1/16 inch (1.6 mm) to -3/32 inch (2.4 mm) and either 12 inches (305 mm) in length or an integral multiple thereof.

5.7.3.1.2.1.2 Continuous Recorders. The continuous recorder shall accept a 400-foot (121.9 m) roll of recording media, wound on a core of 1 inch, ±1/4 inch (25.4 mm, ±6.4 mm) inside diameter, and 18-5/8 inches (473 mm) wide with tolerances not to exceed +1/16 inch (+1.6 mm) to -3/32 inch (-2.4 mm). If pressure sensitive recording techniques are employed, the transfer tissue shall be supplied from a spool 400 feet (121.9 m) in length, wound on a core of 1 inch, ±1/4 inch (25.4 mm, ±6.4 mm) inside diameter, and 18-5/8 inches (473 mm) wide with tolerances not to exceed +3/8 inch (+9.5 mm) to 0 inch.

5.7.3.1.2.2 Recorded Line Length. The total length of the recorded line shall be 18.85 inches (478 mm).

5.7.3.1.2.3 Recording Direction. The recording direction shall be normal (corresponding to a left-hand helix).

5.7.3.1.2.4 Recording Speed. The recording speed shall be 60, 90, and 120 strokes per minute. The selection of the recording speed shall be by means of a suitable control on the receiver and made by the machine operator.

5.7.3.1.2.5 Line Advance. The line advance shall be 1/96 inch (0.26 mm).

5.7.3.1.2.6 Recording Spot Size. The recorded spot shall be 0.0104 inches x 0.0104 inches (0.26 mm x 0.26 mm).

5.7.3.1.2.7 Index of Cooperation. The index of cooperation shall be 576.

NOTE: The World Meteorological Organization Standards permit 288 (or 576 with alternate line scanners).

5.7.3.1.2.8 Dead Sector. The signal transmitted during the interval the transmitter is scanning the dead sector may be blanked within the recorder if operationally desirable.

5.7.3.1.2.9 Dimensional Stability. Dimensional distortion between the transmitted and received copy shall not exceed 1/96 inch (0.26 mm) per linear inch (25.4 mm) when measured along the scanning line or perpendicular to the scanning line.

5.7.3.1.2.10 Signal Characteristics.

5.7.3.1.2.10.1 Input Circuit. The input circuit shall have a nominal impedance of 600 ohms, balanced to ground, with a minimum return loss of 20 dB against a 600-ohm resistance over the frequency range of 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB. The input circuit shall be designed to withstand the ringing voltage impressed on a telephone circuit.

5.7.3.1.2.10.2 Input Power Level. The receiver shall operate properly when input signals corresponding to a high signal contrast between -9 dBm and -36 dBm are received.

5.7.3.1.2.11 Operating Controls. A gain control, an independent density control, a manual phasing control, a start-stop control, and a white/black transmission selector shall be provided in a convenient location on the receiver.

5.7.3.1.2.12 Synchronization. The scanning rates of the recorder shall be controlled by a self-contained frequency standard maintained at the assigned frequency within 3 parts per million. The frequency driving the synchronous drive system of the receiver shall be 300 Hz or an integral multiple thereof.

> NOTE: The World Meteorological Organization Standards specify a frequency standard maintained at only five parts per million for synchronization purposes.

5.7.3.1.2.13 Control Functions. The facsimile recorder shall reliably start, phase, and stop when signals are received from the transmitter. It shall be possible for the operator to override any automatic function with operating controls described above.

5.7.3.1.2.14 Power Requirements. No power requirements are stipulated in these standards; however, no information or frequency obtained from the power source shall be used to derive any frequency or timing rate within the receiver.

5.7.3.1.3 Meteorological Facsimile Receiver (Small Format).

5.7.3.1.3.1 General. The facsimile receiver shall employ continuous recording techniques and a recording medium capable of resolving at least 200 lines per inch (25.4 mm). The receiver shall employ a recording medium that is stable in its operating environment, has indefinite storage life, and does not fade upon exposure to light.

5.7.3.1.3.2 Recorded Copy Size. The recorded copy shall be 8-1/2 inches (216 mm) wide. The length is dependent on the duration of the transmission. The recorder shall accept a 400-foot (121.9 m) roll of recording medium spooled on a 1 inch ±1/4 inch (25.4 mm ± 6.4 mm) inside diameter core and, if carbon tissue is employed, the carbon tissue shall be supplied from a separate roll of 400 feet (121.9 m) spooled on a core 1 inch ±1/4 inch (25.4 mm ±6.4 mm) inside diameter.

5.7.3.1.3.3 Recorded Line Length. The total recorded line length shall be 8.64 inches (220 mm).

5.7.3.1.3.4 Recording Direction. The recording direction shall be normal (corresponding to a left-hand helix).

5.7.3.1.3.5 Recording Speed. The recording speed shall be 60, 90, and 120 strokes per minute. The selection of the recording speed shall be by means of a suitable control on the receiver and made by the machine operator.

5.7.3.1.3.6 Index of Cooperation. The indices of cooperation shall be 576 and 264. Selection of the index shall be accomplished by a suitable control on the receiver and made by the machine operator.

> NOTE: Certain meteorological charts are transmitted at an index of 288. Operation using an index of 264 when recording these transmissions will result in negligible dimensional distortion. The capability to operate at an index of cooperation of 264 affords interoperability with other facsimile systems without dimensional distortion.

5.7.3.1.3.7 Line Advance. The line advance shall be 1/209.5 inch (0.12 mm) for an index of cooperation of 576 or 1/96 inch (0.26 mm) for an index of cooperation of 264, selected by the index of cooperation control.

5.7.3.1.3.8 Recording Spot Size. The recording spot size shall be 1/209.5 inch by 1/209.5 inch (0.12 mm by 0.12 mm) for an index of cooperation of 576 or 1/96 inch by 1/96 inch (0.26 mm by 0.26 mm) for an index of cooperation of 264, with the marking stylus or element being changed for the particular index of cooperation being employed.

5.7.3.1.3.9 Dead Sector. The signal transmitted during the interval the transmitter is scanning the dead sector may be blanked if operationally desirable.

5.7.3.1.3.10 Signal Characteristics.

5.7.3.1.3.10.1 Input Circuit. The input circuit shall have a nominal impedance of 600 ohms, balanced to ground, with a maximum return loss of 20 dB against a 600-ohm resistance over the frequency range of 300 Hz to 3400 Hz. The electrical symmetry shall be sufficient to suppress longitudinal currents at least 40 dB. A high impedance bridging input of at least 2500 ohms shall also be provided. The input circuits shall be designed to withstand the ringing voltage normally impressed on a telephone circuit for signaling.

5.7.3.1.3.10.2 Input Power Level. The receiver shall operate properly when input signals corresponding to a high signal contrast between -9 dBm and -36 dBm are received.

5.7.3.1.3.11 Operating Controls. A gain control, an independent density control, a manual phasing control, a start/stop control, and a white/black transmission selector shall be provided in a convenient location on the receiver.

5.7.3.1.3.12 Synchronization. The scanning rates of the recorder shall be controlled by a self-contained frequency standard maintained at the assigned frequency within three parts per million. The frequency driving the synchronous drive system of the receiver shall be 300 Hz or an integral multiple thereof.

> NOTE: The World Meteorological Organization Standards specify a frequency standard maintained at only five parts per million for synchronization purposes.

5.7.3.1.3.13 Control Functions. The facsimile recorder shall reliably start, phase, and stop when activated by the transmitted signal. It shall be possible for the operator to override any automatic function with the operating controls described in "Operating Controls" above. The receiver shall start one to three seconds after receipt of a 1800-Hz or 2400-Hz signal from the transmitter, automatically switch into a phasing mode for 10-12 seconds, and then automatically switch into the recording mode. The receiver shall stop three to five seconds after the 1800-Hz or 2400-Hz signal disappears and shall then be capable of immediate recycling. This mode of operation is not fully compatible with the World Meteorological Organization Standards.

5.7.3.1.3.14 Power Requirements. No power requirements are stipulated in these standards; however, no information or frequency obtained from the power source shall be used to derive any frequency or timing rate within the receiver.

5.7.3.2 General Purpose (Black/White) Facsimile Equipment. (Under consideration.)

5.7.3.3 Commonality between Meteorological and General Purpose Facsimile Equipment. (Under consideration).

5.8 End Instruments - Digital.

5.8.1 General. The following paragraphs contain standards which are common to long haul and tactical end instruments which transmit or receive a digital signal. Specifically included are teletypewriter equipment (including page printers, paper tape readers, and paper tape punches), recording media, polar relays, and optical character recognition equipment.

5.8.1.1 Standard Code for Information Interchange. The standard code and character set shall be as specified in subparagraph 4.3.1.2.1. Appendix B is applicable to the representation of character-coded information in information interchange and describes the alphabet that is to be used as common basic language for data transmission.

5.8.1.2 Interim Codes and Alphabets. Due to the widespread usage of 5-unit start/stop equipment, the interim standard coded character set specified in subparagraph 4.3.1.2.2 shall be used for those equipments which are presently in existence and for modifications or additions to existing equipments where it is impractical or impossible to utilize the standard code. For new equipment, see subparagraph 4.3.1.2.1.

5.8.1.3 Character Interval. The character intervals for start/stop transmission and for synchronous transmission are shown and described in Appendix B.

5.8.1.4 Modulation Rate. The modulation rate at the end instrument shall conform to the requirements of subparagraph 4.3.1.1.

5.8.1.5 Interface Characteristics. The standard low level digital interface specified in subparagraph 4.3.1.3 shall apply.

5.8.2 Teletypewriter Equipment.

5.8.2.1 Functional Characteristics.

5.8.2.1.1 Page Printing Equipment. The basic unit employed in printing telegraphy is the page printer. This is a device which generally types a line of printed characters on rolled paper stock. Some machines also use fanfold paper. The paper may be fed by friction, or sprockets, or both.

5.8.2.1.1.1 Line Length, Page Copy. The printer shall be capable of printing 80 characters (printing positions) per line.

5.8.2.1.2 Keyboards. Refer to MIL-STD-1280 for standard keyboard arrangements.

5.8.2.1.3 Paper Tape Readers. There are two basic classes of mechanical tape readers: (1) Coincident selection in which all pins of the tape reader sense the tape simultaneously; and (2) sequential selection readers in which pins are successively presented to the tape to determine the presence or absence of a perforation. Each method of selection has certain mechanical design advantages.

Many of the modern tape readers employ a photosensitive technique for determining the presence or absence of a perforation. Some of these readers operate on the "sequential selection" principle but operation on the "coincident selection" principle is more predominant.

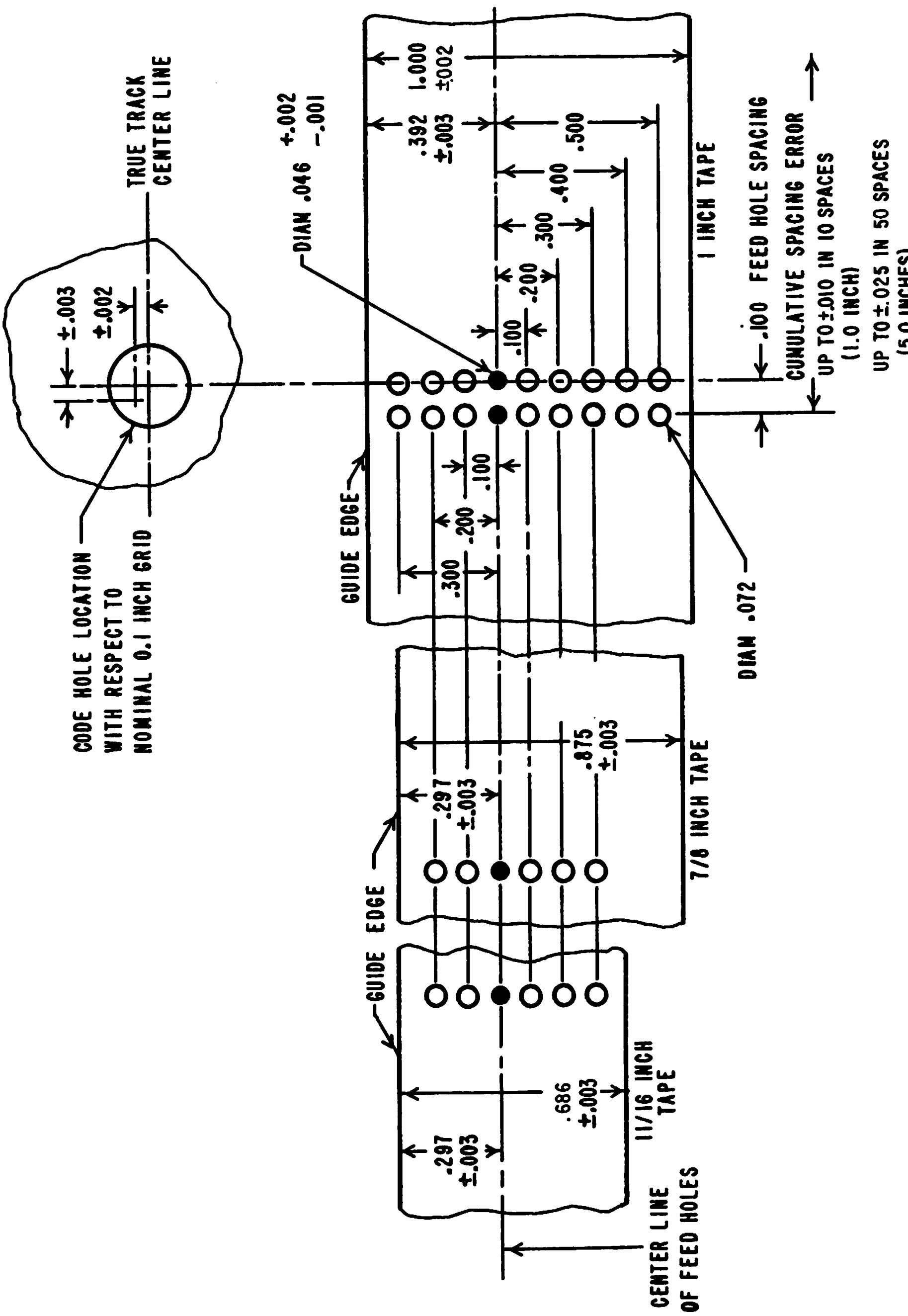
There are no standards established at this time for the method of sensing punched tape beyond that the reader can correctly sense the standard tape without modification of, or damage to, the standard tape.

5.8.2.1.4 Paper Tape Punches. The paper tape punch is an end instrument designed for the recording of information on punched paper tape. The drive pulses required to activate the punch may be furnished by a typewriter keyboard, data communications circuit, or other digital instrumentation. There are two basic types of punches: (1) Nonprinting punches in which only data and feed holes are punched in the tape; and (2) printing punches in which, in addition to punching data and feed holes, the characters are printed on the tape (see Figure 5.8-1).

There are two methods of printing the tape: (1) The printing is in line with the feed holes and six characters behind the corresponding data holes; and (2) the printing is between the sixth and seventh feed holes following the corresponding data holes (see Figure 5.8-2).

In each type of punch there are two methods of punching the holes: (1) Chadless or partially punched holes; and (2) chadded or fully punched holes.

Each punching method has its advantages but the chadded or fully punched method shall be standard.



NOTES
1—UNLESS OTHERWISE INDICATED ALL TOLERANCES ARE ±.003

Figure 5.8-1. Paper Tape Information Tracks

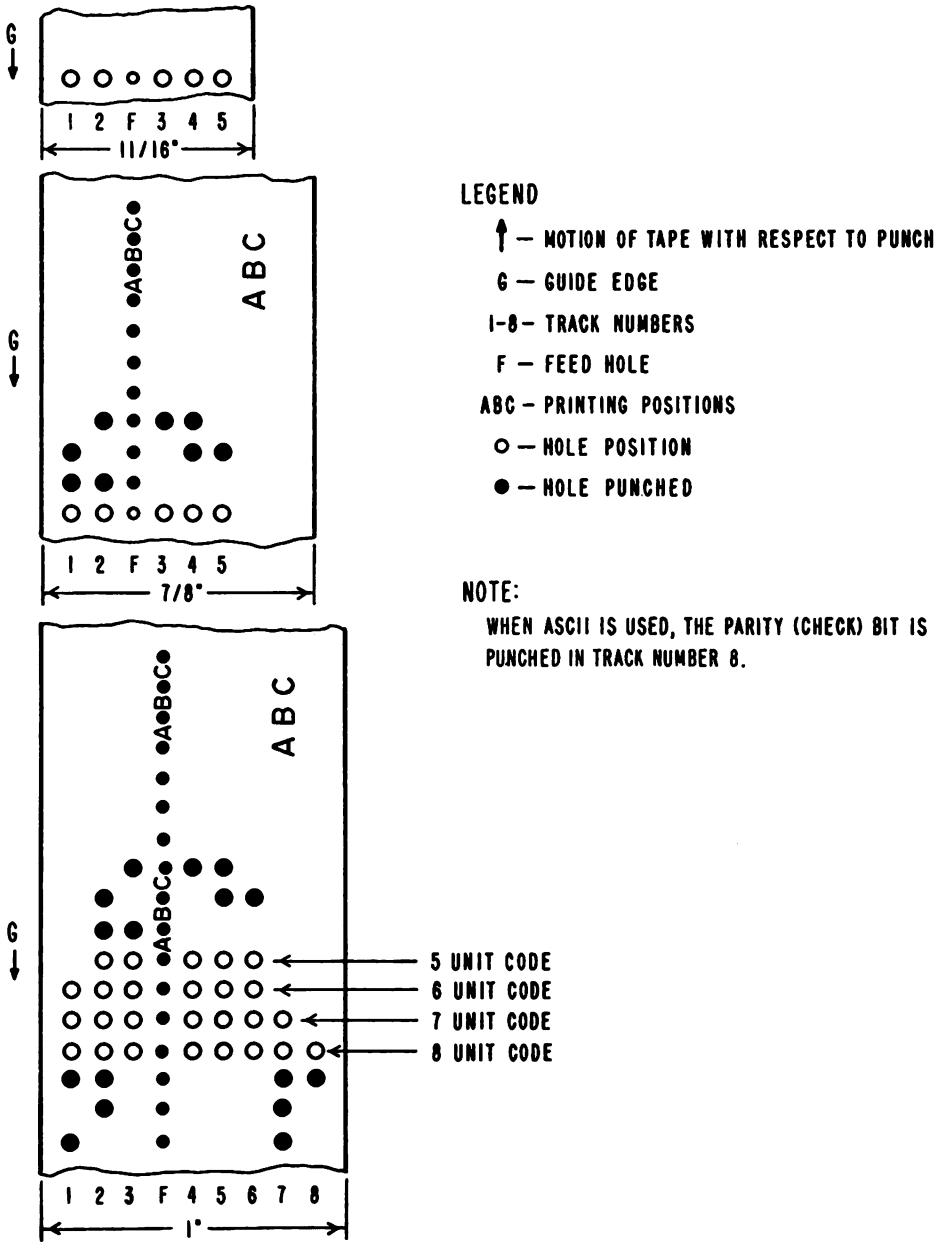


Figure 5.8-2. Standard Printing and Punching Plan for Paper Tape

5.8.2.2 Performance Characteristics.

5.8.2.2.1 Transmitting Equipment Output Distortion. The output distortion (all types) of high performance electromechanical, electronic, or composite transmitting devices (either sequential or coincidental selection) shall not exceed one percent.

5.8.2.2.2 Receiving Device Distortion Tolerance. The following standards are applicable to high performance receiving devices.

5.8.2.2.2.1 Electromechanical Receiving Devices. Electromechanical receiving devices shall be capable of tolerating signal distortion in accordance with the following tabulation:

Receiving Device Performance

	Mark (%)	Space (%)
Switched Bias Distortion	45	45
Bias Distortion	45	45
End Distortion	45	45
Cyclic Distortion	22.5	22.5

5.8.2.2.2.2 Electronic-Input Receiving Devices. Receiving devices utilizing electronic input circuitry shall be capable of tolerating signal distortion in accordance with the following tabulation.

Electronic Receiving Device Performance

	Mark (%)	Space (%)
Switched Bias Distortion	49	49
Bias Distortion	49	49
End Distortion	49	49
Cyclic Distortion	24.5	24.5

5.8.2.2.3 Modulation Rate Accuracy (Start/Stop Distortion). High performance transmitting and receiving equipment shall maintain a modulation rate accuracy so that, in each character interval, every transition shall be within one percent of the theoretically correct transition point measured with reference to the start transition of that character at the given modulation rate.

5.8.2.2.4 Paper Line Feed Operation. Start/stop receiving equipment for 15 characters per second or less shall be capable, in one character interval, of returning the printing point to the left side of the page and advancing the page one step (1 or 2 lines) in response to the code combination for Line Feed. (For higher speed equipment appropriate techniques may be applied.)

5.8.2.2.5 Bit Stepped Operation. Equipment employing electronic input/output shall be capable of operating under external bit stepped control at the applicable modulation rate in the bit synchronous transmission mode with 4 through 16 units per character interval. (Refer to subparagraph 4.3.1.6.1.)

5.8.2.2.6 Character Stepped Operation. Start/stop equipment shall be capable of operating under external character stepped control where the step interval is equal to or greater than the character interval at the applicable modulation rate.

5.8.2.3 Recording Media.

5.8.2.3.1 Teletypewriter Roll Paper. The standard roll paper is for use with friction feed operation; it shall be 8-1/2 inches wide and 5 inches in diameter, and shall be in accordance with Federal Specification UU-P-547.

5.8.2.3.2 Teletypewriter 8-1/2 Inch Fanfold Paper. The standard 8-1/2 inch fanfold paper is for sprocket feed operation and shall be in accordance with MIL-P-40023. The paper colors and number of parts may be varied since these parameters do not adversely affect the standardization of the printing machines.

5.8.2.3.3 Paper Tape.

5.8.2.3.3.1 Information Tracks. Standard teleprinter punched tape shall have 5 or 8 information tracks, as appropriate for the coded character set being used. A perforation shall represent a "mark" or "one" and no perforation shall represent a "space" or "zero". Two standard printing and punching plans for paper tape are specified (see Figures 5.8-1 and 5.8-2).

(a) Systems which utilize three information tracks between the guiding edge and the feed hole.

(b) Systems which utilize two information tracks between the guiding edge and the feed hole.

5.8.2.3.3.2 Tape Width.

5.8.2.3.3.2.1 Minimum Tape Width of 1 Inch. A minimum tape width of 1 inch (with tolerances as specified in Federal Specification UU-T-120B) is established for systems with the capability of utilizing three information levels between the guiding edge and the feed hole.

5.8.2.3.3.2.2 Minimum Tape Width of 11/16 Inch and 7/8 Inch. Minimum tape width of 11/16 inch and 7/8 inch (with tolerance as specified in Federal Specification UU-T-120B) are established for systems with the capability of utilizing two information levels only between the guiding edge and the feed hole.

5.8.2.3.3.3 Chadded Tape. Where perforated tape is used, holes shall be completely perforated (chadded).

5.8.3 Line Relay Characteristics.

5.8.3.1 Electromechanical Polar Relays. Standards for electromechanical polar relays are not specified. Subparagraph 4.3.1.3 provides standards for low level digital interfaces. The performance characteristics in the following subparagraphs 5.8.3.1.1 through 5.8.3.2.10 are for information purposes only.

5.8.3.1.1 Side Stable. The relays shall be side stable, i.e., they shall remain in the last signaled contact position.

5.8.3.1 2 Operating Differential. 5 milliamperes (maximum).

5.8.3.1.3 Distortion. Total distortion introduced into the transmission facilities, attributable to the relay, shall be less than two percent.

5.8.3.1.4 Winding Current. The operating current per winding shall not exceed 80 milliamperes.

5.8.3.1.5 Winding DC Resistance. The relay shall contain two operating windings each having a dc resistance of not less than 100 ohms and not greater than 200 ohms.

5.8.3.1.6 Winding Reactance. Not specified.

5.8.3.1.7 Contact Material. Not specified.

5.8.3.1.8 International Octal Base Pin Connections. Relays shall be of a plug-in type configured for an international octal base with pin connections as viewed from the bottom of the socket as follows:

Pin #1, Coil #1 positive (potential causing relay armature to make marking contact) termination

Pin #2, Coil #2 negative termination

Pin #3, Coil #2 positive termination

Pin #4, Space contact

Pin #5, Ground of relay case if applicable

Pin #6, Armature (tongue) of relay

Pin #7, Marking contact

Pin #8, Coil #1 negative termination

5.8.3.2 Electronic Polar Relays. Great care must be made in accepting an electronic (solid state) substitute for the electromechanical polar relay. It shall meet the following minimum requirements.

NOTE: With the shift from high to low level operation, the need for this device is minimal.

5.8.3.2.1 Side Stable. The relays shall be side stable, i.e., they shall remain in the last signaled contact position.

5.8.3.2.2 Operating Differential. 2 milliamperes (maximum).

5.8.3.2.3 Modulation Rates. Modulation rates up to 4800 Bauds are considered desirable. However, to minimize the relay's response to transients, it may be useful to dampen the relay in a manner that limits its operation in a given application to ranges under 100, 500, 1000, 1500, 2500, 5000, etc., Bauds.

5.8.3.2.4 Distortion. Total distortion introduced into the transmission facilities, attributable to the relay, shall be less than one percent.

5.8.3.2.5 Winding Current. The relay shall contain the equivalent circuitry for two independent windings. This equivalent circuitry shall be capable of passing currents up to and including 80 milliamperes.

5.8.3.2.6 Winding DC Resistance. The relay shall contain the equivalent circuitry for two independent windings, and this equivalent circuitry shall present an almost pure resistive load to the source of not less than 100 ohms and not more than 200 ohms.

5.8.3.2.7 Winding Reactance. The winding reactance shall be essentially zero ohms at the applicable modulation rate.

5.8.3.2.8 Output Characteristics. The output impedance shall be less than 50 ohms. The maximum signal current shall be 150 milliamperes. The maximum potential applied across the mark and the tongue or space and tongue shall be 260 volts.

5.8.3.2.9 Contacts. The relay shall contain the equivalent circuitry for an electro-mechanical relay armature and two independent and isolated contacts. The equivalent circuitry shall be capable of carrying up to and including 0.150 ampere of current at 260 volts. (The maximum voltage referenced to signal ground shall be 130 V.)

5.8.3.2.10 International Octal Base Pin Connections. Relays shall be of a plug-in type configured for an international octal base as described in subparagraph 5.8.3.1.8.

5.8.4 Optical Character Recognition Equipment. (Under consideration - see Appendix C.)

CUSTODIANS:

ARMY - SC, EL
NAVY - EC
AIR FORCE - 17

REVIEW ACTIVITIES:

ARMY - SC, EL, CE, ME
NAVY - AS, OS, YD, MC, CG, SH
AIR FORCE - 1, 11, 13, 71, 80, 89

PREPARING ACTIVITIES:

DCA - DC
ARMY - EL

USER ACTIVITIES:

ARMY
NAVY - MC, YD, SH
AIR FORCE

OTHER INTEREST:

JCS - J6

NSA - NS

TRI - TAC

(BLANK)

APPENDIX A

10. DESIGNATION OF EMISSIONS AND BANDWIDTH

This Appendix contains Tutorial Information in support of MIL-STD-188-100.

FOREWORD

The content of this appendix is derived from ITU Radio Regulations, Geneva, 1959. Emissions are designated according to their classification and their necessary bandwidth.

APPENDIX A

TABLE OF CONTENTS

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10. DESIGNATION OF EMISSIONS AND BANDWIDTH

10.1 Designation of Emissions and Bandwidth.

10.1.1 Classification of Emissions. Emissions are classified and symbolized according to the following characteristics:

(a) Type of modulation of main carrier.
(b) Type of transmission.
(c) Supplementary characteristics.

10.1.1.1 Types of Modulation of Main Carrier.

	Symbol
(a) Amplitude	A
(b) Frequency (or phase)	F
(c) Pulse	P

10.1.1.2 Types of Transmission.

(a) Absence of any modulation intended to carry information	0
(b) Telegraphy without the use of a modulating audio frequency	1
(c) Telegraphy by the on-off keying of a modulating audio frequency or audio frequencies, or by the on-off keying of the modulated emission (special case: an unkeyed modulated emission)	2
(d) Telephony (including sound broadcasting)	3
(e) Facsimile (with modulation of main carrier either directly or by a frequency modulated subcarrier)	4
(f) Television (vision only)	5
(g) Four-frequency diplex telegraphy	6
(h) Multichannel voice-frequency telegraphy	7
(i) Cases not covered by the above	9

10.1.1.3 Supplementary Characteristics.

(a) Double sideband	None
(b) Single sideband:	
Reduced carrier	A
Full carrier	H
Suppressed carrier	J
(c) Two independent sidebands	B
(d) Vestigial sideband	C
(e) Pulse:	
Amplitude modulated	D
Width (or duration) modulated	E
Phase (or position) modulated	F
Code modulated	G

10.1.1.4 Examples of Emissions. The classification of typical emissions is tabulated as follows:

Type of Modulation of Main Carrier	Type of Transmission	Supplementary Characteristics	Symbol
Amplitude modulation	With no modulation		A0
	Telegraphy without the use of a modulating audio frequency (by on-off keying)		A1
	Telegraphy by the on-off keying of an amplitude-modulating audio frequency or audio frequencies, or by the on-off keying of the modulated emission (special case: an unkeyed emission amplitude modulated).		A2
	Telephony	Double sideband	A3
		Single sideband, reduced carrier	A3A
		Single sideband, suppressed carrier	A3J
		Single sideband, full carrier	A3H
		Two independent sidebands	A3B
	Facsimile (with modulation of main carrier either directly or by a frequency modulated subcarrier)		A4
		Single sideband, reduced carrier	A4A
	Television	Vestigial sideband	A5C
	Multichannel voice-frequency telegraphy	Single sideband, reduced carrier	A7A
	Cases not covered by the above, e.g., a combination of telephony and telegraphy	Two independent sidebands	A9B
Frequency (or phase) modulation	Telegraphy by frequency shift keying without the use of a modulating audio frequency: one of two frequencies being emitted at any instant		F1
	Telegraphy by the on-off keying of a frequency modulating audio frequency or by the on-off keying of a frequency modulated emission (special case: an unkeyed emission, frequency modulated)		F2

Type of Modulation of Main Carrier	Type of Transmission	Supplementary Characteristics	Symbol
	Telephony		F3
	Facsimile by direct frequency modulation of the carrier		F4
	Television		F5
	Four-frequency diplex telegraphy		F6
	Cases not covered by the above, in which the main carrier is frequency modulated		F9
Pulse modulation	A pulsed carrier without any modulation intended to carry information (e.g., radar)		P0
	Telegraphy by the on-off keying of a pulsed carrier without the use of a modulating audio frequency		P1D
	Telegraphy by the on-off keying of a modulating audio frequency or audio frequencies, or by the on-off keying of a modulated pulsed carrier (special case: an unkeyed modulated pulsed carrier)	Audio frequency or audio frequencies modulating the amplitude of the pulses	P2D
		Audio frequency or audio frequencies modulating the width (or duration) of the pulses	P2E
		Audio frequency or audio frequencies modulating the phase (or position) of the pulses	P2F
	Telephony	Amplitude modulated pulses	P3D
		Width (or duration) modulated pulses	P3E
		Phase (or position) modulated pulses	P3F
		Code modulated pulses (after sampling and quantization)	P3G
	Cases not covered by the above in which the main carrier is pulse modulated		P9

10.1.2 Bandwidths. Whenever the full designation of an emission is necessary, the symbol for that emission, as given above, shall be preceded by a number indicating in kilohertz the necessary bandwidth of the emission. Bandwidths shall generally be expressed to a maximum of three significant figures, the third figure being almost always a nought or a five.

10.1.2.1 Examples of Necessary Bandwidths and Designations of Emission. The necessary bandwidth may be determined by one of the following methods:

(a) Use of the formulae included in the following table which also gives examples of necessary bandwidths and designation of corresponding emissions.

(b) Computation in accordance with CCIR recommendations.

(c) Measurement, in cases not covered by (a) or (b) above.

The value so determined should be used when the full designation of an emission is required. However, the necessary bandwidth so determined is not the only characteristic of an emission to be considered in evaluating the interference that may be caused by that emission.

In the formulation of the following table, these terms have been employed:

B_n = Necessary bandwidth in Hz.
B = Telegraph speed in bauds.
N = Maximum possible number of black plus white elements to be transmitted per second, in facsimile and television.
M = Maximum modulation frequency in Hz.
C = Subcarrier frequency in Hz.
D = Half the difference between the maximum and minimum values of the instantaneous frequency. Instantaneous frequency is the rate of change of phase.
t = Pulse duration in seconds.
K = An overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion.

Description and Class of Emission	Necessary Bandwidth (Hz)	Examples - Details	Designation of Emission
I. AMPLITUDE MODULATION			
Continuous wave telegraphy, A1	$B_n = BK$ K = 5 for fading circuits K = 3 for nonfading circuits	Morse code at 25 words per minute. B = 20, K = 5; Bandwidths: 100 Hz	0.1A1
		Four-channel time-division multiplex, 7-unit code, 42.5 bauds per channel, B = 170, K = 5; Bandwidth: 850 Hz	0.85A1

Description and Class of Emission	Necessary Bandwidth (Hz)	Examples - Details	Designation of Emission
Telegraphy modulated by an audio frequency, A2	$B_n = BK + 2M$ K = 5 for fading circuits K = 3 for nonfading cuits	Morse code at 25 wpm, B = 20, M = 1000, K = 5; Bandwidth: 2100 Hz	2.1A2
Telephony, A3	$B_n = M$ for single sideband $B_n = 2M$ for double sideband	Double sideband telephony, M = 3000; Bandwidth: 6000 Hz	6A3
		Single sideband telephony, reduced carrier, M = 3000; Bandwidth: 3000 Hz	3A3A
		Telephony, two independent sidebands, M = 3000; Bandwidth: 6000 Hz	6A3B
Sound broadcasting, A3	$B_n = 2M$ M may vary between 4000 and 10,000 depending on the quality desired	Speech and music, M = 4000; Bandwidth: 8000 Hz	8A3
Facsimile, carrier modulated by tone and by keying, A4	$B_n = KN + 2M$ K = 1.5	The total number of picture elements (black plus white) transmitted per second is equal to the circumference of the cylinder multiplied by the number of lines per unit length and by the speed of rotation of the cylinder in revolutions per second Diameter of cylinder = 70 mm, number of lines per mm = 5, speed of rotation = 1 rps, N = 1100, M = 1900; Bandwidth: 5450 Hz	5.45A4
Television (vision and sound), A5 and F3	Refer to relevant CCIR documents for the bandwidths of the commonly used television systems	Number of lines = 625; number of lines per second = 15,625; Video bandwidth: 5 MHz Total vision bandwidth 6.25 MHz FM sound bandwidth including guard bands; 0.75 MHz, Total bandwidth: 7 MHz	6250A5C 750F3

Description and Class of Emission	Necessary Bandwidth (Hz)	Examples - Details	Designation of Emission
II. FREQUENCY MODULATION			
Frequency-shift telegraphy, F1	$B_n = 2.6D + 0.55B$ for $1.5 < 2D/B < 5.5$ $B_n = 2.1D + 1.9B$ for $5.5 \leq 2D/B \leq 20$	Four-channel time-division multiplex with 7-unit code, 42.5 bauds per channel, B = 170, D = 200; 2D/B = 2.35, therefore the first formula in column 2 applies Bandwidth: 613 Hz	0.6F1
Commercial telephony, F3 Sound broadcasting, F3	$B_n = 2M + 2DK$ K is normally 1 but under certain conditions a higher value may be necessary	For an average case of commercial telephony, D = 15,000, M = 3000; Bandwidth: 36,000 Hz	36F3
	$B_n = 2M + 2DK$	D = 75,000, M = 15,000 and assuming K = 1; Bandwidth: 180,000 Hz	180F3
Facsimile, F4	$B_n = KN + 2M + 2D$ K = 1.5	(See facsimile, amplitude modulation.) Diameter of cylinder = 70 mm, number of lines per mm = 5, speed of rotation = 1 rps, N = 1100, M = 1900, D = 10,000; Bandwidth: 25,450 Hz	25.5F4
Four-frequency diplex telegraphy, F6	If the channels are not synchronized, $B_n = 2.6D + 2.75B$ where B is the speed of the channel If the channels are synchronized the bandwidth is as for F1, B being the speed of either channel	Four-frequency diplex system with 400 Hz spacing between frequencies, channels not synchronized, 170 bauds keying in each channel, D = 600, B = 170; Bandwidth: 2027 Hz	2.05F6

Description and Class of Emission	Necessary Bandwidth (Hz)	Examples - Details	Designation of Emission
III. PULSE MODULATION			
Unmodulated pulse, P0	$B_n = 2K/t$ K depends upon the ratio of pulse duration to pulse rise time. Its value usually falls beween 1 and 10 and in many cases it does not exceed 6	$t = 3 \times 10^{-6}$, $K = 6$; Bandwidth: 4×10^{6} Hz	4000P0
Modulated pulse, P2 or P3	The bandwidth depends on the particular types of modulation used, many of these being still in the development stage		

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APPENDIX B

20. STANDARD CODE FOR INFORMATION INTERCHANGE AND RELATED DATA TRANSMISSION STANDARDS

This Appendix contains Supplementary Information and is part of MIL-STD-188-100.

ACKNOWLEDGEMENT

The American National Standards Institute, Inc., copyright holder of the copyrighted material used herein, has given the Department of Defense permission to reproduce portions of the following American National Standards:

1. American National Standard Code for Information Interchange, X3.4-1968 (Revision of X3.4-1967), approved October 10, 1968.

2. American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission, X3.15-1966, approved August 19, 1966.

3. American National Standard Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange, X3.16-1966, approved August 19, 1966.

4. American National Standard Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication in the American National Standard Code for Information Interchange, X3.25-1968, approved September 27, 1968.

Appendix B to this standard provides information that is reproduced, in part, from the source material listed above. Copies of the referenced standards may be purchased from the American National Standards Institute at 1430 Broadway, New York, New York 10018.

APPENDIX B

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

20. STANDARD CODE FOR INFORMATION INTERCHANGE AND RELATED DATA TRANSMISSION STANDARDS

20.1 Scope. This Appendix contains the criteria and other design considerations that were used in the development of the standard.

20.2 Purpose. This Appendix is a part of MIL-STD-188-100 and is included to facilitate its understanding and use.

20.3 Criteria. The following criteria were adopted to reflect the needed transitions from historically developed divergent coded character set designs to a standard that is compatible for use in Federal information processing systems, communications systems, and associated equipments.

20.3.1 Name of Standard. The standard coded character set used is titled "Code for Information Interchange". The standard code may be identified by the use of the notation ASCII (pronounced as'-key) and should ordinarily be taken to mean the code prescribed by the latest issue of the standard that was approved as a USA Standard by the United States of America Standards Institute on October 10, 1968. This USA Standard was adopted as a Federal Information Processing Standard and approved by the President of the United States on March 11, 1968.

The Code for Information Interchange was issued by the National Bureau of Standards as a Federal Information Processing Standard (FIPS) on November 1, 1968. FIPS PUB 1 adopted in whole the USA Standard Code for Information Interchange X3.4-1967 and in part X3.4-1968 (a revision of X3.4-1967). That portion of X3.4-1968 which has not been adopted in this Federal standard is the "New Line" (NL) convention as cited in the definition of LF (Line Feed) in subparagraph 20.3.6.2 of this Appendix.

20.3.2 Standard Coded Character Set. The standard coded character set to be used for the general interchange of information among information processing systems, communications systems, and associated equipment is shown in Figure 1.

20.3.3 Character Representation. The standard 7-bit character representation with b_7 the high-order bit and b_1 the low-order bit, is shown below:

EXAMPLE: The bit representation for the character "K", positioned in column 4, row 11 is

b_7	b_6	b_5	b_4	b_3	b_2	b_1
1	0	0	1	0	1	1

The code table position for the character "K" may also be represented by the notation "column 4, row 11" or alternatively as "4/11". The decimal equivalent of the binary number formed by bits b_7, b_6, and b_5, collectively, forms the column number, and the decimal equivalent of the binary number formed by bits b_4, b_3, b_2, and b_1, collectively, forms the row number.

b_7					0	0	0	0	1	1	1	1
b_6					0	0	1	1	0	0	1	1
b_5					0	1	0	1	0	1	0	1
Bits b_4	b_3	b_2	b_1	Row ↓ / Column →	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DCI	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 1. Standard Code

20.3.4 Control Characters.

NUL	Null	DLE	Data Link Escape (CC)
SOH	Start of Heading (CC)	DC1	Device Control 1
STX	Start of Text (CC)	DC2	Device Control 2
ETX	End of Text (CC)	DC3	Device Control 3
EOT	End of Transmission (CC)	DC4	Device Control 4 (Stop)
ENQ	Enquiry (CC)	NAK	Negative Acknowledge (CC)
ACK	Acknowledge (CC)	SYN	Synchronous Idle (CC)
BEL	Bell (audible or attention signal)	ETB	End of Transmission Block (CC)
BS	Backspace (FE)	CAN	Cancel
HT	Horizontal Tabulation (punched card skip) (FE)	EM	End of Medium
		SUB	Substitute
LF	Line Feed (FE)	ESC	Escape
VT	Vertical Tabulation (FE)	FS	File Separator (IS)
FF	Form Feed (FE)	GS	Group Separator (IS)
CR	Carriage Return (FE)	RS	Record Separator (IS)
SO	Shift Out	US	Unit Separator (IS)
SI	Shift In	DEL	Delete (1)

20.3.5 Graphic Characters.

Column/Row	Symbol	Name
2/0	SP	Space (Normally Non-Printing)
2/1	!	Exclamation Point
2/2	"	Quotation Marks (Diaeresis) (2)
2/3	#	Number Sign (3,4)
2/4	$	Dollar Sign
2/5	%	Percent
2/6	&	Ampersand
2/7	'	Apostrophe (Closing Single Quotation Mark; Acute Accent) (2)
2/8	(	Opening Parenthesis
2/9	)	Closing Parenthesis
2/10	*	Asterisk
2/11	+	Plus
2/12	,	Comma (Cedilla) (2)

NOTES

(CC) Communication Control (FE) Format Effector (IS) Information Separator

(1) In the strict sense, DEL is not a control character. (See Definitions, subparagraph 20.3.6.2).

