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MILITARY STANDARD

SUBSYSTEM DESIGN/ENGINEERING AND EQUIPMENT TECHNICAL DESIGN STANDARDS FOR LONG HAUL LINE OF SIGHT (LOS) DIGITAL MICROWAVE RADIO TRANSMISSION

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

SLHC

DEPARTMENT OF DEFENSE

WASHINGTON DC 20301

SUBSYSTEM DESIGN/ENGINEERING AND EQUIPMENT
TECHNICAL DESIGN STANDARDS FOR
LONG HAUL LINE OF SIGHT (LOS) DIGITAL
MICROWAVE RADIO TRANSMISSION

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: RADC (RBRD) Griffiss AFB, New York 13441 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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 for digital LOS Microwave Radio Transmission.

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.

6. It is the intent of this document to achieve RF interoperability. At the present time, however, there is insufficient information to specify the necessary parameters including: 1. the optimum modulation technique to achieve operation at 2.0 b/s per Hz and 2. framing for multiplexing the Mission and Service Channel Bit Streams.

IDENTIFICATION OF

INTERNATIONAL STANDARDIZATION AGREEMENT

Certain provisions of this standard are the subject of international standardization agreement. When revision or cancellation of this standard is proposed, the departmental custodian will inform his respective Departmental Standardization Office so that appropriate action may be taken respecting the international agreement concerned.

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1.0 SCOPE.

1.1 Purpose. The purpose of this document is to describe standards of performance and design for digital microwave radio links and radio equipment (herein after referred to as the "radio") for long haul line of sight (LOS) digital microwave transmission.

1.2 Application. This standard is to be used for the design and engineering of new digital microwave radio subsystems, links, and equipment for digital LOS microwave transmission. To the maximum extent possible this standard shall also be used for digital LOS microwave communications implementations involving the conversion of existing analog LOS microwave techniques or equipment to digital service. When these are converted they shall meet the subsystem, link, and interface parameters defined in this document.

a. This standard applies to radios that normally operate in the following frequency bands: 4.4 to 5.0 gigahertz (GHz), 7.125 to 8.4 GHz and 14.4 to 15.4 GHz.

b. This standard requires that the radios have standardized interfaces and data rates as specified herein. The data rates, service channel frame formats, timing information (clocks), and alarm functions shall be identical".

c. RF interoperability shall be required at such time as additional parameters germane to this requirement are established.

1.3 Frequency spectrum.

a. The use of the frequency spectrum is regulated by international agreements embodied in "Radio Regulations, General Secretariat of the International Telecommunications Union", Geneva, 1971. These regulations are further qualified by Federal Government (Office of Telecommunication Policy, OTP), the Interdepartment Radio Advisory Committee (IRAC), and military agencies (Joint Chiefs of Staff (JCS), and Military Communications-Electronics Board (MCEB).

b. Military frequency planning, including joint function frequency allocation tables, is established as a joint military action area under the MCEB.

1.4 Parameter value requirements. The parameters contained in this document are standards and are required unless identified as a design objective (DO).

1.4.1 Standards. Standards are defined as the following:

a. The minimum required performance characteristics based on measured data under specific operating conditions.

b. The specified characteristics not dictated by performance requirements but necessary to permit interoperability and meet other constraints such as the mission data and service channel interface and primary power requirements.

1.4.2 Design objectives. A design objective (DO) is defined as a performance characteristic which is based on performance desired, but which is not considered feasible as a STANDARD at this time. Examples of reasons for designating a performance characteristic as a DO rather than as a standard are: (1) it may require an advancement in the state-of-the-art, (2) the requirement may not have been fully confirmed by measurement or experience, (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 equipment or systems and which shall be used if technically and economically practicable at the time such specifications are written.

2.0 REFERENCED DOCUMENTS

2.1 Military. The following documents form a part of this standard to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-E-4158	Electronic Equipment, Ground General: Requirements For

STANDARDS

MILITARY

MIL-STD-188-100	Common Long Haul and Tactical Military Communication System Technical Standards
MIL-STD-188-114	Electrical Characteristics of Digital Interface Circuits
MIL-STD-188-120	Military Communication System Standards Terms and Definitions
MIL-STD-210	Climatic Extremes for Military Equipment
MIL-STD-454	Standard General Requirements For Electronic Equipment
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements For Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions andSystems of Units, Electromagnetic Interference Technology
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)

MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-781	Reliability Test: Exponential Distribution
MIL-STD-785	Reliability Program For Systems and Equipment Development and Production
MIL-STD-810	Environmental Test Methods
MIL-STD-1472	Human Engineering Design Criteria For Military Systems, Equipment and Facilities

HANDBOOKS

MILITARY

MIL-HDBK-237	Electromagnetic Compatibility/Interference Program Requirements

2.2 Other Documents.

General Secretariat of the International Telecommunications Union, Geneva, 1971	Radio Regulations
Office of Telecommunications	Manual of Regulations and Procedures for Radio Frequency Management, 1 Jan 73 (with revisions)
CCIR Report 338-1, Geneva, 1970	Propagation Data Required For Line of Sight Radio Relay Systems

(Copies of CCIR reports may be obtained from International Telecommunication Union, Consultant Committee International Radio Geneva, Switzerland).

3.0 Terms and Definitions

Updated terms and definitions for the entire MIL-STD-188 series will be published in MIL-STD-188-120. The terms and definitions applicable for 188-322 has been moved to Appendix A of the document.

4.0 General Requirements

4.1 Multi-link Subsystems and Links. The Defense Communications System (DCS) provides communications service in every essential functional area: command and control, logistics, intelligence, weather and administration. Traffic in the system may be analog (voice and facsimile) or digital (graphics, teletypewriter and data), and may be transmitted as analog, quasi-analog or digital traffic. This document provides standards for long haul line of sight (LOS) digital microwave radio transmission for the DCS. These standards are derived in part by propagation considerations and in part by the proration of the parameters of the DCS 12,000 nautical miles (nmi) (22214 kilometers (km)) Reference Circuit to the LOS Digital Microwave Reference Radio Subsystem and Reference Radio Links.

4.2 DCS 12,000 Nautical Mile (22214 km) Reference Circuit. For the purpose of establishing performance standards for LOS digital microwave radio links, a 12,000 nmi (22214 km) reference circuit. This 12,000 nmi (22214 km) reference circuit consisting of two satellite or submarine cable reference sections of 3,000 nmi (5556 km) each, and the balance consisting of terrestrial LOS microwave reference sections has been defined. Each terrestrial LOS microwave reference section is subdivided into three reference subsystems of 600 km (approximately 333 nmi) in length (reference Figure 1). The reference subsystem is further subdivided into 12 reference links of 50 km (approximately 27 nmi) for operation below 10 GHz. For operation above 10 GHz, the LOS digital microwave reference subsystem has been subdivided into 24 reference links of 25 km each (approximately 13.5 nmi) reference Figure 1).

4.3 Allocation of Performance Parameters. Based on the 12,000 nmi (22214 km) reference circuit established above, and a bit error rate (BER) performance for the two satellite reference sections of $1X10^{-8}$ each, the following performance parameter allocations are derived.

4.3.1 Bit Error Rate. For all digital transmission, the user-to-user BER performance is standardized at $1X10^{-5}$. An allocation of $45X10^{-7}$ is made to each local loop. Thus, the transmission channel performance requirement is $1X10^{-6}$. Allocation through the reference circuit results in the performance requirements contained in Table I.