(2) The use of the symbols in 2/2, 2/7, 2/12, 5/14, 6/0, and 7/14 as diacritical marks is described in subparagraph 20.3.7(4).

(3) These characters should not be used in international interchange without determining that there is agreement between sender and recipient. See subparagraph 20.3.7(2).

(4) In applications where there is no requirement for the symbol #, the symbol £ may be used in position 2/3.

Column/Row	Symbol	Name
2/13	-	Hyphen (Minus)
2/14	.	Period (Decimal Point)
2/15	/	Slant
3/10	:	Colon
3/11	;	Semicolon
3/12	<	Less Than
3/13	=	Equals
3/14	>	Greater Than
3/15	?	Question Mark
4/0	@	Commercial At (3)
5/11	[	Opening Bracket (3)
5/12	\	Reverse Slant (3)
5/13	]	Closing Bracket (3)
5/14	^	Circumflex (2,3)
5/15	_	Underline
6/0	`	Grave Accent (2,3) (Opening Single Quotation Mark)
7/11	{	Opening Brace (3)
7/12	|	Vertical Line (3)
7/13	}	Closing Brace (3)
7/14	~	Overline (3) [Tilde(2); General Accent(2)]

20.3.6 Definitions.

20.3.6.1 General.

(CC) Communication Control. A functional character intended to control or facilitate transmission of information over communication networks.

(FE) Format Effector. A functional character which controls the layout or positioning of information in printing or display devices.

(IS) Information Separator. A character which is used to separate and qualify information in a logical sense. There is a group of four such characters which are to be used in a hierarchical order.

20.3.6.2 Control Characters.

NUL. The all zeros character.

SOH (Start of Heading). A communication control character used at the beginning of a sequence of characters which constitutes a machine-sensible address of routing information. Such a sequence is referred to as the "heading". An STX character has the effect of terminating a heading.

STX (Start of Text). A communication control character which precedes a sequence of characters that is to be treated as an entity and entirely transmitted through to the ultimate destination. Such a sequence is referred to as "text". STX may be used to terminate a sequence of characters started by SOH.

ETX (End of Text). A communication control character used to terminate a sequence of characters started with STX and transmitted as an entity.

EOT (End of Transmission). A communication control character, used to indicate the conclusion of a transmission which may have contained one or more texts and any associated headings.

ENQ (Enquiry). A communication control character used in data communication systems as a request for a response from a remote station. It may be used as a "Who Are You" (WRU) to obtain identification, or may be used to obtain station status, or both.

ACK (Acknowledge). A communication control character transmitted by a receiver as an affirmative response to a sender.

BEL. A character for use when there is a need to call for human attention. It may control alarm or attention devices.

BS (Backspace). A format effector which controls the movement of the printing position one printing space backward on the same printing line (applicable to display devices).

HT Horizontal Tabulation). A format effector which controls the movement of the printing position to the next in a series of predetermined positions along the printing line. (Applicable also to display devices and the skip function on punched cards.)

LF (Line Feed). A format effector which controls the movement of the printing position to the next printing line (applicable also to display devices). Where appropriate, this character may have the meaning "New Line" (NL), a format effector which controls the movement of the printing point to the first printing position on the next printing line. Use of this convention requires agreement between sender and recipient of data.

VT (Vertical Tabulation). A format effector which controls the movement of the printing position to the next in a series of predetermined printing lines (applicable also to display devices).

FF (Form Feed). A format effector which controls the movement of the printing position to the first predetermined printing line on the next form or page (applicable also to display devices).

CR (Carriage Return). A format effector which controls the movement of the printing position to the first printing position on the same printing line (applicable to display devices).

SO (Shift Out). A control character indicating that the code combinations which follow shall be interpreted as outside of the character set of the standard code table until a Shift In character(s) is (are) reached.

SI (Shift In). A control character indicating that the code combinations which follow shall be interpreted according to the standard code table.

DLE (Data Link Escape). A communication control character which will change the meaning of a limited number of contiguously following characters. It is used exclusively to provide supplementary controls in data communication networks. DLE is usually terminated by a Shift In character(s).

DC1, DC2, DC3, DC4 (Device Controls). Characters for the control of ancillary devices associated with data processing or telecommunication systems, more especially switching devices "on" or "off". (If a single "stop" control is required to interrupt or turn off ancillary devices, DC4 is the preferred assignment.)

NAK (Negative Acknowledge). A communication control character transmitted by a receiver as a negative response to the sender.

SYN (Synchronous Idle). A communication control character used by a synchronous transmission system in the absence of any other character to provide a signal from which synchronism may be achieved or retained.

ETB (End of Transmission Block). A communication control character used to indicate the end of a block of data for communication purposes. ETB is used for blocking data where the block structure is not necessarily related to the processing format.

CAN (Cancel). A control character used to indicate that the data with which it is sent is in error or is to be disregarded.

EM (End of Medium). A control character associated with the sent data which may be used to identify the physical end of the medium or the end of the used, or wanted, portion of information recorded on a medium. (The position of the character does not necessarily correspond to the physical end of the medium.)

SUB (Substitute). A character that may be substituted for a character which is determined to be invalid or in error.

ESC (Escape). A control character intended to provide code extension (supplementary characters) in general information interchange. The Escape character itself is a prefix affecting the interpretation of a limited number of contiguously following characters. ESC is usually terminated by a Shift In character(s).

FS (File Separator), GS (Group Separator), RS (Record Separator), and US (Unit Separator). These information separators may be used within data in optional fashion, except that their hierarchical relationship shall be: FS is the most inclusive, then GS, then RS, and US is least inclusive. (The content and length of a File, Group, Record, or Unit are not specified.)

DEL (Delete). This character is used primarily to "erase" or "obliterate" erroneous or unwanted characters in perforated tape. (In the strict sense, DEL is not a control character.)

20.3.6.3 Graphic Characters. SP (Space): A normally nonprinting graphic character used to separate words. It is also a format effector which controls the movement of the printing position, one printing position forward. (Applicable also to display devices.)

20.3.7 General Considerations.

(a) This standard does not define the means by which the coded set is to be recorded in any physical medium, nor does it include any redundancy or define techniques for error control. Further, this standard does not define data communication formats, code extension techniques, or graphic representation of control characters.

(b) Deviations from the standard may create serious difficulties in information interchange and should be used only with full cognizance of the parties involved.

(c) The relative sequence of any two characters, when used as a basis for collation, is defined by their binary values.

(d) No specific meaning is prescribed for any of the graphics in the code table except that which is understood by the users. Furthermore, this standard does not specify a type style for the printing or display of the various graphic characters. In specific applications, it may be desirable to employ distinctive styling of individual graphics to facilitate their use for specific purposes as, for example, to stylize the graphics in code positions 2/1 and 5/14 into those frequently associated with logical OR (|) andlogical NOT (¬), respectively. It is to be noted that these two symbols are not standard.

20.4 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the Code for Information Interchange. Federal Information Processing Standards Publication 17 (FIPS PUB 17) specifies the method of transmitting the Standard Code for Information Interchange (FIPS 1) in the serial-by-bit, serial-by-character data transmission. Included in the standard is the position and sense of the character parity bit. This standard is applicable to the transmission of the Standard Code (refer to subparagraph 4.3.1.2) in a serial-by-bit stream form at the interface between data terminal equipment and data communications equipment. Data terminal equipments transmitting an approved Federal subset or superset of FIPS 1 are not precluded.

20.4.1 Synchronous Data Communication. The standard character structure for synchronous data communication shall consist of eight bits (seven ASCII bits plus one character parity bit) having equal time intervals (see Figure 2).

The standard sense of character parity for synchronous data communication shall be "odd" over the eight bits, i.e., an odd number of "1" (marking) bits per character.

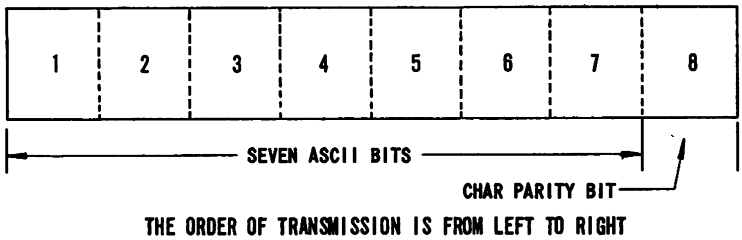


Figure 2. Standard Character Interval Structure for Synchronous Transmission

20.4.2 Asynchronous Data Communication. The standard character structure for asynchronous data communication shall consist of ten (10) signal elements having equal time intervals; one "0" (spacing) start element, seven ASCII bits, one character parity bit, and one "1" (Marking) stop element. The intercharacter interval (the time interval between the end of a stop element and the beginning of the next start element) may be of any length, and is of the same sense as the stop element, i.e., "1" (marking) (see Figure 3).

The standard sense of character parity for asynchronous data communication shall be even over the eight bits (seven ASCII bits and character parity bit), i.e., an even number of "1" (marking) bits per character.

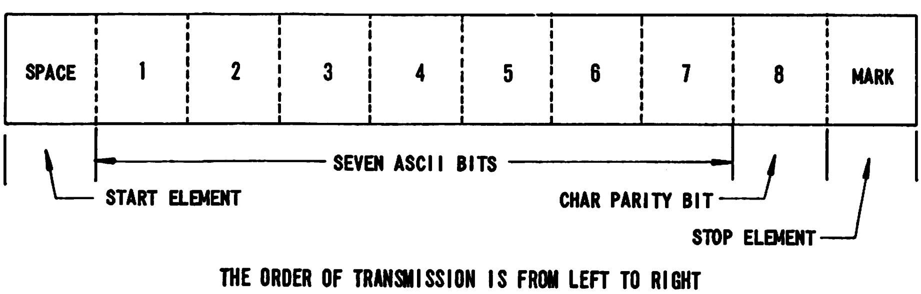


Figure 3. Standard Character Interval Structure for Asynchronous Transmission

NOTE 1: Some configurations of communication facilities cannot operate satisfactorily with the stop element specified in the asynchronous character structure. Where this is the case, a stop element of two time intervals will be necessary. This exception to character structure is intended to provide relief where character regenerators are employed (as on long-haul, multi-station networks), and its use will require prior agreement between users.

NOTE 2: Receiving equipments must be capable of operation with any intercharacter interval, or with a single-unit stop element whose duration will be reduced by a time interval equal to the deviation corresponding to the degree of gross start-stop distortion permitted at the receiver unit.

NOTE 3: In AUTODIN, odd parity is used for transmission of message characters in both the synchronous and asynchronous modes. Even parity is used for transmission of control characters for channel control and coordination.

20.5 Bit Sequencing of the Code for Information Interchange in Serial-by-Bit Data Transmission. Federal Information Processing Standards Publication 16 (FIPS PUB 16) specifies the position of the character parity bit, if transmitted with the information bits of the Standard Code for Information Interchange (FIPS 1), in serial-by-bit, serial-by-character data transmission. This standard is applicable to the transmission of the standard code in a serial bit stream form at the interface between data terminal equipment and data communications equipment.

20.5.1 Standard Bit Sequence. The standard bit sequence for an ASCII character shall be least significant bit first to most significant bit--in terms of FIPS nomenclature (Standard Code for Information Interchange) b_1 through b_7 in ascending (consecutive) order.

NOTE: This statement does not specify that a character parity bit shall or shall not be transmitted, nor does it specify the total number of bits per character, the bit rate, the character rate, or the transmission technique. However, in the DoD the equipment ordinarily should be designed to transmit and receive a bit in the parity position. If the bit is not used as a parity bit, it should be transmitted as a mark and ignored by the receiver. If used as a parity bit, the transmitter and receiver must be programmed or adjusted accordingly. The reason is to preclude several types of equipment that are incompatible and limited in their use. Any equipments designed not to transmit and receive a parity bit must be used in limited and closed networks where parity is not needed and transmission efficiency is paramount over equipment logistics. Character and bit rates are defined elsewhere in these standards.

20.5.2 Character Parity. A character parity, if transmitted, is to follow the most significant bit, b_7, of the character to which it applies.

20.6 Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication in the Code for Information Interchange. Federal Information Processing Standards Publication 18 (FIPS PUB 18) specifies the channel assignment for transmitting the Standard Code for Information Interchange (FIPS 1) in parallel-by-bit serial-by-character data transmission. Included in the standard is the position and sense of the character parity bit applicable to the Standard Code in a parallel bit form at the interface between data terminal equipment and data communications equipment. Data terminal equipments transmitting an approved subset of FIPS 1 are not precluded.

20.6.1 Standard Character Structure. The standard character structure shall consist of eight bits, i.e., seven information bits plus one character parity bit.

20.6.2 Standard Bit-to-Channel Relationship. The seven information bits (b_1 through b_7) plus the character parity bit (P) shall be assigned to an ordered series of channel designators as follows: b_1 to the lowest designator and, in ascending order, with P to the highest designator.

Information-Bit:	b_1	b_2	b_3	b_4	b_5	b_6	b_7	P
Channel	1	2	3	4	5	6	7	8

20.6.3 Standard Sense of Character Parity.

(a) Where the transmission system is of the type where character timing is not separately signaled, the sense of the character parity shall be ODD; that is, the parity bit for each Character shall be such that there are an odd number of "1" (marking) bits in the character.

(b) Where the transmission system is of the type providing character timing information by means of a separate timing channel, the sense of the character parity shall be EVEN; that is, the parity bit for each character shall be such that there are an even number of "1" (marking) bits in the character.

20.7 Coded Subsets of the Standard Code for Information Interchange. If the full character set of the Federal Standard Code for Information Interchange (FIPS 1) cannot be applied, the largest possible character subset should be used, and the FIPS 1 collating sequence observed.

Subsets of 95, 64, and 16 graphic characters that conform to the specifications cited in FIPS PUB 15 are provided in this standard. These character subsets are to be used for printers, display devices, punched card equipment and other data processing or communications equipment in those systems or applications that do not require the full 128-character set discussed in paragraph 20.8.1. Each subset is defined and, where appropriate, this standard requires that one of the three specific subsets described herein will be specified when a subset is used.

20.7.1 Specifications for 95-Character Graphic Character Subset. This graphic character subset is derived from the Federal Standard Code for Information Interchange (FIPS 1) which in turn was adopted from the American National Standard Code for Information Interchange (ASCII). This character subset is intended to be used in those systems or applications whose needs are adequately served by a 95-character graphic subset of the standard 128-character set contained in FIPS 1. This 95-character graphic subset contains all of the characters in columns 2, 3, 4, 5, 6, and 7 of the FIPS 1 code table, except the character Delete (DEL) in position 7/15. Figure 4 shows the 7-bit code table of FIPS 1 with the 95-character graphic subset of this standard outlined. It is emphasized that the coded representation of this 95-character subset in input/output media and data communications will conform to the specifications cited in other applicable Federal Information Processing Standards.

20.7.2 Specifications for 64-Character Graphic Character Subset. This graphic character subset is derived from the Federal Standard Code for Information Interchange (FIPS 1) which in turn was adopted from the American National Standard Code for Information Interchange (ASCII). This character subset is intended to be used in those systems or applications whose needs are adequately served by a 64-character graphic subset of the standard 128-character set contained in FIPS 1. This 64-character graphic subset contains all the characters in columns 2, 3, 4, and 5 of the FIPS code table. Figure 5 shows the 7-bit code table of FIPS 1 with the 64-character graphic subset of this standard outlined. It is emphasized that the coded representation of this 64-character subset in input/output media and data communication will conform to the specifications cited in other applicable Federal Information Processing Standards.

20.7.3 Specifications for 16-Character Numeric Subset. This numeric subset is derived from the Federal Standard Code for Information Interchange (FIPS 1) which in turn was adopted from the American National Standard Code for Information Interchange (ASCII). This subset is intended to be used in those systems or applications whose needs are adequately served by a 16-character numeric subset of the standard 128-character set contained in FIPS 1. This 16-character graphic numeric subset contains the ten numerals from the top ten positions of column 3 and six symbols: Asterisk, Plus, Comma, Hyphen (Minus), Period (Decimal Point) and Slant, from the bottom six positions of column 2. Figure 6 shows the 7-bit code table of FIPS 1 with the 16-character graphic subset of this standard outlined. It is emphasized that the coded representation of this 16-character subset in input/output media and data communications will conform to the specifications cited in other applicable Federal Information Processing Standards.

Systems and applications employing this limited 16-character set, when receiving information via standard media or communications from systems employing the full 128-character set, the 95-character graphic set, or the 64-character graphic subset, should ignore all characters outside of this numeric subset. This feature is desirable in most instances, but is not mandatory for applications requiring some other interpretation of the characters outside of this numeric subset.

20.8 Printing Subsets of the Standard Code for Information Interchange. The last paragraph considers coded subsets. These coded subsets refer to the transmitter/receiver repertoire of coded characters used. On the other hand, printing subsets refer to receiver printing capability using specific symbols for certain or all characters. For example, a transmitter/receiver system may use all ASCII characters but not print all of them. The following printing sets or subsets are standard.

20.8.1 128-Character Printing Subset. This printing set shall be used for special applications such as high quality monitoring receivers, line quality research, etc. The set involves all of the graphics shown in Figure 1 plus the symbols shown in Figure 9 for the 32 control characters, space, and delete for a total of 128 characters. Figure 9

b₇b₆b₅ →					000	001	010	011	100	101	110	111
b_4	b_3	b_2	b_1	Column → / Row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 4. Federal Standard Code for Information Interchange (FIPS 1) Showing 95-Character Graphic Subset

Bits b_4	b_3	b_2	b_1	$b_7 b_6 b_5$ → / Column → / Row ↓	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
					0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 5. Federal Standard Code for Information Interchange (FIPS 1) Showing 64-Character Graphic Subset

$b_7 b_6 b_5$					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
Bits b_4	b_3	b_2	b_1	Column → / Row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 6. Federal Standard Code for Information Interchange (FIPS 1) Showing 16-Character Numeric Subset

symbols are included for guidance only and are extracted from the CCITT White Book, Volume VIII, Supplement 2, page 2, Mar Del Plata 1968. A FIPS is in preparation on this subject that is substantially the same as Figure 9. When published, the FIPS shall take precedence over Figure 9.

20.8.2 94-Character Printing Subset. This set consists of the 94 graphics shown on Figure 1. It omits the 32 control characters, space, and delete shown in Figure 9. This printing set is used for high quality data and narrative message recording where both upper and lower case printing is desired (see Figure 7). This printing set may be used also for less exacting monitoring applications than those discussed in the previous paragraph by printing a heart (♡) for the 34 symbols shown in Figure 9. This adds a 95th symbol to the 94-character printing set.

20.8.3 63-Character Printing Subset. This set consists of the same graphics in the 94-character printing set minus the 31 characters, other than Delete in columns 6 and 7; in other words all of the graphics in columns 2, 3, 4, and 5. This is the normal communication printing subset that prints in upper case only (see Figure 8).

20.8.4 95- and 64-Character Printing Subset. These two subsets are the same as the 94- and 63-character printing subset with the addition of the symbol for the substitute character (position 1/10 in Figure 9). When error detection is used, this symbol is printed to indicate that the character it replaced was in error but that the correct character is unknown.

20.9 The Standard Punched Card Code. ASCII can be used as a punched card code. Devices have been manufactured that punch both paper tape and edged punched cards. There has been some objection to using ASCII to punch cards because pure numerical work results in punching bits 5 and 6 in all columns of the card. This is called lacing and weakens the card. For that reason, plus the great investment in Hollerith Card punching and reading equipment, the Hollerith punched card code is still used in most applications. The code, shown in Figure 10, has been extended to cover 256 characters, including the 128 ASCII characters and 128 additional but, as yet, undefined characters. This code is standardized in FIPS PUB 14. When using punched cards the codes given in Figures 10, 11, and 12 shall be used. This standard permits the use of only certain characters but equipment should have a capability of operating with a complete ASCII set or a complete 95- or 64-character subset of ASCII. At present AUTODIN uses a Hollerith punched card code set that differs from FIPS PUB 14 standard by a few characters. Plans are being formulated to rectify this situation. A third version of the Hollerith punched card code as published in JCS PUB 7 is employed in the National Military Command System. These three versions are given in Figure 13. It is a Design Objective to convert all systems to the FIPS 14 standard.

20.9.1 Standard Physical Properties. The standard physical properties of the punched card are defined in FIPS PUB 13.

20.10 Five Unit Teletypewriter Coded Character Set. Teletypewriter message transmission systems have been employed in Department of Defense communications for a number of years and are expected to be used for some time to come. The five unit teletypewriter coded character set (Figure 14) used throughout these systems has for many years been established as a standard and is included in this publication as an interim standard since it will remain in use for an undetermined period of time.

$b_7 b_6 b_5$					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4	b_3	b_2	b_1	Row ↓ / Column →	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 7. 94-Character Printing Subset

$b_7 b_6 b_5$ → / Bits					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	Column → / Row ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	—	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Figure 8. 63-Character Printing Subset

Position in the 7-bit set table	Set table name	2-Lettered Abbreviation	Symbol	Position in the 7-bit set table	Set table name	2-Lettered Abbreviation	Symbol
0/0	NUL	NL		1/1	DC_1	D1	
0/1	(TC_1)SOH	SH		1/2	DC_2	D2	
0/2	(TC_2)STX	SX		1/3	DC_3	D3	
0/3	(TC_3)ETX	EX		1/4	DC_4	D4	
0/4	(TC_4)EOT	ET		1/5	(TC_8)NAK	NK	
0/5	(TC_5)ENQ	EQ		1/6	(TC_9)SYN	SY	
0/6	(TC_6)ACK	AK		1/7	(TC_{10})ETB	EB	
0/7	BEL	BL		1/8	CAN	CN	
0/8	FE_0(BS)	BS		1/9	EM	EM	
0/9	FE_1(HT)	HT		1/10	SUB	SB	
0/10	FE_2(LF)	LF		1/11	ESC	ES	
0/11	FE_3(VT)	VT		1/12	IS_4(FS)	FS	
0/12	FE_4(FF)	FF		1/13	IS_3(GS)	GS	
0/13	FE_5(CR)	CR		1/14	IS_2(RS)	RS	
0/14	SO	SO		1/15	IS_1(US)	US	
0/15	SI	SI		2/0	SP	SP	
1/0	(TC_7)DLE	DL		7/15	DEL	DE	

Figure 9. Control Characters, Space, and Delete Symbols

ZONES	12				12	12		12
		11				11	11	11
			0		0		0	0
DIGIT PUNCH ROWS								
	&	-	0	SP	{	|	}	11/10
1	A	J	/	1	a	j	¬	13/9
2	B	K	S	2	b	k	s	13/10
3	C	L	T	3	c	l	t	13/11
4	D	M	U	4	d	m	u	13/12
5	E	N	V	5	e	n	v	13/13
6	F	O	W	6	f	o	w	13/14
7	G	P	X	7	g	p	x	13/15
8	H	Q	Y	8	h	q	y	14/0
9	I	R	Z	9	i	r	z	14/1
8-2	[	]	\	:	12/4	12/11	13/2	14/2
8-3	.	$	,	#	12/5	12/12	13/3	14/3
8-4	<	*	%	@	12/6	12/13	13/4	14/4
8-5	(	)	_	'	12/7	12/14	13/5	14/5
8-6	+	;	>	=	12/8	12/15	13/6	14/6
8-7	!	^	?	"	12/9	13/0	13/7	14/7
8-1	10/8	11/1	11/9	`	12/3	12/10	13/1	13/8
9-1	SOH	DC1	8/1	9/1	10/0	10/9	9/15	11/11
9-2	STX	DC2	8/2	SYN	10/1	10/10	11/2	11/12
9-3	ETX	DC3	8/3	9/3	10/2	10/11	11/3	11/13
9-4	9/12	9/13	8/4	9/4	10/3	10/12	11/4	11/14
9-5	HT	8/5	LF	9/5	10/4	10/13	11/5	11/15
9-6	8/6	BS	ETB	9/6	10/5	10/14	11/6	12/0
9-7	DEL	8/7	ESC	EOT	10/6	10/15	11/7	12/1
9-8	9/7	CAN	8/8	9/8	10/7	11/0	11/8	12/2
9-8-1	8/13	EM	8/9	9/9	NUL	DLE	8/0	9/0
9-8-2	8/14	9/2	8/10	9/10	14/8	14/14	15/4	15/10
9-8-3	VT	8/15	8/11	9/11	14/9	14/15	15/5	15/11
9-8-4	FF	FS	8/12	DC4	14/10	15/0	15/6	15/12
9-8-5	CR	GS	ENQ	NAK	14/11	15/1	15/7	15/13
9-8-6	SO	RS	ACK	9/14	14/12	15/2	15/8	15/14
9-8-7	SI	US	BEL	SUB	14/13	15/3	15/9	15/15

NOTE:

A card code position that has not been assigned a corresponding ASCII Code character is designated with the corresponding, though not yet assigned, column/row of the ASCII Codes.

Figure 10. Standard Hollerith Punched Card Code

$b_4\,b_3\,b_2\,b_1$ (Row - ASCII Code)	ROW (Row - Hollerith Code) \ COL	0 (b8=0 b7=0 b6=0 b5=0)	1 (b8=0 b7=0 b6=0 b5=1)	2 (b8=0 b7=0 b6=1 b5=0)	3 (b8=0 b7=0 b6=1 b5=1)	4 (b8=0 b7=1 b6=0 b5=0)	5 (b8=0 b7=1 b6=0 b5=1)	6 (b8=0 b7=1 b6=1 b5=0)	7 (b8=0 b7=1 b6=1 b5=1)
0000	0	NUL 12-0-9-8-1	DLE 12-11-9-8-1	SP NO PCH	0 0	@ 8-4	P 11-7	8-1	p 12-11-7
0001	1	SOH 12-9-1	DC1 11-9-1	! 12-8-7	1 1	A 12-1	Q 11-8	a 12-0-1	q 12-11-8
0010	2	STX 12-9-2	DC2 11-9-2	" 8-7	2 2	B 12-2	R 11-9	b 12-0-2	r 12-11-9
0011	3	ETX 12-9-3	DC3 11-9-3	# 8-3	3 3	C 12-3	S 0-2	c 12-0-3	s 11-0-2
0100	4	EOT 9-7	DC4 9-8-4	$ 11-8-3	4 4	D 12-4	T 0-3	d 12-0-4	t 11-0-3
0101	5	ENQ 0-9-8-5	NAK 9-8-5	% 0-8-4	5 5	E 12-5	U 0-4	e 12-0-5	u 11-0-4
0110	6	ACK 0-9-8-6	SYN 9-2	& 12	6 6	F 12-6	V 0-5	f 12-0-6	v 11-0-5
0111	7	BEL 0-9-8-7	ETB 0-9-6	' 8-5	7 7	G 12-7	W 0-6	g 12-0-7	w 11-0-6
1000	8	BS 11-9-6	CAN 11-9-8	(12-8-5	8 8	H 12-8	X 0-7	h 12-0-8	x 11-0-7
1001	9	HT 12-9-5	EM 11-9-8-1	) 11-8-5	9 9	I 12-9	Y 0-8	i 12-0-9	y 11-0-8
1010	10	LF 0-9-5	SUB 9-8-7	* 11-8-4	: 8-2	J 11-1	Z 0-9	j 12-11-1	z 11-0-9
1011	11	VT 12-9-8-3	ESC 0-9-7	+ 12-8-6	; 11-8-6	K 11-2	[12-8-2	k 12-11-2	{ 12-0
1100	12	FF 12-9-8-4	FS 11-9-8-4	, 0-8-3	< 12-8-4	L 11-3	\ 0-8-2	l 12-11-3	| 12-11
1101	13	CR 12-9-8-5	GS 11-9-8-5	- 11	= 8-6	M 11-4	] 11-8-2	m 12-11-4	} 11-0
1110	14	SO 12-9-8-6	RS 11-9-8-6	. 12-8-3	> 0-8-6	N 11-5	∧ 11-8-7	n 12-11-5	¬ 11-0-1
1111	15	SI 12-9-8-7	US 11-9-8-7	/ 0-1	? 0-8-7	O 11-6	_ 0-8-5	o 12-11-6	DEL 12-9-7

Column - ASCII Code (b8, b7, b6, b5)

Column - Hollerith Code (COL)

Row - Hollerith Code (ROW)

Row - ASCII Code (b4, b3, b2, b1)

NOTE: ASCII Character is in top portion of box while the Hollerith Code Hole(s) position is in the bottom portion of box.

Figure 11. Hollerith Hole-Pattern Cross Reference to ASCII (128 Characters)

Column - Hollerith Code
Column - ASCII Code

b8 b7b6b5		1 000	1 001	1 010	1 011	1 100	1 101	1 110	1 111
bbbb 4321	COL ROW	8	9	10	11	12	13	14	15
0000	0	11-0-9-8-1	12-11-0-9-8-1	12-0-9-1	12-11-9-8	12-11-0-9-6	12-11-8-7	12-11-0-8	12-11-9-8-4
0001	1	0-9-1	9-1	12-0-9-2	11-8-1	12-11-0-9-7	11-0-8-1	12-11-0-9	12-11-9-8-5
0010	2	0-9-2	11-9-8-2	12-0-9-3	11-0-9-2	12-11-0-9-8	11-0-8-2	12-11-0-8-2	12-11-9-8-6
0011	3	0-9-3	9-3	12-0-9-4	11-0-9-3	12-0-8-1	11-0-8-3	12-11-0-8-3	12-11-9-8-7
0100	4	0-9-4	9-4	12-0-9-5	11-0-9-4	12-0-8-2	11-0-8-4	12-11-0-8-4	11-0-9-8-2
0101	5	11-9-5	9-5	12-0-9-6	11-0-9-5	12-0-8-3	11-0-8-5	12-11-0-8-5	11-0-9-8-3
0110	6	12-9-8	9-6	12-0-9-7	11-0-9-6	12-0-8-4	11-0-8-6	12-11-0-8-6	11-0-9-8-4
0111	77	11-9-7	12-9-8	12-0-9-8	11-0-9-7	12-0-8-5	11-0-8-7	12-11-0-8-7	11-0-9-8-5
1000	8	0-9-8	9-8	12-8-1	11-0-9-8	12-0-8-6	12-11-0-8-1	12-0-9-8-2	11-0-9-8-6
1001	9	0-9-8-1	9-8-1	12-11-9-1	0-8-1	12-0-8-7	12-11-0-1	12-0-9-8-3	11-0-9-8-7
1010	10	0-9-8-2	9-8-2	12-11-9-2	12-11-0	12-11-8-1	12-11-0-2	12-0-9-8-4	12-11-0-9-8-2
1011	11	0-9-8-3	9-8-3	12-11-9-3	12-11-0-9-1	12-11-8-2	12-11-0-3	12-0-9-8-5	12-11-0-9-8-3
1100	12	0-9-8-4	12-9-4	12-11-9-4	12-11-0-9-2	12-11-8-3	12-11-0-4	12-0-9-8-6	12-11-0-9-8-4
1101	13	12-9-8-1	11-9-4	12-11-9-5	12-11-0-9-3	12-11-8-4	12-11-0-5	12-0-9-8-7	12-11-0-9-8-5
1110	14	12-9-8-2	9-8-6	12-11-9-6	12-11-0-9-4	12-11-8-5	12-11-0-6	12-11-9-8-2	12-11-0-9-8-6
1111	15	11-9-8-3	11-0-9-1	12-11-9-7	12-11-0-9-5	12-11-8-6	12-11-0-7	12-11-9-8-3	EC 12-11-0-9-8-7

Row - Hollerith Code
Row - ASCII Code

NOTE: The eight columns of Figure 11 present the 128 hole-patterns for the 128 characters of USASCII. The above eight columns present the extension of the code to 256 characters. This extension has been approved by ANSI and will be published as AN Standard X3.26-1969. For the present, only the hole-patterns have been assigned to the bit-patterns in the extension.

Figure 12. Hollerith Hole-Pattern Cross-Reference to ASCII (Extension of 128 Characters)

	12	11	0		12-0	12-11	11-0	12-9
	&	-	0	SP	{	|	}	
	-	/	0	SP	~	na	^	
	+	-	0	Blk	?	na	!	
1	A	J	/	1	a	j	¬	
	A	J	&	1	na	na	na	
	A	J	/	1	na	na	na	
2	B	K	S	2	b	k	s	
	B	K	S	2	na	na	na	
	B	K	S	2	na	na	na	
3	C	L	T	3	c	l	t	
	C	L	T	3	na	na	na	
	C	L	T	3	na	na	na	
4	D	M	U	4	d	m	u	
	D	M	U	4	na	na	na	
	D	M	U	4	na	na	na	
5	E	N	V	5	e	n	v	
	E	N	V	5	na	na	na	
	E	N	V	5	na	na	na	
6	F	O	W	6	f	o	w	
	F	O	W	6	na	na	na	
	F	O	W	6	na	na	na	
7	G	P	X	7	g	p	x	DEL
	G	P	X	7	na	na	na	na
	G	P	X	7	na	na	na	na
8	H	Q	Y	8	h	q	y	
	H	Q	Y	8	na	na	na	
	H	Q	Y	8	na	na	na	
9	I	R	Z	9	i	r	z	
	I	R	Z	9	na	na	na	
	I	R	Z	9	na	na	na	

	12	11	0	
8-1				`
				na
				na
8-2	[	]	\	:
	na	na	_	'
	na	na	≠	b
8-3	.	$	,	#
	.	[	,	#
	.	$	,	=
8-4	<	•	%	@
	<	•	%	>
	)	•	(	'
8-5	(	)	_	'
	+	]	?	:
	[	]	~	:
8-6	+	;	>	=
	(	;	$	)
	<	;	\	>
8-7	!	^	?	"
	=	!	`	"
	≠	^	⧻	✓

← Standard Hollerith
← AUTODIN
← JCS Pub 7
na means not assigned

Figure 13. Correspondence of Standard Hollerith, AUTODIN, and JCS Pub 7 Punched Card Codes

CHARACTERS LOWER CASE	UPPER CASE COMM	UPPER CASE WEATHER	START	1	2	3	4	5	STOP	CCITT NO.2 UPPER CASE ✱
A	—	↑		▨	▨				▨	
B	?	⊕		▨			▨	▨	▨	
C	:	○			▨	▨	▨		▨	
D	$	↗		▨			▨		▨	WRU
E	3	3		▨					▨	
F	!	→		▨		▨	▨		▨	UNASSIGNED
G	&	↘			▨		▨	▨	▨	UNASSIGNED
H	STOP	↓				▨		▨	▨	UNASSIGNED
I	8	8			▨	▨			▨	
J	'	↙		▨	▨		▨		▨	AUDIBLE SIGNAL
K	(	←		▨	▨	▨	▨		▨	
L	)	↖			▨			▨	▨	
M	.	.				▨	▨	▨	▨	
N	,	⦶				▨	▨		▨	
O	9	9					▨	▨	▨	
P	0	0			▨	▨		▨	▨	
Q	1	1		▨	▨	▨		▨	▨	
R	4	4			▨		▨		▨	
S	BELL	BELL		▨		▨			▨	'(APOSTROPHE)
T	5	5						▨	▨	
U	7	7		▨	▨	▨			▨	
V	;	⦶			▨	▨	▨	▨	▨	=
W	2	2		▨	▨			▨	▨	
X	/	/		▨		▨	▨	▨	▨	
Y	6	6		▨		▨		▨	▨	
Z	"	+		▨				▨	▨	+
BLANK		—							▨	
SPACE						▨			▨	
CAR. RET.							▨		▨	
LINE FEED					▨				▨	
FIGURES				▨	▨		▨	▨	▨	
LETTERS				▨	▨	▨	▨	▨	▨	

NOTE: UPPER CASE H (COMM) MAY BE STOP OR #

▨ MARKING PULSE

□ SPACING PULSE

✱ THIS COLUMN SHOWS ONLY THOSE CHARACTERS WHICH DIFFER FROM THE U.S.A. VARIATION

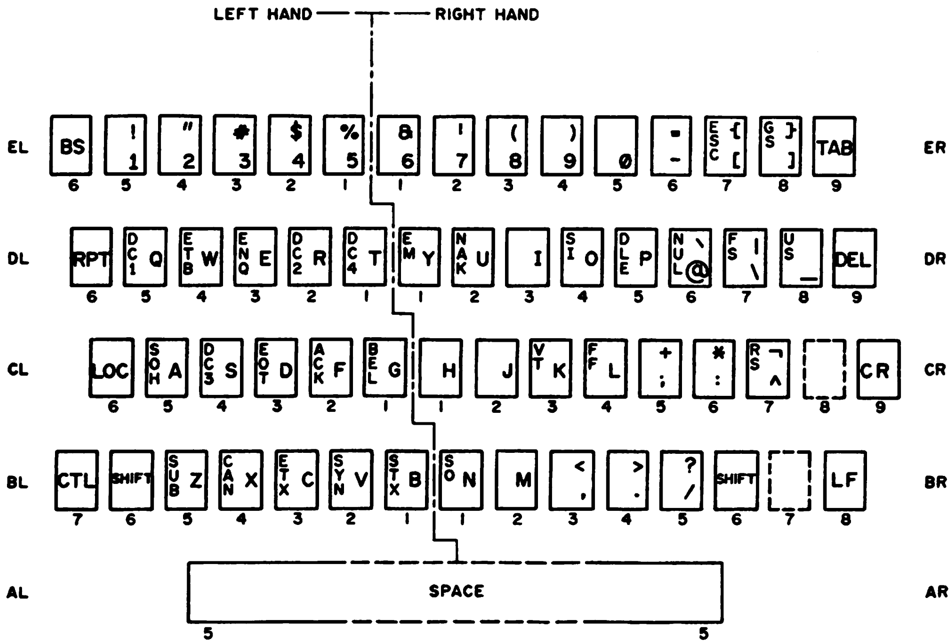
Figure 14. International Telegraph Alphabet No. 2, American Variation

20.11 Keyboard Arrangements. The keyboard arrangement used has no bearing on interoperability of equipment but is important from training and efficiency standpoints.

20.11.1 ASCII Keyboard Arrangements. Four-row keyboards are standard for the implementation of ASCII and for OCR message preparation units. The standard arrangements are included in Figures 15, 16, and 17. For details on the application of these arrangements, the designer is advised to consult MIL-STD-1280, Keyboard Arrangements. No FIPS PUB has been approved for keyboard arrangements for Government use but action is being taken to develop a federal standard. When such a standard is approved, MIL-STD-1280 will be revised accordingly.

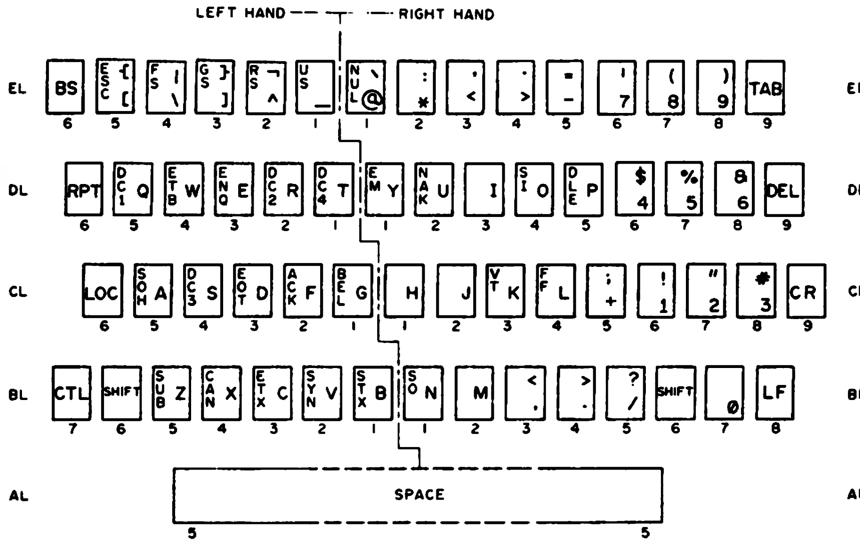
20.11.2 ITA No. 2 Keyboard Arrangements. The standard keyboard arrangements for use of the International Telegraph Alphabet (ITA) No. 2 USA variation are given in Figure 18.

20.12 EBCDIC Card Code. The EBCDIC card code is widely used but is not a US, Federal, or DoD standard. It is shown in Figure 19 for informational purposes only. The 128 characters of ASCII each have EBCDIC punched card hole patterns. The remaining 128 characters of this 256 character code have no character assignments as is the case with the Hollerith punched card code.



NOTES
1 PHYSICAL CHARACTERISTICS AND LOCATIONS (i.e. SIZE, SHAPE, SKEW, ETC) OF SPACE BAR OR KEYS ARE NOT TO BE INFERRED
2 ARRANGEMENT TYPE I, CLASS I AS PER MIL-STD-1280

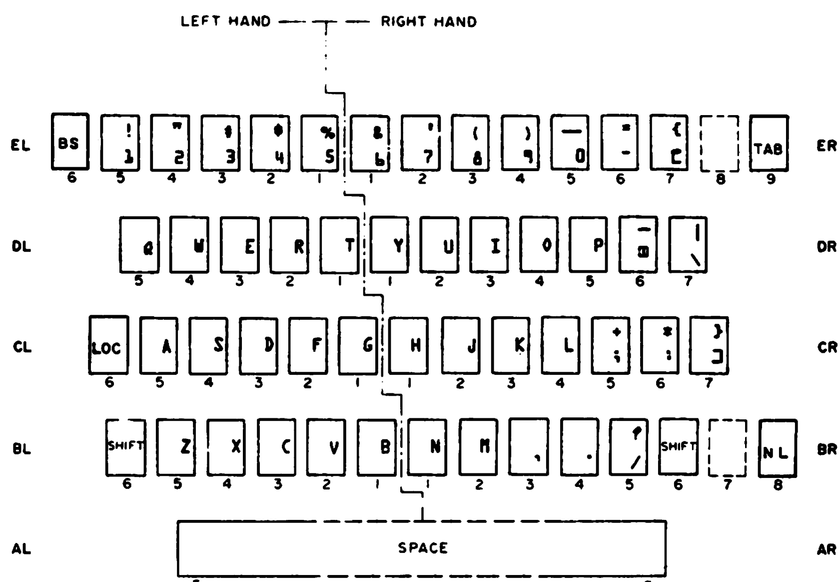
Figure 15. Type I, Class 1, Standard Keyboard Arrangement



NOTES

1 PHYSICAL CHARACTERISTICS AND LOCATIONS (i.e. SIZE, SHAPE, SKEW, ETC) OF SPACE BAR OR KEYS ARE NOT TO BE INFERRED
2 ARRANGEMENT TYPE I, CLASS 2 AS PER MIL-STD-1280

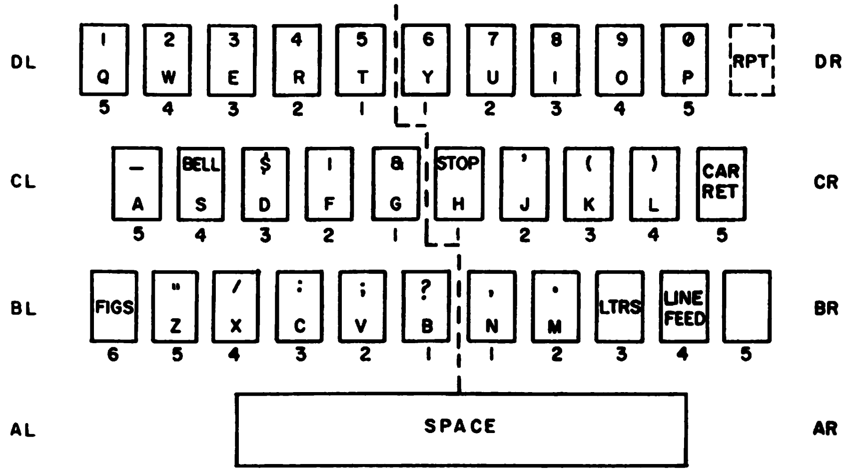
Figure 16. Type I, Class 2, Standard Keyboard Arrangement



NOTES

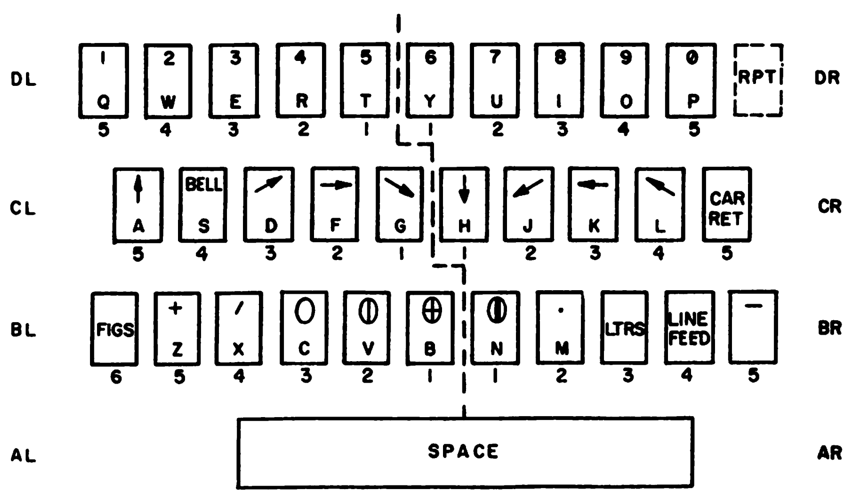
1 PHYSICAL CHARACTERISTICS AND LOCATIONS (i.e SIZE, SHAPE, SKEW, ETC) OF SPACE BAR OR KEYS ARE NOT TO BE INFERRED
2 SOLID KEY OUTLINES CORRESPOND TO USAS X4.7-1966
3 THE UPPER CHARACTER ON KEY ER5 WILL BE THE "GROUP ERASE" WHICH WILL APPEAR IN A REVISION OF USAS X3.17-1966

Figure 17. Type II, Class 1, Standard Keyboard Arrangement



NOTE: UPPER CASE H MAY BE STOP OR #

THREE ROW COMMUNICATION KEYBOARD (INTERIM STANDARD)



THREE ROW WEATHER KEYBOARD (INTERIM STANDARD)

Figure 18. Three-Row Keyboards

Bits xxxx 4567	Hexadecimal Row	Digit Punches																	
			00				01				10				11				Bits x0, x1
			00	01	10	11	00	01	10	11	00	01	10	11	00	01	10	11	Bits x2, x3
			0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	Hex. Col.
			12 9	11 9	0 9	9	12 0 9	12 11 9	11 0 9	12 11 0 9	12 0	12 11	11 0	12 11 0	12	11	0		Zone Punches
0000	0	8-1	*1 NUL	*2 DLE	*3	*4	*5 SP	*6 &	*7 -	*8					*9 {	*10 }	*11 \	*12 0	8-1
0001	1	1	SOH	DC1					*13 /		a	j	¬		A	J	*14	1	1
0010	2	2	STX	DC2		SYN					b	k	s		B	K	S	2	2
0011	3	3	ETX	DC3							c	l	t		C	L	T	3	3
0100	4	4									d	m	u		D	M	U	4	4
0101	5	5	HT		LF						e	n	v		E	N	V	5	5
0110	6	6		BS	ETB						f	o	w		F	O	W	6	6
0111	7	7	DEL		ESC	EOT					g	p	x		G	P	X	7	7
1000	8	8		CAN							h	q	y		H	Q	Y	8	8
1001	9	8-1		EM						`	i	r	z		I	R	Z	9	9
1010	A	8-2					[	]	*15 |	:									8-2
1011	B	8-3	VT				.	$	,	#									8-3
1100	C	8-4	FF	FS		DC4	<	*	%	@									8-4
1101	D	8-5	CR	GS	ENQ	NAK	(	)	_	'									8-5
1110	E	8-6	SO	RS	ACK		+	;	>	=									8-6
1111	F	8-7	SI	US	BEL	SUB	!	^	?	"									8-7
			12 9	11 9	0 9	9	12	11	0		12 0	12 11	11 0	12 11 0	12 0 9	12 11 9	11 0 9	12 11 0 9	Zone Punches

Card Hole Patterns

*1, 12-0-9-8-1
*2, 12-11-9-8-1
*3, 11-0-9-8-1
*4, 12-11-0-9-8-1
*5, No Punches
*6, 12
*7, 11
*8, 12-11-0
*9, 12-0
*10, 11-0
*11, 0-8-2
*12, 0
*13, 0-1
*14, 11-0-9-1
*15, 12-11

Figure 19. EBCDIC Card Code

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APPENDIX C

30. OPTICAL CHARACTER RECOGNITION EQUIPMENT

This Appendix Contains Supplementary Information and is part of MIL-STD-188-100.

FOREWORD

1. DoD policy on font standardization is contained in OASD (Telecommunications) Memorandum dated 16 Dec. 70 which is quoted in part below:

"The development of high resolution scanners and improved character recognition units permits procurement of multi-font OCRE on a competitive basis from several firms. The current generation OCRE permits expansion of the font reading capability by changes in the software and logic of the recognition units. Should there be significant quantities of OCR-A font equipped typewriters at a facility scheduled to receive OCRE, it is expected that OCR-A will be specified as one of the character sets capable of being processed by the equipment. In all other situations selection of OCRE should be based on a cost effectiveness analysis with appropriate consideration given to the type fonts on the equipment previously procured or programmed to be used with the OCRE."

2. As of this printing, the only ANSI (American National Standard Institute) standard for OCRE is X3.17-1966 which is for OCR-style A (OCR-A). Accordingly, the characteristics of subparagraph 30.5.4 are those for OCR (Style A) size I. It is expected that these parameters will be essentially the same in the style B font standard currently being developed by ANSI subcommittee X3A1.

APPENDIX C

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

30. OPTICAL CHARACTER RECOGNITION EQUIPMENT

30.1 Scope. This appendix concerning Optical Character Recognition Equipment (OCRE) is applicable to communications only. This OCRE is to be used to generate binary electrical signals in the appropriate code and alphabet by a process of reading (scanning) messages prepared in a standard manner on a standard message format using typewriters suitable for preparation of messages accurately readable by OCRE. The message format is discussed in subparagraph 30.8.2 of this appendix. Suitable typewriters are discussed in paragraph 30.6 of this appendix.

30.2 Purpose. This appendix is a part of MIL-STD-188-100 and is included to facilitate its use in connection with OCRE.

30.3 Use of OCRE. The OCRE may be used on-line, feeding the generated signals directly to the line or to any of a number of lines as required by the traffic situation; or the OCRE may be used off-line by recording on paper tape, magnetic tape, drum, etc. When used off-line the recorded message is subsequently read to the appropriate line. Which method of operation is used is a matter of command prerogative, but the design should be such that both on-line and off-line operation is possible.

30.4 OCRE Signals.

30.4.1 Code and Alphabet. The binary signals generated by the OCRE shall be coded in the "Code for Information Exchange" which is also known as ASCII (pronounced as'-key) or USASCII (pronounced you-sas'-key). This coded character set is discussed in Appendix B.

30.4.2 Low Level Signaling. The signals generated by the OCRE shall be in accordance with subparagraph 4.3.1.3 (Low Level Digital Interfaces) of the basic standard.

30.4.3 Modulation Rate. The modulation rate of the OCRE signal shall be as specified in subparagraph 4.3.1.1 (Modulation and Data Signaling Rates) of the basic standard.

30.4.4 Character Reading Rate. The character reading (scanning) rate bears a definite relationship to the rate at which signals are dispersed to the line unless a buffer storage is provided between the two. The maximum scanning rate shall be consistent with the headquarters traffic load, economics, accuracy in reading, and sound engineering practices.

30.4.5 Bit Transmission. Bits (per character) transmission between the OCRE and the off-line recorder may be in serial or parallel form. When the OCRE is operating on-line the bit stream must ultimately be serialized before transmission.

30.4.6 Parity. When the ASCII is used pursuant to subparagraph 30.4.1 of this appendix, the parity bit shall be generated by the OCRE in accordance with subparagraphs 20.4.1 and 20.4.2 of Appendix B.

30.5 OCRE Capabilities.

30.5.1 Monocase ASCII OCRE (Preferred Standard for Message Preparation). The minimum reading capability of monocase OCRE operating in an ASCII communication link shall be the characters given in Table I of this appendix. Any additional character reading capability shall be limited to those characters given in Figure 1 of Appendix B.

30.5.2 Dualcase ASCII OCRE. Dualcase readers shall have the same capability of reading lower case alphabetic characters printed in the same font design as the upper case alphabetic characters. Dualcase OCRE is not recommended for ordinary communications use because dualcase receiving teleprinters will not generally be available. The use of dualcase OCRE is appropriate only in properly equipped closed networks, when dualcase receiving teleprinters are generally available and when using ASCII (see Figure 4 of Appendix B).

30.5.3 Character Set Capabilities.

30.5.3.1 Single Character Set OCRE (Monocase). The use of monocase character set OCRE (upper case only) has the disadvantages of necessitating more complete standardization of message preparation typewriters throughout the headquarters than does OCRE utilizing dualcase and multiple character sets. However, monocase OCRE has an advantage in cost and reliability of reading over dualcase OCRE and it has a very considerable advantage in cost and reliability of reading over multiple character set OCRE. For DoD policy and guidance on fonts, refer to the foreword of this appendix.

30.5.3.2 Multiple Character Set OCRE. OCRE having multiple character set capability allows more flexibility in the use of typewriters but it costs considerably more and is much less reliable in reading than the single character set OCRE. Multiple character set OCRE shall have the capability of the character set described in Table I and subparagraph 30.5.4 of this appendix.

30.5.4 Minimum Character Set Capability. OCRE shall have the minimum capability of reading a character set defined by Table I when the:

(a) Horizontal character spacing is 10 per inch,
(b) Line spacing is 6 lines per inch,
(c) Maximum character height, H, is 0.094 inches,
(d) Maximum character width, W, is 0.055 inches, and
(e) Nominal stroke width, T, is 0.014 inches.

The character height and width are defined as centerline height and width. Therefore, the actual maximum height is H + T and the actual maximum width is W + T.

30.5.5 Multiple Character Set Capability. One of the character sets shall be as described in subparagraph 30.5.4 of this appendix. All other character sets are specified only to the extent of having the character spacing of subparagraph 30.5.4 of this appendix.

30.5.6 Automatic Message Heading (Optional). OCRE equipped for automatic message heading generation shall read the heading elements which are typed in the appropriate places on DD Form 173. Using this information, the OCRE shall automatically generate an appropriate message heading.

30.5.7 Automatic Message Ending (Optional). OCRE equipped for automatic message heading generation shall also automatically generate a compatible and appropriate end-of-message format.

30.6 Typewriters.

30.6.1 General Performance Characteristics. Adequate typing quality is mandatory in order to minimize OCRE reading errors. This requires appropriate typewriters, ribbons, maintenance, and a consistently strong touch. All of this can be obtained most adequately by using electrical typewriters and one-time ribbons. Making such practice mandatory will pay dividends in added message reliability.

30.6.2 Dualcase Typewriters. Dualcase typewriters shall ordinarily be used for message preparation so that they also may be used for other work. The lower case characters may be any suitable style unless the headquarters is equipped with an OCRE with both an upper and a lower case reading capability. In such a case the lower characters shall be the appropriate characters as provided in subparagraph 30.5.2 of this appendix.

30.6.3 Monocase Typewriters. Monocase typewriters shall ordinarily not be used for message preparation even though messages normally will continue to be prepared in upper case letters only.

30.6.4 Keyboard Arrangement. The detail requirements for a standard keyboard arrangement for OCR typewriters are given in MIL-STD-1280, Military Standard Keyboard Arrangements.

30.7 Print Quality. Print quality is a combination of the following: Minimum print contrast signal (PCS) within character outline, the maximum (PCS) outside the character outline, voids, extraneous ink areas, stroke width variation, and conformance of character shapes to nominal character shapes specification. These factors are largely determined by the printing systems employed. The performance of OCR systems depends to a large extent on the print quality. Hence, every effort should be made to provide "good" print quality, i.e.:

(a) The printed character should present as high a contrast as possible to the background document.

(b) Stroke width should be held as close as possible to the nominal.

(c) Insofar as possible, there should be no voids within the stroke outline. When these cannot be prevented, the number of void areas within a stroke should be minimized. The size of individual voids should not exceed half of the nominal stroke width, and the distance between individual voids should be as great as possible.

(d) Insofar as possible there should be no extraneous ink within the clear area. When this cannot be prevented, the number of extraneous ink spots should be minimized, the size of the spots should not exceed half the nominal stroke width, and the distance between unit spots should be as great as possible.

30.8 Standard Message Form Use.

30.8.1 Paper Specifications. The quality of the paper used in message forms must be controlled for OCRE applications. A suitable specification for paper quality may be obtained by reference to paragraph 4, Paper Specifications, of the "USA Standard Character Set for Optical Character Recognition" (USAS X3.17-1966). This standard is published by the United States of America Standards Institute, 10 East 40th Street, New York, N.Y. 10016.

30.8.2 Printed Format.

30.8.2.1 First Sheet DD Form 173 (OCR). The joint message form includes the heading information required for a computer to generate the appropriate standard format for the message heading in accordance with JANAP 128 (AUTODIN), ACP 127 (NATO Traffic Only), or other appropriate format as determined by the requirements.

30.8.2.2 Continuation Sheet. The same form is used as a continuation sheet for those messages that require more than one page.

30.8.2.3 Printed Details. See Figure 1.

30.8.2.4 Message Component Symbolization.

30.8.2.4.1 Orientation (Benchmark) Symbol. It shall be standard not to use a special printed symbol for the OCRE to orient itself with respect to the printed page. The equipment shall orient itself with respect to edges of the paper by the difference between the paper reflectance and that of machine background, or may be oriented on the first typed character In the event a reader is used that does not have such a capability, the typist may be instructed to type in a special symbol at an appropriate place on the page. In any event the OCRE shall be programmed to start its scan at the first line of typing after becoming oriented.

30.8.2.4.2 Start of Heading (SOH). No Start of Heading (SOH) symbol is used in the interest of economy. Such a symbol would have to be printed in black. A two color form would be more costly than a single color (blue) printed form. To have the typist type in a SOH would complicate her job unnecessarily. The OCRE shall be programmed to recognize the Start of Heading by the message pagination, that is page "1" or "X" pages.

30.8.2.4.3 Action Addressee Symbol. Not used, handled by software. The first Action Addressee may be recognized by the OCRE as being indented 20 spaces. Subsequent Action Addressees, if any, are also indented 20 spaces. Double spacing is used vertically.

30.8.2.4 4 Information Addressee Symbol. The sequence "INFO:" shall be used to indicate the first Information Addressee. The colon is used to prevent a random sequence "INFO" in the message from giving a false result. "INFO:" is typed by the drafter's typist two lines below the last Action Addressee, starting immediately to the right of the left blue margin line using no indentation. The Info Addressees are indented 20 spaces as are the Action Addressees and are also double spaced vertically. The OCRE may thus recognize the end of Action Addressees and the beginning of Information Addressees by the typed "INFO:" starting at the margin. If there are no Information Addressees the OCRE will recognize this fact by finding "XMT:" at the left margin line, no indentation, using double spacing from the last Action or Information Addressee as the case may be. The exempted headquarters or routing indicator(s) shall be typed in starting directly under the start of the addressees, namely 20 spaces from the left margin line. If there be more than one line of exempted routing indicators, the second line shall also be indented 20 spaces. Thus, the OCRE can recognize the Start of Text by the next nonindented typing.

30.8.2.4.5 Start of Text (STX) Symbol. Not used, handled by software.

30.8.2.4.6 End of Text (Message) (ETX) Symbol. Not used, handled by software. The OCRE can recognize the ETX by the end of the printing in the last page of the message. The last page is identified by the pagination in the page block in the first line of typed material. On the last page the page number is the same as the number of pages, such as page 2 of 2.

30.8.2.4.7 Indentation Symbol. It shall be standard to program the computer to effect indentation and tabulation at the receiver by counting and transmitting the appropriate number of spaces. This method allows for tabulation without any prearrangement between the originator or drafter and the addressee. When the ASCII is used, however, tabular material can be sent by prearrangement between the transmitter and receiver. This requires sending tabular codes rather than spaces and also employing appropriate page printers at the receiver.

30.8.2.4.8 Automatic Local Distribution. If the OCRE is used in conjunction with a Local Message Distribution Unit (LDMX) the local distribution may be typed in the appropriate place on the Joint Message form. A vertical line is used to indicate that this data is for local distribution and not part of the message.

30.8.2.5 Use of Erase Symbols.

30.8.2.5.1 Group Erase Symbol. It shall be standard to use a continuous dash (Group Erase Symbol) through the first three characters in a line to indicate that the line is in error and must be omitted by the OCRE. This symbol is shown in Table II.

30.8.2.5.2 Character Erase Symbol. The standard character erase symbol shall be a solid black printed rectangle having a size equal to a nominal character space. In use the character erase symbol is printed over a character to indicate that the character is in error.

TABLE I

APPENDIX C

Repertoire of Characters to be Used in Message Preparation
for OCRE Handling*

COLUMN →	0	1	2	3	4	5	6	7	
b7 b6 b5	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1	ROW ↓
b4 b3 b2 b1	←NON-PRINTING	→	←96-SYMBOL PRINTING SUBSET					→	
0 0 0 0			SP	Ø		P			0
0 0 0 1				1	A	Q			1
0 0 1 0			"	2	B	R			2
0 0 1 1				3	C	S			3
0 1 0 0			$	4	D	T			4
0 1 0 1			%	5	E	U			5
0 1 1 0			&	6	F	V			6
0 1 1 1			' (APOS)	7	G	W			7
1 0 0 0			(	8	H	X			8
1 0 0 1			)	9	I	Y			9
1 0 1 0			*	:	J	Z			10
1 0 1 1			+	;	K				11
1 1 0 0			,		L			|	12
1 1 0 1			-	=	M				13
1 1 1 0			.		N				14
1 1 1 1			/	?	O				15

*Based on ASCII, Figure 1, Appendix B

TABLE II

APPENDIX C

OCR-A CHARACTER SET FOR MONOCASE OCRE

OCR-A Character Set Representing ASCII Characters

Alphabet		Numerals	Punctuation Symbols	Name
A	N	1	.	Period
B	O	2	,	Comma
C	P	3	:	Colon
D	Q	4	;	Semi-Colon
E	R	5	=	Equals
F	S	6	+	Plus
G	T	7	/	Slant
H	U	8	$	Dollar Sign
I	V	9	*	Asterisk
J	W	0	"	Quotation Mark
K	X		&	Ampersand
L	Y		'	Apostrophe
M	Z		-	Hyphen
			(	Left Parenthesis
			)	Right Parenthesis
			%	Percent
			?	Question Mark
			|	Vertical Line

Special ANSI Symbols

Symbols	Name	Use
⑁	Hook	None
⑂	Fork	None
⑃	Chair	None
—	Group Erase	Erase complete line
⑄	Character Erase	Erase character

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APPENDIX D

40. COMMON TEST METHODS

This Appendix contains Tutorial Information in Support of MIL-STD-188-100.

APPENDIX D

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

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40. COMMON TEST METHODS

40.1 Scope.

This Appendix provides general measurement techniques and methods of measuring the values for the common parameters of voice and data service specified in the other sections of MIL-STD-188-100.

40.1.1 Purpose. Appendix D is not a part of MIL-STD-188-100. It is provided for information and to facilitate understanding of the parameters included in the standard. When using these test techniques some precautions must be observed so that satisfactory results may be obtained and, in some cases, to insure the safety of the personnel and equipment involved.

40.1.2 Application.

This appendix discusses test methods which are common to all voice frequency channels derived from tactical or long-haul subsystems. It is essential to recognize that this appendix discusses general methods of testing rather than step-by-step procedures for performing a particular test. The latter would vary considerably among the many different equipment configurations which exist and would involve a level of detail not appropriate to an appendix of a general standards document. The test methods discussed herein can be used as a guide to develop detailed procedures for measuring the critical parameters for voice or data service over voice frequency channels.

40.2 General Measurement Techniques.

The following paragraphs have general application to the voice frequency test methods discussed in paragraph 40.3.

40.2.1 Accuracy of Measurements.

The measurement techniques used in measuring the various operating parameters of long haul and tactical systems should be devised to reduce the number of errors which can contribute to the final accuracy of measurement. In general, more than one method may be available for measurement of a particular parameter. The method which results in the least number of errors should be chosen whenever possible. For example, insertion loss measurements could be made by either the direct method or by the comparison method (see paragraph 40.3.1.4). In the direct method, all the inaccuracies inherent in the equipment contribute to the overall accuracy of the test, while in the comparison method the inaccuracies of only one piece of equipment (i.e., an attenuator) contribute to the overall measurement accuracy. Other technical and economic factors may have significance when selecting a test method; however, consideration should always be given to reducing the sources of measurement error. The following sources of error should be considered:

a. Impedance Matching

Attention must be paid to matching the sending and receiving impedances of the testing equipment to the nominal input and output impedances respectively of the system or network under test.

b. Calibration

Improperly calibrated instruments will always yield measurement errors when direct reading methods are employed.

c. Equipment Errors

Equipment errors are caused by many factors. For example, a direct reading selective level measuring set will be subject to variances in level indication as a function of frequency, temperature variations, and attenuator accuracies when switching ranges.

d. Human Errors

Human errors result in inaccuracies which can easily exceed the cumulative inaccuracies due to all the other sources of errors. It is therefore essential that test personnel become thoroughly familiar with the test equipment and the system under test. Test equipments can also be provided with numerous features which reduce the possibility of human error, e.g. scale calibrations which allow for easy interpolation.

40.2.2 Use of Digital Displays.

> [NOTE: A distinction should be drawn between instruments which display a digital representation of a continuously variable quantity (e.g., a digital decibelmeter) and instruments which are essentially event-counters and thus naturally lend themselves to a digital display (e.g., an error-rate counter). The latter are not the subject of this discussion.]

In general it is considered that the use of digital displays is desirable for some (but not all) transmission measurements. The quantity being measured should preferably be steady for a digital display since it is more difficult to form an estimate of the rate and extent of fluctuations of a varying quantity with this form of presentation than with a conventional scale-and-pointer display.

Digital displays would be suitable for non-specialized staff, but economic considerations, technical complexity, and the possible physical size of portable equipment might limit their extensive use.

Digital display instruments can be used for measurements requiring the highest accuracy. Human errors are reduced and (for a given cost) it is often easier to make a digital display instrument more accurate than an analog display instrument in that the least-significant-figure error can often readily be made less than the scale error of a conventional meter.

In general, a digital display takes less time to read than a scale indication; hence, digital displays would be superior to analog displays for making measurements in quick succession. A facility for a printed or punched output might be provided usefully by the instrument for this purpose.

A digital display is not considered suitable if the quantity being measured is varying continuously (as, for example, when the level of a signal is being adjusted with a potentiometer) and for this type of measurement a conventional pointer and meter display is preferred. However, if the adjustment is made in steps, then a digital display would be satisfactory.

Digital display instruments are, in general, not considered quite so suitable for localizing sources of trouble giving rise to variations in level as analog displays although they might be used for such a purpose if there was facility for a printed output. They are not considered suitable for studies of intermittent faults.

Digital display instruments have been used or could be used for the following purposes:

Automatic recording of measured results particularly with a view to subsequent evaluation by a computer

In conjunction with automatic loss and level measuring equipments

40.2.3 Direct-Reading Methods Versus Null or Comparison Methods.

(It should be noted that many types of digital display instruments are inherently comparison or null systems, the accuracy of which depends on the long-term stability of some internal reference device, for example, a zener diode. However, this section refers to comparison or null methods performed manually; hence, digital display instruments are regarded here as direct-reading instruments.)

In general, comparison or null methods requiring the operator manually to adjust a control should be used only for measurements requiring the highest accuracy (e.g., measurement of crosstalk ratios and noise levels).

Portable instruments could use this method with advantage in that the stability is, in principle, vested in comparatively robust components such as attenuators, rather than in a meter.

In general, direct-reading techniques are considered suitable for most other types of measurements, particularly when cost or time must be conserved.

Some measuring sets capable of precise measurements combine manually-operated controls with a direct-reading instrument. These are the so-called "level lens" or "off-set zero" instruments in which, for example, the input level being measured is set equal to within say ±0.5 dB of the reference signal by means of switched attenuators, the least step of which is in this case 1 dB, and the residual difference between the measured signal and reference signal is displayed on a center-zero decibelmeter which indicates the sign as well as the magnitude of the difference. The level measured is given by the sum of the attenuator setting and the meter reading. The meter can be engraved readily to permit easy interpolation.

40.2.4 Use of Selective Measuring Sets.

Selective measuring sets are necessary when the wanted signal is accompanied by other signals or noise at relatively high levels, for example, crosstalk levels. Selective measuring sets may be either fixed-frequency or continuously variable. Fixed-frequency selective measuring sets are in general accurate and fast and tend to reduce human errors. However, they are restricted in use and it would be costly to provide a great variety of them. On the other hand continuously variable selective measuring sets require more skill to use and sometimes, and for some applications, they are not so accurate or so fast.

40.2.5 Compensating for the Losses of Test-Trunks and Test Cords.

A broad distinction can be made usefully between centralized measuring apparatus (which is often necessarily remote from the transmission equipment, rack-mounted measuring apparatus (which can be installed near the transmission equipment) or mobile measuring apparatus (which can be brought up close to the transmission equipment).

40.2.5.1 Centralized Measuring Apparatus. Examples of this are automatic measuring apparatus for circuits, etc., or centralized measuring centers serving remote installations. In these cases it is often convenient to build out the loss of the test-trunk or test-circuit with pads or amplifiers, sometimes equalizing if necessary, and off-setting any residual loss by suitably increasing the sending level or the receiving sensitivity so that the measuring instrument effectively indicates the level at the remote transmission equipment.

40.2.5.2 Measuring Apparatus Mounted or Brought Close to the Transmission Equipment. In this case, the preferred technique is to keep the testing cords as short as possible. The calibration technique can often be arranged to allow for the loss of the test cords.

The test cords should be short compared with the shortest wavelength within the spectrum of signals being measured. When this is not possible, a test lead may be derived which is effectively decoupled from the transmission path (for example, by means of a test hybrid which may be a transformer or a network of resistors), the test lead being properly terminated by the measuring apparatus. In these circumstances it is useful to arrange for the test lead to be similar in composition and length to the transmission path from the transmission equipment to the associated distribution frame so that measurements at the end of the test lead are as if they were made at the distribution frame.

40.3 Voice Frequency Test Methods.

40.3.1 Insertion Loss.

40.3.1.1 Applicability. These measurements are applicable to all voice frequency channels, circuits and two-terminal pair networks.

40.3.1.2 Principles of Test. The insertion loss of a two-terminal pair network inserted between a sending impedance Z_E and a receiving impedance Z_R is the ratio P_1/P_2 expressed in dB, where P_1 and P_2 represent the apparent power in the receiving impedance Z_R before and after the insertion of the two-terminal pair network concerned.

This loss is given by the expression:

$$10 \log_{10} \frac{P_1}{P_2} \text{ dB}$$

If the result has a negative sign, an insertion gain is indicated.

The measurement of insertion is made in accordance with Figure D-1. The ratio of apparent power is usually based on the ratio of the voltages across Z_R before and after the insertion of the two-terminal pair network.

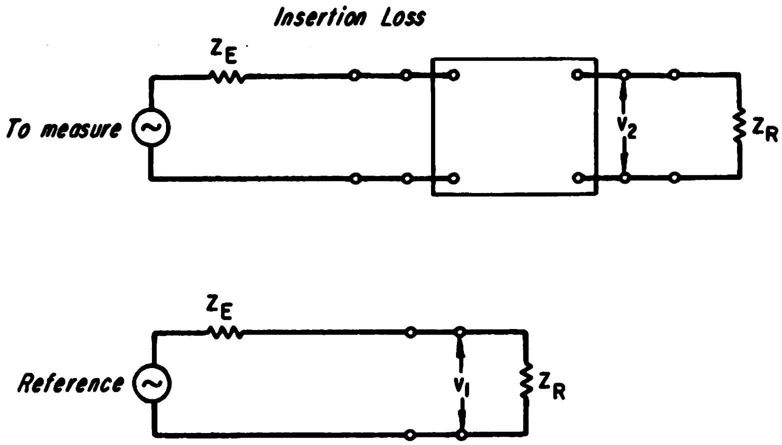


Figure D-1

40.3.1.3 Apparatus. Testing equipment used for making loss or gain measurements consists basically of a suitable generator for providing the test signal and a measuring device for measuring the level of the received signal. For each equipment or system to be measured, the generator will have to provide a test signal at a suitable frequency or over a range of frequencies and over an appropriate range of levels. The measuring device is basically a voltmeter but indicating voltage or power levels. The measuring equipment will usually include sending and receiving units to provide the desired sending and receiving conditions at impedances appropriate to the measurements which are to be made.

40.3.1.4 Test Methods. Two methods of measuring gain or loss are commonly used; these are direct-reading measurements and measurements by a comparison method.

a. Direct-reading measurements

For such measurements the network or line N to be measured is inserted between a sending device G and a measurement set M (Figure D-2).

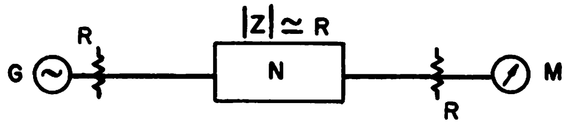


Figure D-2

In practice, the sending device G simulates a constant voltage generator of known source e.m.f and impedance. The prime calibration of such an arrangement in the field is maintained with reference to the power developed by the generator in a thermocouple of the correct impedance. The measuring set M is used to make a direct measurement of the power level of the received signal at the output of N. The difference between the sent and received power levels is a direct measurement of the insertion loss or gain of N. The generator and measuring circuits must be designed and used to give the appropriate sending and receiving impedance conditions. The diagram represents the simplest — and at the same time most usual— case in which terminal impedances are equal to the input and output impedances of the two-terminal pair network.

b. Loss measurements using a comparison method

For such measurements the output from the sending device G is connected via a branching network to provide two outputs, one of which is connected to the network N to be tested and the other to a calibrated attenuator A. At the receiving end a measuring circuit M is used to compare the level of the signal received via the network under test and via the calibrated attenuator (Figure D-3).

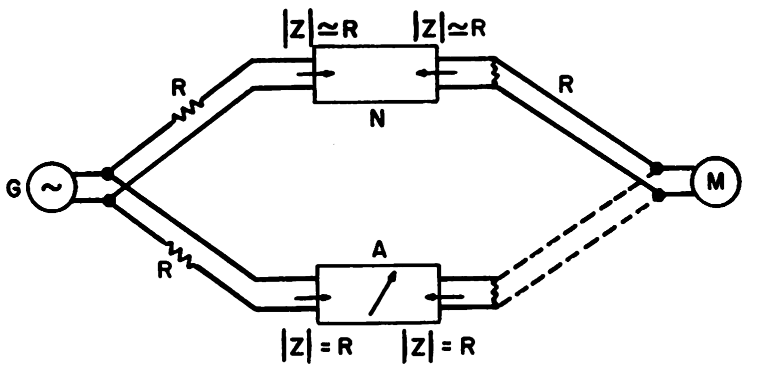


Figure D-3

The loss of the attenuator A is adjusted so that the same level is indicated on the measuring meter when it is switched to either the network or the attenuator; the loss of the network is then given by the setting of the calibrated attenuator.

An extension of this method can be used to measure the loss of a circuit or system where the two ends are not available at the same point. In this case a second generator is required at the receiving end of the circuit under test. At the sending end the test signal generator is adjusted to send the required frequency at an appropriate level into the circuit under test. At the receiving end a second generator is used to send the same frequency at the same level into a calibrated attenuator. The measuring circuit is used to compare the level of signal received via the circuit under test and the signals from the calibrated attenuator, which is adjusted until the two levels are the same. The setting of the calibrated attenuator then gives the loss of the circuit under test.

It should be noted that these comparison methods do not require the use of a calibrated measuring device. An uncalibrated indicator of appropriate sensitivity may be used, the accuracy of the measurements being a function of the accuracy of the calibrated attenuator. Due regard must be paid to the sending and receiving impedance conditions when making the measurements. The diagram represents the simplest — and at the same time most usual — case, in which the terminal impedances are equal to the input and output impedances of the quadripole and to the input and output impedances of the attenuator.

The insertion loss test should be repeated at various frequencies over the voice frequency bandwidth to determine the insertion loss vs. frequency characteristic. Swept frequency generators and measuring sets which can be used to drive an X-Y recorder are useful in reducing the manual effort required for direct reading tests.

40.3.2 Envelope Delay Distortion.

40.3.2.1 Applicability. The methods described are applicable to measurement of envelope delay distortion of a circuit or channel, on an end-to-end or looped basis.

40.3.2.2 Principles of Test. A technical discussion of envelope delay and envelope delay distortion appears in Appendix E. The methods used for testing this parameter utilize commercially available test equipment specifically designed for the measurement of increments of envelope delay on telephone transmission circuits. This equipment consists essentially of a transmitter and receiver. The transmitter supplies a variable carrier frequency (c) (e.g., in the range 200 Hz to 4,000 Hz) modulated with a frequency (f) that is low compared with the lowest carrier frequency present. The receiver accepts the modulated wave as sent from the transmitter over the intervening transmission circuit. The received signal is demodulated and the low-frequency (f) envelope recovered. The phase of (f) is compared to a reference wave of frequency (f) and the phase difference between the two is indicated on a meter. This phase difference approximates the slope at frequency (c) of the phase vs frequency characteristic of the circuit test and, hence, gives a measure of the envelope delay at the selected carrier frequency. The transmitter carrier frequency can either be adjusted manually throughout the frequency range of interest or it can be swept over the range by an internal motor drive in the transmitter with envelope delay recorded on an X-Y plotter at the receiver. By either means a plot of envelope delay vs frequency can be obtained from which the envelope delay distortion can be evaluated.

40.3.2.3 Apparatus. This test requires a delay distortion measuring set which consists essentially of two units:

(1) A carrier oscillator whose frequency (c) is adjustable over the range of interest (voice frequencies) and which is amplitude modulated at a low frequency (f) by a modulating oscillator.

(2) A phase comparator capable of indicating the difference in phase between two signals of frequency (f). The signals can be derived in a variety of ways depending on the specific test arrangement. The comparator may be implemented in either analog or digital form and may involve null balancing or direct readout.

Item (1) is the sending unit and (2) is the receiving unit. Where they are co-located, as in measurement of the characteristics of lumped constant device or a looped test, direct comparison of the phase of the transmitted and received envelopes is possible. In measuring the characteristics of a communication channel on an end-to-end basis, the send and receive points will be separated and the problems of providing a reference signal of frequency (f) at the comparator arises. Alternate means of satisfying this requirement are discussed in the following paragraph.

40.3.2.4 Test Methods. Figure D-4 illustrates the basic test arrangement where the input and output terminal pairs are at the same location.

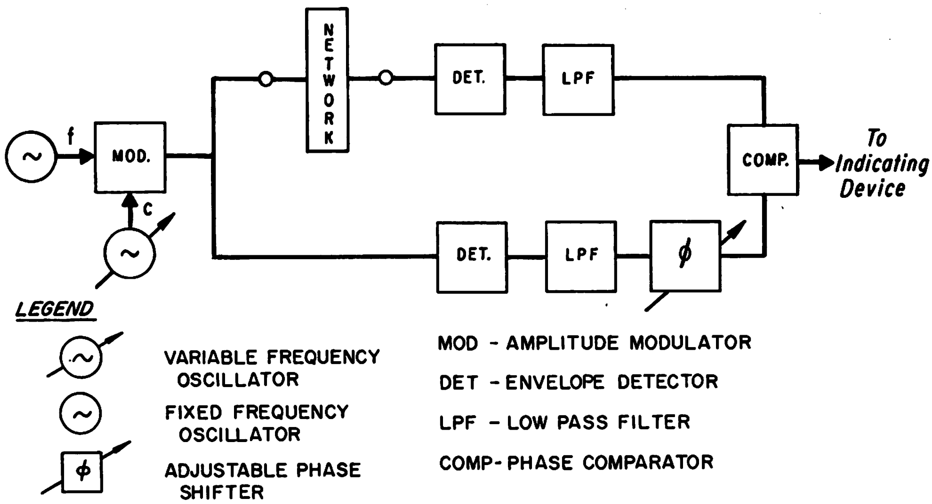


Figure D-4

The frequency (c) of the carrier oscillator is adjustable in the voice frequency range. The phase shifter is set to provide a convenient comparator reading at the reference frequency (e.g., mid-band or 1000 Hz).

The following variations of the method are used where the output and input are separated:

A separate local oscillator of frequency (f) is provided at the receiver terminal. The arrangement is shown in Figure D-5. It is clear that in this case synchronization between the oscillators at both ends is a problem and that accurate and stable oscillators are required to prevent a drift in the meter reading.

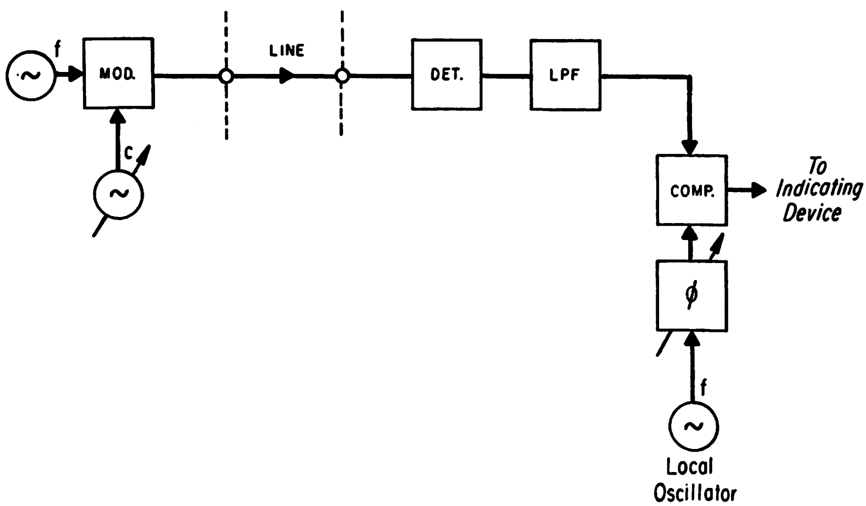
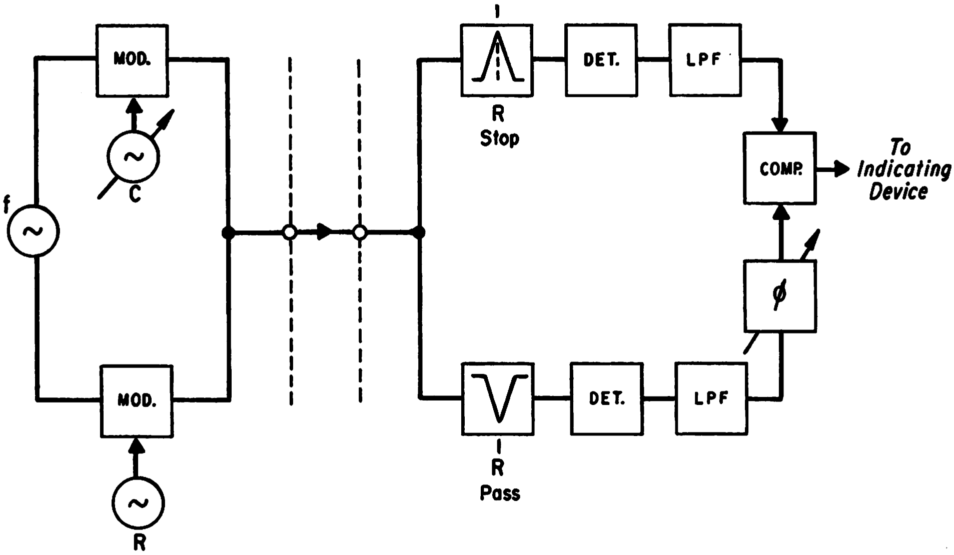


Figure D-5

Another method is shown in Figure D-6. The modulating frequency (f) is transmitted to the remote terminal by means of a "reference" carrier which is kept constant throughout the measurement. The modulation envelopes of the carriers (r) and (c) are detected separately and the phase of these envelopes are compared, yielding a relative measure of envelope delay.