LONG HAUL

NORMAL DISTANCE	MEDIA	VOICE BW
1000 N. MI. (1852 Km	REF SECTION LOS DIGITAL M/W RADIO	PCM
1000 N. MI. (1852 Km)	REF SECTION LOS DIGITAL M/W RADIO	PCM
1000 N. MI. (1852 Km)	REF SECTION LOS DIGITAL M/W RADIO	PCM
3000 N. MI (5556 Km)	SATELLITE	PCM
3000 N. MI (5556 Km)	SATELLITE	PCM
1000 N. MI (1852 Km)	REF SECTION LOS DIGITAL M/W RADIO	PCM
333 N. MI. (617 Km) 333 N. MI. (617 Km) 333 N. MI. (617 Km)	SUBSYSTEM SUBSYSTEM SUBSYSTEM	PCM PCM PCM
1000 N. MI. (1852 Km)	REF SECTION LOS DIGITAL M/W RADIO	PCM

Fig. 1 DEVIVATION OF LOS DIGITAL MICROWAVE RADIO LINK

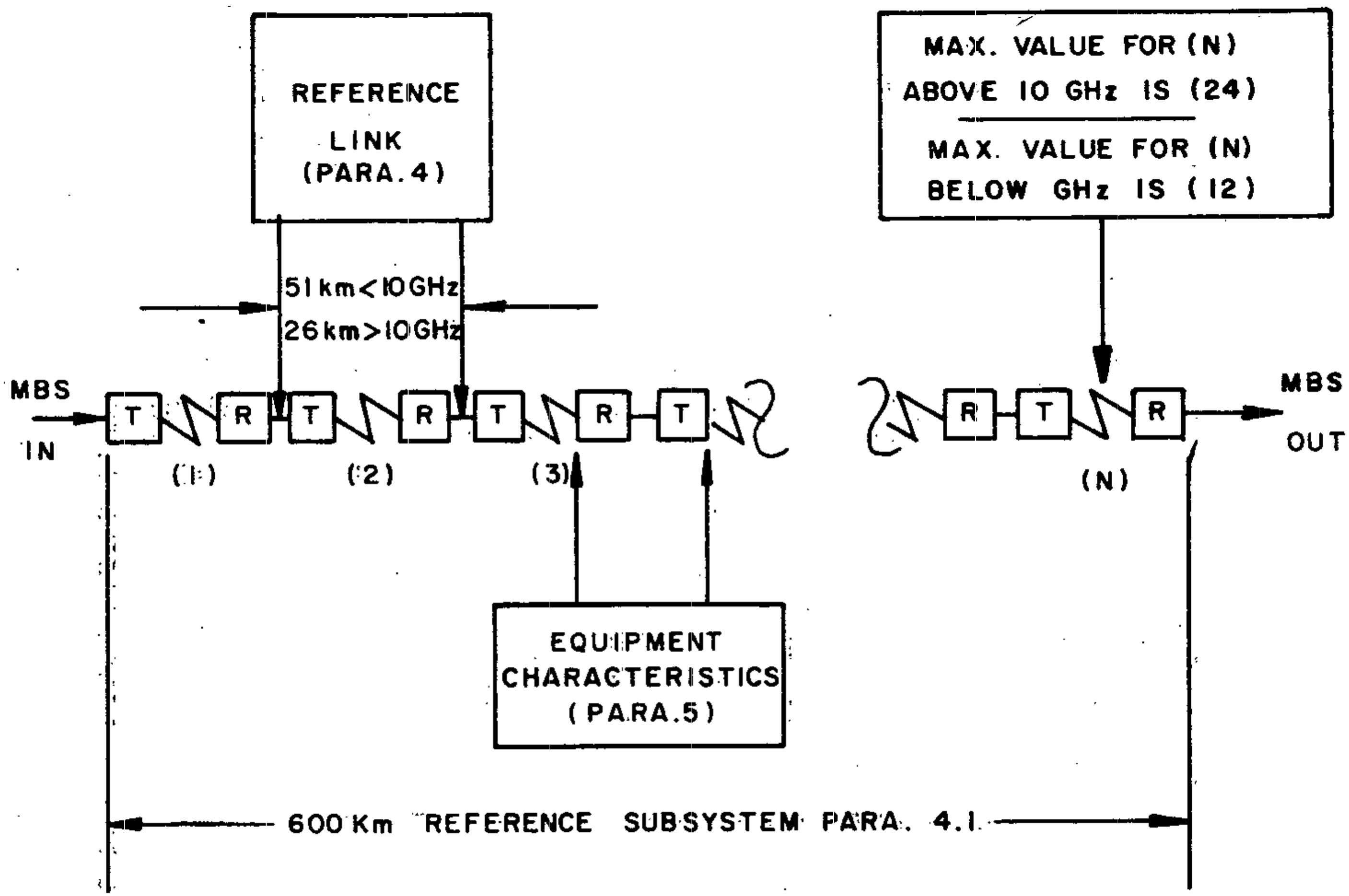

Fig.1 DEVIVATION OF LOS DIGITAL MICROWAVE RADIO LINK — CONTINUED

TABLE I

PERFORMANCE PARAMETERS FOR LOS DIGITAL MICROWAVE TRANSMISSION

PARAMETER	REFERENCE SUBSYSTEM	*REFERENCE LINK
BIT ERROR RATE		
a. below 10 GHz	60×10^{-9}	5×10^{-9}
b. above 10 GHz	48×10^{-9}	2×10^{-9}
AVAILABILITY		
a. BER = 5×10^{-9} below 10 GHz	.9994	.99995
b. BER = 1×10^{-2} below 10 GHz	.9997	.99998
c. BER = 2×10^{-9} above 10 GHz	.9992	.99997
d. BER = 1×10^{-2} above 10 GHz	.9995	.99998
BIT COUNT INTEGRITY	TBD	TBD

* REFERENCE LINK = one full duplex radio path with one radio at each end.

Travel time to site for repair is not included in availability calculation.

TBD = To be determined.

These BER requirements contain all bits in error including those generated by the randomizer. Installed link and subsystem performance shall meet the requirements of Table I columns "link" and "subsystem" respectively.

4.3.2 Availability. Using an availability of 0.998 for each of the two satellite reference sections, allocation through the reference circuits results in the performance requirements contained in Table I. The availability specified in the table combines both path availability and equipment availability. Installed link and subsystem performance shall meet the requirement of Table I columns "link" and "subsystem" respectively.

4.3.3 Bit Count Integrity (BCI). Bit count integrity cannot be easily prorated independently based on a user-to-user requirement. It is anticipated that standards for bit count integrity will be established in the future.

4.3.4 Summation Rules.

4.3.4.1 Availability. The end-to-end availability of a subsystem is equal to the multiplication of the individual equipment and link availabilities. Table I contains a column for path availability, all other columns include both path and equipment availabilities.

4.3.4.2 Bit Error Rate. Linear proration shall be used for BER proration.

4.3.4.3 Bit Count. Under consideration.

4.4 Radio Link Design.

4.4.1 Radio Link Engineering. The propagation analysis shall consist of path loss calculations and determining propagation availability in accordance with pertinent documents. Radio links shall be designed to satisfy the requirements of Table I.