R is the reference carrier oscillator

Figure D-6

When a return circuit is available it can be used to transmit the reference carrier as shown in Figure D-7 from the receiving station to the sending end. In one further modification of this arrangement the modulating oscillator and the comparator may be located at the sending station as in Figure D-8.

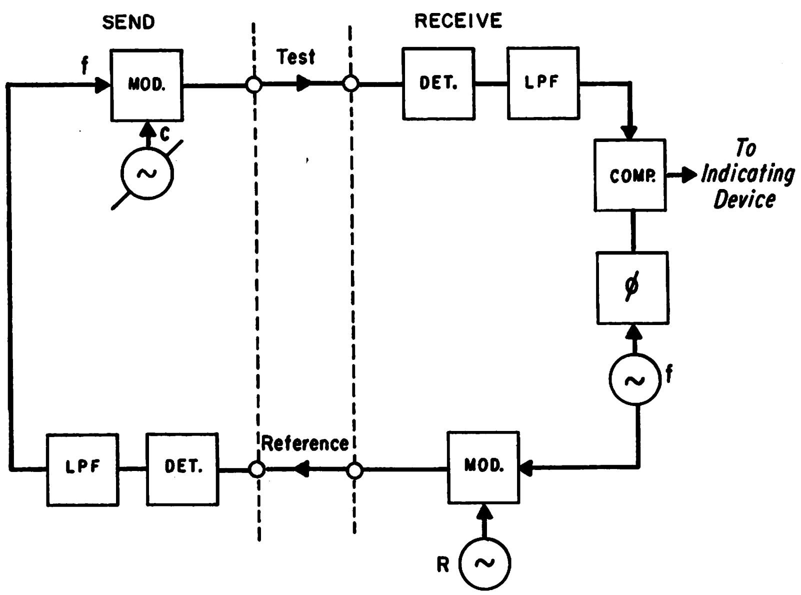


Figure D-7

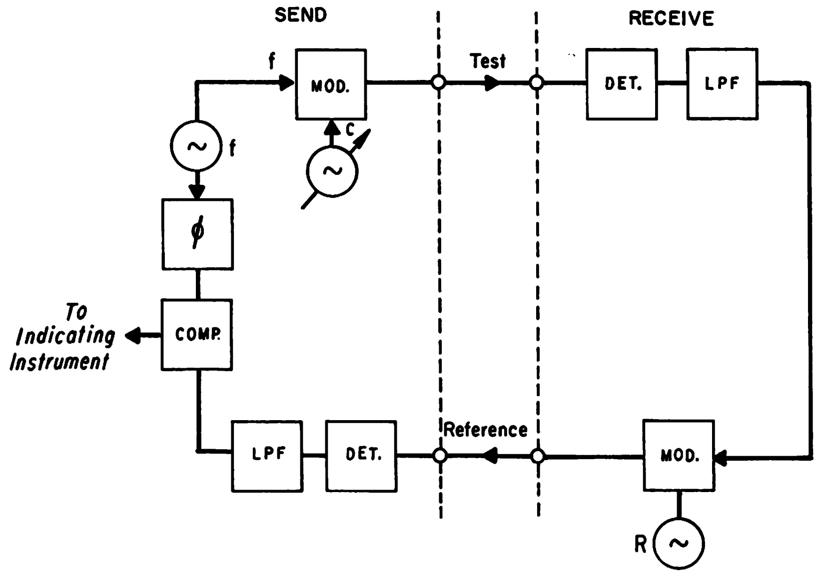


Figure D-8

40.3.3 Circuit Noise and Single Tone Interference.

40.3.3.1 Applicability. This paragraph applies to measurement of the level of total noise and single tone interference on a voice frequency circuit.

The measurement of impulse noise is covered separately in paragraph 40.3.4.

40.3.3.2 Principles of Test. Total circuit noise includes both basic noise (fluctuation noise, hum, carrier leak, etc.) and the interference (crosstalk, intermodulation, etc.) arising from other traffic carried by the communication system.

The interfering effect of noise on a telecommunication circuit is fairly well described by a measurement of noise power level which is specially "weighted" to account for the characteristics of the telephone set, the voice-frequency circuit, and the human ear. The required attenuation/frequency characteristics of weighting networks have been developed by subjective tests. The two principal weighting characteristics in current use are CCITT psophometric weighting and C-message weighting. Figure D-9 shows these two weighting curves. It will be noted that both heavily attenuate low-frequency hum. Single frequency tones have a substantial disturbing effect on the user. The measurement of the level of interfering tones should be performed in conjunction with circuit noise tests.

40.3.3.3 Apparatus. The measurement of circuit noise requires a noise measuring set consisting of a true rms voltmeter with prescribed attenuator. Single tone interference is best measured with a frequency selective voltmeter (FSVM).

40.3.3.4 Test Method. Briefly the measurement technique calls for the use of a noise measuring set to measure the total noise level of a voice frequency circuit and a FSVM to measure single tone interference levels when the sending end is terminated in the circuit input impedance. The test configuration is shown in Figure D-10 and the test is described broadly as follows:

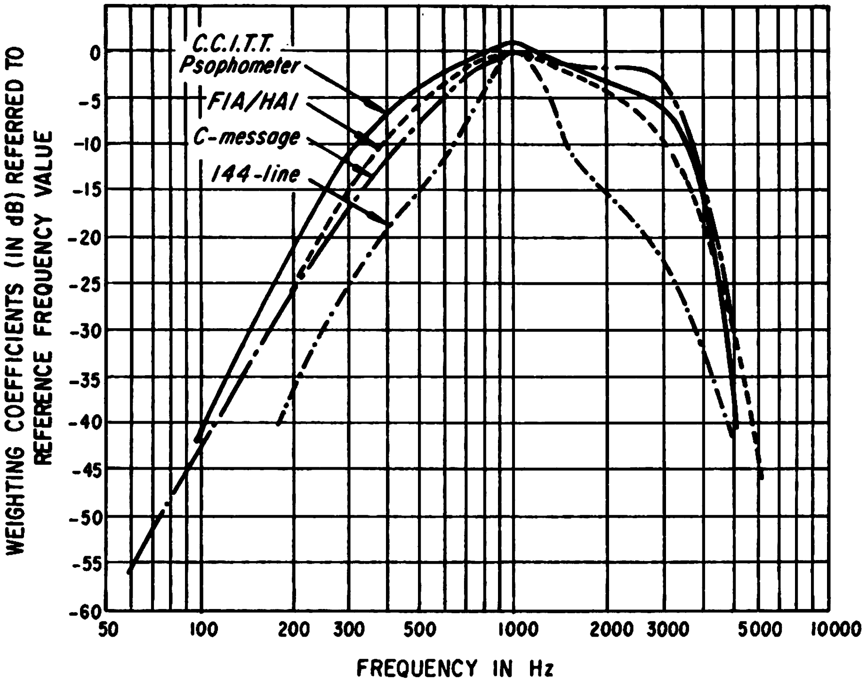


Figure D-9

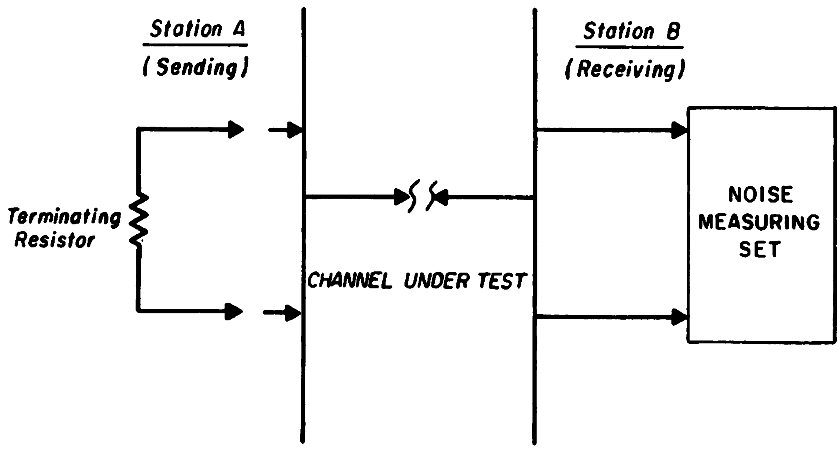


Figure D-10. Basic or Random Noise Test Arrangement

a. Perform an accuracy check on the noise measuring set. This may be done using an audio frequency oscillator with a calibrated output level indicator. The noise measuring set is connected to the oscillator and, for a given weighting scheme, the readings from the noise measuring set are compared with the calibrated oscillator output levels. The following is an example of this technique used with C-message weighting:

   Set the signal generator frequency to 1000 Hz and the output level to -60 dBm. The level measuring set should read 30 dBrnc. Change the signal generator output level to -10 dBm. The level measuring set should read 80 dBrnc. If the dBrnc readings differ from these values by 1 dB or more, the level calibration of both instruments should be checked.

b. Ensure that the circuit under test is in its normal operating condition and that the system is carrying traffic (i.e., loaded noise test).

c. Terminate the transmit end of the circuit with an impedance equal to the input impedance of the circuit (generally 600 ohms).

d. Ensure that the input impedance of the noise measuring set matches that of the circuit under test and the desired weighting network.

e. Connect the noise measuring set to the receiving end of the circuit as shown in Figure D-10.

f. Record the reading of the noise measuring set. The noise measurement so obtained may be referenced to the Transmission Level Point as follows:

   (Noise referred to zero level) = (Measured Noise) - TLP

   <u>Example</u>:

   If a noise power (using C-message weighting) of 35 dBrnc is measured at a TLP of -10 dBm, it would be expressed as:

   $$35 - (-10) = 35 + 10 = 45 \text{ dBrnc0}$$

   NOTE: Table D-1 may be used to convert measurements made using a given weighting network to the units of a different weighting scheme.

g. Single Tone Interference is detected by either terminating the circuit with a headset or by observing the "spikes" in the noise spectrum displayed on a spectrum analyzer CRT display.

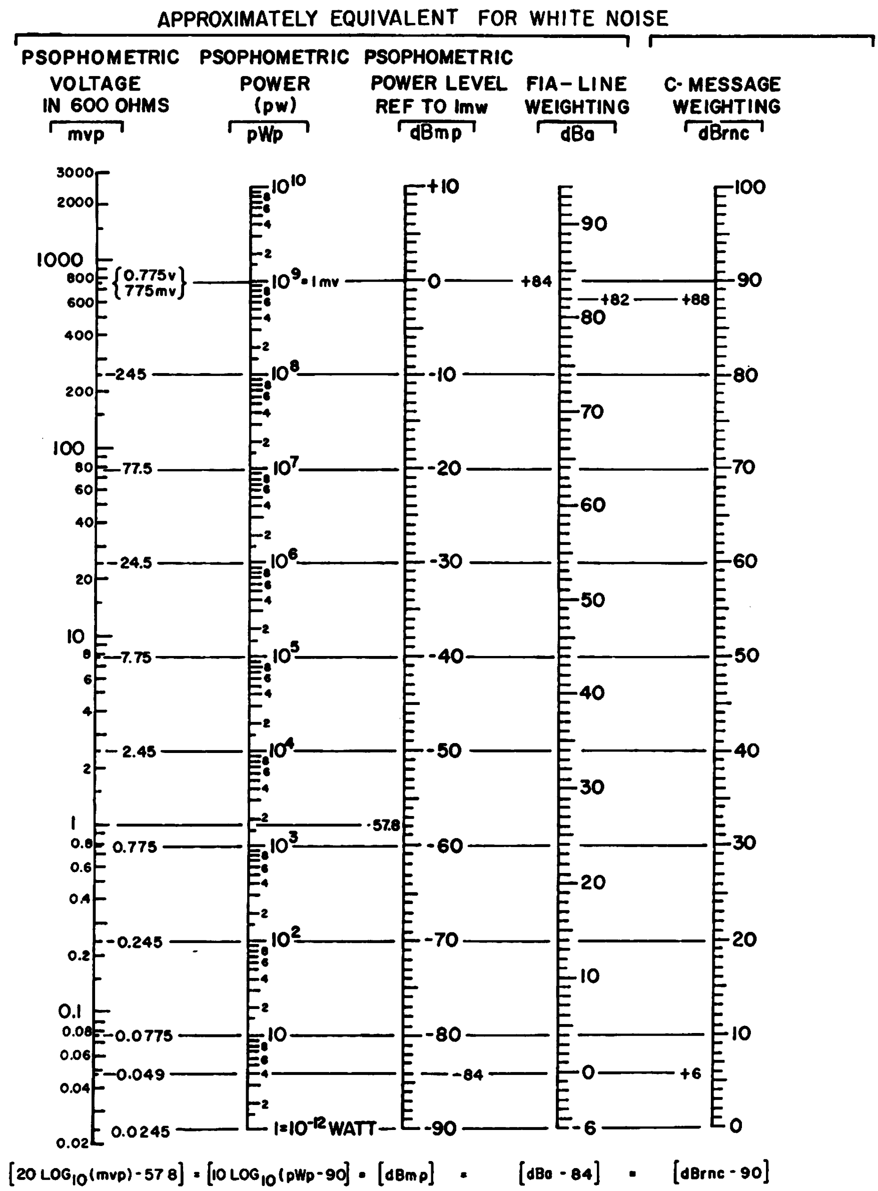
h. Measure single tone interference by maximizing the scale indication (dBm) of the FSVM at the disturbing frequency(s).

i. Convert the value measured in dBm to dBrnc as follows:

   $$\text{dBrn} = 90 + \text{dBm}$$

   then use the "C-message" curve in Figure D-9 to convert dBrn to dBrnc.

Table D-1. Conversion Chart: Psophometric, F1A and C-Message Noise Units



BASIS FOR CHART CONSTRUCTION

A. dBm, PSOPH WTD (dBmp) = dba - 84

B. ONE mw UNWEIGHTED 3kHz WHITE NOISE READS +82 dBa = +88.5 dBrnc (C-MESSAGE), ROUNDED OFF TO: +88.0 dBrnc

C. ONE mw INTO 600 OHMS = 775 MILLIVOLTS = 0 dBm = 10^9 PICOWATTS

READINGS OF NOISE MEASURING SETS WHEN CALIBRATED ON ONE MILLIWATT OF TEST TONE
- FIA-LINE: AT 1000 Hz READS +85 dBa
- C-MESSAGE: AT 1000 Hz READS +90 dBrn
- PSOPHOMETER (1951), 800 Hz READS 0 dBm

Example:

FSVM reading = -55 dBm at 600 Hz

dBrn = 90 + (-55) = 35 dBrn

dBrnc = 35 dBrn - 5 dB (600 Hz) = 30 dBrnc

40.3.4 Impulse Noise.

40.3.4.1 Applicability. This test provides a generalized method for measuring impulse noise on voice frequency circuits.

40.3.4.2 Principles of Test. Impulse noise is comprised of short spikes of energy with an approximately flat frequency spectrum over the desired bandwidth. The impulse noise arises from switching transients in central offices and from other external electrical disturbances which are inductively coupled to the circuit. Digital signals such as data and PCM are affected differently by noise than are analog voice signals. Thermal noise which presents an annoying hiss to the human ear has no detrimental effect on digital signals unless the amplitude of the noise approaches the amplitude of the signals. Impulse noise which manifests itself as audible clicks or pops on voice circuits causes almost certain errors on digital circuits because of the high impulse amplitudes.

Impulse counters have been designed to measure impulse noise and consist of a weighting network, a rectifier, a threshold detector, and a counter of events above threshold. The measuring sets include a timer which can be set to automatically count the events above a certain threshold for a fixed time interval. The time interval and the threshold level can usually be adjusted.

A choice of a terminating impedance (600 ohms) or a high bridging impedance is also a common feature.

Simultaneous measurements using several impulse counters can be used at different thresholds to obtain information about the distribution of the magnitudes of the impulses. Some impulse counters have this multiple feature as part of the equipment capabilities.

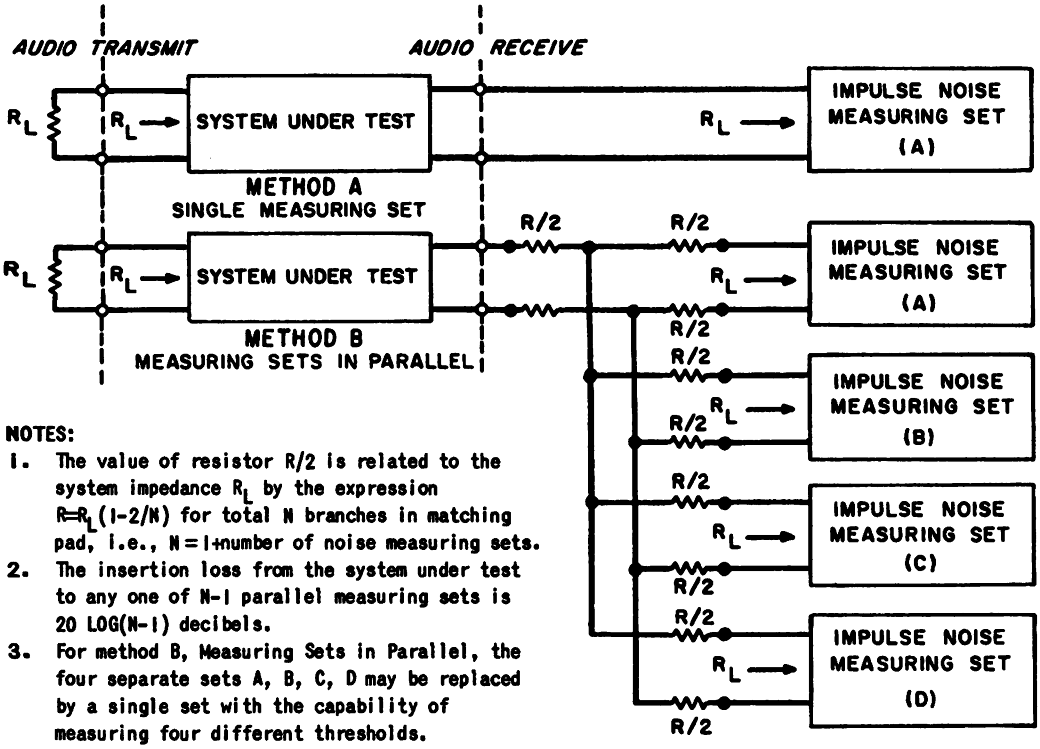
40.3.4.3 Apparatus.

Impulse Noise Measuring Set (quantity as required by number of thresholds to be measured).

Terminating Resistors (as required).

40.3.4.4 Test Method. In general, the occurrence rate of noise impulses is a function of system activity and hence, for system evaluation purposes, measurements of impulse noise should normally be made during periods of peak system activity. The test method outlined below is applicable either for the use of one Noise Measuring Set to obtain a cumulative count of impulses above threshold or for the use of several sets to measure an impulse amplitude distribution. Figure D-11 shows both test configurations; the general test method, which in each instance is essentially the same, is described as follows:

a. Check the calibration of the Impulse Noise Measuring Sets to be used.



NOTES:

1. The value of resistor R/2 is related to the system impedance R_L by the expression $R=R_L(1-2/N)$ for total N branches in matching pad, i.e., N = 1+number of noise measuring sets.
2. The insertion loss from the system under test to any one of N-1 parallel measuring sets is 20 LOG(N-1) decibels.
3. For method B, Measuring Sets in Parallel, the four separate sets A, B, C, D may be replaced by a single set with the capability of measuring four different thresholds.

Figure D-11. Measurement of Impulse Noise in a Voice Channel

b. Terminate the transmit end of the voice frequency circuit under test with a resistor equal to the input resistance of the circuit.

c. Set the input impedance controls of the Impulse Noise Measuring Set to the terminating mode and to the impedance which matches that of the channel under test. If an impulse noise amplitude distribution is being measured, several Impulse Noise Measuring Sets should be connected in parallel via splitting pads, as shown in Figure D-11.

d. If the Impulse Noise Measuring Set being used has the capability for a number of different frequency weightings, adjust the weighting switch to the type desired for the current test.

e. Set the timer to the desired count duration period.

f. At the end of the count period, record the total pulse count indicated on each Impulse Noise Measuring Set.

If an amplitude distribution is being determined, record the total pulse count displayed on each Impulse Noise Measuring Set and plot a characteristic in terms of percentage of total noise impulses exceeding a given level above threshold against peak amplitude relative to threshold level.

> NOTE: If the incidence rate of the pulses to be counted exceeds the maximum counting rate of the Impulse Noise Measuring Sets, then occasional noise pulses will be missed by these instruments. In general, dependent upon its maximum counting rate, the manufacturer of the instrument will supply a correction factor to apply to the total count registered by the instrument when this total exceeds a given quantity. This correction factor should be incorporated when necessary.

40.3.5 Harmonic Distortion.

40.3.5.1 Applicability. In this paragraph, methods are described for measuring single-harmonic distortion and total-harmonic distortion. These methods permit the measurement of harmonic distortion of audio frequency signals sent over a physical circuit or multiplexed transmission system. They also enable any individual part of the audio system (e.g., channel amplifier) to be measured, provided that the input and output frequencies are in the same audio range.

Looped measurements over a part of an FDM system can be made by looping the appropriate group at the GDF or SDF.

40.3.5.2 Principles of Test. The harmonic distortion in a telephone channel arising from the non-linearity of its gain characteristic is predominantly of the second order category, which will vary approximately as the square of the test tone level. The signal source used for testing obviously must have very low harmonic distortion if accurate results are to be expected.

If a pure single-frequency test signal from an oscillator is applied at the desired level to the system under test, any harmonics generated within the system under test due to its non-linearity will appear at its output together with the test signal (which is the fundamental or "first harmonic"). The single-harmonic distortion (for any single harmonic) is the ratio of the power at the fundamental frequency to the power at the harmonic frequency selected, expressed in dB. The total-harmonic distortion is the ratio of the power at the fundamental frequency to the sum of the powers at all the harmonic frequencies (usually only the second and third harmonics) expressed in dB.

40.3.5.3 Apparatus.

	Reference
Oscillator (low distortion)	A
Variable Attenuator	B
Level Measuring Set (Bridging)	C
Level Measuring Set (Terminating)	D
Distortion Measuring Set (Bridging)	E
Selective Level Measuring Set (Bridging)	G
Terminating Resistors (as required)	-

40.3.5.4 Test Methods.

a. General

This discussion applies to all the methods described in subparagraphs b., c., and d. Figures D-12 and D-13 are alike except for the measuring sets E and G. The impedance R_L is normally 600 ohms. If otherwise, suitable impedance matching transformers should be used. Oscillator A supplies the test signal to the attenuator through a pair of resistors (e.g., 300 ohms each) to limit current and to maintain the correct circuit impedance when very low or zero settings of the attenuator are used. With higher attenuator settings, these resistors are not necessary but it is good practice to use them. Allowance is made for these resistors when adjusting the amplitude of the test signal. The following alternative methods can be used at the sending station.

(1) With level measuring set C, which has an input impedance high compared with R_L, the oscillator output is adjusted to read +6 dBm on C. This results in 0 dBm at the attenuator input. (The oscillator faces an impedance of $2R_L$, so that the oscillator voltage has to be double that required to produce 0 dBm across 600 ohms. This will read on C as +6 dBm.)

(2) With level measuring set D, which has an input impedance equal to R_L, the oscillator output is adjusted to read 0 dBm at D. This results in 0 dBm at the attenuator input. (Because of the symmetry of the two right hand branches of the circuit, the level at the attenuator input is the same as that measured at D.)

Where the system under test consists of transmitting and receiving equipment, it should be looped through suitable attenuator and amplifier equipment as required to allow correct system line-up.

b. Single Harmonic Distortion (Figure D-12)

The selective level measuring set G is assumed to have an input impedance large compared with R_L. If its input impedance is equal to R_L, the termination resistor marked R_L should be omitted. The selective level measuring set is tuned successively to the frequencies of the fundamental (i.e., the test signal normally 1000 Hz) and of the second, third, etc. harmonic (normally 2000 and 3000 Hz). The ratio, in dB, of the power of the fundamental to the power of a particular harmonic is the single-harmonic distortion for that harmonic.

c. Total Harmonic Distortion (Figure D-12)

The method is the same as for single harmonic distortion, except that the powers of the 2nd, 3rd, etc., harmonics are added on a power-additive basis before taking the ratio of fundamental to harmonic powers.

d. Total Harmonic Distortion (Figure D-13)

The distortion measuring set is assumed to have an input impedance large compared with R_L. If its input impedance is equal to R_L, the termination resistor marked R_L should be omitted. With the oscillator set to provide a test signal (normally 1000 Hz), the reading of the distortion measuring set in its broadband condition is compared with its reading with the 1000 Hz rejection filter cut in. This gives the ratio of the total wave

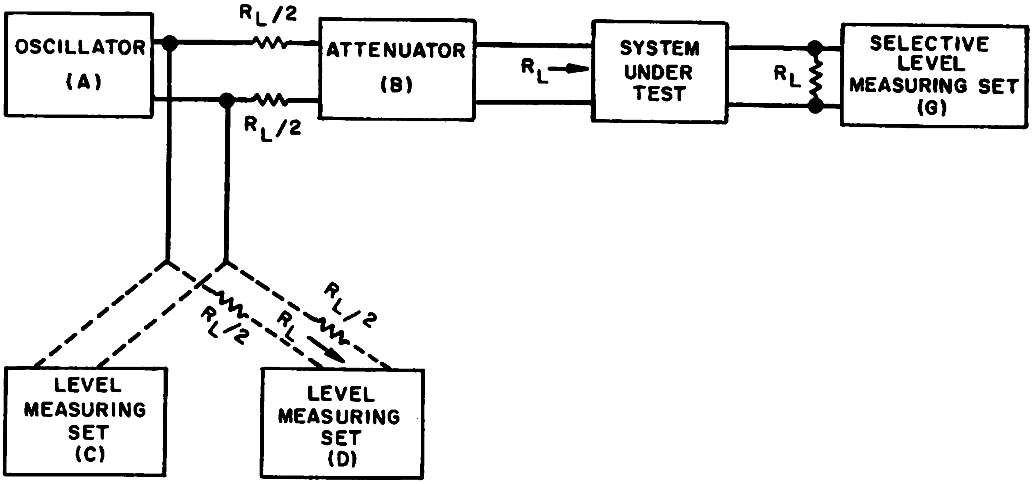


Figure D-12. Measurement of Single and Total Harmonic Distortion

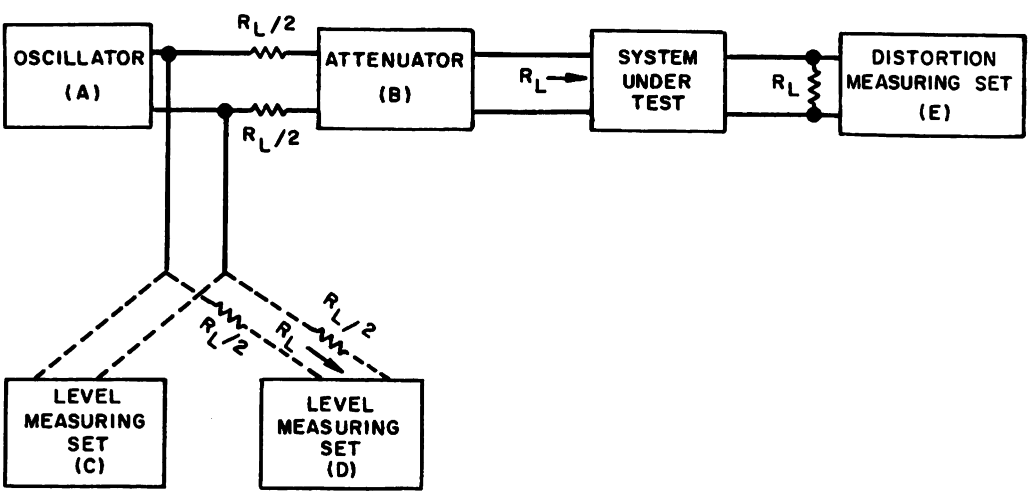


Figure D-13. Measurement of Total Harmonic Distortion (fundamental plus all harmonics) to the sum of the harmonics. It may be expressed in dB or as a percentage. To convert the above ratio to a ratio of the fundamental to the sum of the harmonics (as total harmonic distortion is defined in these military standards), the following method can be used. If the ratio of the fundamental plus the sum of the harmonics to the sum of the harmonics is expressed in dB, convert it to a percentage (D_1) using Figure D-14. Then proceed as follows:

$$D_2 = \frac{D_1}{\left[1 - \left(\frac{D_1}{100}\right)^2\right]^{1/2}}$$

where

D_1 = percentage distortion determined from the measurement of

$$\frac{\text{Fundamental plus all harmonics}}{\text{All harmonics}}$$

and

D_2 = percentage distortion determined from:

$$\frac{\text{Fundamental}}{\text{All harmonics}}$$

Note 1 - The decibel expression for harmonic distortion may be obtained by calculating $10 \log_{10} (100/D)^2$ or by using Figure D-14.

Note 2 - D_1 and D_2 are approximately equivalent for values of $D_1 \leq 10\%$.

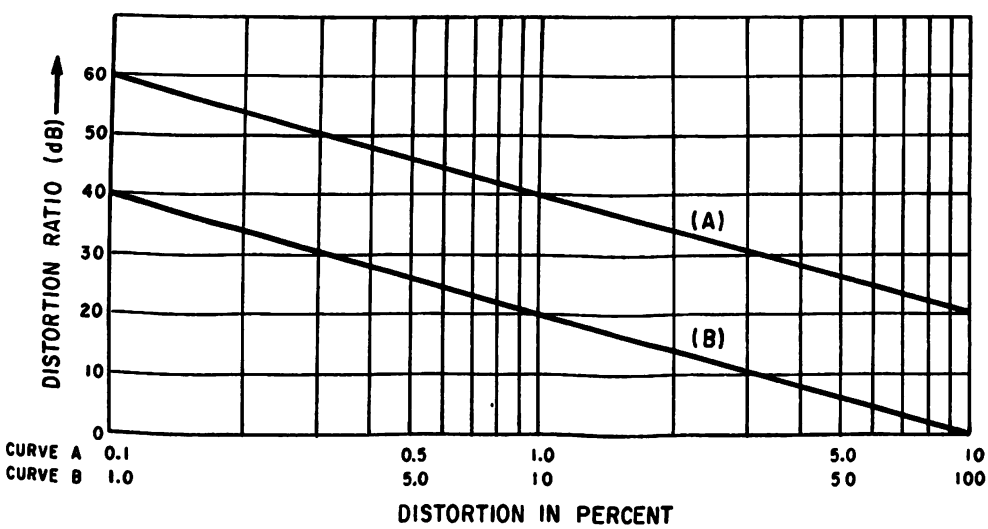


Figure D-14. Relationship Between Distortion in Percent and dB

40.3.6 Frequency Translation.

40.3.6.1 Applicability. This test method is applicable only to channels derived by frequency division multiplex methods. The purpose of the test is to measure the frequency translation of a 1 kHz test tone transmitted through a voice frequency channel in one direction. Frequency translation is defined as a change in the frequency received compared with the frequency transmitted. This effect is due to lack of perfect synchronization between the master oscillators of the FDM equipment from one end of the channel to the other, including any intermediate frequency translations. No method is described for measuring frequency translation on looped FDM equipments, since if both the transmitting and receiving multiplex equipments are supplied by the same master oscillator, and the two directions of any given channel are used in the measurement, the transmitting frequency displacement is exactly equal and opposite to the receiving frequency displacement, so that they will cancel to show zero translation overall.

40.3.6.2 Principles of Test. The method is simple and direct and its accuracy depends on the stability of the test signal oscillator, and the accuracy of the two frequency counters. A frequency counter is basically a device for counting the number of cycles occurring during a definite time duration, and for indicating the result as a numerical presentation, e.g., 1000.1 Hz. Obviously the accuracy of the measurement depends on the accuracy and stability of the time interval device. It is found that the stability and accuracy of available frequency counters is adequate for the purpose. The test consists simply of applying a 1000-Hz test signal from a stable oscillator, to the circuit, measuring the frequency of the tone simultaneously by two frequency counters at both ends of the circuit. The magnitude and sense of any difference is simply obtained by comparing the readings.

40.3.6.3 Apparatus.

Test Unit	Reference in Figure D-15
Audio frequency oscillator (stable frequency)	A
Frequency counter	B,C
Level measuring set	D

40.3.6.4 Test Method. Set the frequency of the stable frequency oscillator A to 1000 Hz, and adjust the output level to -10 dBm0. The input signal frequency is monitored on frequency counter B. At the far end of the circuit, the channel is correctly terminated by R_L or by a terminating condition of the level measuring set, which is used mainly to determine that a test signal is being received. The output frequency is monitored by frequency counter C. The test is made by the two operators at each end of the system making a simultaneous readings of the frequency. The frequency translation is the difference between the readings of B and C (see Figure D-15).

40.3.7 Phase Jitter.

40.3.7.1 Applicability. This test method is applicable to voice frequency circuits and channels of multiplex equipment, FDM and TDM/PCM.

40.3.7.2 Principle of Test. The purpose of this test is to measure and evaluate rapid incremental changes in phase of a single frequency test signal transmitted

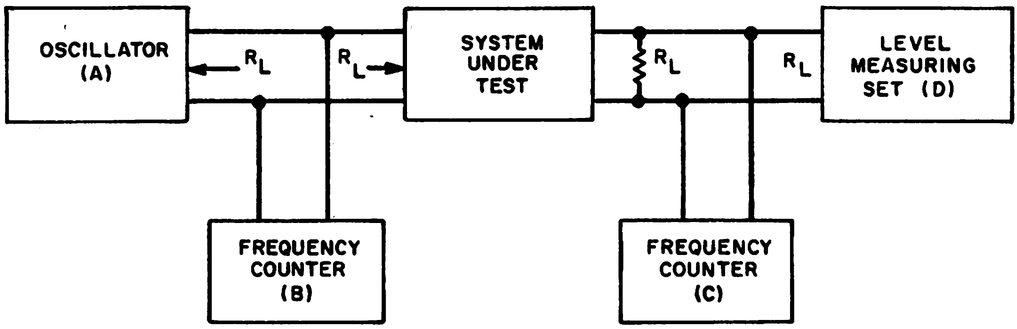


Figure D-15. Overall Change in Audio Frequency, End to End of a Channel

through a voice frequency channel. Phase jitter results from phase modulation (or variation) of the input signal as it is processed through a communications system. As the result of phase jitter, the received signal will consist of a finite frequency signal which also exhibits rapid incremental changes in phase angle. Large instantaneous changes in phase of a single frequency signal transmitted through a voice channel are defined as phase hits, and will not be recorded as part of this test. Data transmission at 1200 bits per second and higher is particularly sensitive to phase jitter, which ranks in importance with impulse noise, signal-to-noise ratio, insertion loss versus frequency characteristic, and envelope delay distortion as a cause of channel errors. Formerly, measurement of phase jitter involved use of an oscilloscope and considerable care was required in the setting up and use of the equipment. Phase jitter meters are now available, which allow these measurements to be made more simply. A typical phase jitter meter measures peak-to-peak phase jitter on 3 degree and 30 degree full scale ranges, and input levels on 0 dBm and -20 dBm meter ranges, and can be used with channels derived by either FDM or TDM/PCM multiplex equipments. Test signals from an audio oscillator can be used, and the meter will accept signals in the vicinity of 1000 or 1020 hertz, over a very limited range. The jitter of the test oscillator should be checked. It should be under one degree, peak-to-peak.

40.3.7.3 Apparatus.

Test Unit	Reference in Figure D-16
Audio Frequency Oscillator	A
Phase Jitter Meter	B

40.3.7.4 Test Method. The test oscillator is connected to the sending end of the circuit, and adjusted to a level below standard test tone level, for instance -10 or -13 dBm0, and to a frequency of 1000 Hz. (For PCM systems, this should be changed to 1020 Hz to avoid submultiples of the sampling frequency of the PCM system.) At the receiving end, the phase jitter meter is connected to the output of the circuit under test, and measurement made following instructions provided in the Technical Order or the manufacturer's handbook (see Figure D-16).

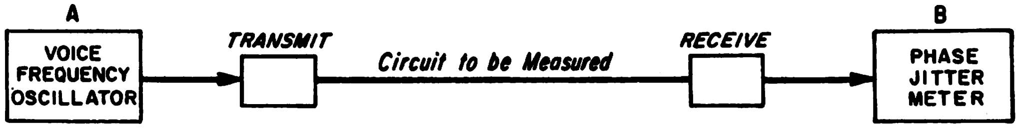


Figure D-16

40.3.8 Crosstalk.

40.3.8.1 Applicability. These measurements are applicable to all voice-frequency bandwidth channels and circuits.

40.3.8.2 Principles of Test. The basic testing arrangement is shown in Figure D-17. The disturbing signal is applied to the disturbing channel, at a level which generally should not exceed 0 dBm0 (1 mW at a zero relative level point), and the crosstalk level on the disturbed channel is then measured. Near-end crosstalk is measured at the end of the disturbed channel nearest to the source of the disturbing signal (i.e., in Figure D-17 near-end crosstalk would be that measured by M1). Far-end crosstalk is measured at the end of the disturbed channel remote from the source of the disturbance (i.e., in Figure D-17 far-end crosstalk would be that measured by M2).

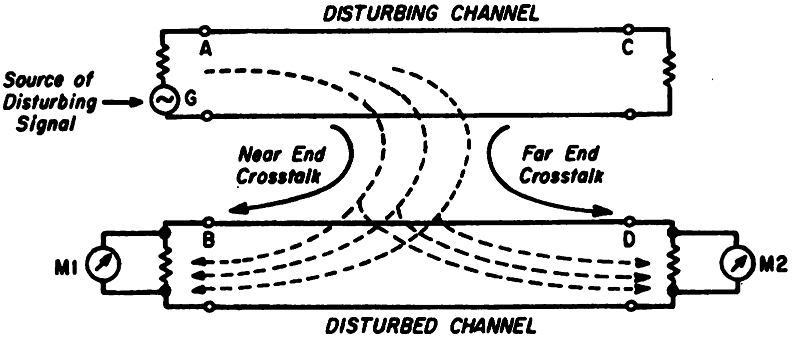


Figure D-17

The disturbing and disturbed channels may comprise the two directions of transmission of the same four-wire circuit in which case it is the near-end crosstalk (go-to-return crosstalk) which should be measured. When the disturbing and disturbed channels are in different circuits the crosstalk is known as the between-circuit crosstalk.

If the two channels are for opposite directions of transmission near-end crosstalk is important whereas when the channels are for the same direction of transmission it is the far-end crosstalk which must be considered.

Crosstalk measurements are expressed in two different ways, as follows:

a. Crosstalk Attenuation

This is the ratio expressed in transmission units of the power delivered by a source (G in Figure D-17) to a disturbing channel to the power received at the point of measurement on the disturbed channel, both channels being correctly terminated at both ends. Measurements of crosstalk attenuation are mainly used for direct measurement of crosstalk between cable pairs.

b. Signal/Crosstalk Ratio

It is generally more meaningful, when dealing with complete transmission systems, to express crosstalk in terms of a signal/crosstalk ratio which takes into account any difference in the nominal relative levels of the measuring points A, B, and D. This is achieved by expressing both of the measured levels in dBm0.

40.3.8.3 Apparatus. The choice of apparatus depends on the test method chosen (see paragraph 40.3.8.4).

Single frequency near-end and far-end crosstalk measurements can be made using the following:

- Channel Terminating Resistors
- Voice Frequency Oscillator
- Level Measuring Set

If the noise spectrum approach is selected, the oscillator and level measuring set should be replaced with a noise generator and a noise measuring set respectively. Shaping and weighting filters can also be used in this type of test.

A noise measuring set and a spectrum analyzer can occasionally be used to distinguish crosstalk levels from noise levels or pickup.

40.3.8.4 Test Methods. The following alternative methods of measurement are available.

a. Measurement of the crosstalk at a single frequency, generally the reference frequency 1000 Hz.

b. Measurements made using a uniform spectrum random noise or closely spaced harmonic series shaped in accordance with a speech power density curve. The measurements are made in this case by means of a noise measuring set.

c. Voice/ear subjective tests, in which speech is used as the disturbing source and the crosstalk is measured by listening and comparing the received level with a reference source the level of which can be adjusted by some form of calibrating network.

The first method is the preferred approach for routine measurements.

The apparatus is arranged as in Figure D-17 and level measurements are made in dBm0.

Precaution is necessary in shielding and grounding arrangements to avoid stray coupling. The operating procedure should permit positive distinction between crosstalk and other disturbances such as circuit noise and stray pickup.

40.3.9 Impedance.

40.3.9.1 Applicability. In testing transmission systems, input and output impedance are measured at important system interfaces. In addition measurements may be required on individual items of equipment prior to installation, i.e., either in the factory or in the field.

The various sections of these standards specify these impedances generally as a return loss against a nominal value. The preferred method of measurement in these cases is a direct measurement of return loss as described in paragraph 40.3.10.

The standard bridge method of impedance measurement described herein may be used as an alternative to the return loss measurement. Should sections that specify impedance directly be added to these standards, it would in these cases be the preferred method.

Direct measurements of impedance can be used to obtain return loss as described under paragraph 40.3.10. Impedance measurements at radio frequencies are not included here.