4.4.1.1 Path Profiles. Path predictions shall consist of calculations, based on detailed and up-to-date topographic maps and actual field surveys to determine the propagation characteristics and path loss. Path measurements shall be made using optical or radio devices.

4.4.1.2 Path Clearances. The clearance provided over each path shall be determined by the use of path profiles to achieve the required radio link propagation availability. Consideration shall be given to potential path obstruction, ground reflections, and the variability of the gradient of the atmospheric refractive index.

4.4.2 Fade Margin. It is a design objective to have a 30-dB minimum fade margin for all paths. All radio links are required to have a minimum annual path availability of 0.99995 for maintaining a bit error rate of 5×10^{-9} for operation below 10 GHz. All radio links are also required to have a minimum annual path availability of 0.999995 for maintaining a bit error rate of 1×10^{-2}. The 30 dB minimum was established to protect against temporary degradation of equipment such as loss of diversity.

4.4.2.1 Fade Margin Variation. The fade margin typically required for an operational circuit is 30 dB for diversity and 40 dB for non-diversity circuits. The achieved fade margin will be different from the designed value as a result of effects such as:

a. Diffraction loss.

b. Refractive fading.

c. Fresnel zone clearance.

d. Equipment misalignment.

e. Meteorological effects particularly above 10 GHz.

f. Cochannel and adjacent channel interference.

g. Cross polarization interference.

4.5 Electromagnetic Compatibility (EMC). Successful radio link engineering design requires that the possibility of interference with co-located antennas and equipments be analyzed. In addition, potential radio frequency interference to SHF SATELLITE communications links must be analyzed during the frequency planning phase to insure proper frequency separation. Equipment shall be designed to the applicable requirements of MIL-STD-461. MIL-HDBK-237 provides guidance in establishing a viable EMC program. An EMC analysis shall be conducted in accordance with the current procedures of the Agency/ Military Department.

4.6 Operational Configurations. The required performance standards are in some cases only achievable with more complex radio hardware and antenna configurations. The following operational configurations may be used, as required, to achieve the performance requirements of the subsystem:

a. Dual Frequency Diversity

b. Dual Space Diversity

c. Hot Standby - (Non-diversity)

d. Cross Polarization

e. 1:2 Hot Standby - (One for two)

f. Quadruple Diversity

The description of these configurations is provided in Appendix B.

5.0 Equipment Characteristics.

5.1 General. The radio shall operate LOS using radio frequency (RF) carriers at fixed operating frequencies in one of three RF bands. A digital service channel port shall be included as part of the radio. The transmitter shall combine the mission and the service channel bit streams and modulate the RF carrier. The receiver shall accept the modulated RF carrier and demodulate the signal into output mission and service channel bit streams. The timing shall be distributed to the individual radios through the transmitted digital bit streams or through station clocks. The station clock may be a time standard of sufficient accuracy to insure that performance parameters are met, it may be a time signal that has the same source as all the other radios in the subsystem or it may be a derived time that has been established to provide subsystem and/or system operation. A functional block diagram is shown in Figure 2. The following paragraphs describe the performance and design of the radio.

5.2 RF Frequency and Bandwidth Assignments. The radio may operate in one of three RF bands shown in Table II.

Table II. RF FREQUENCY AND BANDWIDTH ASSIGNMENTS

Band	RF Frequency	Assigned Bandwidth
I	4.4 to 5.0 GHz	3,5, 7.0, 10.5, 14 MHz
II	7.125 to 8.4 GHz	3.5. 7.0, 10.5, 14, 20, MHz
III	14.4 to 15.4 GHz	20, 28, 40 MHz

5.3 Radio Low Level Digital Interface Requirements.

5.3.1 General. The radio shall have the capability of accepting one or two synchronous mission bit stream of equal rates specified herein. In addition, the radio shall accept a 192 kb/s service channel bit stream which shall be integrated with the mission bit stream at selected rate. The received traffic shall demodulated and provided to the appropriate output ports. The input/output interface shall conform to the requirements of the low level digital interface of MIL-STD-188-114 (above MBS rates of 10 Mb/s, MIL-STD-188-114 shall be a goal). As a strappable option, data timing to the radio shall be slaved to the input timing. It is the intent to achieve digital input/output interface inter-

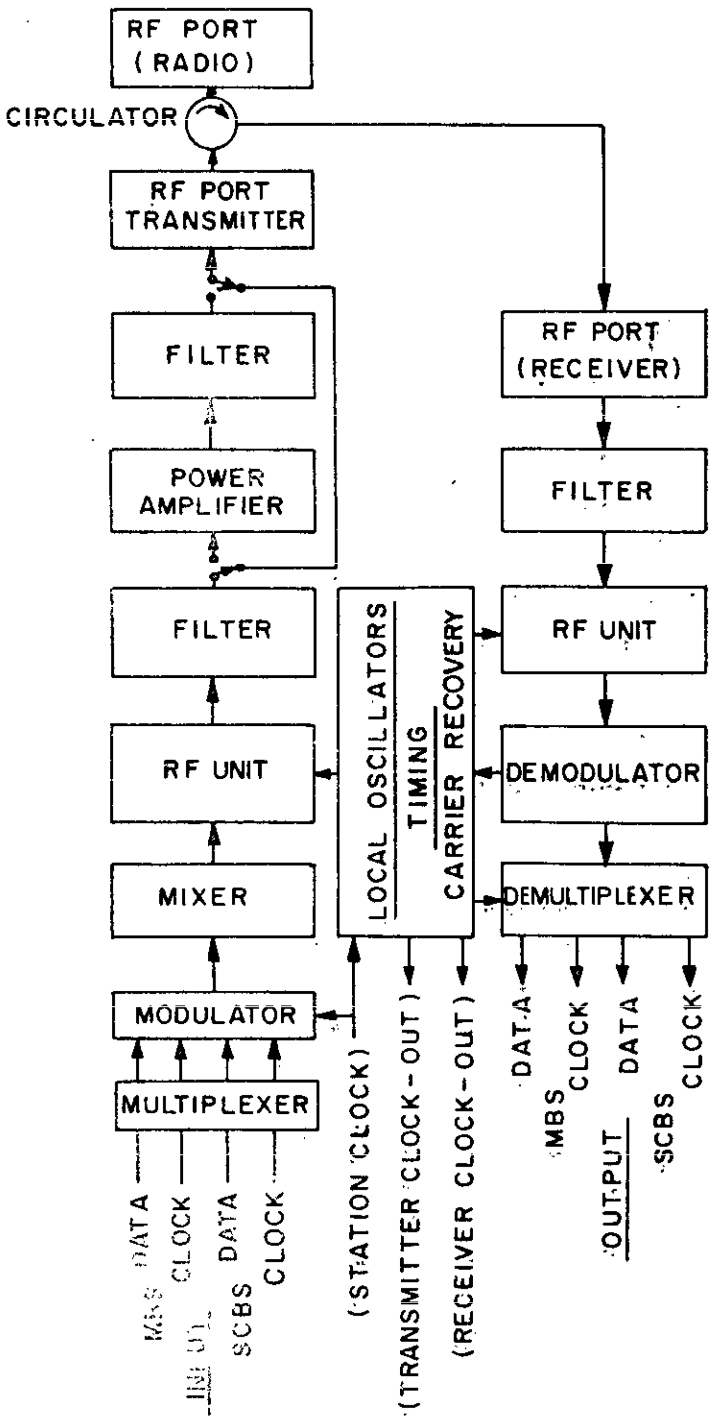

Fig. 2 TYPICAL RADIO FUNCTIONAL BLOCK DIAGRAM

operability between all radios procured in accordance with this standard.