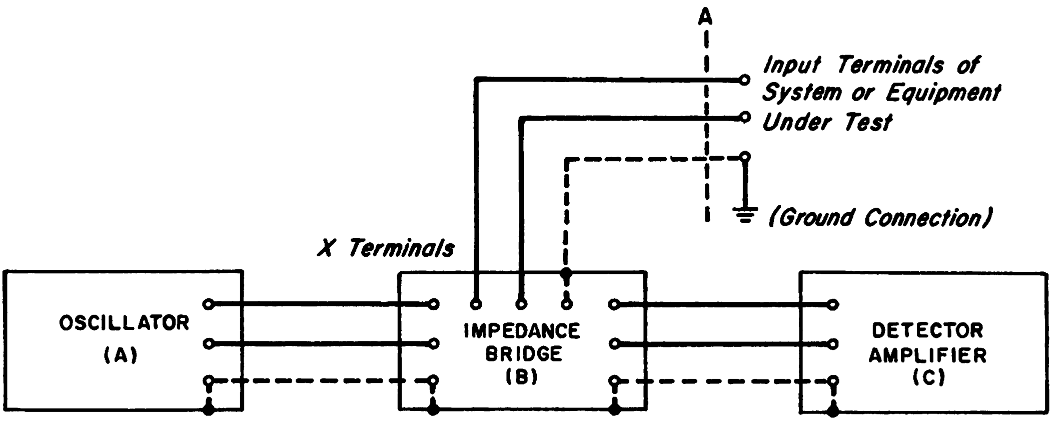
40.3.9.2 Principles of Test. This method uses a standard alternating-current bridge to measure the impedances. Normally, the impedance of transmission system inputs and outputs should be measured at the test tone level used at that point of the system. For instance, the input impedance of a standard voice channel modulator should be measured at a test tone level of -16 dBm. This is assured by measuring the power level across the impedance to be measured. Test methods are described for two kinds of AC bridges.

40.3.9.3 Apparatus.

Test Unit	Reference
Oscillator	A
Impedance Bridge	B
Detector Amplifier	C
Level Measuring Set	-
Zero Balance Resistors (75,135,150,600 or 900 ohms, as required)	-

40.3.9.4 Test Method.

a. Connect the test units together as shown in Figure D-18. The test lead from the X terminals of Impedance Bridge B connects with the system interface or equipment under test (point A).



Notes:

1. Equipment used will depend on specific test.
2. Test leads either screened twisted pair or coaxial pair (see text).

Figure D-18. Measurement of Input or Output Impedance of a System or Equipment

In general bridge measurements, the test lead would be on open circuit at point A while the bridge zero balance was carried out. However, the system impedances under test range from 75 to 900 ohms (low impedance) and for greatest accuracy a different zero balance procedure should be carried out as specified in step b.

b. Choose resistors 75, 135, 150, 600 or 900 ohms appropriate to the particular test, of the same order (within ±1%) as the nominal value of the system or equipment point under test.

Carry out the bridge zero balance with the test lead connected to the X terminals of Impedance Bridge B terminated in the appropriate zero balance resistor at its other end (point A).

Remove the zero balance resistor and connect the test lead to the system or equipment point under test.

c. Set the Impedance Bridge B decades to a rough balance (this is known) and using the Level Measuring Set in its high impedance position adjust Oscillator A output so that the correct test level is applied to the system or equipment point under test. In the case of low level points the sensitivity may be increased by 10 to 20 dB above the test tone level for one channel but the effect of this on the measurement should be checked.

The Level Measuring Set is not shown in Figure D-18 but is listed under subparagraph 40.3.9.3. It should be disconnected from the circuit when a measurement is made.

If the Level Measuring Set used is a VTVM, the tabulation below will serve as a guide in setting the test level.

Impedance of Test Point →	75Ω	135Ω	150Ω	600Ω	900Ω
Oscillator Output Point ↓	VTVM (mV)	VTVM (mV)	VTVM (mV)	VTVM (mV)	VTVM (mV)
0 dBm	274	368	387	775	950
-10 dBm	87	116	122	245	300
-20 dBm	27.4	37	38.7	77.5	95.0
-30 dBm	8.7	11.6	12.2	24.5	30.0

d. Measure the impedance of the system or equipment point under test in accordance with the handbook instructions for the particular bridge in use.

Figure D-19 is a schematic illustrating the basic structure of a parallel RC bridge. The schematic illustrates the position of the standard resistance (R) and capacitance (C) decades for the measurement of either a capacitive or inductive minimum reading on the detector and is given in terms of parallel R and C components. The zero balance components, switches, and range switches are not shown in the schematic. The arrangement of these will differ for different makes of bridges. Both balanced and unbalanced impedance are involved in these measurements. Follow specific directions on the particular make of bridge employed to assure accuracy in cases where balance impedances must be measured with the unbalanced bridge.

The impedance modulus and angle are given by the formula:

$$Z \angle \varphi = \frac{R}{\sqrt{1 + (\omega RC)^2}} \angle -\tan^{-1} \omega RC^{*}$$

where

R = the value of parallel resistance as read from the bridge

C = the value of capacitance as read from the bridge

40.3.10 <u>Return Loss</u>.

40.3.10.1 <u>Applicability</u>. This test is used to measure the impedance mismatch characteristics of voice bandwidth junction points or end instruments.

40.3.10.2 <u>Principles of Test</u>. A transmission line or interface equipment is normally terminated in its characteristic impedance. A mismatch in impedance produces a discontinuity to the normal propagation of the voltage and current

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*If the impedance is inductive, the bridge must be configured as in Figure D-19 (B) and the angle of the impedance will be $+\tan^{-1} \omega RC$.

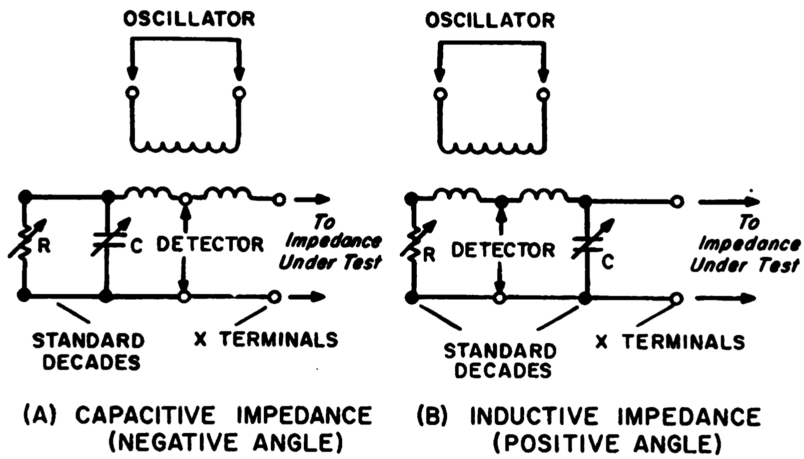

Figure D-19. Schematic Illustrating Measurement of Impedance Using Parallel RC Bridge

waves and gives rise to the reflection of a portion of the incident waves. The reflected waves may result in conditions such as singing, distortion and echo. Reflected waves on a communication channel appear as echos to the telephone user. The magnitude of echo signals is determined by the overall circuit loss undergone by a signal travelling through the transmission facilities to the distant termination and/or intermediate points of impedance mismatch and returning to the signal source.

Return loss is the ratio of the incident to reflected power (expressed in dB) at a point of discontinuity caused by an impedance mismatch. Return loss is a measure of the extent to which impedances of connected equipment are matched. Figure D-20 graphically describes the relationship of return loss as a measure of impedance mismatch with a 600 ohm reference load. Return loss in terms of the two different absolute impedance values at an interface point is expressed as follows:

$$\text{Return loss} = 20 \log_{10} \left| \frac{Z_2 + Z_1}{Z_2 - Z_1} \right| \text{ dB}$$

where Z_1 and Z_2 are the two impedances

40.3.10.3 Apparatus.

Test Unit	Figure D-21 Reference
Signal Generator (Oscillator)	(A)
Frequency Counter	(F)
Return Loss Bridge (of suitable impedance)	(C)
Voltmeter (level measuring set)	(B), (D)
Matching/Isolation Transformer	(As required)

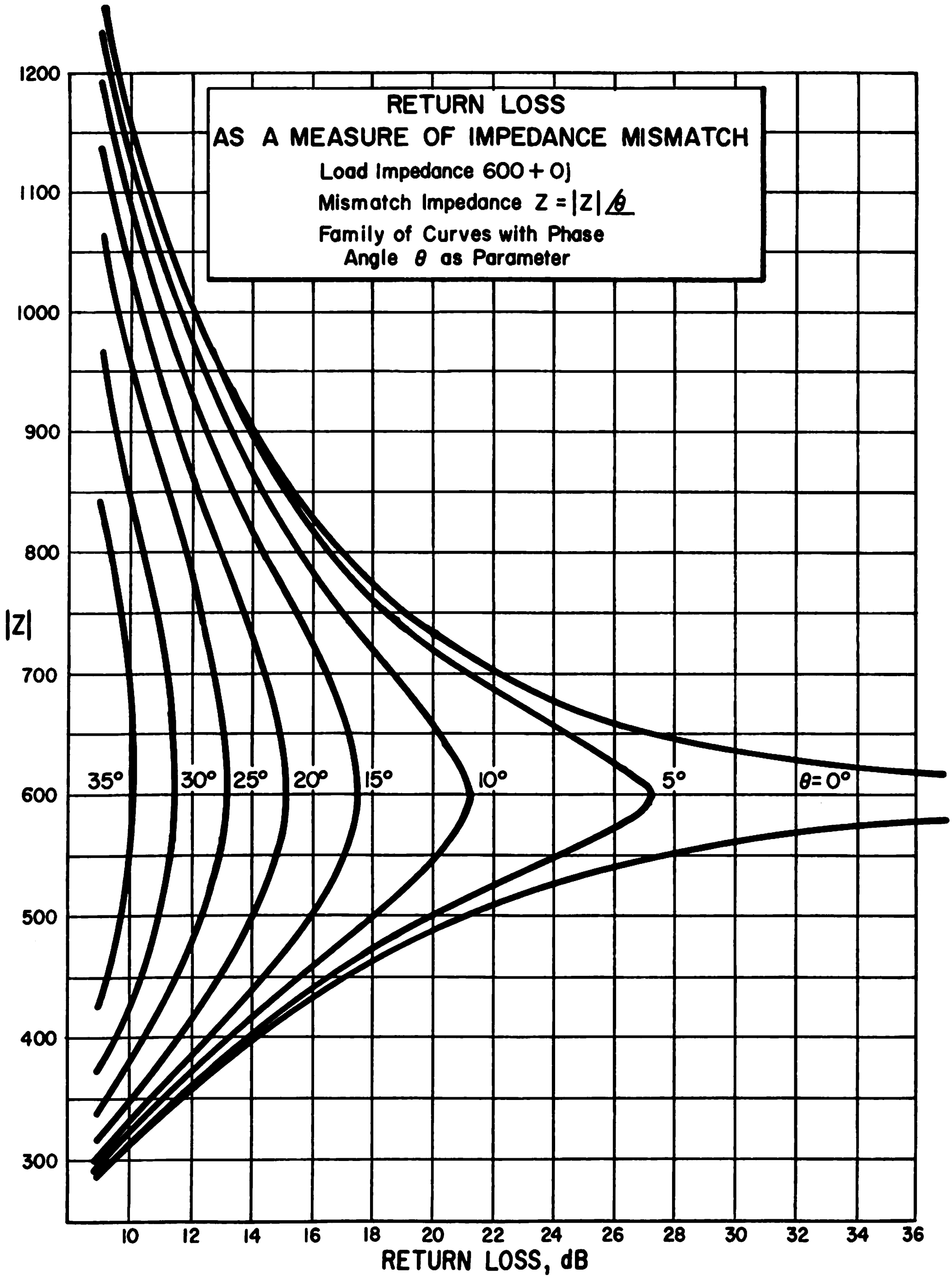
RETURN LOSS
AS A MEASURE OF IMPEDANCE MISMATCH
Load Impedance 600 + 0j
Mismatch Impedance Z = |Z| /θ
Family of Curves with Phase
Angle θ as Parameter
1200
1100
1000
900
800
|Z|
700
600
500
400
300
35°
30°
25°
20°
15°
10°
5°
θ= 0°
10
12
14
16
18
20
22
24
26
28
30
32
34
36
RETURN LOSS, dB

Figure D-20

40.3.10.4 Test Method (see Figure D-21). Measurements of return loss of an impedance compared with a stated resistance can be made with a return loss bridge. The return loss bridge is essentially a hybrid transformer made into a convenient piece of test apparatus. See Figure D-21 which shows one type of hybrid coil used in a return loss measuring circuit. Currents from the oscillator (A) flow through one winding of the hybrid transformer (C). The two parts of the second winding are carefully matched so that the same potential is induced in each. The left part causes current to flow in resistance R. The right part causes current to flow in the X branch. If an impedance equal to R is connected through switch (E), the currents in the left and right branches will be equal, so that no potential exists across R/2. This will be indicated by a zero voltage at the level measuring set (B), representing a perfect balance, which is an infinite return loss.

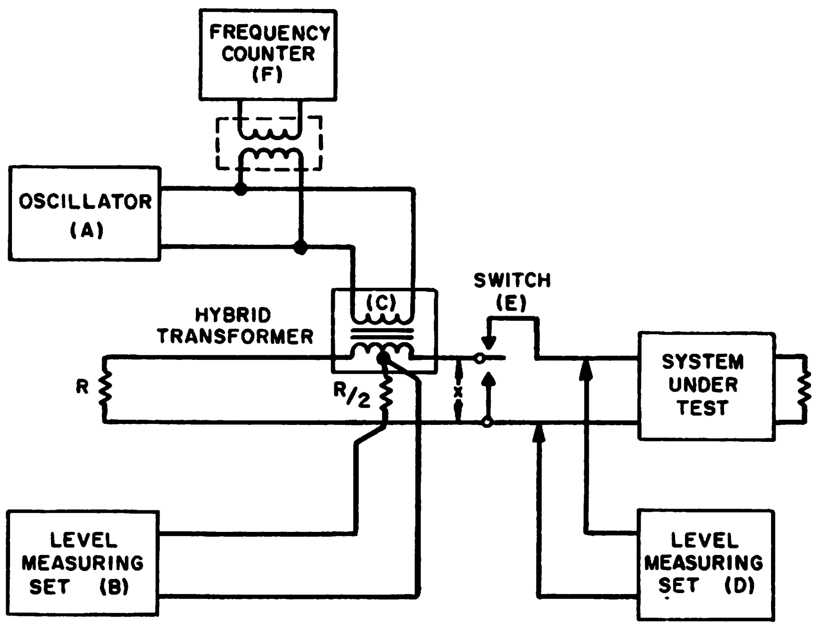

Figure D-21. Principles of Return Loss Bridge Test Arrangement

However, the balance is rarely perfect, and B will indicate some level, expressed in dBm. If the switch (E) is now moved down to the short circuited connection, the reading of (B) will be substantially larger. The difference between the short circuit reading and the reading when the system to be tested is connected is the return loss in dB. The second level measuring set D is used to set the test tone level into the system under test at the normal value (e.g. -16 dBm for standard multiplex modulator inputs). Resistance R is generally provided by the circuit of the bridge. A frequency counter can be used to check the exact frequency of the oscillator setting.

40.3.11 Longitudinal Balance.

40.3.11.1 Applicability. This test measurement is applicable to balanced voice frequency circuits and the balanced end instruments which terminate these circuits.

40.3.11.2 Principles of Test. Because a transmission patch has to operate in the real world, it can never be entirely isolated from the electrical influences that exist there. The line may be exposed in different ways. A power line may parallel it. It may be in a cable or wire line with similar circuits paralleling it. It passes through central offices where it may pick up substantial transients from switching equipment. It is necessary to consider such sources of interference. In the early days of telephony, ground-return circuits were used, but with the rise of electric power lines, which tended to follow the same routes, and the change from open wire to cable facilities, balanced pairs became standard. The great advantage of a balanced pair is that interfering currents induced equally in both wires balance out. By illustration, Figure D-22 shows a balanced circuit between the two line transformers. The signal voltage, E_G, causes a line current, I_{SIG}, to flow through the two wires of the pair. The current flows in opposite directions on the two wires, and thus passes through the line winding of the right-hand transformer, causing current to flow through the load Z_L. The generators in series with the two wires, E_1 and E_2, represent an interference which is induced by an external source. The currents I_1 and I_2 flow in the same direction and, if they are equal, these currents will cancel in the balanced windings of the transformer, so that no current flows in Z_L. The term "metallic circuit currents" is applied to the currents which flow in opposite directions in the wires of the pair, while those that flow in the same direction are called "longitudinal currents". If there is any difference between the longitudinal currents in the line winding of the transformer, they will not completely balance out, causing unwanted currents to flow in the load Z_L. This unbalance may be due to a higher resistance in one wire than in the other, such as a bad splice. Or, if the two windings of the transformer are not perfectly balanced, the effects of the two parts of the longitudinal current will not cancel and Z_L will receive unwanted currents. The degree of such an unbalance is measured by the tests described in this paragraph.

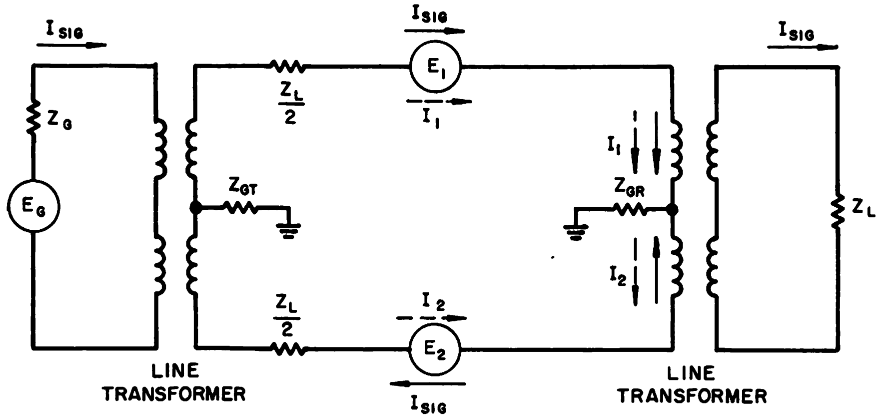

Figure D-22. Signals and Interferences in a Balanced Pair

40.3.11.3 Apparatus.

Test Unit	Reference in Figure D-23
Audio Oscillator	A
Frequency Selective Voltmeter	B
AC Voltmeter	C
Center Tapped Transformer (if not included in audio oscillator or transmission measuring set)	D
Isolation Transformer (if not included in the voltmeter C)	E
Terminating Resistor ($R_L/4$ ohms, where R_L is the nominal circuit impedance)	F

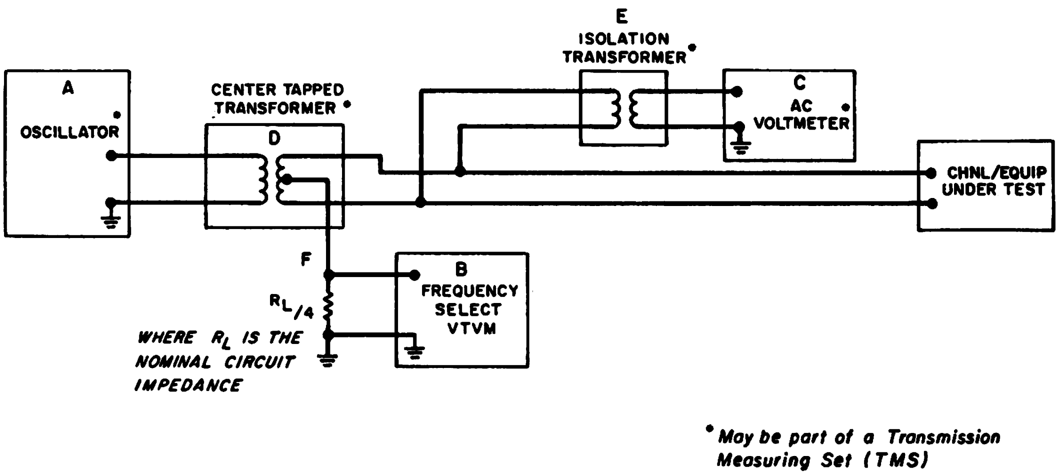

Figure D-23. Longitudinal Balance

40.3.11.4 Test Methods (see Figure D-23).

a. Input Circuits. This method is used for input circuits, and other circuits not having an output at the terminals to be tested. In the circuit shown, adjust the oscillator to the desired test frequency and to the proper power level for the apparatus to be tested, as read on voltmeter C. For example, for standard voice channel multiplex inputs, it is -16 dBm. With the frequency-selective voltmeter B in its narrow bandwidth position, tune it to maximum response at the test frequency used. The use of a frequency selective voltmeter is necessary at B because the wide bandwidth of an ordinary ac voltmeter may allow it to pick up common mode signals other than the low level imbalance signal. The difference, in dB, between the reading of C, in dBm, and the reading of B, in dBm, is taken as the longitudinal balance. This test should be repeated for different frequencies over the audio band as required.

b. Output Circuits. Check the output circuit to make sure that no other signal is present, as it would interfere with the results of this test. Using the same circuit as above, follow the procedure described for input circuits. In this case, the test signal is inserted "backwards", i.e., into the output of the channel with the distant end terminated. This is immaterial for the purpose of this test. Again, the longitudinal balance is the difference between the reading of C and the reading of B.

For example: if C reads 16 dBm, and B reads -56 dBm, then the longitudinal balance is 40 dB which is calculated as follows:

$$\begin{aligned} \text{Longitudinal Balance} &= C - B \\ &= (-16 \text{ dBm}) - (-56 \text{ dBm}) \\ &= 40 \text{ dB} \end{aligned}$$

APPENDIX E

50. DELAY DISTORTION

This Appendix contains Explanatory Information in support of MIL-STD-188-100.

APPENDIX E

TABLE OF CONTENTS

50. DELAY DISTORTION

50.1 Definition. The following explanatory information is provided for a better understanding of definitions for Delay Distortion, Envelope Delay Distortion, Phase Distortion Standards for limits on these distortion phenomena.

50.1.1 Phase Delay (T_p). The time delay between an input sinusoidal waveform to a circuit or network and the output waveform is called Phase Delay. This may be determined from the phase shift characteristic as shown in the following figure. The phase delay at any frequency (ω_1) can be computed as:

$$T_p = \frac{\beta_1 \text{ radians}}{\omega_1 \text{ radians/second}}, \quad \text{where } \omega_1 = 2\pi f_1\text{; also}$$

$$T_p = \frac{\beta_2}{\omega_2} \text{ at frequency } f_2, \quad \text{where } \omega_2 = 2\pi f_2.$$

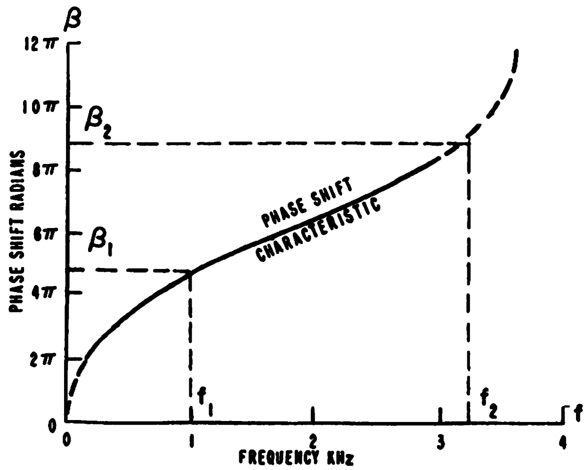

Figure E-1

50.1.2 Delay Distortion (T_d). The distortion of a complex waveform, made up of two or more different frequencies, caused by the difference in arrival time of each frequency at the output, is called delay distortion. It is the direct result of a nonlinear phase-shift characteristic in the transmission medium. Delay distortion may be defined as

$$T_d = \frac{\beta_2}{\omega_2} - \frac{\beta_1}{\omega_1}$$

which is the difference in phase delays at the two frequencies.

50.1.3 Absolute Envelope Delay (envelope delay) is the amount of delay encountered by the modulating energy in a signal between the input and output of any circuit. It is measured by transmitting a narrowband signal at the frequency(s) of interest and using the same reference at the receiver. It is the derivative of the phase-shift curve (as shown in Figure E-1) at the frequency of measurement (see Figure E-2).

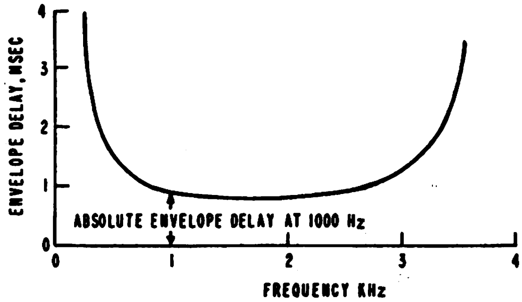

Figure E-2

50.1.4 Relative Envelope Delay. Relative envelope delay is the difference in envelope delay at various frequencies but with a specific frequency selected as a reference point for all other frequencies. The delay at the reference frequency is considered to be 0 microseconds, and all other frequencies will either have more (positive) or less (negative) delay than the reference frequency (Figure E-3).

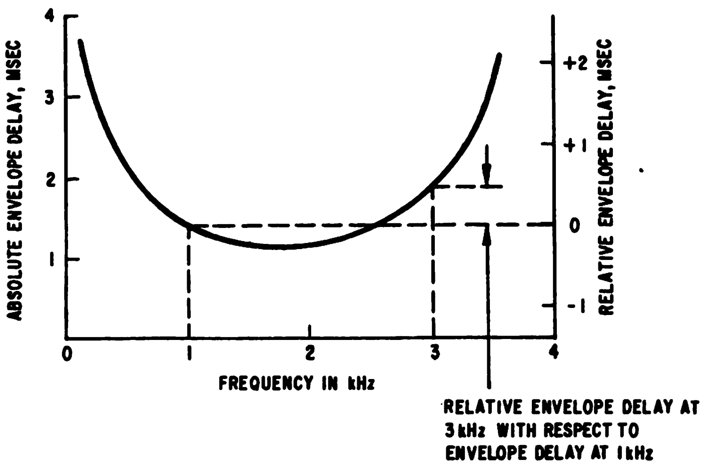

Figure E-3

50.1.5 Envelope Delay Distortion. True delay distortion as determined from the phase characteristic is often confused with envelope delay distortion as determined from the envelope delay characteristic. Envelope delay distortion is the maximum difference of the envelope delay characteristic in a band between any two specified frequencies (Figure E-4). It is not directly related to delay distortion (T_d).

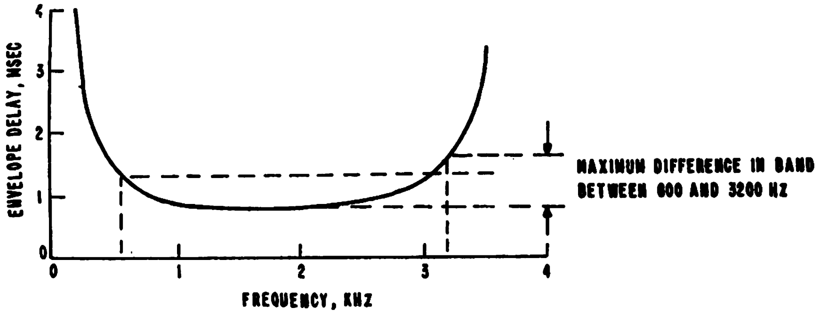

Figure E-4

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APPENDIX F

60. GLOSSARY OF TERMS AND DEFINITIONS

This Appendix contains definitions of key-terms used in MIL-STD-188-100.

144-LINE WEIGHTING. See WEIGHTING. 144-LINE.

144-RECEIVER WEIGHTING. See WEIGHTING, 144-RECEIVER.

ABSORPTION. Absorption is the loss of energy in the transmission of waves over radio or wire paths due to conversion into heat or other forms of energy. In wire transmission, the term is usually applied to loss of energy in extraneous media.

ACTIVITY FACTOR. See FACTOR, ACTIVITY.

ADDRESS. Address in communication usage is the coded representation of the destination of a message. In data processing it is an identification, represented by a name, label or number, for a register or location in storage. Addresses are also a part of an instruction word along with commands, tags, and other symbols.

ADDRESS PATTERN. See PATTERN, ADDRESS.

ALPHABET. See ALPHABET, DIGITAL.

ALPHABET, DIGITAL. A table of correspondence between characters and functions and the bit structures which represent them.

ALPHABET TRANSLATION. See TRANSLATION, ALPHABET.

ALPHANUMERIC. Alphabetic and numeric, including letters, numbers and symbols.

AMPLITUDE DISTORTION. Amplitude distortion is distortion occurring in an amplifier or other device when the amplitude of the output is not a linear function of the input amplitude.

NOTE: Amplitude distortion is measured with the system operating under steady-state conditions with a sinusoidal input signal. When other frequencies are present, the term amplitude refers to that of the fundamental only. This term is sometimes used when non-linear distortion is intended. Non-linear distortion can be measured using multiple tones or noise loading.

AMPLITUDE FREQUENCY RESPONSE. Amplitude frequency response is the amplitude transfer function of frequency. The amplitude response may be stated as actual gain, loss, amplification or attenuation, or as a ratio of any one of these quantities, at a particular frequency with respect to that at a specified reference.

AMPLITUDE MODULATION. See MODULATION, AMPLITUDE.

AMPLITUDE VS FREQUENCY DISTORTION. See DISTORTION, AMPLITUDE VS FREQUENCY.

ANALOG DATA. See DATA.

ANALOG SIGNAL. See SIGNAL, ANALOG.

ANTENNA GAIN. See GAIN, ANTENNA.

AREA, ELEMENTAL (FAX). Any segment of a scanning line of the subject copy the dimension of which along the line is exactly equal to the nominal line width.

NOTE: Elemental area is not necessarily the same as the scanning spot.

ARQ SYSTEM. See SYSTEM, ERROR DETECTING AND FEEDBACK.

ASSIGNED FREQUENCY. See FREQUENCY, ASSIGNED.

ASYNCHRONOUS TRANSMISSION. See TRANSMISSION, ASYNCHRONOUS.

ATTENUATION. The action by which, or the result of which, the power of an electrical signal is decreased; expressed in dB.

ATTENUATION, ECHO. In a four-wire (or two-wire) circuit in which the two directions of transmission can be separated from each other, the attenuation, R_e, of the echo currents (which return to the input of the circuit under consideration) is determined by the ratio of the transmitted power, P_1, to the echo power received, P_2; expressed in dB.

AVAILABLE LINE. See LINE, AVAILABLE.

BALANCE, LONGITUDINAL. The electrical symmetry of the two wires of a pair with respect to ground. See BALANCED.

BALANCED. Electrically symmetrical with respect to ground.

BALANCED LINE (TWO-CONDUCTOR). A transmission line consisting of two conductors in the presence of ground and capable of being operated in such a way that when the voltages of the two conductors at all transverse planes are equal in magnitude and opposite in polarity with respect to ground, the currents in the two conductors are equal in magnitude and opposite in direction.

BALANCED WIRE CIRCUIT. See CIRCUIT, BALANCED WIRE.

BALUN. An impedance-matching device for converting between balanced and unbalanced transmission lines, normally used between equipment and transmission lines or transmission lines and antennas.

BAND, GUARD. A frequency band between two channels which gives a margin of safety against mutual interference.

BAND-PASS FILTER. A filter having a single transmission band, neither of the cut-off frequencies being zero or infinite.

BAND-STOP FILTER. A filter having a single attenuation band, neither of the cut-off frequencies being zero or infinite.

BAND, TIME GUARD. A time interval before or after (or both) the detection/integration interval which may be used to reduce the effects of intersymbol interference in the time domain.

BANDWIDTH. The difference between the limiting frequencies of a continuous frequency band. The bandwidth of a device is the difference between the limiting frequencies within which performance in respect to some characteristic falls within specified limits.

BANDWIDTH, FACSIMILE. In a given facsimile system, the difference in hertz between the highest and the lowest frequency components required for adequate transmission of the facsimile signals.

BANDWIDTH, NECESSARY. For a given class of emission, the minimum value of the occupied bandwidth sufficient to insure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions requires for the proper functioning of the receiving equipment, as, for example, the emission corresponding to the carrier of reduced carrier systems, shall be included in the necessary bandwidth. (This is used for frequency assignment purposes.)

BANDWIDTH, NOMINAL. The maximum band of frequencies, inclusive of guard bands, assigned to a channel (not to be confused with the term radio-frequency emission).

BANDWIDTH, OCCUPIED (FOR A TRANSMITTER). The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission. In some cases, for example, multichannel frequency division systems, the percentage of 0.5 percent may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidth; in such cases a different percentage may prove useful.

BANDWIDTH, RF (FOR A TRANSMITTER). The difference between the highest and the lowest emission frequencies in the region of the carrier or principal carrier frequency.

NOTE: In practice, the region of the carrier or principal carrier frequency is considered to be that region which the amplitude of any frequency resulting from modulation by signal and/or subcarrier frequencies and their distortion products is less than 5 percent (-26 dB) of the rated peak output amplitude of:

a. The carrier or a single-tone sideband, whichever is greater, for single-channel emission; or

b. Any carrier or a single-tone sideband thereof, whichever is greater, for multiplex emission.

BASEBAND. In the process of modulation, the frequency band occupied by the aggregate of the transmitted signals when first used to modulate a carrier. The term is commonly applied to cases where the ratio of the upper to the lower limit of the frequency band is large compared to unity.

BASEBAND, MULTIPLEX. The frequency band occupied by the aggregate of the transmitted signals applied to the facility interconnecting the multiplexing and radio or line equipments. The multiplex baseband is also defined as the frequency band occupied by the aggregate of the received signals obtained from the facility interconnecting the radio or line and multiplexing equipment.

BASEBAND, MULTIPLEX RECEIVE TERMINALS. The point in the baseband circuit nearest the multiplex equipment from which connection is normally made to the radio baseband receive terminals or intermediate facility.

BASEBAND, MULTIPLEX SEND TERMINALS. The point in the baseband circuit nearest the multiplex equipment from which connection is normally made to the radio baseband send terminals or intermediate facility.

BASEBAND, RADIO. The frequency band available for the transmission of all the combined telephone channels and/or other communication channels.

BASEBAND, RADIO RECEIVE TERMINALS. The point in the baseband circuit nearest the radio receiver from which connection is normally made to the multiplex baseband receive terminals or intermediate facility.

BASEBAND, RADIO SEND TERMINALS. The point in the baseband circuit nearest the radio transmitter from which connection is normally made to the multiplex baseband send terminal or intermediate facility.

BAUD. The unit of modulation rate. One baud corresponds to a rate of one unit interval per second. The modulation rate is expressed as the reciprocal of the duration in seconds of the unit interval. Example: If the duration of the unit interval is 20 milliseconds, the modulation rate is 50 bauds.

BIAS, INTERNAL (TELETYPEWRITER). That bias, either marking or spacing that may occur within a start-stop teletypewriter receiving mechanism and which will have the same effect on the margin of operation as bias external to the receiver. See DISTORTION, BIAS.

BIAS DISTORTION. See DISTORTION, BIAS.

BINARY CODE. See CODE, BINARY.

BINARY DIGIT. See DIGIT, BINARY.

BINARY NOTATION. See NOTATION, BINARY.

BINARY NUMBER. See NUMBER, BINARY.

BIT. A contraction of the term binary digit. There are several types of bits.

BIT, CHECK. See BIT, PARITY.

BIT, ERRONEOUS. A bit which is not in accordance with that which should have been received.

BIT ERROR RATE (BER). The number of incorrect or erroneous bits divided by the total number (correct plus incorrect bits) over some stipulated period of time. The two types are: Transmission BER - number of erroneous bits received versus total number of bits transmitted; and Information BER - number of erroneous decoded (corrected) bits versus total number of decoded (corrected) bits. The BER is usually expressed as a number in 10^n, e.g., 2.5×10^{-5}. See RATE, ERROR.

BIT, FRAMING. A bit used to denote the beginning or end of a predetermined group of bits.

BIT, INFORMATION. A bit which is generated by the data source and delivered to the data sink and which is not used by the data transmission system.

BIT INVERSION. See INVERSION, BIT.

BIT, OVERHEAD. A bit other than an information bit.

BIT PAIRING. See PAIRING, BIT.

BIT, PARITY. A bit associated with a character or block for the purpose of checking the absence of error within the character or block.

BIT, SERVICE. An overhead bit which is not a parity bit (i.e., request for repetition, numbering sequence, etc.).

BIT STREAM. See TRANSMISSION, LOCAL.

BITERNARY TRANSMISSION. See TRANSMISSION, BITERNARY.

BLACK FACSIMILE TRANSMISSION. See TRANSMISSION, BLACK FACSIMILE.

BLACK RECORDING (FACSIMILE). In an amplitude-modulation system, that form of recording in which the maximum received power corresponds to the maximum density of the record medium. In a frequency-modulation system, that form of recording in which the lowest received frequency corresponds to the maximum density of the record medium.

BLACK TRANSMISSION (FACSIMILE). See TRANSMISSION, BLACK FACSIMILE.

BLOCK. A group of bits, or binary digits, transmitted as a unit over which an encoding procedure is generally applied for error-control purposes.

BLOCK, ERRONEOUS. A block in which there are one or more erroneous bits.

BREAK. To break, in a communication circuit, is for the receiving user to interrupt the sending user and take control of the circuit; used especially in connection with half-duplex telegraph circuits and two-way telephone circuits equipped with voice-operated devices.

BROADBAND SYSTEM. See WIDEBAND SYSTEM.

BROADCAST OPERATION. See OPERATION, BROADCAST.

BROADCAST REPEATER. See REPEATER, BROADCAST.

BUFFER, DATA. A storage device used to compensate for a difference in rate of flow of information or time of occurrence of events.

BURST, ERROR. A group of bits in which two successive erroneous bits are always separated by less than a given number(M) of correct bits.

C-MESSAGE WEIGHTING. See WEIGHTING, C-MESSAGE.

CARRIER.

a. A wave suitable for modulation by the intelligence to be transmitted over a communication system. The carrier can be a sinusoidal wave or a recurring series of pulses. See also SUBCARRIER.

b. An unmodulated emission.

CARRIER BEAT (IN FACSIMILE). The undesirable heterodyne of signals each synchronous with a different stable reference oscillator causing a pattern in received copy. Where one or more of the oscillators is fork controlled, this is called Fork Beat.

CARRIER FREQUENCY. See FREQUENCY, CARRIER.

CARRIER NOISE LEVEL. See LEVEL, CARRIER NOISE.

CARRIER POWER. See POWER, CARRIER (RADIO TRANSMITTER).

CARRIER TERMINAL. A carrier terminal is the assemblage of apparatus at one end of a carrier transmission system, whereby the process of modulation, demodulation, filtering, amplification, and associated functions are effected.

CARRIER-TO-NOISE RATIO (CNR). The ratio in decibels of the value of the carrier to that of the noise after selection and before any non-linear process such as amplitude limiting and detection.

CASE SHIFT. The change-over of the translating mechanism of a telegraph receiving machine from letters-case to figures-case or vice versa. This shift is normally performed in telegraph apparatus by preceding the transmission of letters-case characters or functions by a letters-shift signal and the transmission of figures-case characters or functions by a figures-shift signal.

CENTER, SWITCHING. (Also called Switching Facility, Switching Exchange or Central Office). An installation in a communication system in which switching equipment is used to interconnect communication circuits on a message or circuit switching basis.

CENTRAL OFFICE. See CENTER, SWITCHING.

CHANNEL. The term channel may signify either a one-way path providing transmission in one direction only or a two-way path providing transmission in two directions. The word "path" is to be interpreted in a broad sense to include separation by frequency or time division.

CHANNEL NOISE LEVEL. See NOISE LEVEL.

CHARACTER. Letter, figure, number, punctuation, or other sign contained in a message. Besides such characters, there may be additional characters for special symbols and for some control functions.

CHARACTER, CODE. The representation of a discrete value or symbol in accordance with a code. See ALPHABET, DIGITAL.

CHARACTER AND BIT COUNT INTEGRITY. See INTEGRITY, CHARACTER AND BIT COUNT.

CHARACTER INTERVAL. See INTERVAL, CHARACTER.

CHARACTER SET. See SET, CHARACTER.

CHARACTERISTIC DISTORTION. See DISTORTION, CHARACTERISTIC.

CHARACTERISTIC FREQUENCY. See FREQUENCY, CHARACTERISTIC.

CHARACTERISTIC, HALFTONE (FAX). A relation between the density of the recorded copy and the density of the subject copy.

NOTE: The term may also be used to relate the amplitude of the facsimile signal to the density of the subject copy or the record copy when only a portion of the system is under consideration. In a frequency-modulation system an appropriate parameter is to be used instead of the amplitude.

CHARACTERISTIC, LOADING (MULTICHANNEL TELEPHONY SYSTEMS). Loading for multi-channel telephony systems indicates for the busy hour the equivalent mean power and the peak power of multi-channel systems as a function of the number of voice channels. The equivalent power of a complex multi-channel signal, referred to zero relative level (0 dBr) is a function of the number of channels and has for its basis a specified mean voice channel power.

CHECK BIT. See BIT, PARITY.

CHECK DIGIT. A digit used for checking purposes but otherwise redundant.

CHECK PARITY. See PARITY, CHECK.

CIRCUIT. The complete electrical path between end-terminal instruments over which one-way or two-way telecommunications are is provided.

CIRCUIT, BALANCED-WIRE. A circuit whose two sides are electrically alike and symmetrical with respect to ground and other conductors. The term is commonly used to indicate a circuit whose two sides differ only by chance.

CIRCUIT, COMPOSITED. A circuit which can be used simultaneously for telephony and direct-current telegraphy, or signalling, separation between the two being accomplished by frequency discrimination.

CIRCUIT, DUPLEX. A duplex circuit, or system, is a telegraph circuit or system which affords simultaneous independent operation in opposite directions over the same channel.

CIRCUIT, FOUR-WIRE. A four-wire circuit is a two-way circuit using two paths so arranged that the electric waves are transmitted in one direction only by one path and in the opposite direction only by the other path.

NOTE: The transmission paths may or may not employ four wires.