5.3.2 Input/Output Ports. The radio shall provide the following data and clock ports as required:

a. One or two transmit and receive mission bit stream ports.

b. Clock inputs.

c. Clock outputs.

d. Transmit and receive service channel bit stream port.

e. One synchronous transmit clock output.

5.3.3 Input/Output Signal Characteristics. The radio shall accept/provide serial non-return-to-zero (NRZ) data and timing at each of the input/output ports. Below 10 Mb/s the requirements of MIL-STD-188-114 are standard, above 10 Mb/s these requirements are DO's. Provision shall be made to reverse the polarity of the data signal at the input/output ports as a strappable option such that it is clearly indicated that the signal state has or has not been inverted. All equipment shall provide the balanced interface of 5.1 of MIL-STD-188-114. Additionally, the unbalanced interface of 5.2 of MIL-STD-188-114 may be provided as a strappable option.

5.3.3.1 Balanced-to-Unbalanced Conversion. As a strappable option, the balanced interface shall be convertible to the unbalanced interface of paragraph 4.3.1.3.3 of MIL-STD-188-100.

5.3.3.2 Data/Timing Relationship. Provision shall be made so that the relative time of positive-to-negative transitions of the received clock shall occur within ± 10.0 percent of the nominal center of the received data unit interval.

5.3.4 Mission Bit Stream Data Rates. The radio shall be designed to to accept any one of the rates specified in Table III as an input rate and provide that rate at the mission bit stream output port. Those elements of the radio that are sensitive to the mission bit stream data rate shall be modularly separate from the remainder of the radio so that the allowable bit rate may be changed with a minimum replacement. The radio, with replacement of bit rate sensitive modules shall be capable of accepting any bit rate consistent with the packing density and the assigned bandwidth.

Table III Mission Bit Stream Data Rates and Tolerances

Data Rate	Tolerance
2.304 Mb/s	±200 b/s
3.323 Mb/s	±30 ppm
6.464 Mb/s	±30 ppm
9.696 Mb/s	±30 ppm
12.928 Mb/s	±30 ppm
13.024 Mb/s	±30 ppm
20.064 Mb/s	±30 ppm
26.752 Mb/s	±30 ppm

5.3.4.1 Internal Synchronous Time Division Multiplex (TDM) Performance.

The details of this paragraph are under consideration.

5.3.4.2 Internal Synchronous TDM Frame Format.

The details of this paragraph are under consideration.

5.3.5 Monitoring, Alarm and Control Interfaces. The radio shall provide interface terminals on the radio to efficiently and effectively couple the radio set monitoring circuits, alarms and controls to external hardware such as technical control equipment. The details of this interface cannot be specified at this time but will be established with the first acceptable field equipment. As a DO these interfaces should resemble the mission bit stream data port interfaces as close as practical.

5.3.6 Service Channel.

5.3.6.1 Service Channel Bit Stream (SCBS) Rate. It is the intent of this standard to achieve SCBS interface interoperability between all radios procured in accordance with this standard. To this end, the composition and use of the 192 Kb/s SCBS will be specified.

5.3.6.2 Local Orderwire. A single voice channel shall be derived using 64 Kb/s PCM to provide the local orderwire function.

5.3.6.3 Maintenance Coordination Circuit (MCC). A single voice channel shall be derived using 64 Kb/s PCM to provide the MCC function.

5.3.6.4 Transmission Status Monitoring and Change (TSMC). The details of the TSMC are under consideration and will be provided later.

5.3.6.5 Digital Quality. The BER performance of the Service Channel is under consideration and will be provided later.

5.3.6.6 SCBS Frame. The SCBS Frame structure is under consideration and will be provided later.

5.4 Digital Service Quality.

5.4.1 Digital Service Quality for MBS. The radio link design shall be such as to provide the mission bit stream with the minimum acceptable performance parameters set forth in Table I.

5.5 Accuracy and Stability.

5.5.1 Radio Frequency Accuracy. The RF accuracy shall be in accordance with the Manual of Regulations and Procedures for Radio Frequency Management as published by the Office of Telecommunication Policy.

5.5.2 Radio Frequency Stability. The receiver and transmitter, each separately, shall have a frequency stability better than 0.0005 percent (five part in 10^{-6}) with respect to the assigned RF carrier.

5.5.3 Sampling Interval. At the digital input, NRZ data and timing signals shall be detected and processed at the zero crossing of the positive-to-negative transition of the timing signal occurring within $\pm$25 percent of the center of the nominal data unit interval of the NRZ data.

5.5.4 Combined Effects of Jitter. The radio shall operate properly with digital NRZ data and timing inputs each having jitter equal to as much as 12.5 percent data unit interval or a peak timing to peak data excursion of 25 percent of the data unit interval.

5.6 Modulation.

5.6.1 Efficiency. The radio shall achieve a nominal RF bandwidth efficiency of 1 b/s-per-Hz of assigned bandwidth with the minimum system gain specified in 5.7. In addition, the radio shall achieve a nominal RF bandwidth efficiency of 2 b/s-per-Hz of assigned bandwidth. As a DO, the conversion from one bandwidth efficiency to the other shall be accomplished through the replacement of reconfiguration of appropriate modules.

5.6.2 Modulation Scheme. The details of this paragraph are under consideration and will be provided later.

5.7 System Gain. The system gain of the LOS radio shall be at least 95 dB. System gain is defined as the difference between transmitter RF power output and required receiver input to retain a $5x10^{-9}$ bit error rate where transmitter output and receiver input are measured at the equipment/waveguide interface.

5.8 Transmitter.

5.8.1 Transmitter Output Power. The power output of the radio shall not be less than 0.5 watts nor more than 10 watts as measured at the RF interface point.

5.8.2 Power Amplifier. Where the requirement exists, the transmitter shall have the capability of adding an optional power amplifier module with a maximum power output as delineated in paragraph 5.8.1.

5.8.2.1 Power Amplifier Performance. The transmitter with amplifier shall have the same characteristics and performance as specified for the transmitter.

5.8.3 Return Loss. The radio terminal return loss, when measured into the RF interface point, shall not be less than 26 dB at any frequency within 10 MHz of the assigned transmit and receive, carrier frequencies. The radio terminal shall provide specified performance when the antenna feedline presents any return loss greater than 14 dB.

5.8.4 Emission Limitations. The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following criteria:

Where : A = attenuation (in decibels) below the mean output power level.

P = percent removed from the carrier frequency.

B = authorized bandwidth in MHz.

5.8.4.1 Operating Frequencies in Bands I and II. The transmitter spectrum in any 4 kHz band, the center of frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth, shall be as specified by the following equation:

$$A = 35 + 0.8\,(P-50) + 10 \log_{10} B.$$

The attenuation shall not be less than 50 dB. Attenuation greater than 80 dB is not required.