CIRCUIT, GROUND-RETURN. A circuit which has a conductor (or two or more in parallel) between two points and which is completed through the ground or earth.

CIRCUIT, HALF-DUPLEX. A circuit designed for duplex operation, but which on account of the nature of the terminal equipment can be operated alternately only.

CIRCUIT, METALLIC. A circuit of which the ground or earth forms no part.

CIRCUIT, SIMPLEX. A circuit derived from a pair of wires by using the wires in parallel with ground return.

CIRCUIT, SIMPLEXED. A two-wire metallic circuit from which a simplex circuit is derived, the metallic and simplex circuits being capable of simultaneous use.

CIRCUIT SWITCHING. See SWITCHING, CIRCUIT.

CIRCUIT, TWO-WIRE. A metallic circuit formed by two conductors insulated from each other.

NOTE: The term is also used in contrast with four-wire circuit to indicate a circuit using one line or channel for transmission of electric waves in both directions.

CIRCUIT, UNBALANCED WIRE. A circuit whose two sides are inherently electrically unlike.

CIRCUIT WORKING, CLOSED. A method of single-current operation in which a current exists in the circuit while the transmitting device is at rest.

CIRCUIT WORKING, OPEN. A method of single-current operation in which no current exists in the circuit while the transmitting device is at rest.

CLIPPER. See LIMITER.

CLOCK. A reference source of timing information for a machine or system.

CLOSED-CIRCUIT WORKING. See CIRCUIT WORKING, CLOSED.

CODE (Telegraph or Data). A system of rules and conventions according to which the telegraph signals forming a message or the data signal forming a block are formed, transmitted, received, and processed.

CODE, BINARY. A code composed of a combination of entities, each of which can assume one of two possible states.

CODE, CHARACTER. See CHARACTER, CODE.

CODE CONVERSION. See CONVERSION, CODE.

CODE ELEMENT. See ELEMENT, CODE.

CODE, ERROR-CORRECTING. A code in which each telegraph or data signal conforms to specific rules of construction so that departures from this construction in the received signals can be detected automatically, and which permits the automatic correction, at the receiving terminal, of some or all of the errors. Such codes require more signal elements than are necessary to convey the basic information.

CODE, ERROR-DETECTING. A code in which each telegraph or data signal conforms to specific rules of construction, so that departures from this construction in the received signals can be detected automatically. Such codes require more signal elements than are necessary to convey the fundamental information.

CODE, M -ARY. See N-ARY INFORMATION ELEMENT.

CODE, REDUNDANT. A code using more signal elements than necessary to represent the intrinsic information. For example:

a. A 5-unit code using all the characters of International Telegraph Alphabet No.2 is not redundant.

b. A 5-unit code using the digits only in International Telegraph Alphabet No.2 is redundant.

c. A 7-unit code using only signals made of 4 space and 3 mark digits is redundant.

d. An 8-unit code using one of the bits for parity is redundant.

CODE SET OR DIGITAL ALPHABET. See ALPHABET, DIGITAL.

COEFFICIENT, REFLECTION.

a. The reflection coefficient at the junction of a uniform transmission line and a mismatched terminating impedance is the vector ratio of the electric field associated with the reflected wave to that associated with the incident wave.

b. At any specified place in a uniform transmission line between a source of power and an absorber of power, the reflection coefficient is the vector ratio of the electric field associated with the reflected wave to that associated with the incident wave. It is given by the formula

$$(Z_2 - Z_1)/(Z_2 + Z_1) \text{ or } (SWR - 1)/(SWR + 1)$$

where Z_1 is the impedance of the source and Z_2 is the impedance of the load.

COHERENT PULSE OPERATION. A method of pulse operation in which a fixed phase relationship is maintained from one pulse to the next.

COMMON BATTERY SIGNALLING. See SIGNALLING, COMMON BATTERY.

COMMUNICATION SINK. See SINK, COMMUNICATION.

COMMUNICATION SOURCE. See SOURCE, COMMUNICATION.

COMPANDOR. A contraction of the terms compressor and expander. The compressor is used to compress the dynamic range of an analog signal which is to be processed and transmitted. The expandor inverts the compressor function to restore the original dynamic range of the processed or transmitted analog signal. Depending on the reaction time, compandors are often referred to as slow acting, syllabic, fast acting, or instantaneous.

COMPATIBLE SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND, COMPATIBLE.

COMPOSITED CIRCUIT. See CIRCUIT, COMPOSITED.

COMPUTER WORD. See WORD, COMPUTER.

CONFERENCE OPERATION. See OPERATION, CONFERENCE.

CONFERENCE REPEATER. See REPEATER, CONFERENCE.

CONGRUENCY (FAX). The ability of a facsimile transmitter or receiver to perform in an identical manner to the transmitter or receiver of another facsimile system.

CONTRAST, SIGNAL (FAX). The ratio expressed in decibels between white signal and black signal.

CONTROL EQUIPMENT, REMOTE. The apparatus used for monitoring, controlling, supersivising, or a combination of these, a prescribed function or functions at a distance by electrical means.

CONVERSION, CODE. The process by which a code of some pre determined bit structure (for example, 5, 6, 14 bits per character interval) is converted to a second code with more or less bits per character interval. No alphabetical significance is assumed in this process. In certain cases, such as the conversion from start/stop telegraph equipment to synchronous equipment, a code conversion process may only consist of discarding the stop and start element and adding a sixth element to indicate the stop and start condition. In other cases, it may consist of addition or deletion of control and/or parity bits.

CONVERTER, FACSIMILE. A device which changes the type of modulation.

CONVERTER, FACSIMILE RECEIVING. (FS TO AM CONVERTER). A device which changes the type of modulation from frequency-shift to amplitude.

CONVERTER, FACSIMILE TRANSMITTING. (AM TO FS CONVERTER). A device which changes the type of modulation from amplitude to frequency-shift.

CONVERTER, SIGNAL. A device in which the input and output signals are formed according to the same code, but not according to the same type of electrical modulation.

COOPERATION, INDEX OF, DIAMETRAL OR INTERNATIONAL (IN FACSIMILE). The product of the drum diameter and the line advance in scanning lines per unit length. The unit length must be the same as that used for expressing the drum diameter.

COPY, SUBJECT (FAX). The material in graphic form which is to be transmitted for facsimile reproduction.

CRITICAL FREQUENCY. In radio propagation by way of the ionosphere, the critical frequency is the limiting frequency below which a wave component is reflected by, and above which it penetrates through, an ionospheric layer of vertical incidence.

NOTE: The existence of the critical frequency is the result of electron limitation; i.e., the inadequacy of the existing number of free electrons to support reflection at higher frequencies.

CROSSBAR SWITCH. See SWITCH, CROSSBAR.

CROSSTALK. The phenomenon in which a signal transmitted on one circuit or channel of a transmission system is detectable in another circuit or channel.

CROSSTALK COUPLING LOSS. See LOSS, CROSSTALK COUPLING.

CROSSTALK, FAR-END. Crosstalk which is propagated in a disturbed communication channel in the same direction as the propagation in the disturbing channel. The terminals of the disturbed channel and the energized terminal of the disturbing channel are usually remote from each other.

CROSSTALK, NEAR-END. Crosstalk which is propagated in a disturbed channel in the direction opposite to the direction of propagation of the current in the disturbing channel. The terminal of the disturbed channel at which the near-end crosstalk is present is ordinarily near or coincides with the energized terminal of the disturbing channel.

CX SIGNALLING. See SIGNALLING, CX.

CYCLIC DISTORTION. See DISTORTION, CYCLIC.

DATA. (ANALOG OR DIGITAL). Material transmitted or processed to provide information or to control a process.

DATA BUFFER. See BUFFER, DATA.

DATA SIGNALLING RATE. See RATE, DATA SIGNALLING.

DATA SINK. See SINK, DATA.

DATA SOURCE. See SOURCE, DATA.

DATA TERMINAL. See TERMINAL, DATA.

dB. Decibel. The standard unit for expressing transmission gain or loss and relative power ratios. The decibel is one-tenth of a bel, the latter being too large a unit for convenient use. Both units are expressed in terms of the logarithm to the base 10 of a power ratio, the decibel formula being:

$$dB = 10 \log_{10} \frac{P_1}{P_2}$$

Power ratios may be expressed in terms of voltage or current. If the resistances for both the power measurements are the same, they cancel out in the power ratio so the formulas in terms of voltage or current become as follows:

$$dB = 10 \log \left[\frac{E_1^2}{R_1} \Big/ \frac{E_2^2}{R_2}\right] = 10 \log \left[\frac{I_1^2 \quad R_1}{I_2^2 \quad R_2}\right]$$

$$dB = 10 \log \frac{E_1^2}{E_2^2} = 10 \log \frac{I_1^2}{I_2^2}$$

$$dB = 20 \log \frac{E_1}{E_2} = 20 \log \frac{I_1}{I_2} \text{ where } R_1 = R_2$$

dBa, dBrn ADJUSTED. Weighted circuit noise power in dB referred to 3.16 picowatts (-85 dBm), which is 0 dBa. Use of F1A-line or HA1-receiver weighting shall be indicated in parentheses as required. When the proper weighting is not specified, F1A weighting is assumed. See WEIGHTING, NOISE.

NOTE: A one milliwatt, 1000 Hz tone will read +85 dBa, but the same power as white noise, randomly distributed over a 3 kHz band (nominally 300 to 3300 Hz), will read +82 dBa due to the frequency weighting.

dBa (F1A). Weighted circuit noise power in dBa, measured on a line by a noise-measuring set with F1A-line weighting. See WEIGHTING, NOISE.

dBa (HA1). Weighted circuit noise power in dBa, measured across the receiver of a 302 type or similar subset, by a noise-measuring set with HA1-receiver weighting. See WEIGHTING, NOISE.

dBaO. Circuit noise power in dBa referred to or measured at a point of zero relative transmission level (0 dBr). When the proper weighting is not specified, FlA weighting is assumed.

NOTE: It is preferred to convert circuit noise readings from dBa to dBaO, as this makes it unnecessary to know or state the relative transmission level at the point of actual measurement.

dBm. a. dB referred to one milliwatt; employed in communication work as a measure of absolute power values. Zero dBm equals one milliwatt.

b. In noise power measurement, noise power in dB referred to one milliwatt.

NOTE: In American practice unweighted measurement is normally understood, applicable to a certain bandwidth which must be stated or implied, as indicated by context.

dBm (PSOPH). A unit of noise power in dBm, measured with psophometric weighting. See WEIGHTING, NOISE.

NOTE: Conversion regulation with other weighted units:

$$\text{dBm (psoph)} = \left[10 \log_{10} (\text{pWp})\right] - 90 = \text{dBa} - 84$$

dBm CONVERSION TO VU. See TALKER VOLUME DISTRIBUTION, MEAN POWER OF THE.

dBmO. In power measurement, power in dBm, referred to or measured at a point of zero transmission level (OTLP).

dBmOp. Circuit power in dBmO, measured on a line by a psophometer or measuring set having psophometric weighting. See WEIGHTING, NOISE.

dBr. See TRANSMISSION LEVEL.

dBrn. (Decibels Above Reference Noise). Weighted circuit noise power in dB referred to 1.0 picowatt (-90 dBm), which is 0 dBrn. Use of 144-line, 144-receiver, C-message (dBrnc), or flat weighting shall be indicated in parentheses as required. See WEIGHTING, NOISE.

NOTE: (1) With C-message weighting, a one milliwatt, 1000 Hertz tone will read +90 dBrn, but the same power as white noise, randomly distributed over a 3 kHz band (nominally 300 to 3300 Hz) will read approximately +88.5 dBrn, (rounded off to +88 dBrn), due to the frequency weighting. (2) With 144 weightings, a one milliwatt, 1000 Hz tone will also read +90 dBrn, but the same 3 kHz white noise power will read only +82 dBrn, due to the different frequency weighting.

dBrn (144 LINE). Weighted circuit noise power in dBrn, measured on a line by a noise measuring set with 144-line weighting. See WEIGHTING, NOISE.

dBrn (144 RECEIVER). Weighted circuit noise power in dBrn, measured across the receiver of a subset with a No.144-receiver by a noise measuring set with 144-receiver weighting. See WEIGHTING, NOISE.

dBrn (C-message). Also shown as dBrnc. Weighted circuit noise power in dBrn, measured on a line by a noise measuring set with C-message weighting.

dBrn. (F1-F2). Flat noise power in dBrn, measured over the frequency band between frequencies f_1 and f_2. See WEIGHTING, NOISE (FLAT WEIGHTING).

dBrnc. See NOISE.

dBrncO. See NOISE.

DECAY TIME, PULSE. The time required for the instantaneous amplitude to go from 90% to 10% of the peak value.

DEFINITION (FAX). Distinctness or clarity of detail or outline in a record sheet or other reproduction.

DEGREE OF DISTORTION. See DISTORTION, DEGREE OF.

DEGREE OF INDIVIDUAL DISTORTION OF A PARTICULAR SIGNIFICANT INSTANT (OF A MODULATION OR OF A RESTITUTION). See DISTORTION, DEGREE OF INDIVIDUAL.

DEGREE OF ISOCHRONOUS DISTORTION. See DISTORTION, DEGREE OF ISOCHRONOUS.

DEGREE OF SIGNIFICANT INSTANT DISTORTION. See DISTORTION, DEGREE OF INDIVIDUAL.

DEGREE OF START-STOP DISTORTION. See DISTORTION, DEGREE OF START-STOP.

DELAY,ABSOLUTE. The amount of time by which a signal is delayed. It may be expressed in time (milliseconds, etc.) or in number of characters (pulse times, word times, major cycles, minor cycles, etc.).

DELAY, DIFFERENTIAL. The difference between the maximum and the minimum frequency delays occurring across a band.

DELAY DISTORTION. See DISTORTION, ENVELOPE DELAY.

DELAY DISTORTION (FAX). See DISTORTION, ENVELOPE DELAY.

DELAY EQUALIZER. A corrective network designed to make the phase delay or envelope delay of a circuit or system substantially constant over a desired frequency range.

DELAY LINE. a). A real or artificial transmission or equivalent device designed to introduce delay. b). A sequential logic element or device with one input channel in which the output channel state at a given instant, t, is the same as the input channel state at the instant t-n; i.e., the input sequence undergoes a delay of n units. There may be additional taps yielding output channels with smaller values of n.

DELAY, PHASE (FAX). In the transfer of a single-frequency wave from one point to another in a system, the time delay of a part of the wave identifying its phase.

NOTE: The phase delay is measured by the ratio of the total phase shift in cycles to the frequency in cycles per second (Hz).

DELTA MODULATION. See MODULATION, DELTA.

DEMODULATION. A function wherein a wave resulting from previous modulation is processed to derive a wave having substantially the characteristics of the original modulating wave. See RESTITUTION.

DENSITY (FAX). A measure of the light-transmitting or reflection properties of an area. It is expressed by the common logarithm of the ratio of incident to transmitted or reflected light flux.

NOTE: There are many types of density which will usually have different numerical values for a given material; e.g., Diffuse Density, Double Diffuse Density, Specular Density. The relevant type of density depends upon the geometry of the optical system in which the material is used.

DESIGN OBJECTIVE. See OBJECTIVE, DESIGN.

DESIGNATION, FREQUENCY SPECTRUM. See FREQUENCY, SPECTRUM DESIGNATION OF.

DEVICE, INPUT-OUTPUT. (I/O). Any equipment which introduces data into or extracts data from a data communication system.

DIBIT. A group of two bits. The four possible states for a dibit are 00, 01, 10, and 11.

DIFFERENTIAL MODULATION. See MODULATION, DIFFERENTIAL.

DIGIT, BINARY. An information state in binary notation (e.g., 0 or 1).

DIGITAL ALPHABET OR CODE SET. See ALPHABET, DIGITAL.

DIGITAL DATA. See DATA.

DIGITAL SIGNAL. See SIGNAL, DIGITAL.

DIPLEX. Permitting simultaneously and in the same direction the transmission or reception of two signals over a circuit or channel.

DIPLEXER. A multicoupler device for permitting the simultaneous use of several transmitters or several receivers in connection with a common element such as antenna system; the diplexer does not permit simultaneous transmit and receive.

DIRECT RECORDING (FAX). See RECORDING, DIRECT (FAX).

DIRECTION OF SCANNING (FAX). See SCANNING, DIRECTION OF (FAX).

DIRECTIONAL COUPLER. A transmission coupling device for separately (ideally) sampling, through a known coupling loss for measuring purposes, either the forward (incident) or the backward (reflected) wave in a transmission line. Similarly, it may be used to excite in the transmission line either a forward or backward wave.

A unidirectional coupler has available terminals or connections for sampling only one direction of transmission; a bidirectional coupler has available terminals for sampling both directions.

DIRECTIVE GAIN. The power gain of an antenna is 4 times the power delivered to a unit solid angle divided by the power delivered to 4 steradians.

DISTORTION, AMPLITUDE VS FREQUENCY (of a transmission system). That distortion caused by the nonuniform attenuation, or gain, of the system with respect to frequency under specified terminal conditions.

DISTORTION, BIAS. Distortion affecting a two-condition (or binary) modulation in which all the significant intervals corresponding to one of the two significant conditions have uniformly longer or shorter duration than the corresponding theoretical durations.

DISTORTION, CHARACTERISTIC. Distortion caused by transients which, as a result of modulation, are present in the transmission channel and depend on its transmission qualities.

DISTORTION, CYCLIC. (of telegraph signals). Distortion which is neither characteristic, bias, nor fortuitous and which, in general, has a periodic character. Its causes are, for example, irregularities in the duration of contact time of the brushes of a transmitter distributor, interference by disturbing alternating currents, etc.

DISTORTION, DEGREE OF. A measurement of the deviation of a digital signal from the theoretically perfect signal. It is expressed as a percent of the theoretically perfect unit interval.

DISTORTION, DEGREE OF INDIVIDUAL, OF A PARTICULAR SIGNIFICANT INSTANT (OF A MODULATION OR A RESTITUTION). Ratio to the unit interval of the displacement, expressed algebraically, of this significant instant from an ideal instant. This displacement is considered positive when a significant instant occurs after the ideal instant. The degree of individual distortion is usually expressed as a percentage.

DISTORTION, DEGREE OF ISOCHRONOUS. Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and the theoretical intervals separating any two significant instants of modulation (or restitution), these instants being not necessarily consecutive. The degree of distortion (of an isochronous modulation or restitution) is usually expressed as a percentage.

NOTE: The result of the measurement should be completed by an indication of the period, usually limited, of the observation. For a prolonged modulation (or restitution) it will be appropriate to consider the probability that an assigned value of the degree of distortion will be exceeded.

DISTORTION, DEGREE OF SIGNIFICANT INSTANT. See DISTORTION, DEGREE OF INDIVIDUAL.

DISTORTION, DEGREE OF START-STOP. Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical intervals separating any significant instant of modulation (or of restitution) from the significant instant of the start-stop modulation (or restitution), usually expressed as a percentage.

DISTORTION, DELAY. See DISTORTION, ENVELOPE DELAY.

DISTORTION, DELAY (OF A TRANSMISSION SYSTEM). The distortion of a complex waveform, made up of two or more different frequencies, caused by the difference in arrival time of each frequency at the output.

DISTORTION, END (OF START-STOP TELETYPEWRITER SIGNALS). The shifting of the end of all marking pulses from their proper positions in relation to the beginning of the start pulse.

DISTORTION, ENVELOPE DELAY. Envelope delay distortion is the maximum difference of the envelope delay characteristic in a band between any two specified frequencies.

DISTORTION, FORTUITOUS (OF TELEGRAPH SIGNALS). Distortion resulting from causes generally subject to random laws, for example, accidential irregularities in the operation of the apparatus and moving parts, disturbances affecting the transmission channel, etc.

DISTORTION, INTERMODULATION. Nonlinear distortion characterized by the appearance in the output of frequencies equal to sums and differences of integral multiples of the component frequencies present in the input.

NOTE. Harmonic components also present in the output are usually not included as part of the intermodulation distortion. When harmonics are included, a statement to that effect should be made.

DISTORTION, NONLINEAR. Distortion caused by a deviation from a linear relationship between the input and output of a system or component.

DISTORTION, PHASE. See DISTORTION, ENVELOPE DELAY.

DISTORTION, SINGLE-HARMONIC. The ratio of the power at the fundamental frequency, measured at the output of the transmission system considered,to the power of any single harmonic observed at the output of the system because of its nonlinearity, when a single frequency signal of specified power is applied to the input of the system; expressed in dB.

DISTORTION, START-STOP TTY. The shifting of the transition of the signal pulses from their proper positions relative to the beginning of the start pulse. The magnitude of the distortion is expressed in percent of a perfect unit pulse length.

DISTORTION, TELETYPEWRITER SIGNAL. See DISTORTION, START-STOP TTY.

DISTORTION, TOTAL HARMONIC. The ratio of the power at the fundamental frequency, measured at the output of the transmission system considered, to the power of all harmonics observed at the output of the system because of its nonlinearity, when a single frequency signal of specified power is applied to the input of the system; expressed in dB.

DISTRIBUTION FRAME. A structure for terminating wires and connecting them together in any desired order.

DIVERSITY. That method of transmission and/or reception, whereby, in order to reduce the effects of fading, a single received information signal is derived from a combination of, or selection from, a plurality of signals containing the same information. Improvement gained shall be expressed in dB.

DIVERSITY, DUAL. The term applied to the simultaneous combining of, or selection from, two signals and their detection through the use of space, frequency, angle or polarization characteristics.

DIVERSITY, FREQUENCY. Any method of transmission and reception wherein the same information signal is transmitted and received simultaneously on two or more distinct frequencies.

DIVERSITY, POLARIZATION. A method of transmission and/or reception of information accomplished by the use of separate vertically and horizontally polarized antennas.

DIVERSITY, QUADRUPLE. The term applied to the simultaneous combining of, or selection from, four signals and their detection through the use of space, frequency, angle, or polarization characteristics or combinations thereof.

DIVERSITY, RECEPTION. That method of radio reception whereby, in order to minimize the effects of fading, a resultant signal is obtained by combination of and/or selection from two or more sources of received-signal energy which carry the same modulation or intelligence, but which may differ in strength or signal-to-noise ratio at any given instant.

DIVERSITY, SPACE. Any method of transmission and/or reception which employs antennas having spatial separation.

DOPPLER EFFECT. See EFFECT, DOPPLER.

DOUBLE-CURRENT TRANSMISSION. See TRANSMISSION, DOUBLE-CURRENT.

DOUBLE-SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND, DOUBLE, REDUCED OR SUPPRESSED CARRIER and TRANSMISSION, SIDEBAND, DOUBLE.

DRUM FACTOR (FAX). See FACTOR, DRUM (FAX).

DRUM SPEED (FAX). See SPEED, DRUM (FAX).

DUAL DIVERSITY. See DIVERSITY, DUAL.

DUPLEX CIRCUIT. See CIRCUIT, DUPLEX.

DUPLEX, OPERATION. See OPERATION, DUPLEX.

DUPLEX SYSTEM OR CIRCUIT. See CIRCUIT, DUPLEX.

DUPLEXER. A device for permitting the simultaneous use of a transmitter and a receiver in connection with a common element such as an antenna system.

DX SIGNALLING. See SIGNALLING, DX.

DYNAMIC RANGE. The dynamic range of a transmission system is the difference in decibels between the noise level of the system and its overload level.

E&M LEAD SIGNALLING. See SIGNALLING, E&M LEAD.

ECHO. A wave which has been reflected and otherwise returned with sufficient magnitude and delay to be perceived.

ECHO ATTENUATION. See ATTENUATION, ECHO.

ECHO SUPPRESSOR. A voice-operated device for connection to a two-way telephone circuit to attenuate echo currents in one direction caused by telephone currents in the other direction.

EFFECT, DOPPLER. The phenomemon evidenced by the change in the observed frequency of a wave in a transmission system and caused by a time rate of change in the effective length of the path of travel between the source and the point of observation.

EFFECT, KENDALL (FAX). A spurious pattern or other distortion in a facsimile record caused by unwanted modulation products arising from the transmission of a carrier signal and appearing in the form of a rectified baseband that interferes with the lower sideband of the carrier.

NOTE: This occurs principally when the single sideband width is greater than half the facsimile carrier frequency.

EFFECTIVE HEIGHT.

a. The effective height of an antenna is the height of its center of radiation above the effective ground level.

b. In low-frequency applications the term effective height is applied to loaded or nonloaded vertical antennas and is equal to the moment of the current distribution in the vertical section divided by the input current.

NOTE: For an antenna with symmetrical current distribution the center of radiation is the center of distribution. For an antenna with asymmetrical current distribution the center of radiation is the center of current moments when viewed from directions near the direction of maximum radiation.

EFFECTIVE RADIATED POWER. See POWER, EFFECTIVE RADIATED.

EFFECTIVE SPEED OF TRANSMISSION. The rate at which information is processed by a transmission facility expressed as the average rate over some significant time interval. This quantity is usually expressed as average characters per unit time or average bits per unit time. (Rate of transmission, average is more common usage.)

EFFICIENCY FACTOR, IN TIME (OF A TELEGRAPH COMMUNICATION). See EFFICIENCY, TELEGRAPH COMMUNICATION.

EFFICIENCY, TELEGRAPH COMMUNICATION. The efficiency factor of a communication is the ratio of the time to transmit a text automatically and at a specified modulation rate to the time actually taken to receive the same text with a specified error rate.

NOTE: (a) The whole of the apparatus comprising the communication is assumed to be in the normal condition of adjustment and operation.

(b) A telegraph communication may have a different efficiency factor in time for the two directions of transmission.

(c) The practical conditions of measurement should be specified; in particular, the duration.

EHF. EXTREMELY HIGH FREQUENCY. 30 to 300 GHz.

ELECTRICALLY-POWERED TELEPHONE. See TELEPHONE, ELECTRICALLY-POWERED.

ELECTROCHEMICAL RECORDING (FAX). See RECORDING, ELECTROCHEMICAL (FAX).

ELECTROLYTIC RECORDING (FAX). See RECORDING, ELECTROLYTIC (FAX).

ELECTROMECHANICAL RECORDING (FAX). See RECORDING, ELECTROMECHANICAL (FAX).

ELECTRONIC LINE SCANNING (FAX). See SCANNING, ELECTRONIC LINE (FAX).

ELECTROSTATIC RECORDING (FAX). See RECORDING, ELECTROSTATIC (FAX).

ELEMENT, CODE. One of a finite set of parts of which the characters in a given code may be composed.

ELEMENT, SIGNAL. Each of the parts constituting a telegraph or data signal and distinguished from the other by its nature, magnitude, duration, and relative position (or by one or some of these features only).

ELEMENTAL AREA (FAX). See AREA, ELEMENTAL (FAX).

ELF. EXTREMELY LOW FREQUENCY. Below 300 Hz.

END DISTORTION. See DISTORTION, END.

END INSTRUMENT. See INSTRUMENT, END.

ENVELOPE DELAY DISTORTION. See DISTORTION, ENVELOPE DELAY.

EQUALIZATION. The process of reducing amplitude, frequency, and/or phase distortion of a circuit by the introduction of networks to compensate for the difference in attenuation and/or time delay at the various frequencies in the transmission band.

EQUIPMENT, OFF-LINE. The equipment or devices not in direct communication with the distant terminal.

EQUIPMENT, ON-LINE. The equipment or devices in direct communication with the distant terminal.

EQUIPMENT, REMOTE CONTROL. See CONTROL EQUIPMENT, REMOTE.

ERLANG. A measure of the volume of telephone call traffic. An Erlang = mp where m = 100 sources, P = 6 - minute call/hours; thus, P = 6/60 = 0.1 erlangs = 100 X 0.1. In "lost call design" the grade of service is the probability that a call not be lost to traffic congestion; a grade of service of 0.999 means that the probability of a call being lost is .001 or 1 out of a 1000 calls.

ERRONEOUS BIT. See BIT, ERRONEOUS.

ERROR. See ERROR; SINGLE, DOUBLE, TRIPLE, ETC.

ERROR BURST. See BURST, ERROR.

ERROR-CORRECTING CODE. See CODE, ERROR-CORRECTING.

ERROR-CORRECTING SYSTEM. See SYSTEM, ERROR CORRECTING.

ERROR-DETECTING AND FEEDBACK SYSTEM. See SYSTEM, ERROR-DETECTING AND FEEDBACK.

ERROR-DETECTING CODE. See CODE, ERROR-DETECTING.

ERROR-DETECTING SYSTEM. See SYSTEM, ERROR-DETECTING.

ERROR RATE. See RATE, ERROR.

ERROR-RATE,RESIDUAL. (Undetected error-rate). The ratio of the number of bits, unit elements, characters, or blocks incorrectly received but undetected or uncorrected by the error-control equipment to the total number of bits, unit elements, characters, or blocks sent.

ERROR: SINGLE, DOUBLE, TRIPLE, ETC. A group of 1, 2, 3,etc., consecutive erroneous bits, characters, words, blocks, or elements preceded and followed immediately by at least one correct bit, character, word, block, or element.

EXALTED CARRIER RECEPTION. See RECEPTION, EXALTED CARRIER.

F1A-LINE WEIGHTING. See WEIGHTING, F1A-LINE.

FACSIMILE. A line scanning system of telecommunication for the transmission of fixed images, with or without half-tones, with a view to their reproduction in a permanent form. (Wirephoto and telephoto are facsimile through wire circuits; radiophoto is facsimile via radio.) See GRAPHICS.

FACSIMILE BANDWIDTH. See BANDWIDTH, FACSIMILE.

FACSIMILE CONVERTER. See CONVERTER, FACSIMILE.

FACSIMILE RECEIVER. See RECEIVER, FACSIMILE.

FACSIMILE RECORDER. See RECORDER, FACSIMILE.

FACSIMILE SIGNAL. See SIGNAL, FACSIMILE.

FACSIMILE SIGNAL LEVEL. See SIGNAL LEVEL, FACSIMILE.

FACSIMILE TRANSMITTER. See TRANSMITTER, FACSIMILE.

FACTOR, ACTIVITY. Activity factor, for a voice-communication channel, is the percentage of the time during the busiest traffic hour when a signal is present in the channel in one direction.

FACTOR, DRUM (FAX). The ratio of drum length used to drum diameter. Where drums are not used it is the ratio of the equivalent dimensions.

FADING. The fluctuation in intensity and/or relative phase of any or all frequency components of the received radio signal due to changes in the characteristics of the propagation path.

FADING, FLAT. That type of fading in which all frequency components of the received radio signal fluctuate in the same proportion simultaneously.

FADING, SELECTIVE. That type of fading in which the various frequency components of the received radio signal fluctuate independently.

FALL TIME. See DECAY TIME, PULSE.

FAR-END CROSSTALK. See CROSSTALK, FAR-END.

FAULT. A malfunction that is reproducible, as contrasted to an error which is defined as a malfunction which is not reproducible. A malfunction is considered reproducible if it occurs consistently under the same circumstances.

FAX. A shorthand reference to facsimile.

FIDELITY. See LINEARITY.

FIXED REFERENCE MODULATION. See MODULATION, FIXED REFERENCE.

FLAT FADING. See FADING, FLAT.

FLAT WEIGHTING. See WEIGHTING, FLAT.

FLUTTER. In communication practice, flutter is:

(1) Distortion due to variation in loss resulting from the simultaneous transmission of a signal at another frequency.

(2) A similar effect due to phase distortion.

(3) In recording and reproducing, deviation of frequency which results, in general, from irregular motion during recording, duplication, or reproduction.

(4) A radio wave characterized by rapidly-changing signal amplitude levels, together with variable multipath time delays, caused by the reflection and possible partial absorption of the radio signal from aircraft flying through the beam or common scatter volume.

NOTE: One important usage is to denote the effect of variation in the transmission characteristics of a loaded telephone circuit caused by the action of telegraph direct currents on the loading coils.

FORMAT. Arrangement of bits or characters within a group, such as a word, message or language; shape, size, and general makeup of a document.

FORTUITOUS DISTORTION. See DISTORTION, FORTUITOUS.

FOUR-WIRE CIRCUIT. See CIRCUIT, FOUR-WIRE.

FRAME (FAX). A rectangular area, the width of which is the available line and the length of which is determined by the service requirements.

FRAME (TDM). The condition which exists when there is a channel-to-channel and bit-to-bit correspondence (exclusive of transmission errors) between all inputs of a time division multiplexer and the output of its associated demultiplexer.

FRAME FREQUENCY. The frame frequency is the number of times per second that a frame of information is transmitted or received.

FRAMING BIT. See BIT, FRAMING.

FRAMING (FAX). The adjustment of the picture to a desired position in the direction of line progression.

FRAMING SIGNAL. A signal used for adjustment of the picture to a desired position in the direction of line progression.

FREQUENCIES, PICTURE (FAX). The frequencies which result solely from scanning subject copy.

NOTE: This does not include frequencies which are part of a modulated carrier signal.

FREQUENCY. The number of complete cycles per unit of time. When the unit of time is one second, the measurement unit is hertz (cycles per second).

FREQUENCY ACCURACY. The degree of precision relative to a specified value of a frequency.

FREQUENCY ASSIGNED. The frequency of the center of the radiated bandwidth shall be designated the assigned frequency. (The frequency of the RF carrier, whether suppressed or radiated, shall be referred to in parentheses following the assigned frequency and shall be the frequency appearing in the dial settings of RF equipment intended for single sideband or independent sideband.)

NOTE: The frequency of the RF carrier is usually referred to in this standard as f_o and the assigned frequency as f_c.

FREQUENCY CARRIER. The frequency of the unmodulated carrier.

FREQUENCY-CHANGE SIGNALLING. See SIGNALLING, FREQUENCY CHANGE.

FREQUENCY, CHARACTERISTIC. A frequency which can be easily identified and measured in a given emission.

FREQUENCY DEVIATION. Frequency deviation, in frequency modulation, is the peak difference between the instantaneous frequency of the modulated wave and the carrier frequency.

FREQUENCY DIVERSITY. See DIVERSITY, FREQUENCY.

FREQUENCY DIVISION MULTIPLEX (FDM). See MULTIPLEX, FREQUENCY DIVISION (FDM).

FREQUENCY-EXCHANGE SIGNALLING, TWO-SOURCE FREQUENCY. See SIGNALLING FREQUENCY EXCHANGE.

FREQUENCY, MAXIMUM KEYING (FAX). The frequency in cycles per second numerically equal to the spot speed divided by twice the "scanning-spot X dimension."

FREQUENCY, MAXIMUM MODULATING (FAX). The highest picture frequency required for the facsimile transmission system.

NOTE: The maximum modulating frequency and the maximum keying frequency are not necessarily equal.

FREQUENCY, MODULATION. See MODULATION, FREQUENCY.

FREQUENCY, REFERENCE. A frequency having a fixed and specified position with respect to the assigned frequency. The displacement of this frequency with respect to the assigned frequency has the same absolute value and sign that the displacement of the characteristic frequency has with respect to the center of the frequency band occupied by the emission.

FREQUENCY, SAMPLING. The rate at which signals in an individual channel are sampled for subsequent modulation, quantization, and/or coding.

FREQUENCY, SCANNING LINE (FAX). See SPEED, STROKE (FAX).

FREQUENCY-SHIFT KEYING. See KEYING, FREQUENCY-SHIFT.

FREQUENCY SHIFT, SIGNAL (FAX). In a frequency-shift facsimile system, the numerical difference between the frequencies corresponding to white signal and black signal at any point in the system.

FREQUENCY-SHIFT SIGNALLING. See KEYING, FREQUENCY-SHIFT.

FREQUENCY, SPECTRUM DESIGNATION OF. A method of referring to a range or band of communication frequencies. In American practice the designator is a two or three letter abbreviation of the name. In ITU practice the designator is a numeric. These ranges or bands are:

AMERICAN BAND	FREQUENCY	ITU BAND
ELF (Extremely Low Frequency)	Below 300 Hz	-
ILF (Infra Low Frequency)	300 - 3000 Hz	-
VLF (Very Low Frequency)	3 - 30 kHz	4
LF (Low Frequency)	30 - 300 kHz	5
MF (Medium Frequency)	300 - 3000 kHz	6
HF (High Frequency)	3 - 30 MHz	7
VHF (Very High Frequency)	30 - 300 MHz	8
UHF (Ultra High Frequency)	300 - 3000 MHz	9
SHF (Super High Frequency)	3 - 30 GHz	10
EHF (Extremely High Frequency)	30 - 300 GHz	11
- - - - - -	300 - 3000 GHz	12

FREQUENCY STABILITY. The ability of a device (transmitter, receiver, etc.) to maintain an assigned frequency.

FREQUENCY TOLERANCE. The maximum permissible departure of the center frequency of the frequency band occupied by an emission from the assigned frequency or of the characteristic frequency of an emission from the reference frequency. This includes both the initial setting tolerance and excursions to short-and long-term stability and aging. The frequency tolerance is expressed in parts in 10^n, in hertz or in percentages.

FREQUENCY TRANSLATION. The transfer en bloc of signals occupying a definite frequency band (such as a channel or group of channels) from one position in the frequency spectrum to another, in such a way that the arithmetic frequency difference of signals within the band is unaltered.

FULL DUPLEX OPERATION. See OPERATION, DUPLEX.

GAIN. The action by which, or the result of which, the power of an electrical signal is increased; expressed in dB.

GAIN, ANTENNA. Antenna gain is commonly defined as the ratio of the maximum radiation intensity in a given direction to the maximum radiation intensity produced in the same direction from a reference antenna with the same power input.

GAIN, INSERTION. The insertion gain of a transmission system (or component thereof) inserted between two impedances Z_e (transmitter) and Z_r (receiver) is the ratio of the power measured across the receiver Z_r after insertion of the transmission system considered to the power measured before insertion; expressed in dB. If the resulting number in dB thus obtained is negative, an insertion loss is indicated. See LOSS, INSERTION.

GAIN, NET. See LOSS, NET.

GHz. GIGAHERTZ. 10 to power of 9, hertz.

GRAPHICS. The art or science of conveying intelligence through the use of graphs, letters, lines, drawings, pictures, etc. (Facsimile is one form of technology for electrically transporting intelligence in graphic form from one point to another.)

GRAY SCALE. An optical pattern in discrete steps between light and dark.

GROUND-RETURN CIRCUIT. See CIRCUIT, GROUND-RETURN.

GROUP. See WIDEBAND SYSTEM.

GROUP DELAY (ENVELOPE DELAY). The distortion caused by the difference between the maximum transit time and the minimum transit time of frequencies with the normal (48 kHz) FDM group bandwidth.

GROUP, TRUNK. Two or more trunks between the same two points.

GROUPING (FAX). Periodic error in the spacing of recorded lines.

GUARD BAND. See BAND, GUARD.

GUARD BAND, TIME. See BAND, TIME GUARD.

HA1-RECEIVER WEIGHTING. See WEIGHTING, HA1-RECEIVER.

HALF-DUPLEX CIRCUIT. See CIRCUIT, HALF-DUPLEX.

HALF-DUPLEX OPERATION. See OPERATION, HALF-DUPLEX.

HALFTONE CHARACTERISTIC (FAX). See CHARACTERISTIC, HALFTONE.

HERTZ. A unit of frequency - one cycle per second, 1 Hz.

HF. High Frequency, 3 - 30 MHz.

HIGH PERFORMANCE EQUIPMENTS. See PERFORMANCE, EQUIPMENTS, HIGH.

Hz. Hertz.

HYBRID COMMUNICATION NETWORK. A communication system which utilizes a combination of trunks, loops, or links some of which are capable of transmitting (and receiving) only analog or quasi-analog signals and some of which are capable of transmitting (and receiving) only digital signals which usually contain a binary pulse signal structure.

ILF. Infra low frequency, 300 - 3000 Hz.

IMPEDANCE, TERMINAL. The complex impedance as seen at the unloaded output terminals of a transmission equipment or line which is otherwise in normal operating condition.

IMPULSE RESPONSE. The time/amplitude output of a channel when the input is stimulated by the insertion of a very short pulse or impulse.

INBAND NOISE POWER RATIO (MULTICHANNEL EQUIPMENT). See NOISE POWER RATIO, INBAND (MULTICHANNEL EQUIPMENT).

INBAND SIGNALLING. See SIGNALLING, INBAND.

IN-CHANNEL NOISE POWER RATIO (MULTICHANNEL EQUIPMENT). See NOISE POWER RATIO, INBAND (MULTICHANNEL EQUIPMENT).

INDEPENDENT SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND, INDEPENDENT.

INDEX OF COOPERATION, DIAMETRAL OR INTERNATIONAL. See COOPERATION, INDEX OF (FAX).

INDEX OF COOPERATION (FAX). See COOPERATION, INDEX OF (FAX).

INFORMATION BIT. See BIT, INFORMATION.

INFORMATION CHANNEL. An information channel is a dimensionless electromagnetic channel between two or more locations for the transmission and reception of information. Dimension is given to the channel by either specifying bandwidth or class of service.

INFORMATION TRANSFER. See TRANSFER, INFORMATION.

INK VAPOR RECORDING (FAX). See RECORDING, INK VAPOR (FAX).

INPUT-OUTPUT DEVICE. See DEVICE, INPUT-OUTPUT.

INSERTION GAIN. See GAIN, INSERTION.

INSERTION LOSS. See LOSS, INSERTION.

INSTANTS, SIGNIFICANT. The instants at which the successive significant conditions recognized by the appropriate device of the modulation or restitution begin. Each of these instants is determined as soon as the appropriate device takes up the significant condition usable for a recording or a processing.

INSTRUMENT, END. A device which is connected to the terminal of a circuit and used to convert usable intelligence into electrical signals or vice-versa.

INTEGRITY, CHARACTER AND BIT COUNT. That condition in which the precise number of characters, or bits, that are originated in a message test (in the case of message communication) or per unit time (in the case of a user to user connection) are preserved.

INTERACTION CROSSTALK COUPLING. Interaction crosstalk coupling between a disturbing and a disturbed circuit in any given section is the vector summation of all possible combinations of crosstalk coupling, within one arbitrary short length, between the disturbing circuit and all circuits other than the disturbed circuit (including phantom and ground return circuits) with crosstalk coupling, within another arbitrary short length, between the disturbed circuit and all circuits other than the disturbing circuit.