5.8.4.2 Operating Frequencies in Band III. The transmitted spectrum in any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth, shall be specified by the following equation:

$$A = 11 + 0.4\,(P-50) + 10 \log_{10} B.$$

The attenuation shall not be less than 11 dB. Attenuation greater than 56 dB is not required.

5.8.5 Pseudo-Randomizing the Radiated Signal. The transmitter shall provide for the randomizing of the transmitted bit stream to minimize intensity of discrete spectral components in the transmitted spectrum. All BER performance and availability requirements shall be met with the Randomizer operating. A strapping option shall be provided to bypass the randomizer.

5.8.5.1 Performance. As a DO the randomizer or randomizers shall insure that no spectral component shall be stronger than 30 dB below the power output level of the transmitter or power amplifier. This protection shall apply to the radiated signal due to loss of activity on either the mission bit stream or the service channel bit stream.

5.9 Receiver.

5.9.1 Noise Figure. The receiver noise figure shall be measured with the noise source located at the RF interface port. The noise figure shall be equal to or better than that required to achieve the ratio of transmitter power to RSL stipulated in the paragraph on Transmitter Power Output. Under no condition shall the noise figure be greater than 10 dB below 10 GHz, nor greater than 14 dB above 10 GHz.

5.9.2 Receiver Dynamic. The receiver dynamic range shall be a minimum of 50 dB. For a stable received signal level that is 20 dB greater than the minimum stable received signal level providing a BER of 5 in 10^9 bits the receiver shall provide a BER less than 1 in 10^{10} bits. The receiver, in the configuration to be employed, shall provide the radio link performance stipulated in Table I.

5.9.3 Adjacent Channel Interference. The receiver shall provide specified performance with adjacent channel interference of any type having a level with respect to the desired signal of:

a. To be determined below 10 GHz.

b. To be determined above 10 GHz.

5.9.4 Co-channel Interference. As a DO the receiver shall provide specified performance with less than 2 dB degraded receiver threshold, for interference of any type within the specified receiver passband having the following levels with respect to the desired signal:

a. Minus 20 dB for frequencies below 10 GHz.

b. Minus 25 dB for frequencies above 10 GHz.

5.9.5 Carrier and Clock Recovery. The details of this paragraph are under consideration.

5.9.6 Return Loss. The radio terminal return loss, when measured into the RF interface point, shall not be less than 26 dB at any frequency within 10 MHz of the assigned transmit and receive, carrier frequencies. The radio terminal shall provide specified performance when the antenna feedline presents any return loss greater than 14 dB.

5.9.7 Regeneration. The receiver shall reshape and retime the mission bit stream and the service channel bit stream. The bit-to-bit jitter shall not exceed 10 percent and the total deviation from the digital microwave subsystem time base shall not exceed 10 percent.

5.9.8 Receiver BER Threshold. The receiver shall provide a BER performance of 5 in 10^9 at the received signal levels specified for the following bandwidth efficiencies:

5.9.8.1 Performance Level I (Nominal 1b/s-per-Hz of assigned bandwidth). To be determined.

5.9.8.2 Performance Level II (Nominal 2b/s-per-Hz of assigned bandwidth). To be determined.

5.10 Terminal Configurations.

5.10.1 Terminal Configuration Operation. Receivers, transmitters, circulators, diversity distribution equipment, diversity reception equipment, hot standby equipment, controls and antennas shall be used to provide operational configurations necessary to achieve the performance requirements stipulated in Table I. A number of possible configurations are provided in Appendix B for application where direct connection of the individual transmitters and receivers or of the radio set as a whole to the antennas will not achieve the performance required. These possible configurations involve Hot Standby or diversity type operations.

5.10.2 Transmitter Redundancy Operation. For radio types II and III of Appendix B a transmitter control function shall be provided for redundancy operation. Provision shall be included to automatically transfer operation from the active transmitter to the standby transmitter. The automatic transfer of operation shall be based on the following parameters:

a. Loss for more than 10 milliseconds of data or timing transitions at transmitter MBS ports.

b. Loss for more than 10 milliseconds of modulator output.

c. Transmitter frequency drift exceeding two percent of authorized RF transmission bandwidth.

d. Transmitter output power reduction by 3 dB or more relative to specified RF power output.

e. Loss for more than 10 milliseconds of data or timing transitions at the transmitter SCBS port.

5.10.2.1 Manual or Remote Transfer. In addition to the automatic transfer feature, provision shall be made to manually or to remotely induce a transfer of operation from the active transmitter to the standby transmitter. The manual or remote transfer command shall take precedence over the automatic transfer command. Terminals shall be provided for connection of a remote control signal. If a remote transfer signal is applied to the remote control terminals, the cessation of this signal shall return the radio to its state prior to the application of the remote transfer signal. Any transmitter transfer shall not cause a loss of BCI. As a DO, a manual or remotely induced transfer shall not cause any errors in the MBS or the SCBS.

5.10.2.2 Differential Time Delay. For radio types I and II (of Appendix B) it is anticipated that the transmitter transmission line will introduce as much as 350 nanoseconds of differential time delay between the two transmit signals. Provision shall be made for synchronization of the signal processing of alternate sources of signals. The transfer of transmitters shall not cause loss of BCI with up to 350 nanoseconds of differential time delay in transmit signals.

5.10.3 Receiver Diversity Operation. For radio types I, II and III (of Appendix B), provision shall be made to transfer operation to the better receiver. This transfer shall be automated and based upon the following parameters:

a. Received signal level.

b. Eye pattern degradation.

c. Equipment failure.

5.10.3.1 Manual or Remote Transfer. In addition to the automatic transfer feature, provision shall be made to manually or to remotely induce a transfer of operation from the active receiver to the standby receiver. The manual or remote transfer command shall take precedence over the automatic transfer command. Terminals shall be provided for connection of a remote control signal. If a remote transfer signal is applied to the remote control terminals, the cessation of this signal shall return the radio to its state prior to the application of the remote transfer signal. Any receiver transfer shall not cause a loss of BCI. A manually or remotely induced transfer shall not cause any errors in the MBS or the SCBS.

5.10.3.2 Differential Time Delay. For radio types I and II (of Appendix B), it is anticipated that the receive transmission line will introduce as much as 350 nanoseconds of differential time delay between the two received signals. Provision shall be made for synchronization of the signal processing of alternate sources of signals. The transfer of receivers shall not cause loss of BCI with up to 350 nanoseconds of differential time delay in receive signals.

5.10.3.3 Performance Under Switching. Diversity and hot standby operational configurations shall provide for synchronization of the signal processing of alternate sources of signals. The switching shall not cause bit errors or loss of BCI with differential absolute delays up to 350 nanoseconds for transmitter signals and up to 350 nanoseconds for receive signals.

5.11 Monitoring.

5.11.1 Status Indicators and Alarms. The radio shall include circuitry to monitor critical functions and provide local and remote alarms in the event of degraded performance or failure. Terminals shall be provided for connection of remote alarm signals. A separate remote alarm shall be provided for each function monitored. The functions monitored shall be those necessary to provide adequate assurance of require subsystem performance. The functions monitored shall include the following:

a. Loss for more than 10 milliseconds of data or timing transitions in transmit mission bit stream.

b. Loss for more than 10 milliseconds of data or timing transitions in receive mission bit stream.

c. Transmitter frequency drift exceeding two percent of authorized RF transmission bandwidth.

d. Receiver frequency drift exceeding two percent of authorized RF transmission bandwidth.

e. Loss of power input to the radio terminal.

f. Loss of radio receive frame synchronization.

g. Identification of active transmitter (radio types I and III of Appendix B).

h. Identification of active receiver (radio types I, II and III of Appendix B).

5.11.2 Performance Monitors. The radio shall include circuitry to monitor critical functions and provide separate signals directly related to the monitored quantities. Terminals shall provide external access to monitor signals. The monitor signals shall be of such type and quality as necessary to provide adequate assurance of required subsystem performance. The quantities monitored shall include the following:

a. MBSs BERs at receiver output ports.

b. RSL at demodulator input.

c. Transmit RF interface output power.

d. Demodulated MBS eye pattern quality prior to regeneration.

5.12 General Design.

5.12.1 Electromagnetic Interference. The radio and radio terminal shall be designed to meet those requirements of MIL-STD-461 specified by the procuring agency with measurement as specified in MIL-STD-462 and MIL-STD-463.

5.12.2 Human Engineering Design. The radio and radio terminal shall be designed in accordance with those requirements of MIL-STD-1472 specified by the procuring agency.

5.12.3 Environmental Test Methods. The radios shall be designed to meet those environmental test methods of MIL-STD-810 specified by the procuring agency.

5.12.4 Climatic Extremes. All radios shall be designed to meet those climatic conditions of MIL-STD-210 specified by the procuring agency.

5.12.5 Reliability.

5.12.5.1 Quantitative Reliability. The radio configuration as defined in paragraph 5.10 shall be designed to provide a specified mean-time-between-failures (MTBF) of no less than 1600 hours. Tested to meet requirements of MIL-STD-781 and program conducted in accordance with MIL-STD-785.

5.12.5.2 Radio Reliability. The radio shall demonstrate a Mean-Time-Between outage (defined as loss of MBS(s)) for greater than 100 milliseconds (ms) of 100,000 hours. This shall be determined based upon MTBF, MTTR, and fault sensing, switching and alarm circuitry.

5.12.5.3 Reliability-Definitions of Failure. A failure is defined as any malfunction which causes the radio to cease operating within specified limits, or for which maintenance action is required.

5.12.6 Maintainability. Quantitative maintainability values. The radio shall possess a mean-corrective-maintenance-time (M_{ct}) of no greater than 30 minutes and maximum-corrective-maintenance-time ($M_{max_{ct}}$) of no greater than 90 minutes (95th percentile) when repaired by maintenance technicians of skill level 5 or equivalent. Test methods in accordance with MIL-STD-471 and program conducted in accordance with MIL-STD-470.

5.12.7 General Requirements. The standard general requirements of MIL-STD-454 shall apply in the design of the multi-link subsystem.

5.13. Input Power. The radio equipment shall operate and provide specified performance when connected to any one of the following sources of primary power.

a. A direct current (dc) power source having any output voltage from 44 to 56 volts, with any variation therein, negative (positive ground), with ripple and noise not to exceed 100 millivolts peak-to-peak.

b. An alternating current (ac) power source which shall conform to MIL-E-4158, Table V, Condition I, and shall have the following nominal steady-state ratings:

(1) Input voltage - 117/220 volts ac ±10 percent, single phase.

(2) Input frequency - 47 to 420 Hz.

5.13.1 Reverse Polarity Protection. The radio terminal equipment shall suffer no damage from and shall provide specified performance after removal of a reversed polarity condition.

Custodians:
Army - SC
Navy - EC
Air Force - 17

Preparing Activity:
Air Force - 17

Review Activities:
Army - SC, EL
Navy - AS, YD
Air Force - 1, 11, 13, 89, 90, 99

(Assignee Activity - DC)

(Project SLHC 3220)

User Activities:
Army-SC, EL
Navy-YD
Air Force - 90

Other Interest:
JCS - J6
NSA - NS
TRI-TAC

APPENDIX A

10. GLOSSARY OF TERMS AND DEFINITIONS

This Appendix Contains Definitions Of
Key Terms Used in MIL-STD-188-322

10. Glossary of Terms and Definitions.

10.1 Multiplexing. A technique for combining multiple data sources, each using the same timing clock.

10.2 Carrier Recover. A technique which permits the coherent detection of a received signal without maintaining, at the receiver, an oscillator which is phase locked to the transmitter.

10.3 Digital Radio. A digital radio is defined to consist of a receiver, a transmitter, power amplifier (if used), and a circulator which together are optimized for the transmission of digital information. The RF carrier is encoded to a particular state according to the data, selected at regular timing intervals by a data clock.

10.4 Elastic Buffer. An elastic buffer compensates for dynamic variations in the differential delay between two inputs, allowing these inputs to be synchronized for further processing.

10.5 Eye Pattern. An eye pattern is defined by all the possible bit states at the point in the demodulator just before bit decisions are made. The eye pattern is visualized by super imposing all the bit states on the same time scale. An ideal eye pattern will result in an eye pattern voltage of 1 (normalized) at the sample time for every bit. Eye pattern degradations are defined as those effects present in a practical (non-ideal) system that cause reduction in the eye voltage at the same time for some of the bits. Such effects include intersymbol interference, errors in the phase of the carrier recovery and errors in the clock sampling time.

10.6 Frame. Time division multiplex input signals are combined into a serial output signal in a periodic manner. The periodic structure is a line format; one basic period is a frame. A framed digital signal consists of a periodic sequence of frames.

10.7 Interoperability, RF. RF interoperability requires that radios fabricated by different vendors shall interface and operate satisfactorily when they comprise opposite ends of the same radio link. The standard mission data interface, data rates, timing information, radio service channel, multiplex frame format, and differential encoding/decoding must be identical.

10.8 Intersymbol Interference. Distortion caused by the overlap (pulse stretching) of energy from one received symbol into the time interval of another symbol.

10.9 Quadrature Phase Shift Keying Modulation. A digital modulation technique whereby a sine wave carrier is shifted to any one of four equally spaced phase states according to the pair of binary digits to be transmitted.

10.10 Radio Link, Reference. A reference radio link consists of single microwave line of sight hop; each 25 km (above 10 GHz) or 50 km (below 10 GHz) in length.

10.11 Receiver Threshold. Receiver threshold is defined as the received signal level required to achieve an output BER of $4X10^{-5}$ below 10 GHz and $2X10^{-9}$ above GHz.

10.12 Subsystem. A subsystem is defined as one or more radio links in tandem with terminal, or drop and insert, stations at each end.

10.13 Bit Count Integrity. Bit count integrity is defined as one-for-one correspondence between transmitted and received bits. The relationship between information and clock bits shall be maintained starting at transmission through reception.

APPENDIX B

20. OPERATIONAL CONFIGURATIONS

This Appendix Explains and Supplements
Information Contained in MIL-STD-188-322

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Paragraph			Page
20.		Operational Configurations........	B-1
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20.2	Type II	Dual Space Diversity..............	B-1
20.3	Type III	Hot Standby (Non-Diversity)	B-1
20.4	Type IV	Cross Polarization................	B-1

LIST OF ILLUSTRATIONS

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B-2	Dual Space Diversity (Typical)........	B-4
B-3	Hot Standby (Non-diversity)...........	B-5
B-4	Cross Polarization....................	B-6

20. Operational Configurations. Specifications developed from this standard shall include one or more of the typical terminal configurations shown in Figures B-1 through B-4. Selection of the particular terminal configurations will depend on the application and the need to meet system performance requirements on the application.