INTERCHARACTER INTERVAL. See INTERVAL, INTERCHARACTER.

INTERFACE. A concept involving the specification of the interconnection between two equipments or systems. The specification includes the type, quantity, and function of the interconnection circuits and the type and form of signals to be interchanged via those circuits. Mechanical details of plugs, sockets, pin numbers, etc., are included within the context of the definition.

INTERMEDIATE DISTRIBUTION FRAME (IDF). An intermediate distributing frame in a local central telephone or communications office is a distributing frame, the primary purpose of which is to cross-connect the subscriber-line multiple to the subscriber line circuit. In a private exchange the intermediate distributing frame is for similar purposes.

INTERMODULATION DISTORTION. See DISTORTION, INTERMODULATION.

INTERMODULATION NOISE. See NOISE, INTERMODULATION.

INTERNAL BIAS. See BIAS, INTERNAL.

INTERVAL, CHARACTER. The total number of unit intervals (including synchronizing, intelligence, error checking, or control bits) required to transmit any given character in any given communication system. Extra signals which are not associated with individual characters are not included. For example, additional time added between the end of the customary stop element and the beginning of the next start element as a result of a speed change, buffering, etc., is defined as the intercharacter interval. The intercharacter interval may be of any length and is of the same sense as the stop element, i.e., "1" (marking). See INTERVAL, INTERCHARACTER.

INTERVAL, INTERCHARACTER. That time period between the end of the stop element of one character and the beginning of the following character. The signal sense of the intercharacter interval is always the same as the sense of the stop element; i.e., "1" or marking. See INTERVAL, CHARACTER.

INTERVAL, SIGNIFICANT. Time interval between two consecutive significant instants.

INTERVAL, UNIT. In a system using an equal-length code or in a system during isochronous modulation (or demodulation), that interval of time such that the theoretical durations of the significant intervals of a telegraph modulation are all whole multiples of the interval.

INTRINSIC NOISE. In a transmission path or device, intrinsic noise is that noise which is' inherent to the path or device and is not contingent upon modulation.

INVERSION, BIT. The deliberate or fortuitous changing of the state of a bit to the opposite state.

IONOSPHERIC DISTURBANCES. Occasionally, a sudden outburst of ultraviolet light on the sun, known as a solar flare or chromospheric eruption, produces abnormally high ionization densities in the D region. The result is a sudden increase in radio-wave absorption, which is most severe in the upper MF and lower HF frequencies. The effects on the critical frequencies and heights of the reflecting layers, are negligible but the increase in transmission loss may be enormous. This phenomenon is called a sudden ionospheric disturbance (SID). It often results in a complete loss of communications, and its effects may last for several hours in severe cases. Since the SID is produced by direct ultraviolet radiation, it never occurs on the dark side of the earth. The term SID is used to describe general ionospheric effects of this type of disturbance. The term shortwave fade out (SWF) is also used to describe ionospheric effects of this type.

ISOCHRONOUS MODULATION. See MODULATION, ISOCHRONOUS.

ISOTROPIC ANTENNA. An isotropic antenna is a hypothetical antenna radiating or receiving equally in all directions.

NOTE: In the case of electromagnetic waves, isotropic antennas do not exist physically but represent convenient reference antennas for expressing directional properties of actual antennas.

JITTER (FAX). Raggedness in the received copy caused by erroneous displacement of recorded spots in the direction of scanning.

JITTER, PHASE. See PERTURBATION, PHASE.

KENDALL EFFECT (FAX). See EFFECT, KENDALL (FAX).

KEYING, FREQUENCY-SHIFT, FREQUENCY-SHIFT SIGNALLING (FSK). A frequency change signalling method in which the frequency or frequencies are varied in accordance with the signals to be transmitted and characterized by continuity of phase during the transition from one signalling condition to another.

KEYING, TWO-TONE TELEGRAPH. A system employing a transmission path comprising two channels in the same direction, one for transmission of the spacing elements of binary modulation, the other for transmitting the marking elements of the same modulation.

kHz. kilohertz. 10 to power of 3, hertz.

LENGTH, SCANNING LINE (FAX). The total length of a scanning line is equal to the spot speed divided by the scanning-line frequency.

NOTE: This is generally greater than the length of the available line.

LEVEL, CARRIER NOISE. The noise level produced by undesired variations of a carrier in the absence of any intended modulation.

LEVEL, RELATIVE TRANSMISSION. The ratio of the signal power in a transmission system to the signal power at some point chosen as reference. The ratio is usually determined by applying a standard test tone (See TONE, STANDARD TEST) at zero transmission level reference point (or adjusted test tone power at any other reference point) and measuring the gain or loss to the location of interest. Note should be made as to the distinction between the standard test tone power and the expected median power of the actual signal required as the basis for the design of transmission systems. See TRANSMISSION LEVEL AND ZERO TRANSMISSION LEVEL REFERENCE POINT.

LEVEL, SINGLE-SIDEBAND EQUIPMENT, REFERENCE (Voice-Frequency Input Power to a Transmitter, One Sideband Only). The power of one of two equal tones which together cause the transmitter to develop its full rated peak power output.

LF. Low frequency 30 - 300 kHz.

LIMITER. A device which reduces the power of an electrical signal when it exceeds a specified value. The amount of reduction or compression increases with increase of the input power.

LINE, AVAILABLE (FAX). The portion of the scanning line which can be used specifically for picture signals.

LINE, LOCAL. See LOOP, LINE.

LINE, USEFUL (FAX). See LINE, AVAILABLE.

LINE, USER'S. See LOOP, LINE.

LINEARITY. A constant relationship between signal processing devices' input and output characteristics such as frequency, amplitude, phase, and time, over a designated range. See DISTORTION, NONLINEAR.

LINE LOOP. See LOOP, LINE.

LINE SIDE. See SIDE, LINE.

LINE WIDTH, NOMINAL (FAX). The average separation between centers of adjacent scanning or recording lines.

LINK.

a. A portion of a communication circuit.

b. A channel or circuit designed to be connected in tandem with other channels or circuits.

c. A radio path between two points, called a radio link; the resultant circuit may be unidirectional, half-duplex or duplex.

NOTE: The term "link" should be defined or qualified when used. It is generally accepted that the signals at each end of a link are in the same form.

LISTENERS GRADE OF SERVICE. Listeners grade of service ratings for telephone communications rate the received volume and/or other transmission variables by dividing the circuit performance, as evaluated by listeners' judgment, into three major categories or "Good," "Fair," and "Poor or Worse."

LOADING.

a. Multichannel Communications Systems. The insertion of white noise or equivalent dummy traffic at a specified level, to simulate system traffic performance.

b. Multichannel Telephony Systems.

(1) The loading imposed by the busy-hour traffic (the equivalent mean power and the peak power) as a function of the number of voice channels.

(2) The equivalent power of a multichannel complex or composite signal(s), referred to zero relative level (0 dBr), and is a function of the number of channels and the specified mean voice channel power.

c. The insertion of inductors (coils) into a transmission line or circuit to improve its operating characteristics.

d. The insertion of reactance into a circuit to improve performance.

LOADING CHARACTERISTIC (MULTICHANNEL TELEPHONY SYSTEMS). See CHARACTERISTIC, LOADING.

LOST CALL. Any call which has not been completed for any reason other than cases where the called party (termination) is busy. See ERLANG.

LOCAL LINE. See LOOP, LINE.

LOCAL SIDE. See SIDE, LOCAL.

LONGITUDINAL BALANCE. See BALANCE, LONGITUDINAL.

LOOP. A loop is a single message circuit from a switching center and/or individual message distribution point to the terminals of an end instrument.

LOOP, LINE. The portion of a radio or wire circuit that connects a user's end instrument and a central office. (Synonymous terms are "local line" and "user's line.")

LOSS, CROSSTALK COUPLING (Between a Disturbing and a Disturbed Circuit). The ratio of the power in the disturbing circuit to the induced power in the disturbed circuit, observed at definite points of the circuits under specified terminal conditions; expressed in dB.

LOSS, INSERTION. The insertion loss of a transmission system (or component thereof) inserted between two impedances Z_e (transmitter) and Z_r (receiver) is the ratio of the power measured across the receiver Z_r before insertion of the transmission system considered, to the power measured after insertion; expressed in dB. If the resulting number in dB thus obtained is negative, an insertion gain is indicated.

LOSS, NET (GAIN). Net loss (gain) is the loss (gain) overall of a transmission circuit. It is measured by applying a test signal of some convenient power at the beginning of the circuit and measuring the power delivered at the other end. The ratio of these powers expressed in dB is the net loss or gain of the circuit under observation.

LOSS, RETURN. The return loss at the junction of a transmission line and a terminating impedance is the ratio, expressed in dB, of the reflected wave to the incident wave. More broadly, the return loss is a measure of the dissimilarity between two impedances, being the number of decibels which corresponds to the scalor value of the reciprocal of the reflection coefficient, and hence being expressed by the formula:

$$20 \log_{10} \left| \frac{Z_2 + Z_1}{Z_2 - Z_1} \right| \text{ dB}$$

where Z_1 and Z_2 are the two impedances.

LOW-PERFORMANCE EQUIPMENTS. See PERFORMANCE, EQUIPMENTS, LOW.

MAIN DISTRIBUTION FRAME (MDF). A distributing frame on one part of which terminate the permanent outside lines entering the central telephone or communications office building and on another part of which terminate the subscriber-line multiple cabling, trunk multiple cabling, etc., used for associating any outside line with any desired terminal in such a multiple or with any other outside line. It usually carries the central office protective devices and functions as a test point between line and office. In a private exchange the main distributing frame is for similar purposes. The phrase "outside line" includes radio channels or circuits as appropriate.

MARGIN, SINGING. The singing margin of a transmission circuit is defined as the maximum amount by which the net loss of each of the two directions of transmission in a two-wire circuit that has a four-wire portion may be reduced simultaneously before self-oscillation or feedback occurs.

MARKING PULSE. See PULSE, MARKING.

M-ARY INFORMATION ELEMENT. See N-ARY INFORMATION ELEMENT.

MASTER GROUP. See WIDEBAND SYSTEM.

MASTER REFERENCE SYSTEM FOR TELEPHONE TRANSMISSION. The master reference system for telephone transmission, adopted by the International Advisory Committee for long-distance telephone (CCIF), is a primary reference telephone system for determining, by comparison, the performance of other telephone systems and components with respect to the loudness, articulation, or other transmission qualities of received speech. The determination is made by adjusting the loss of a distortionless trunk in the master reference system for equal performance with respect to the quality under consideration.

MAXIMUM KEYING FREQUENCY (FAX). See FREQUENCY, MAXIMUM KEYING (FAX).

MAXIMUM MODULATING FREQUENCY (FAX). See FREQUENCY, MAXIMUM MODULATING (FAX).

MEAN POWER OF THE TALKER VOLUME DISTRIBUTION. See TALKER VOLUME DISTRIBUTION, MEAN POWER OF THE.

MEAN POWER (RADIO TRANSMITTER). See POWER, MEAN (RADIO TRANSMITTER).

MEAN VOLUME TALKER. See TALKER, MEAN VOLUME.

MEASUREMENT UNITS OF NOISE. See NOISE, MEASUREMENT UNITS.

MEDIUM POWER TALKER. See TALKER, MEDIUM POWER.

MEDIUM, RECORD (FAX). The physical medium on which the facsimile recorder forms an image of the subject copy.

MESSAGE. A communication from a source to one or more destinations in a suitable language.

MESSAGE SWITCHING. See SWITCHING, MESSAGE.

METALLIC CIRCUIT. See CIRCUIT, METALLIC.

METRIC UNITS. Standardization of terms on a world-wide basis is essential to enable universal understanding of scientific and technical documents. The following list of technical terms, abbreviations, and definitions reflects the latest developments in international standardization. Such new terms as "hertz" (meaning one cycle per second) or "siemens" [meaning one mho or 1/(1 ohm)] are being standardized, both to recognize certain pioneers in electromagnetic research and development and to provide terms which are recognized in many of the world's languages.

UNIT	ABBREVIATION	VALUE
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Examples:

TERM*	ABBREVIATION*	MEANING
megahertz	MHz	10^{6} hertz (cycles per second)
decibel	dB	10^{-1} bel
picofarad	pF	1 farad X 10^{-12}
nanosecond	ns	1 second X 10^{-9}

*NOTE:
The initial letter of the fundamental unit is capitalized in the abbreviation if the unit is derived from a proper name, but not capitalized when spelling out the unit.

MF. Medium Frequency, 300 to 3000 kHz.

MHz. Megahertz. 10 to power of 6, hertz.

MODEM. Acronym for MOdulator-DEModulator.

MODULATION. The process of varying some characteristic(s) of the carrier wave in accordance with the instantaneous value of samples of the intelligence to be transmitted. See CARRIER.

MODULATION, AMPLITUDE (AM). That form of modulation in which the amplitude of the carrier is varied in accordance with the instantaneous value of the modulating signal.

MODULATION, DELTA. A technique for converting an analog signal to a digital signal. The technique approximates the analog signal with a series of segments. The approximated signal is compared to the original analog wave to determine an increase or decrease in relative amplitude. The decision process for establishing the state of successive binary digits is determined by this comparison. Only the change information, an increase or decrease of the signal amplitude from the previous sample, is sent; thus, a no-change condition remains at the same 0 or 1 state of the previous sample. There are several variations of the simple delta-modulation system.

MODULATION, DIFFERENTIAL. A type of modulation in which the choice of the significant condition for any signal element is dependent on the choice for the previous signal element. Delta modulation is an example.

MODULATION FACTOR. The ratio of the peak variation actually used to the maximum design variation in a given type of modulation.

NOTE: In conventional amplitude modulation the maximum design variation is considered that for which the instantaneous amplitude of the modulated wave reaches zero. (When 0 is reached the modulation is considered 100%).

MODULATION, FIXED-REFERENCE. A type of modulation in which the choice of the significant condition for any signal element is based on a fixed reference.

MODULATION, FREQUENCY (FM). That form of modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating signal.

MODULATION INDEX.

a. Modulation index of an amplitude-modulated wave. See MODULATION FACTOR.

b. Modulation index of a frequency-modulated wave. The ratio of the peak deviation to the frequency of a specified sinusoidal modulation.

c. In angle modulation with a sinusoidal modulating wave, the ratio of the frequency deviation to the frequency of the modulating wave.

MODULATION, ISOCHRONOUS. Modulation (or demodulation) in which the time interval separating any two significant instants is theoretically equal to the unit interval or to a multiple of this.

MODULATION, PHASE (PM). That form of modulation in which the angle relative to the unmodulated carrier angle is varied in accordance with the instantaneous value of the amplitude of the modulating signal.

MODULATION, PULSE-AMPLITUDE (PAM). That form of modulation in which the amplitude of the pulse carrier is varied in accordance with successive samples of the modulating signal.

MODULATION, PULSE-CODE (PCM). That form of modulation in which the modulating signal is sampled and the sample quantized and coded so that each element of information consists of different kinds and/or numbers of pulses and spaces.

MODULATION, PULSE-FREQUENCY (PFM). That form of modulationin which the pulserepetition frequency of the carrier is varied in accordance with successive samples of the modulating signal.

MODULATION, PULSE-TIME (PTM). That form of modulation in which the time of occurrence of some characteristic(s) of the pulse carrier is varied in accordance with successive samples of the modulating signal. (This includes pulse position and pulse duration or pulse-width modulation).

MODULATION RATE. See RATE, MODULATION.

MODULATION, SIGNIFICANT CONDITION OF. A condition assumed by the appropriate device corresponding to the quantized value (or values) of the characteristic (or characteristics) chosen to form the modulation. The following equivalent designations are used to identify the significant conditions for binary modulation:

PASSIVE	ACTIVE
0	1
Current Off	Current On
Tone Off	Tone On
Space	Mark
-	+
No hole (paper tape)	Hole (paper tape)
Frequency High	Frequency Low

MODULATION WITH A FIXED REFERENCE. A type of modulation in which the choice of the significant condition for any signal element is based on a fixed reference.

MULTIPATH. The situation in which an emitted signal arrives at its destination over several propagation paths and, hence, is smeared or delayed in time.

MULTIPLE SPOT SCANNING (FAX). See SCANNING, MULTIPLE SPOT.

MULTIPLEX. Use of a common channel in order to make two or more channels, either by splitting of the frequency band transmitted by the common channel into narrower bands, each of which is used to constitute a distinct channel (frequency-division multiplex), or by allotting this common channel in turn to constitute different intermittent channels (time-division multiplex).

MULTIPLEX, FREQUENCY-DIVISION (FDM). A method of deriving two or more simultaneous, continuous channels from a transmission medium connecting two points by assigning separate portions of the available frequency spectrum to each of the individual channels.

MULTIPLEX, TIME-DIVISION (TDM). A method of deriving several channels from a given frequency spectrum by assigning discrete time intervals in sequence to the different channels. During a given time interval the entire available frequency spectrum can be used by the channel to which it is assigned. In general, time division multiplex systems use pulse transmission. The multiplex pulse train may be considered to be the interleaved pulse trains of the individual channels. The individual channel pulses may be modulated either in an analog or a digital manner.

MULTIPLEX BASEBAND. See BASEBAND, MULTIPLEX.

MULTIPLEX BASEBAND RECEIVE TERMINALS. See TERMINALS, MULTIPLEX BASEBAND RECEIVE.

MULTIPLEX BASEBAND SEND TERMINALS. See TERMINALS, MULTIPLEX BASEBAND SEND.

MUX. A shorthand reference to multiplex.

N-ARY INFORMATION ELEMENT. An information element enabling the presentation of "N" distinct states. "M"-ary code is the generic name applied to all multilevel codes.

NEAR-END CROSSTALK. See CROSSTALK, NEAR-END.

NECESSARY BANDWIDTH. See BANDWIDTH, NECESSARY.

NET OPERATION. See OPERATION, NET.

NEUTRAL DIRECT-CURRENT TELEGRAPH SYSTEM. See SYSTEM, NEUTRAL DIRECT-CURRENT TELEGRAPH.

NODE. (Also called Junction Point, Branch Point, or Vertex). A terminal of any branch of a network or a terminal to two or more branches of a network.

NOISE, EQUIVALENT PCM. The amount of thermal noise power which has a similar effect on the speech quality as any given amount of quantizing noise. One method of measuring equivalent PCM noise consists of comparing subjective listener tests of speech received through two parallel audio channels. In one channel, the speech is transmitted in digitized form derived from PCM; in the other channel, the same speech is transmitted in analog (non-digitized) form. For this comparison, the thermal noise in the non-digitized speech channel is simulated by a noise generator which has an adjustable noise power output. An amount of thermal noise power in the non-digitized speech channel can be determined such that the thermal noise has a similar effect on the speech quality as the quantizing noise which is generated in the PCM channel. The amount of thermal noise power determined by this comparison is called the equivalent PCM noise.

NOISE FIGURE (NOISE FACTOR - NF). The noise figure of a transducer; i.e., radio receiver, is the ratio of: (1) the output noise power to (2) the portion thereof attributable to thermal noise in the input termination at standard noise temperature (usually 290°K). The noise figure is thus the ratio of actual output noise to that which would remain if the transducer itself were made noiseless.

NOTE: In heterodyne systems, output noise power (1) includes spurious contributions from image-frequency transformations, but portion (2) includes only that which appears in the output via the principal-frequency transformation of the system and excludes that which appears via the image-frequency transformation.

NOISE, INTERMODULATION. In a transmission path or device, that noise which is contingent upon modulation and which results from any nonlinear characteristics in the path or device.

NOISE LEVEL (CHANNEL). The channel noise level at any point in a transmission system is the ratio of the channel noise at that point to some arbitrary amount of circuit noise chosen as a reference. This ratio is usually expressed in decibels above reference noise, abbreviated dBrn, signifying the reading of a circuit noise meter; or in adjusted decibels, abbreviated dBa, signifying circuit noise meter reading adjusted to represent interfering effect under specified conditions.

NOISE, MEASUREMENT UNITS. Noise is usually measured in terms of power, either relative or absolute. The decibel is the base unit for these measurements. A suffix is usually added to denote a particular reference base or specific qualities of the measurement. (See WEIGHTING, NOISE.) Noise measurement units defined in this standard are dBa, dBa(F1A), dBa(HA1), dBa0, dBm, dBm0, dBmPsoph, dBm0p, dBrn, dBrn(144-line), dBrn(144-receiver), dBrn(C-message), dBrnc, dBrnc0, dBrn (f_1 - f_2), pW, and pWp.

NOISE POWER OF A RADIO TRANSMITTER (PN). See POWER, NOISE, OF A RADIO TRANSMITTER (PN).

NOISE POWER RATIO, INBAND (NPR) (MULTICHANNEL EQUIPMENT). The noise power ratio, for multichannel equipment, is the ratio of the mean noise power measured in any channel, with all channels loaded with white noise, to the mean noise power measured in the same channel, with all channels but the measured channel loaded with noise.

NOISE POWER RATIO, SINGLE SIDEBAND (NPR) (SSB). NPR (SSB) is the ratio of the mean noise powers measured in the notch filter bandwidth for the notch-in and the notch-out conditions with total system mean noise power output equal for both conditions.

NOISE, QUANTIZING. In a modulation system that employs a quantizing process, quantizing noise is that noise caused by the error of approximation. It is an undesirable random distortion signal which is solely dependent on the particular quantization process used and the statistical characteristics of the quantized signal.

NOISE RATIO, SIGNAL-PLUS-NOISE TO. A ratio of the signal plus noise arriving at a location in a transmission path to the noise normally presenc when the signal is removed at the sending end and replaced by a termination. This usually is measured in dB and the process is abbreviated SNR.

NOISE WEIGHTING. See WEIGHTING, NOISE.

NOMINAL BANDWIDTH. See BANDWIDTH, NOMINAL.

NOMINAL LINE WIDTH (FAX). See LINE WIDTH, NOMINAL (FAX).

NONLINEAR DISTORTION. See DISTORTION, NONLINEAR.

NOTATION, BINARY. A scheme for representing numbers which is characterized by the arrangements of digits in sequence with the understanding that successive digits are interrpreted as coefficients of successive powers of the base two.

NPR. Noise power ratio.

NUMBER, BINARY. A number expressed in binary notation.

OBJECTIVE, DESIGN (DO). An electrical (or mechanical) performance characteristic for communication circuits and equipments which is based on engineering judgment of performance desired but which, for a number of reasons, it is not considered feasible to establish as a STANDARD at the time this standard is written. Examples of reasons for designating a performance characteristic as a DO rather than as an S are: (1) it may be bordering on an advancement in state-of-the-art, (2) the requirement may not have been fully confirmed by measurement or experience with operating circuits, (3) it may not have been demonstrated that it can be met considering other constraints such as cost, size, etc. A DO shall be considered as guidance for Department of Defense agencies in preparation of specifications for development or procurement of new equipment or systems which shall be used if technically and economically practicable at the time such specifications are written. See also STANDARDS, SYSTEM.

OCCUPIED BANDWIDTH. See BANDWIDTH, OCCUPIED.

OFFICE, CENTRAL. See CENTER, SWITCHING.

ONE-WAY REVERSIBLE OPERATION. See OPERATION, ONE-WAY REVERSIBLE.

OPEN-CIRCUIT WORKING. See CIRCUIT WORKING, OPEN.

OPERATION, BROADCAST. That type of operation in which a transmitting point emits information which may be received by one or more stations.

OPERATION, CONFERENCE.

a. In a telephone system, that type of operation in which more than two stations can carry on a conversation.

b. In telegraph or data transmission, that form of simplex or half-duplex operation in which more than two stations may simultaneously exchange information, carry on conversations, or pass messages among one another.

NOTE: In radio systems, the stations receive simultaneously, but must transmit one at a time. The common modes are "push-to-talk" (telephone) and "push-to-type" (telegraph, data transmission).

OPERATION, DUPLEX. That type of operation in which simultaneous two-way conversations, messages, or information may be passed between any two given points.

OPERATION, FULL-DUPLEX. See OPERATION, DUPLEX.

OPERATION, HALF-DUPLEX. That type of simplex operation which uses a half-duplex circuit.

OPERATION, NET. Nets (netted operations) are ordered conferences whose participants have common information in needs or like functions to perform. Nets are characterized by adherence to standard formats. They are responsive to a common supervisor entitled the Net Controller (Net Control Station) whose functions include permitting access to the Net and maintaining circuit discipline.

OPERATION, ONE-WAY REVERSIBLE. Similar to half-duplex operation.

OPERATION, PUSH-TO-TALK. (Press-to-talk). In telephone systems, that method of communication over a speech circuit in which transmission occurs from only one station at a time, the talker being required to maintain a switch closure while he is talking.

OPERATION, PUSH-TO-TYPE. (Press-to-type). In telegraph or data transmission systems, that method of communication in which the operator must maintain a switch closure in order to send from his station. It is generally used in radio systems where the same frequency is employed for transmission and reception.
NOTE: This is a derivative form of transmission and may be used in simplex, half-duplex or duplex operation.

OPERATION, SIMPLEX. That type of operation which permits the transmission of signals in either direction alternately.

NOTE: In radio telegraph or data transmission systems, it may be either (1) the use of one frequency, time slot, or code address for transmission and another frequency, time slot, or code address for reception, or (2) the use of the same frequency, time slot, or code address for both transmission and reception. In wire telegraph systems, simplex operation may be employed over either a half-duplex circuit or over a neutral direct-current circuit.

OPERATION, SPEECH-PLUS-DUPLEX. That method of operation in which speech and telegraphy (duplex or simplex) are transmitted simultaneously over the same circuit, being kept from mutual interference by use of filters.

OPERATION, UNIDIRECTIONAL (SEND ONLY, RECEIVE ONLY). A method of operation between two terminals, one of which is a transmitter and the other a receiver.

ORDER WIRE. See WIRE, ORDER.

OUT-OF-BAND SIGNALLING. See SIGNALLING, OUT-OF-BAND.

OUTPUT RATING. See POWER.

OVERHEAD BIT. See BIT, OVERHEAD.

PAIRING, BIT. The practice of establishing, within a code set, a number of subsets of two characters having identical bit representations except for the state of a specified bit. For example: In the ITA Number 5 and the American Standard Code for Information Interchange (ASCII), the upper-case letters differ from their respective lower-case letters only by the state of bit six.

PAIRED CABLE. A cable consisting of one or more twisted pairs or lines.

PARALLEL TRANSMISSION. See TRANSMISSION, PARALLEL.

PARITY BIT. See BIT, PARITY.

PARITY CHECK. A summation check in which the binary digits in a character or word are added, modulo 2, and the sum checked against a single, previously-computed parity digit; i.e., a check which tests whether the number of ones in a word is odd or even. Synonymous and related to "check, redundant" and to "check, forbidden combination." Odd Parity is standard for military transmission.

PATTERN, ADDRESS. In a digital system,a prescribed recurring pattern of bits transmitted during a digital transmission to enable the receiver to achieve frame synchronization.

PBX. See PRIVATE BRANCH EXCHANGE.

PEAK ENVELOPE POWER (RADIO TRANSMITTER). See POWER, PEAK ENVELOPE (RADIO TRANSMITTER).

PEAK POWER OUTPUT. The output power averaged over the radio frequency cycle having the maximum peak value which can occur under any combination of signals transmitted.

PERFORMANCE, EQUIPMENTS, HIGH. Those equipments having sufficiently exacting characteristics to permit their use in trunk or link circuits. Those equipments designed primarily for use in global and tactical service which are required to operate where the maximum performance and minimum electromagnetic interference capabilities are required for operation in a variety of nets or for fixed point-to-point circuits.

NOTE: Requirements for global and tactical high-performance equipments may differ.

PERFORMANCE, EQUIPMENTS, LOW. Those equipments having insufficiently exacting characteristics to permit their use in trunk or link circuits. Such equipments may be employed in loop circuits whenever they meet loop circuit requirements. Those tactical ground and airborne equipments whose size, weight, and complexity must be kept to a minimum and where the primary requirement is to operate in nets with similar minimum performance standards.

PERTURBATION, PHASE (PHASE JITTER). The existence of this phenomenon has long been recognized by telephone transmission engineers; however, due to the relative insensitivity of the human ear to this form of channel disturbance, relatively little attention has been paid to it. Attention is called to this phenomenon because of the serious detrimental impact it can have on data transmission, particularly that type of modulation which is dependent on the signal phase more than the amplitude or frequency. It is not precisely defined since so little widely-understood or agreed upon technical data exists. For purpose of a working definition, therefore, Phase Perturbation or Phase Jitter is defined as that phenomena which, from causes known or unknown, results in a relative shifting (often quite rapid) in the phase of the signal.

The shifting in phase may appear to be random, cyclic, or both. It is noted that a similar phenomenon related to amplitude perturbation exists which is also not sufficiently understood to be acceptably defined at this time.

The amount of pnase perturbation may be expressed in degrees with any cyclic component expressed in hertz. The instantaneous relative phase may or may not be significant, however, for the sake of clarity it should be assumed a phase perturbation of 36° would be taken to mean $\pm 18^{\circ}$ relative to a single sine wave signal, or $+36^{\circ}$ would assume leading shifting in phase of 36°.

PHASE DELAY (FAX). See DELAY, PHASE (FAX).

PHASE DEVIATION. Phase deviation, in phase modulation, is the peak difference between the instantaneous angle of the modulated wave and the angle of the carrier.

PHASE DISTORTION. See DISTORTION, DELAY.

PHASE EQUALIZER. See DELAY EQUALIZER.

PHASE FREQUENCY DISTORTION. That form of distortion which occurs under either or both of the following conditions:

a. If the phase/frequency characteristic is not linear over the frequency range of interest.

b. If the zero-frequency intercept of the phase/frequency characteristic is not zero or an integral multiple of 2π radians.

PHASE MODULATION. See MODULATION, PHASE.

PHASE PERTURBATION (PHASE JITTER). See PERTURBATION, PHASE.

PHASING (FAX). The adjustment of picture position along the scanning line.

PHOTOSENSITIVE RECORDING (FAX). See RECORDING, PHOTOSENSITIVE (FAX).

PICTURE FREQUENCIES (FAX). See FREQUENCIES, PICTURE (FAX).

PILOT.

a. A signal wave, usually a single frequency, transmitted over the system for supervisory, control, synchronization, or reference purposes. Sometimes it is necessary to employ several independent pilot frequencies. Most radio relay systems use radio or continuity pilots of their own but transmit also the pilot frequencies belonging to the carrier frequency multiplex system.

b. In a transmission system - a signal wave, usually a single frequency, transmitted over the system and used for either level control, synchronization, or both.

PLESIOCHRONOUS (IN THE PROCESSING). Two signals are plesiochronous if their corresponding significant instants occur at nominally the same rate, any variations being constrained within a specified limit. See TRANSMISSION, ASYCHRONOUS, also MODULATION, ISOCHRONOUS.

POLAR DIRECT-CURRENT TELEGRAPH SYSTEM. See SYSTEM, POLAR DIRECT-CURRENT TELEGRAPH.

POLARIZATION DIVERSITY. See DIVERSITY, POLARIZATION.

POWER, CARRIER (PC) (RADIO TRANSMITTER). The average power supplied to the antenna transmission line by a transmitter during one radio-frequency cycle under conditions of no modulation. This definition does not apply to pulse-modulated emissions or FSK.

POWER, EFFECTIVE RADIATED (ERP). The power supplied to the antenna multiplied by the relative gain of the antenna in a given direction.

POWER GAIN OF AN ANTENNA. The power gain of an antenna is 4π times the power delivered to a unit solid angle divided by the power delivered to 4π steradians.

POWER LEVEL. The power level at any point in a transmission system is the ratio of the power at that point to some arbitrary amount of power chosen as a reference. This ratio is usually expressed either in decibels referred to one milliwatt, abbreviated dBm, or in decibels referred to one watt, abbreviated dBw.

POWER, MEAN (PM) (RADIO TRANSMITTER). The power supplied to the antenna transmission line by a transmitter during normal operation, averaged over a time sufficiently long compared with the period of the lowest frequency encountered in the modulation. A time of 1/10 second during which the mean power is greatest will be selected normally.

POWER, NOISE (PN) (RADIO TRANSMITTER). The mean power supplied to the antenna transmission line by a transmitter when loaded with white noise having a Gaussian amplitude distribution.

POWER, PEAK ENVELOPE (PEP) (RADIO TRANSMITTER). The power supplied to the antenna transmission line by a transmitter during one radio-frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation.

POWER RATIO, SINGLE SIDEBAND, NPR (SSB). See NOISE POWER RATIO, SINGLE SIDEBAND, NPR (SSB).

PRIMARY DISTRIBUTION SYSTEM. A system of alternating current distribution for supplying the primaries of distribution transformers from the generating station or substation distribution buses.

PRIVATE BRANCH EXCHANGE (PBX). An internal telephone exchange serving a single organization and having connections to a public telephone exchange.

PROGRAMMER.

a. That part of a digital apparatus having the function of controlling the timing and sequencing of operations.

b. A person who prepares sequences of instructions for a computer.

PSOPHOMETRIC VOLTAGE. See VOLTAGE, PSOPHOMETRIC.

PSOPHOMETRIC WEIGHTING. See WEIGHTING, PSOPHOMETRIC.

PSOPHOMETRICALLY WEIGHTED dBm. See dBm (Psoph) and dBmOp.

PULSE. A signal characterized by the rise and decay in time of a quantity whose value is normally constant.

PULSE-AMPLITUDE MODULATION. See MODULATION, PULSE-AMPLITUDE.

PULSE-CODE MODULATION. See MODULATION, PULSE-CODE.

PULSE DECAY TIME. See DECAY TIME, PULSE.

PULSE DURATION (PULSE LENGTH - PULSE WIDTH). The time interval between points on the leading and trailing edges at which the instantaneous value bears a specified relation to the peak pulse amplitude.

PULSE-FREQUENCY MODULATION. See MODULATION, PULSE-FREQUENCY.

PULSE, MARKING (TTY). That significant condition of a modulation which results in an active selecting operation in a receiving apparatus. See MODULATION, SIGNIFICANT CONDITION OF A.

PULSE-POSITION MODULATION. A form of pulse-time modulation in which the positions in time of pulses are varied, without modifying their duration. Pulse-position modulation is pulse-time modulation in which the value of each instantaneous sample of a modulating wave modulates the position in time of a pulse.

PULSE RISE TIME. See RISE TIME, PULSE.

PULSE, SPACING (TTY). That significant condition of a modulation which results in a passive selecting operation in a receiving apparatus. See MODULATION, SIGNIFICANT CONDITION OF A.

PULSE-TIME MODULATION. See MODULATION, PULSE-TIME.

PUSH-TO-TALK OPERATION. See OPERATION, PUSH-TO-TALK.

PUSH-TO-TYPE OPERATION. See OPERATION, PUSH-TO-TYPE.

pW. (Picowatt. Equal to 10^{-12} Watt or -90 dBm). A unit of absolute power commonly used for both weighted and unweighted noise. Context must be observed.

PwP (pW, PSOPHOMETRICALLY WEIGHTED). See pW and WEIGHTING, NOISE.

QUADDED CABLE. A quadded cable is formed by taking 4, or multiples of 4, paired cables and twisting these together within an overall jacket.

QUADRUPLE DIVERSITY. See DIVERSITY, QUADRUPLE.

QUANTIZATION. The process of converting the exact sample values of a signal wave to their nearest equivalent in a finite set of discrete values to permit digital encoding.

QUANTIZING NOISE. See NOISE, QUANTIZING.

QUASI-ANALOG SIGNAL. See SIGNAL, QUASI-ANALOG.

RADIO BASEBAND RECEIVE TERMINALS. See TERMINALS, RADIO BASEBAND RECEIVE.

RADIO BASEBAND SEND TERMINALS. See TERMINALS, RADIO BASEBAND SEND.

RADIO BASEBAND. See BASEBAND, RADIO.

RADIO FIELD INTENSITY (FIELD STRENGTH). The electric or magnetic field intensity at a given location associated with the passage of radio waves. It is commonly expressed in terms of the electric field intensity (microvolts or volts per meter). In the case of a sinusoidal wave, the root-mean-square value is commonly used. Unless otherwise stated, it is taken in the direction of maximum field intensity.

RANDOM BINARY BIT STREAM SIGNALLING. See SIGNALLING, RANDOM BINARY BIT STREAM.

RATE, DATA SIGNALLING. See Paragraph 4.3.1.1 "Modulation and Data Signalling".

RATE, ERROR (BIT, BLOCK, CHARACTER, ELEMENT). The ratio of the number of bits, elements, characters, or blocks incorrectly received to the total number of bits, elements, characters, or blocks sent. See BIT ERROR RATE.

RATE, MODULATION. Reciprocal of the unit interval measured in seconds. (This rate is expressed in bauds).

RATING, OUTPUT. See POWER.

REAL TIME.

a. Using an ordinary clock as a time standard, real time is the number of seconds measured between two events in a physical system.

b. Computer Time is the number of seconds measured, with the same clock, between corresponding events in the simulated system.

c. The ratio of the time interval between two events in a simulated system to the time interval between the corresponding events in the physical system is the Time Scale. Computer Time is equal to the product of Real Time and the Time Scale.

d. Real-Time computation is computer operation in which the Time Scale is unity. Machine Time is synonymous with Computer Time.

RECEIVER, FACSIMILE. The apparatus employed to translate the signal from the communication channel into a facsimile record of the subject copy.

RECEIVING CONVERTER, FACSIMILE. See CONVERTER, FACSIMILE RECEIVING.

RECEPTION, EXALTED CARRIER. A method of receiving either amplitude or phase modulated signals in which the carrier is separated from the sidebands, filtered and amplified, and then combined with the sidebands again at a higher level prior to demodulation.

RECORD MEDIUM (FAX). See MEDIUM, RECORD (FAX).

RECORD SHEET (FAX). See SHEET, RECORD (FAX).

RECORDED SPOT X DIMENSION (FAX). See SPOT, X DIMENSION OF RECORDED (FAX).

RECORDED SPOT Y DIMENSION (FAX). See SPOT, Y DIMENSION OF RECORDED (FAX).

RECORDED SPOT (FAX). See SPOT, RECORDED (FAX).

RECORDER, FACSIMILE. That part of the facsimile receiver which performs the final conversion of electrical picture signal to an image of the subject copy in the record medium.

RECORDING (FAX). The process of converting the electrical signal to an image on the record medium.

RECORDING, DIRECT (FAX). That type of recording in which a visible record is produced, without subsequent processing, in response to the received signals.

RECORDING, ELECTROCHEMICAL (FAX). Recording by means of a chemical reaction brought about by the passage of signal-controlled current through the sensitized portion of the record sheet.

RECORDING, ELECTROLYTIC (FAX). That type of electromechanical recording in which the chemical change is made possible by the presence of an electrolyte.

RECORDING, ELECTROMECHANICAL (FAX). Recording by means of a signal-actuated mechanical device. field.

RECORDING, ELECTROSTATIC (FAX). Recording by means of a signal-controlled electrostatic field.

RECORDING, ELECTROTHERMAL (FAX). That type of recording which is produced principally by signal-controlled thermal action.

RECORDING, INK VAPOR (FAX). That type of recording in which vaporized ink particles are directly deposited upon the record sheet.

RECORDING, PHOTOSENSITIVE (FAX). Recording by the exposure of a photosensitive surface to a signal-controlled light beam or spot.

RECORDING, SPOT (FAX). See SPOT, RECORDING (FAX).

REDUCED OR SUPPRESSED CARRIER SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND, DOUBLE, REDUCED OR SUPPRESSED CARRIER.

REDUNDANT CODE. See CODE, REDUNDANT.

REFERENCE FREQUENCY. See FREQUENCY, REFERENCE.

REFERENCE LEVEL, SINGLE-SIDEBAND EQUIPMENT. (Voice-Frequency Input Power to a Transmitter, One Sideband Only). The power of one of two equal tones which together cause the transmitter to develop its full rated power output.

REFERENCE POINT, ZERO TRANSMISSION LEVEL. See ZERO TRANSMISSION LEVEL POINT.

REFERENCE TRANSMISSION LEVEL POINT. See TRANSMISSION LEVEL.

REFLECTION COEFFICIENT. See COEFFICIENT, REFLECTION.

REFLECTION LOSS.

a. That part of a transition loss due to the reflection of power at the discontinuity.

b. The ratio in decibels of the power incident upon the discontinuity to the difference between the power incident upon and the power reflected from the discontinuity.

c. The ratio in decibels between the incident and reflected wave. A measure of impedance match.

REGENERATIVE REPEATER. See REPEATER, REGENERATIVE.

RELATIVE TRANSMISSION LEVEL. See LEVEL, RELATIVE TRANSMISSION.

REMOTE CONTROL EQUIPMENT. See CONTROL EQUIPMENT, REMOTE.

REPEATER. A device which amplifies or reshapes and/or retimes an input signal for further retransmission. It may be of either a one-way or two-way type.

REPEATER, BROADCAST. A repeater connecting several channels, one incoming and the others outgoing.

REPEATER, CONFERENCE. A repeater connecting several circuits which receives telegraph signals from any one of the circuits and automatically retransmits them over all the others.

REPEATER, REGENERATIVE. A repeater in which the signals retransmitted are reshaped and retimed.

REPRODUCTION SPEED (FAX). See SPEED, REPRODUCTION (FAX).

RESIDUAL ERROR RATE. See ERROR RATE, RESIDUAL.

RESTITUTION (DEMODULATION). Series of significant conditions determined by the decisions mode according to the products of the demodulation process. See also DEMODULATION.

RETURN LOSS. See LOSS, RETURN.

RF BANDWIDTH. See BANDWIDTH, RF.

RINGDOWN SIGNALLING. See SIGNALLING, RINGDOWN.

RISE TIME, PULSE. The time required for the instantaneous amplitude to go from 10% to 90% of the peak value.

ROTARY SWITCH. See SWITCH, ROTARY.

RTTY. A shorthand reference to radio-teletypewriter.