20.1 Type I - Dual Frequency Diversity. Dual frequency diversity shown in Figure B-1 requires two transmitters and two receivers using one or two antennas. Each transmitter and receiver operates on different frequencies for a total of four RF frequencies. Frequency separation of approximately 2 to 3 percent of the RF carrier is required for frequency diversity.

20.2 Type II - Dual Space Diversity. Dual space diversity shown in Figure B-2 requires one operating and one standby transmitter and two receivers, each on separate antennas. The two receivers operate at the same frequency and the transmitter operates at a different frequency. The standby transmitter shall be co-located and in parallel with the active transmitter and placed in operation by a waveguide switch.

20.3 Type III - Hot Standby (Non-Diversity). Non-diversity (Hot Standby) operation shown in Figure B-3 requires one operating and one stand by transmitter and one operating and one standby receiver. The Hot Standby Transmitter and Standby Receiver shall be in parallel with the on-line transmitter and receiver and placed in operation by a waveguide switch, and by a receiver switch, respectively.

20.4 Type IV - Cross Polarization. Cross polarization (see Figure B-4) operation requires two transmitters and two receivers, each operating at the same frequency (total of two RF Carriers). One transmitter-receiver pair is vertically polarized, the other transmitter-receiver pair is horizontally polarized. The use of cross polarization permits the transmission of two independent Mission Bit Streams over the same path using one RF Carrier with the effect of doubling the Mission Bit Stream.Satisfactory BER performance is achieved when isolation between planes of polarization is approximately 25 to 30 dB.

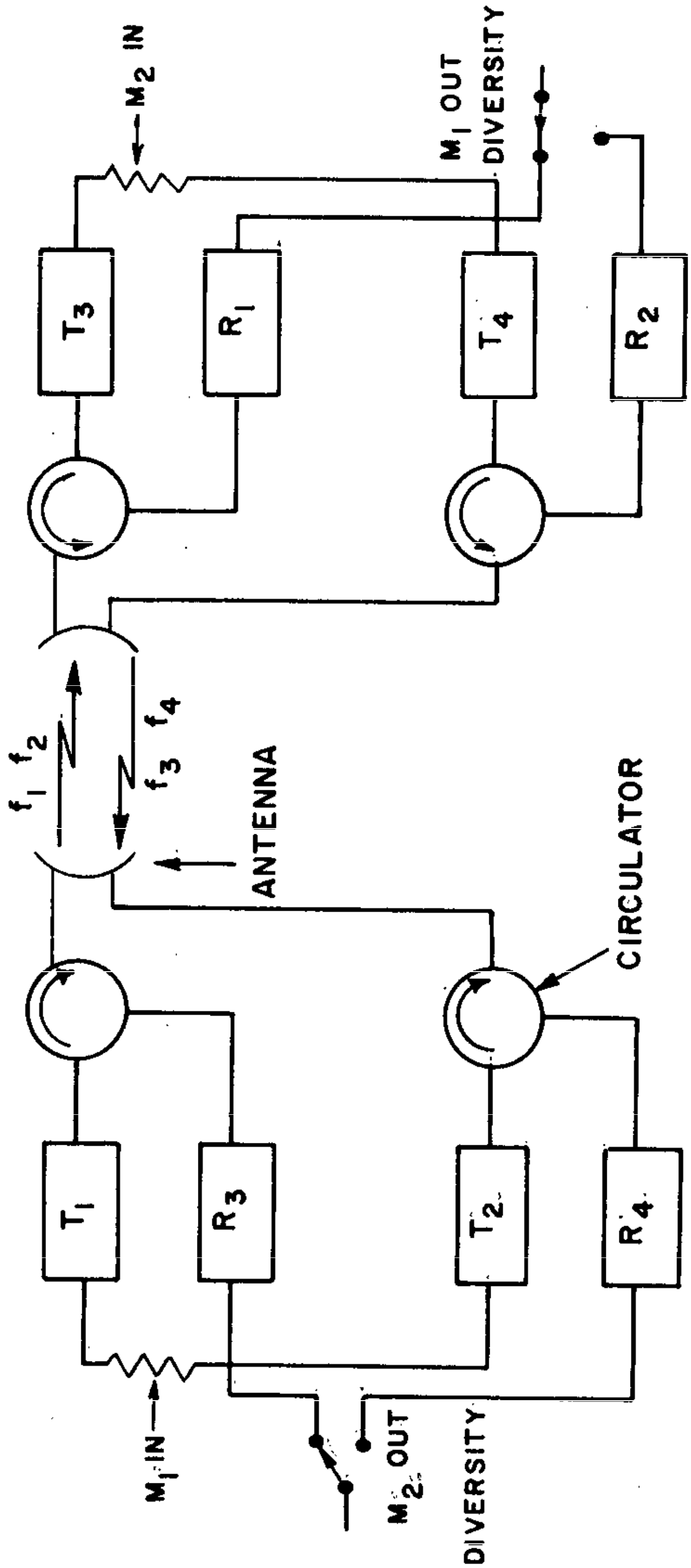


Fig. B-1 DUAL FREQUENCY DIVERSITY

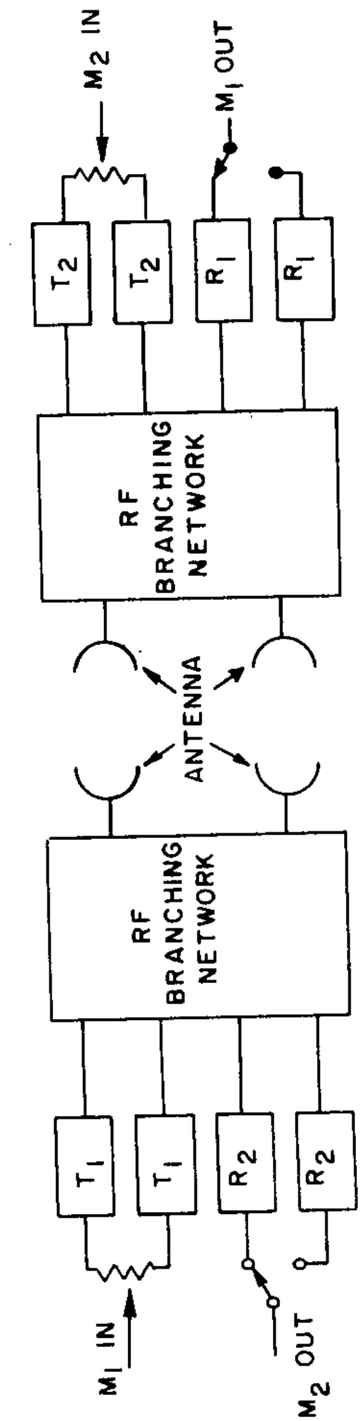


Fig. B-2, DUAL SPACE DIVERSITY (TYPICAL)