SAMPLING FREQUENCY. See FREQUENCY, SAMPLING.

SCANNER (FAX). That part of the facsimile transmitter which systematically translates the densities of the subject copy into signal-wave form.

SCANNING (FAX). The process of analyzing successively the densities of the subject copy according to the elements of a predetermined pattern.

SCANNING, DIRECTION OF (FAX). At the transmitting apparatus, the plane (developed in the case of a drum transmitter) of the message surface is scanned along lines running from right to left commencing at the top so that scanning commences at the top right-hand corner of the surface and finishes at the bottom left-hand corner; this is equivalent to scanning over a right-hand helix on a drum. The orientation of the message on the scanning plane will depend upon its dimensions and is of no consequence.

NOTE: The normal scanning is from left to right and top to bottom of the subject copy as when reading a page of print. Reverse direction is from right to left and top to bottom of the subject copy. The IEEE, ANSI, and WMO Standards consider the normal scanning direction to be from left to right.

At the receiving apparatus scanning takes place from right to left and top to bottom (in the above sense) for "positive" reception and from left to right and top to bottom (in the above sense) for "negative" reception.

NOTE: This is the CCITT Standard for Phototelegraphic apparatus. (See SCANNING (FAX)).

SCANNING, ELECTRONIC LINE (FAX). That method of scanning which provides motion of the scanning spot along the scanning line by electronic means.

SCANNING-LINE FREQUENCY (FAX). See SPEED, STROKE (FAX).

SCANNING-LINE LENGTH (FAX). See LENGTH, SCANNING LINE (FAX).

SCANNING, MULTIPLE-SPOT (FAX). That method in which scanning is carried on simultaneously by two or more scanning spots, each one analyzing its fraction of the total scanned area of the subject copy.

SCANNING, SIMPLE (FAX). Scanning of only one scanning spot at a time during the scanning process.

SCANNING SPOT X DIMENSION (FAX). See SPOT, X DIMENSION OF SCANNING (FAX).

SCANNING SPOT Y DIMENSION (FAX). See SPOT, Y DIMENSION OF SCANNING (FAX).

SCANNING SPOT (FAX). See SPOT, SCANNING (FAX).

SELECTIVE FADING. See FADING, SELECTIVE.

SENSITIVITY, RADIO RECEIVER. The sensitivity of a radio receiver or similar device is taken as the minimum input signal required to produce a specified output signal having a specified signal-to-noise ratio. This signal input may be expressed as power in dBm or as voltage uv/m, with input network impedance stipulated.

SERIAL TRANSMISSION. See TRANSMISSION, SERIAL.

SERVICE BIT. See BIT, SERVICE.

SET, CHARACTER. A "character set" as used herein is a basic group of defined numeric, alphabetic, punctuation, and special-symbol characters of one style. The term is most meaningful when accompanied by a qualifying descriptor, For example: The graphic character set of USASCII.

SET, CODE. See ALPHABET, DIGITAL.

SHEET, RECORD (FAX). The medium which is used to produce a visible image of the subject copy in record form. The record medium and the record sheet may be identical.

SHF. Super High Frequency, 3 to 30 GHz.

SIDE, LINE. That portion of a device which looks toward the transmission path (line circuit, loop, trunk).

SIDE, LOCAL. That portion of a device which looks toward the internal station facilities.

SIDEBANDS. The spectral energies distributed above and below a carrier resulting from a modulated process.

SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND.

SIDETONE, TELEPHONE. The transmission and reproduction of sounds through a local path from transmitting transducer to the receiving transducer of the same telephone set in order that the talker may hear his voice in the receiver.

SIGNAL, ANALOG. A nominally-continuous electrical signal that varies in some direct correlation to a signal impressed on a transducer. The electrical signal may vary its frequency or amplitude, for instance, in response to change in phenomena or characteristics such as sound, light, heat, position, or pressure.

SIGNAL CONTRAST (FAX). See CONTRAST, SIGNAL (FAX).

SIGNAL CONVERTER. See CONVERTER, SIGNAL.

SIGNAL, DIGITAL. A nominally-discontinuous electrical signal that changes from one state to another in discrete steps. The electrical signal could change its amplitude or polarity, for instance, in response to outputs from computers, teletypewriters, etc. Analog signals may be converted to a digital form by quantizing.

SIGNAL ELEMENT. See ELEMENT, SIGNAL.

SIGNAL, FACSIMILE (PICTURE SIGNAL). A signal resulting from the scanning process.

SIGNAL FREQUENCY (FAX). See FREQUENCY SHIFT, SIGNAL (FAX).

SIGNAL LEVEL, FACSIMILE. The maximum facsimile signal power or voltage (rms or dc) measured at any point in a facsimile system.

NOTE: The signal level may be expressed in decibels with respect to some standard value such as 1 milliwatt.

SIGNAL-PLUS-NOISE TO NOISE RATIO. See NOISE RATIO, SIGNAL-PLUS-NOISE TO.

SIGNAL, QUASI-ANALOG. A quasi-analog signal is a digital signal after conversion to a form suitable for transmission over a specified analog channel. The specification of an analog channel would include frequency range, frequency bandwidth, S/N ratio, and envelope delay distortion. When this form of signalling is used to convey message traffic over dialed-up telephone systems, it is often referred to as voice-data.

SIGNAL, STANDARD TEST. A test signal of 1000 Hz $\pm$ 25 Hz. When inserted into an audio circuit at a Zero Transmission Level Point (OTLP), it must have a power level of 1 milliwatt (0 dBm). When inserted at other TLP's in a circuit its power level must be varied accordingly.

NOTE: The Standard Test Signal in CCITT recommendations is 800 Hz.

SIGNAL, START (FAX). A signal which initiates the transfer of a facsimile equipment condition from standby to active.

SIGNAL, START RECORD (FAX). A signal used for starting the process of converting the electrical signal to an image on the record sheet.

SIGNAL, STOP (FAX). A signal used for stopping the process of converting the electrical signal to an image on the record sheet.

SIGNAL, SYNCHRONIZING (FAX). Maintenance of predetermined speed relations between the scanning spot and recording spot within each scanning line.

SIGNAL TRANSITION. See TRANSITION, SIGNAL.

SIGNAL, VOICE-DATA. See SIGNAL, QUASI-ANALOG.

SIGNALLING, COMMON BATTERY. A method of actuating a line or supervisory signal at the distant end of a telephone line by the closure of a dc circuit.

SIGNALLING, CX. Composite signalling (CX) is a signalling arrangement to provide means for direct current and dial pulsing beyond the range of loop signalling methods. CX, like DX signalling, permits duplex operation in that it provides simultaneous two-way signalling.

SIGNALLING, DX. DX signalling (a direct-current signalling unit) is a method whereby the signalling circuit E&M leads use the same cable pair as the voice circuit and no filter is required to separate the signalling frequency from the voice transmission.

SIGNALLING, E&M LEAD. An arrangement whereby communication between a trunk circuit and a separate signalling unit is accomplished over two leads; the "E" lead, which rEceives open or ground signals from the signalling unit, and the "M" lead, which transMits battery or ground signals to the signalling equipments. (Historically, the E&M leads got their names by being vacant or available pins on connectors then in use.)

SIGNALLING, FREQUENCY CHANGE. A signalling method in which one or more particular frequencies corresponds to each desired signalling condition of a code. The transition from one set of frequencies to the other may be either a continuous or a discontinuous change in frequency or in phase.

SIGNALLING, FREQUENCY EXCHANGE (TWO-SOURCE FREQUENCY KEYING). A frequency change signalling method in which the change from one signalling condition to another is accompanied by decay in amplitude of one or more frequencies and by buildup in amplitude of one or more other frequencies.

SIGNALLING, FREQUENCY SHIFT. See KEYING, FREQUENCY SHIFT.

SIGNALLING, INBAND. Signalling which utilizes frequencies within the voice or intelligence band of a channel.

SIGNALLING, OUT-OF-BAND. Signalling which utilizes frequencies within the guard band between channels or bits other than information bits in a digital system. This term is also used to indicate the use of a portion of the channel bandwidth provided by the medium, such as the carrier channel, but denied to the speech or intelligence path by filters. It results in a reduction of the effective available bandwidth.

SIGNALLING, RANDOM BINARY BIT STREAM (INTERMITTENT TIMING). A method of communication that employs bit intermittent transmission of signals on a unit interval basis without regard to the presence or absence of code or alphabet.

SIGNALLING, RINGDOWN. The application of signal to the line for the purpose of bringing in a line signal or supervisory signal at a switchboard or ringing a user's instrument. (Historically, this was a low-frequency signal of about 20 Hz from the user on the line for calling the operator or for disconnect.)

SIGNALLING, SIMPLEX (SX). Simplex (SX) signalling requires the use of two conductors for a single channel, a center tapped coil or its equivalent is being used at both ends for this purpose. The arrangement may be a one-way signalling scheme suitable for intra-office use, or the simplex legs may be connected to (full) duplex signalling circuits which then function like CX signalling with E&M lead control.

SIGNIFICANT CONDITION OF A MODULATION. See MODULATION, SIGNIFICANT CONDITION OF.

SIGNIFICANT INSTANTS. See INSTANTS, SIGNIFICANT.

SIGNIFICANT INTERVAL. See INTERVAL, SIGNIFICANT.

SIMPLE SCANNING (FAX). See SCANNING, SIMPLE (FAX).

SIMPLEX CIRCUIT. See CIRCUIT, SIMPLEX.

SIMPLEX OPERATION. See OPERATION, SIMPLEX.

SIMPLEX SIGNALLING (SX). See SIGNALLING,SIMPLEX (SX).

SIMPLEXED CIRCUIT. See CIRCUIT, SIMPLEXED.

SINGING MARGIN. See MARGIN, SINGING.

SINGLE-CURRENT TRANSMISSION. See TRANSMISSION, SINGLE-CURRENT.

SINGLE-HARMONIC DISTORTION. See DISTORTION, SINGLE-HARMONIC.

SINGLE-SIDEBAND EQUIPMENT REFERENCE LEVEL. See LEVEL, SINGLE-SIDEBAND EQUIPMENT REFERENCE.

SINGLE-SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND.

SINK, COMMUNICATION. A device which receives information, control, or other signals from a communication source(s).

SINK, DATA. The equipment which accepts data signals after transmission.

SKEW (FAX). The deviation of the received frame from rectangularity due to asynchronism between scanner and recorder. Skew is expressed numerically as the tangent of the angle of this deviation.

SOUND-POWERED TELEPHONE. See TELEPHONE, SOUND-POWERED.

SOURCE, COMMUNICATION. A device which generates information, control, or other signals destined for a communication sink(s).

SOURCE, DATA. The equipment which supplies data signals to be transmitted.

SPACE DIVERSITY. See DIVERSITY, SPACE.

SPACE DIVERSITY RECEPTION. That form of diversity reception which utilizes receiving antennas placed in different locations. See DIVERISTY.

SPACE-DIVISION SWITCH. See SWITCH, SPACE-DIVISION.

SPACING PULSE. See PULSE, SPACING (TTY).

SPECTRUM DESIGNATION OF FREQUENCY. See FREQUENCY,SPECTRUM DESIGNATION OF.

SPEECH-PLUS-DUPLEX OPERATION. See OPERATION, SPEECH-PLUS-DUPLEX.

SPEED, DRUM (FAX). The angular speed of the transmitter or recorder drum.

NOTE: This speed is measured in revolutions per minute.

SPEED, REPRODUCTION (FAX). The area of copy recorded per unit time.

SPEED, SPOT (FAX). The speed of the scanning or recording spot within the available line.

NOTE: This is generally measured on the subject copy or on the record sheet.

SPEED, STROKE (FAX). (SCANNING OR RECORDING LINE FREQUENCY). The number of times per minute, unless otherwise stated, that a fixed line perpendicular to the direction of scanning is crossed in one direction by a scanning or recording spot.

NOTE: In most conventional mechanical systems this is equivalent to drum speed. In systems in which the picture signal is used while scanning in both directions, the stroke speed is twice the drum speed.

SPOT, RECORDED (FAX). The image of the recording spot on the record sheet.

SPOT, RECORDING (FAX). The image area formed at the record medium by the facsimile recorder.

SPOT, SCANNING (FAX). The area on the subject copy viewed instantaneously by the pickup system of the scanner.

SPOT SPEED (FAX). See SPEED, SPOT (FAX).

SPOT, X DIMENSION OF RECORDED (FAX). The effective recorded spot dimension measured in the direction of the recorded line.

NOTE: 1. By effective dimension is meant the largest center-to-center spacing between recorded spots which gives minimum peak-to-peak variation of density of the recorded line.

2. This term applies to that type of equipment which responds to a constant density in the subject copy by a succession of discrete recorded spots.

SPOT, X DIMENSION OF SCANNING (FAX). The effective scanning spot dimension measured in the direction of the scanning line on the subject copy.

NOTE: The numerical value of this will depend upon the type of system used.

SPOT, Y DIMENSION OF RECORDED (FAX). The effective recorded spot dimension measured perpendicularly to the recorded line.

NOTE: By effective dimension is meant the largest center-to-center spacing between recorded lines which gives minimum peak-to-peak variation of density across the recorded lines.

SPOT, Y DIMENSION OF SCANNING (FAX). The effective scanning spot dimension measured perpendicularly to the scanning line on the subject copy.

NOTE: The numerical value of this will depend upon the type of system used.

STAGGER (FAX). Periodic error in the position of the recorded spot along the recorded line.

STANDARD TEST SIGNAL. See SIGNAL, STANDARD TEST.

STANDARD TEST TONE. See TONE, STANDARD TEST.

STANDARDS(S). See STANDARDS, SYSTEM.

STANDARDS, SYSTEM.

a. The minimum required electrical performance characteristics of communications circuits which are based on measured performance of developed circuits under the various operating conditions for which the circuits were designed.

b. The specified characteristics not dictated by electrical performance requirements but necessary in order to permit interoperation. (For example, the values for center frequencies for telegraph channels, test tone, etc.) See also OBJECTIVE, DESIGN.

STANDING WAVE RATIO (SWR). The ratio of the amplitude of a standing wave at an antinode to the amplitude at a node.

NOTE: The standing wave ratio in a uniform transmission line is:

$$\frac{1 + Rc}{1 - Rc}$$

Where Rc is the reflection coefficient. See COEFFICIENT OF REFLECTION, also REFLECTION LOSS.

START RECORD SIGNAL (FAX). See SIGNAL, START RECORD (FAX).

START SIGNAL (FAX). See SIGNAL, START (FAX).

START-STOP TTY DISTORTION. See DISTORTION, START-STOP TTY.

STOP RECORD SIGNAL (FAX). See SIGNAL, STOP RECORD (FAX).

STOP SIGNAL (FAX). See SIGNAL, STOP (FAX).

STORAGE-AND-FORWARD SWITCHING CENTER. A message switching center in which the message is accepted from the sender whenever he offers it, held in a physical storage and forwarded to the receiver in accordance with the priority placed upon the message by the initiator (sender). See SWITCHING, MESSAGE.

STORE-AND-FORWARD. See SWITCHING, MESSAGE.

STROKE SPEED (FAX). See SPEED, STROKE (FAX).

SUBCARRIER. A carrier which is applied as modulation on another carrier, or on an intermediate subcarrier See also CARRIER.

SUBJECT COPY (FAX). See COPY, SUBJECT (FAX).

SUBSCRIBER LINE. A telephone line between a central office and a telephone station, private branch exchange, or other end equipment.

SUDDEN IONOSPHERIC DISTURBANCE (SID). An occasional sudden outburst of ultraviolet light on the sun (solar flare) which produces abnormally high ionization densities in the D region. This results in a sudden increase in radio-wave absorption, which is most severe in the upper MF and lower HF frequencies.

SUPERGROUP. See WIDEBAND SYSTEM.

SUPERVISORY SIGNALS. Signals used to indicate the various operating states of circuits or circuit combinations.

SUPPRESSED CARRIER TRANSMISSION. See TRANSMISSION, SUPPRESSED CARRIER.

SWITCHING CENTER. See CENTER, SWITCHING.

SWITCHING, CIRCUIT. The term applied to the method of handling traffic through a switching center, either from local users or from other switching centers, whereby a distant electrical connection is established between the calling and called stations.

SWITCHING, CROSSBAR. A switch consisting of rectangular fields, or matrices, of contact springs operated in coordination by vertical and horizontal selector bars.

SWITCHING, MESSAGE. The term applied to any indirect or store-and-forward (S/F) traffic through a switching center, either from local users or from other switching centers. Message switching, or store-and-forward, is the technique whereby messages are transmitted link by link through the communication network of switching centers.

SWITCHING, ROTARY. A switching system whereby the selecting mechanism consists of a rotating element utilizing several groups of wipers, brushes, and contacts.

SWITCHING, SPACE-DIVISION. A switch whereby single-transmission-path routing determination is accomplished utilizing a physically-separated set of matrix contacts.

SYNCHRONIZING (FAX). The maintenance of predetermined speed relations between the scanning spot and the recording spot within each scanning line.

SYNCHRONIZING PILOT. A reference pilot for the purpose either of maintaining the syncronization of the oscillators of a carrier system or of comparing, when desired, the frequencies (and possibly the phases) of the currents generated by those oscillators.

SYNCHRONIZING SIGNAL (FAX). See SIGNAL, SYNCHRONIZING (FAX).

SYNCHRONOUS. See SYSTEM, SYNCHRONOUS and TRANSMISSION, SYNCHRONOUS.

SYNCHRONOUS SYSTEM. See SYSTEM, SYNCHRONOUS.

SYNCHRONOUS TRANSMISSION. See TRANSMISSION, SYNCHRONOUS.

SYSTEM, ARQ. See SYSTEM, ERROR-DETECTING AND FEEDBACK.

SYSTEM, DUPLEX. See CIRCUIT, DUPLEX.

SYSTEM, ERROR-CORRECTING. A system employing an error-correcting code and so arranged that some or all signals detected as being in error are automatically corrected at the receiving terminal before delivery to the data sink or to the telegraph receiver.

SYSTEM, ERROR-DETECTING. A system employing an error-detecting code and so arranged that any signal detected as being in error is:

a. Deleted from the data delivered to the data sink, in some cases with an indication that such deletion has taken place, or,

b. Delivered to the data sink together with an indication that it has been detected as being in error.

SYSTEM, ERROR-DETECTING AND FEEDBACK (DECISION FEEDBACK SYSTEM, REQUEST REPEAT SYSTEM, ARQ SYSTEM). A system employing an error-detecting code and so arranged that a signal detected as being in error automatically initiates a request for retransmission of the signal detected as being in error.

SYSTEM, NEUTRAL DIRECT-CURRENT TELEGRAPH (SINGLE-CURRENT SYSTEM, SINGLE MORSE SYSTEM). A telegraph system employing current during marking intervals and zero current during spacing intervals for transmission of signals over the line.

SYSTEM, POLAR DIRECT-CURRENT TELEGRAPH. A telegraph system employing positive and negative currents for transmission of signals over the line.

SYSTEM, SYNCHRONOUS. A system in which the sending and receiving instruments are operating continuously at substantially the same frequency and are maintained, by means of correction if necessary, in a desired phase relationship.

SYSTEM STANDARDS. See STANDARDS, SYSTEM.

TAILING (HANGOVER) (FAX). The excessive prolongation of the decay of the signal.

TALKER, MEAN-VOLUME. The mean-volume talker is one who represents the mean volume of a group of talkers measured at a given location. The mean is the value in an ordered set of values below and above which there are an equal number of values.

TALKER, MEDIUM-POWER. The medium-power talker of a log-normal distribution is one who represents that value of talker volume which lies at the medium power of all talkers determining the volume distribution at the point of interest. When the distribution follows a log-normal curve (values expressed in dB), the mean and standard deviation cah be used to compute the medium-power talker. The talker-volume distribution follows a log-normal curve and the medium-power talker is uniquely determined by the average talker volume and the standard deviation as given in the following equation:

$$\overline{V}_{avpr} = \overline{V}_o + 0.115^2 \sigma \text{ VU}$$

Where $\overline{V}_o$ is the average of the talker-volume distribution, $\overline{V}_{avpr}$ is the volume corresponding to the average-power talker expressed in VU and σ is the standard deviation of the distribution.

TALKER-VOLUME DISTRIBUTION, MEAN POWER OF THE. The mean power of the talker-volume distribution is the mean-power-talker volume less a conversion factor to convert from VU to dBm.

NOTE: The factor is taken as 3.9 dB by some authorities and 1.4 dB by others. This standard uses 2.9 dB as the conversion factor. The conversion factor is intended for use by designers of systems, subsystems, and equipments. Operating personnel should not attempt to convert from VU to dBm. No simple relationship exists for converting from VU to dBm. A conversion from VU to dBm is a function of (1) the type of signal passing through a VU meter (speech, sine wave, or white Gaussian noise), (2) the bandwidth of interest, and (3) the nature of the statistics from which the mean power of the talker-volume distribution is derived. A VU meter is intended for measuring only speech.

TAPE RELAY. A system of retransmitting teleprinter traffic from one channel to another in which messages arriving on an incoming channel are recorded in the form of perforated tape, this tape then being either fed directly and automatically into an outgoing channel or transferred to a position with an automatic transmitter on an outgoing channel.

TELECOMMUNICATIONS. Any transmission, emission, or reception of signs, signals, writings, images, and sounds or information of any nature by wire, radio, visual, or some other electromagnetic means.

TELEGRAPH, TWO-TONE. See KEYING, TWO-TONE.

TELEGRAPH COMMUNICATION EFFICIENCY. See EFFICIENCY, TELEGRAPH COMMUNICATION.

TELEPHONE, ELECTRICALLY-POWERED. A telephone in which the operating power is obtained either from batteries located at the telephone (local battery) or from a telephone central office (common battery).

TELEPHONE SIDETONE. See SIDETONE, TELEPHONE.

TELEPHONE, SOUND-POWERED. A telephone in which the operating power is derived from the speech input only.

TELETYPEWRITER SIGNAL DISTORTION. See DISTORTION, START-STOP TTY.

TERMINAL, DATA. Equipment employed at the end of a transmission circuit for the transmission and reception of data. It may include end instruments or signal converters or both.

TERMINAL IMPEDANCE. See IMPEDANCE, TERMINAL.

TERMINALS, MULTIPLEX BASEBAND RECEIVE. The point in the baseband circuit nearest the multiplex equipment from which connection is normally made to the radio baseband receive terminals or intermediate facility.

TERMINALS, MULTIPLEX BASEBAND SEND. The point in the baseband circuit nearest the multiplex equipment from which connection is normally made to the radio baseband send terminals or intermediate facility.

TERMINALS, RADIO BASEBAND RECEIVE. The point in the baseband circuit nearest the radio receiver from which connection is normally made to the multiplex baseband receive terminals or intermediate facility.

TERMINALS, RADIO BASEBAND SEND. The point in the baseband circuit nearest the radio transmitter from which connection is normally made to the multiplex baseband send terminal or intermediate facility.

THz. THz. TeraHertz. 10 to power of 12, hertz.

TIME-DIVISION MULTIPLEX (TDM) See MULTIPLEX, TIME DIVISION (TDM).

TIME, FALL. See DECAY TIME, PULSE.

TIME GUARD BAND. See BAND, TIME GUARD.

TOLL SWITCHING TRUNK. A trunk connecting end office(s) to a Toll Center as the first stage of concentration for intertoll traffic. Operator assistance or participation may be an optional function. In US common carrier telephony service,

a. A Toll Center designated "Class 4C" is an office where assistance in completing incoming calls is provided in addition to other traffic.

b. A Toll Center designated "Class 4P" is an office where operators handle only outbound calls, or where switching is performed without operator assistance.

TONE, STANDARD TEST. A test tone with a frequency of 1000 Hz $\pm$25 Hz (1020 Hz preferred for PCM) inserted into an audio circuit at a OTLP with a power level of -10 dBm (-10 dBm0). When inserted at other TLP's in a circuit its power level must be adjusted accordingly. (See also SIGNAL, STANDARD TEST.)

TORN TAPE RELAY. A tape relay system in which the perforated tape is manually transferred by an operator to the appropriate outgoing transmitter position.

TOTAL HARMONIC DISTORTION. See DISTORTION, TOTAL HARMONIC.

TRANSFER, INFORMATION. (USER) The final result of a data transmission from a data source to a data sink. The information transfer rate may or may not be equal to the transmission modulation rate.

TRANSITION, SIGNAL. The change from one signalling condition to another; for example, the change from mark to space or from space to mark. See also PULSE, MARKING, TELETYPEWRITER.

TRANSLATION, ALPHABET. That process whereby the meaning in a particular bit structure in a particular code is conveyed to one or more different alphabets in the same or different code.

TRANSMISSION, ASYNCHRONOUS. A transmission process such that between any two significant instants in the same group (in data transmission this group is a block or a character, in telegraphy this group is a character) there is always an integral number of unit intervals. Between two significant instants located in different groups there is not always an integral number of unit intervals. See PLESIOCHRONOUS, also ISOCHRONOUS.

TRANSMISSION, BITERNARY. A method of digital transmission in which two binary pulse trains are combined for transmission over a system in which the available bandwidth is only sufficient for transmission of one of the two pulse trains when in binary form. The biternary signal is generated from two synchronous binary signals operating at the same bit rate. The two binary signals are adjusted in time to have a relative time difference of one-half the binary interval and are combined by linear addition to form a biternary signal. Each biternary signal element can assume any one of three possible states; i.e., +1, 0, or -1. Each biternary signalling element contains information on the state of the two binary signalling elements as defined in the following truth table:

B1	B2	BITERNARY
0	0	-1
0	1	0
1	0	0
1	1	+1

The method of addition of B1 and B2 as described above does not permit the biternary signal to change from -1 to +1 or +1 to -1 without an intermediate biternary signal of 0. Since there is half a unit interval time difference between the binary signals B1 and B2 only one of them can change its state during the biternary unit interval. This makes it possible in the decoding process to ascertain the state of the binary signal that has not changed its state and thus avoid ambiguity in decoding a biternary signal of 0.

TRANSMISSION, BLACK FACSIMILE. In an amplitude-modulation system, that form of transmission in which the maximum transmitted power corresponds to the maximum density of the subject copy. In a frequency-modulation system, that form of transmission in which the lowest transmitted frequency corresponds to the maximum density of the subject copy.

TRANSMISSION, DOUBLE-CURRENT (POLAR DIRECT-CURRENT SYSTEM). A form of binary telegraph transmission in which positive and negative direct currents denote the significant conditions.

TRANSMISSION LEVEL. The transmission level (TL) of any point in a transmission system is defined as the power (in dBm) that should be measured at that point when Standard Test Signal (0 dBm, 1000 Hz) is transmitted at some point chosen as a reference point. Thus, a point where a reading of -16 dBm is expected would be a "-16 TL point", sometimes abbreviated "-16 TLP". The transmission level of a point is a function of system design and is a measure of the design (or nominal) gain at 1000 Hz of the system between the chosen reference point (known as the Zero Transmission Level Point or Zero TLP) and the test point in question. Absolute measurements of the power of test signals at any point are influenced by the expected level as well as by any deviations of the system from its desired gain. Since field measurements are usually made either to check that the system is operating properly or to adjust the system to its design values, it is convenient to eliminate the fixed effect that the Transmission Level of the test point has on measurements. This has led to the practice of "referring readings to Zero Transmission Level" using the formula:

Measurement referred to Zero Transmission Level (in dBm0)	=	Actual Measurement (in dBm)	-	Relative Transmission Level of the Test Point (TL)

A measurement expressed in dBm0, therefore, is influenced only by departures of the system from its design value. For example, if a power of -15 dBm is measured at a -16 TLP, then this would be expressed as +1 dBm0, indicating that for some reason the system has 1 dB excess gain.

$$+1 = -15 - (-16)$$

It is often desirable to introduce a test tone into a system at other than the Zero Transmission Reference Level Point. In this case it is usual practice to introduce the test tone at the transmission level of the test point. For example, if the test point is at -16 TL, then the test tone power should be -16 dBm. Note that in this case the -16 dBm test tone is actually 0 dBm0 at the point where it is introduced. In similar manner, noise measurements may also be "referred to Zero Transmission Level Point" to permit measurements made at different test points to be readily compared. For example, a noise power measured at 35 dBrnc at a +7 TLP may be expressed as 35 - (+7) = 28 dBrnc0. See NOISE, MEASUREMENT UNIT. The term "dBr" is often used in international practice, having the same meaning as "TLP". For example, a +7 TLP would be described as a "+7 dBr point".

TRANSMISSION LOSS. In communication, transmission loss (frequently abbreviated loss) is a general term used to denote a decrease in power transmission from one point to another. Transmission loss is usually expressed in decibels.

TRANSMISSION, PARALLEL. The simultaneous transmission of a certain number of signal elements.

Example A: Use of a code according to which each signal element is characterized by a combination of 3 out of 12 frequencies simultaneously transmitted over the channel.

Example B: Use of a separate wire or circuit for each signal element of a character or word so that the signal elements of a character or word are simultaneously transmitted.

TRANSMISSION, SERIAL (SEQUENTIAL TRANSMISSION). Transmission at successive intervals of signal elements constituting a data or telegraph signal.

NOTE: The sequential elements may be transmitted with or without interruption, provided that they are not transmitted simultaneously.

TRANSMISSION, SIDEBAND. When a carrier frequency is modulated by a modulating signal, the two bands of frequencies produced are on either side of the carrier frequency, include components whose frequencies are, respectively, the sum or difference of the carrier and the modulating frequencies. The sum frequencies form the "upper sideband" and the difference frequencies form the "lower sideband". Several forms of sideband transmission are defined.

TRANSMISSION, SIDEBAND, COMPATIBLE. That method of transmission in which the carrier is deliberately reinserted at a lower level after its normal suppression to permit reception by convential amplitude modulation-receivers. This method of transmission is often referred to as Compatible SSB or Amplitude Modulation Equivalent (AME). The normal method of transmitting compatible SSB or AME is the carrier plus upper-sideband.

TRANSMISSION, SIDEBAND, DOUBLE. In double-sideband transmission both the upper and lower sidebands and the carrier are transmitted without reduction or suppression. (This is conventional amplitude modulation (AM).)

TRANSMISSION, SIDEBAND, DOUBLE, REDUCED OR SUPPRESSED CARRIER. That method of communication in which frequencies produced by the process of amplitude modulation are symmetrically spaced both above and below the carrier. The carrier level is suppressed to a value of at least 45 dB below the level of the transmitted sidebands.

TRANSMISSION, SIDEBAND, INDEPENDENT. In independent-sideband transmission the modulation products in the upper and lower sidebands are not related to each other but represent two or more separate sets of modulating signals. The carrier frequency may be either greatly reduced or suppressed.

TRANSMISSION, SIDEBAND, SINGLE. In single-sideband transmission only one of the sidebands is transmitted. The other sideband is suppressed to the maximum extent possible. The carrier may be transmitted fully, reduced, or suppressed.

TRANSMISSION, SINGLE-CURRENT (NEUTRAL DIRECT-CURRENT SYSTEM). A form of telegraph transmission effected by means of unidirectional currents.

TRANSMISSION, SUPPRESSED OR REDUCED CARRIER. That method of communication in which the carrier frequency is suppressed either partially or to the maximum degree possible. One or both of the sidebands may be transmitted.

TRANSMISSION, SYNCHRONOUS. A transmission process such that between any two significant instants in the overall stream, there is always an integral number of unit intervals.

TRANSMISSION, VESTIGIAL SIDEBAND. That method of communication in which frequencies of one sideband, the carrier, and only a portion of the other sideband are transmitted.

TRANSMISSION, WHITE (FAX). In an amplitude-modulation system, that form of transmission in which the maximum transmitted power corresponds to the minimum density of the subject copy. In a frequency-modulation system, that form of transmission in which the lowest transmitted frequency corresponds to the minimum density of the subject copy.

TRANSMITTER, FACSIMILE. That apparatus employed to translate the subject copy into signals suitable for delivery to the communication system. See FACSIMILE.

TRANSMITTER POWER OUTPUT RATING.

a. Whenever the power of a radio transmitter, etc., is referred to, it shall be expressed in one of the following forms:

(1) Peak envelope power (pep), sometimes abbreviated (pp).

(2) Mean power (p_m).

(3) Carrier power (p_c).

b. For different classes of emission, the relationships between peak envelope power, mean power, and carrier power are defined as follows:

(1) Peak envelope power of a radio transmitter: The power supplied to the antenna transmission line by a transmitter during one radio-frequency cycle at the highest crest of the modulation envelope, taken under conditions of normal operation.

(2) Mean power of a radio transmitter: The power supplied to the antenna transmission line by a transmitter during normal operation, averaged over a time sufficiently long compared with the period of the lowest frequency encountered in the modulation. A time of one-tenth second during which the mean power is greatest will be selected normally.

(3) Carrier power of a radio transmitter: The average power supplied to the antenna transmission line by a transmitter during one radio-frequency cycle under conditions of no modulation. This definition does not apply to pulse-modulated emissions.

(4) Effective radiated power: The power supplied to the antenna multiplied by the relative gain or the antenna in a given direction.

TRANSMITTING CONVERTER, FACSIMILE. See CONVERTER, TRANSMITTING FACSIMILE.

TRANSPORTATION (DATA OR TELEGRAPH TRANSMISSION). A transmission defect in which, during one character period, one or more signal elements are changed from one significant condition to the other, and an equal number of elements are changed in the opposite sense.

TROPOSPHERIC SCATTER, (Also TROPO OR TROPOSCATTER). A method of transhorizon communications utilizing frequencies generally considered line-of-sight (LOS); i.e., 350 to 8400 MHz. The propagation mechanics is still not fully understood, but it is known to include several distinguishing but changeable mechanisms such as propagation by means of random reflections and scattering from irregularities in the dielectric gradient density of the troposphere, smooth-earth diffraction, and diffraction over isolated obstacles (knife-edge refraction).

TROPOSPHERIC WAVE. A radio wave that is propagated by reflection from a place of abrupt change in the dielectric constant or its gradient in the troposphere.

NOTE: In some cases the ground wave may be so altered that new components appear to arise from reflection in regions of rapidly-changing dielectric constant. When these components are distinguishable from the other components, they are called tropospheric waves.

TRUNK. A single circuit between two points, both of which are switching centers and/or individual distribution points.

TRUNK GROUP. See GROUP, TRUNK.

TTY. A shorthand reference to teletypewriter.

TWO-TONE KEYING. See KEYING, TWO-TONE.

TWO-TONE TELEGRAPH. See KEYING, TWO-TONE.

TWO-WIRE CIRCUIT. See CIRCUIT, TWO-WIRE.

UHF. Ultra high frequency, 300 to 3000 MHz.

UNBALANCED WIRE CIRCUIT. See CIRCUIT, UNBALANCED WIRE.

UNIDIRECTIONAL OPERATION. See OPERATION, UNIDIRECTIONAL.

UNIT INTERVAL. See INTERVAL, UNIT.

USEFUL LINE (FAX). See LINE, AVAILABLE (FAX).

USER'S LINE. See LOOP, LINE.

VESTIGIAL-SIDEBAND TRANSMISSION. See TRANSMISSION, SIDEBAND, VESTIGIAL.

VHF. Very high frequency, 30 to 300 MHz.

VLF. Very low frequency, 3 to 30 kHz.

VODAS. A system for preventing the overall voice-frequency singing of a two-way telephone circuit by disabling one direction of transmission at all times. The name is derived from the initial letters of the expression "voice-operated device anti-sing".

VOGAD. A voice-operated device used to give a substantially constant volume output for a wide range of inputs. The name is derived from the initial letters of the expression "voice-operated gain-adjusted device".

VOICE-DATA SIGNAL. See SIGNAL, QUASI-ANALOG.

VOLTAGE, PSOPHOMETRIC (PSOPHOMETRIC P.D.). Circuit noise voltage measured in a line with a psophometer which includes a CCIF-1951 weighting network. See NOISE WEIGHTING.

NOTE: Do not confuse with psophometric emf, conceived as the emf in a generator (or line) with 600 ohms internal resistance, and hence, for practical purposes, numerically double the corresponding psophometric voltage.

Psophometric voltage readings are commonly converted to dBm (psoph) by the relation:

$$\text{dBm (psoph)} + 20 \log_{10} V - 57.78 \text{ (V in psophometric millivolts).}$$

VOX. A voice-operated relay circuit that permits the equivalent of push-to-talk operation of a transmitter by the operator. Care must be exercised that speech from the receiver output or other sound sources do not activate the device.

VU. VOLUME UNIT. The unit of measurement for electrical speech power in communication work as measured by a VU meter in the prescribed manner. The VU meter is a volume indicator in accordance with American National Standards Institute (ANSI) c16.5-1942. It has a dBm scale and specified dynamic and other characteristics in order to obtain correlated readings of speech power necessitated by the rapid fluctuation in level of voice currents. Zero VU equals zero dBm in measurements of sine-wave test-tone power.

VU CONVERSION FACTOR FROM VOLUME UNITS TO POWER IN dBm. See TALKER-VOLUME DISTRIBUTION, MEAN POWER OF THE.

WAVEGUIDE. The term "waveguide" designates:

a. A transmission line comprised of a hollow metallic conductor, generally rectangular, eliptical, or round in shape, within which electromagnetic waves may be propagated. The guide may under certain conditions be made of a solid dielectric or a dielectric filled conductor or,

b. A system of material boundaries capable of guiding electromagnetic waves.

WEIGHTING, 144-LINE. A noise weighting used in a noise measuring set to measure noise on a line that would be terminated by an instrument with a No. 144-receiver or similar instrument. The meter scale readings are in dBrn (144-line) dBrn (144-receiver).

WEIGHTING, 144-RECEIVER. A noise weighting used in a noise measuring set to measure noise across the receiver of an instrument equipped with a No. 144-receiver. The meter scale readings are in dBrn (144-receiver).

NOTE: This type of subset, deskstand with hand receiver, is obsolete.

WEIGHTING, C-MESSAGE. A noise weighting used in a noise measuring set to measure noise on a line that would be terminated by a 500-type or similar instrument. The meter scale readings are in dBrn (C-message).

WEIGHTING, F1A-LINE. A noise weighting used in a noise measuring set to measure noise on a line that would be terminated by a 302-type or similar instrument. The meter scale readings are in dBa (F1A).

WEIGHTING, FLAT. A noise measuring set amplitude-frequency characteristic which is flat over a specified frequency range, which must be stated. In addition, the falling-off characteristics must be considered. Flat noise power may be expressed in dBrn $(f_1 - f_2)$ or in dBm $(f_1 - f_2)$. The terms 3 kHz flat weighting and 15 kHz flat weighting are also used for characteristics flat from 30 Hz to the upper frequency indicated.

WEIGHTING, HA1-RECEIVER. A noise weighting used in a noise measuring set to measure noise across the HA1-receiver of a 302-type or similar instrument. The meter scale readings are in dBa (HA1).

WEIGHTING NETWORK. A network whose loss varies with frequency in a predetermined manner. See NOISE, WEIGHTING.

WEIGHTING, NOISE. In a measuring set designed to measure circuit noise a specific amplitude-frequency characteristic or noise weighting characteristic is included to respond to amplitude and frequency of an interference voltage and permit the measuring set to give numerical readings which approximate the interfering effects to an average listener using a particular class of telephone instrument and receiver. Noise weighting measurments are made on lines terminated either by the measuring set or the class of instrument.

NOTE: The noise weightings generally used were established by agencies concerned with public telephone service and are based on characteristics of specific commercial telephone instruments representing successive stages of technological development. The coding of commercial apparatus appears in the nomenclature of certain weightings. The same weighting nomenclature and units are used in military versions of commercial noise measuring sets.

WEIGHTING, PSOPHOMETRIC. A noise weighting established by the International Consultative Committee for Telephony (CCIF, now CCITT), designated at CCIF-1951 weighting, for use in a noise measuring set or psophometer. The shape of this characteristic is virtually identical to that of F1A weighting. The psophometer is, however, calibrated with a tone of 800 Hz, 0 dBm, so that the corresponding voltage across 600 ohms produces a reading called 0.755 volt. This introduces a 1 dB adjustment in the formulas for conversion with dBa. See dBm, PSOPHOMETRICALLY WEIGHTED.

WHITE NOISE. Noise whose spectrum is continuous and uniform as a function of frequency; for practical purposes over a sufficiently large frequency range in relation to a band of fixed width, (with a Gaussian amplitude distribution.)

WHITE TRANSMISSION (FAX). See TRANSMISSION, WHITE (FAX).

WIDEBAND SYSTEM. A system with a multichannel bandwidth of 20 kHz or more. Also called BROADBAND SYSTEM.

a. Group. A subdivision containing a number of voice channels, either within a supergroup or separately, normally comprised of up to 12 voice channels occupying the frequency band 60-108 kHz. Each voice channel may be multiplexed for teletypewriter operation if required.

b. Supergroup. Normally, 60 voice channels of a wideband path or five groups of 12 voice channels each and occupying the frequency band 312-552 kHz.

c. Master Group. Term comprised of 10 groups = 600 channels occupying 60-2660 kHz.

d. Jumbo Group. (Term tentative). Six master groups = 3600 channels. See MULTIPLEX, FREQUENCY DIVISION.

WIRE, ORDER. (Also called Service Wire, Engineering Circuit or Speaker Circuit). A circuit for use by maintenance personnel for communication incident to lineup and maintenance of communication facilities.

WORD (TELEGRAPH). By definition, a telegraph word shall consist of 6 character intervals when computing traffic capacity in words per minute.

$$\text{wpm} = \frac{\text{Mod rate X 10}}{\text{Units per character interval}}$$

WORD, COMPUTER. In computing, a sequence of bits or characters which occupy one storage location and are treated by the computer circuits as a unit and transferred as such.

ZERO TRANSMISSION LEVEL POINT (OTLP). See TRANSMISSION LEVEL.

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SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 22-R255

INSTRUCTIONS: This sheet is to be filled out by personnel, either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.

SPECIFICATION

ORGANIZATION

CITY AND STATE	CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO *(If "yes", in what way?)*

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

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