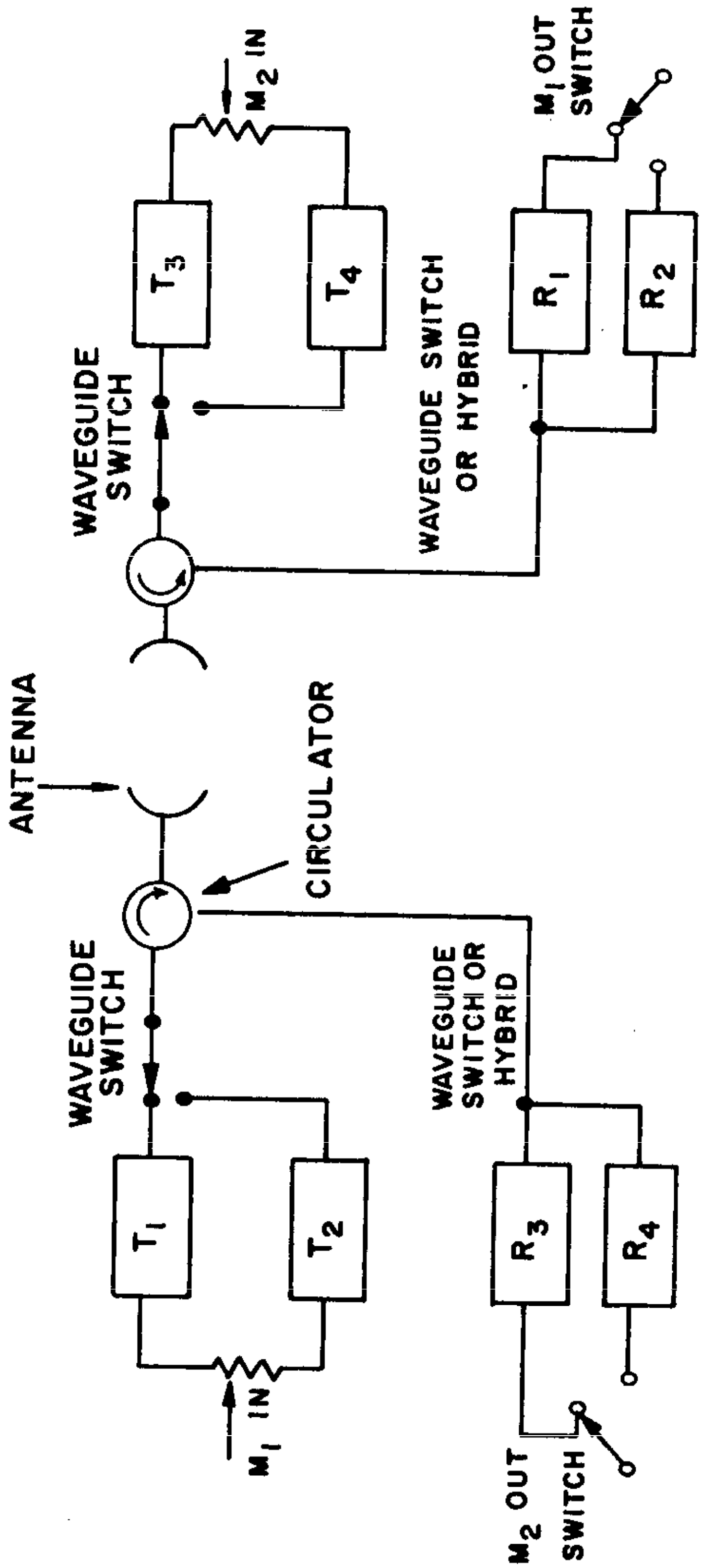
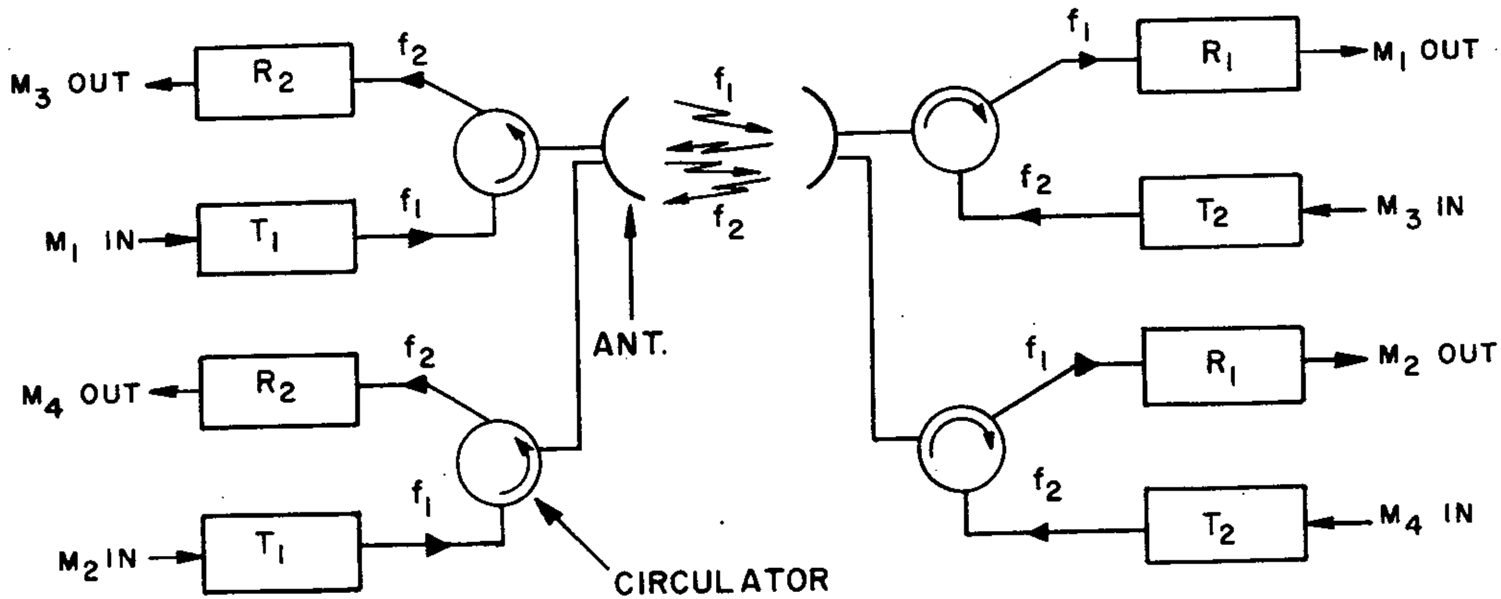


Fig. B-3 HOT STANDBY (NON - DIVERSITY)



CROSS POLARIZATION
NON DIVERSITY OPERATION
TWO INDEPENDENT BIT STREAMS

Fig. B-4 CROSS POLARIZATION

APPENDIX C

30. GUIDANCE DOCUMENTS

The documents listed in this appendix provide supplementary information, criteria and guidance that may be used as applicable, to assist the designer in complying with the requirements of this standard.

30. GUIDANCE DOCUMENTS.

30.1 Environmental Science Service Administration (ESSA)

ESSA Technical Report IER 45-ITSA 45	Computer Programs for Tropospheric Transmission Loss Calculations

30.2 National Bureau of Standards (NBS)

NBS Technical Note No. 101, revised 1967	Transmission Loss Predictions for Tropospheric Communication Circuits

30.3 Office of Telecommunications

OT Report 75-59, April 1975	Refractivity Gradients in the Northern Hemisphere
OT Technical Memorandum, OT TM-104 September 1972	A User's Guide to Path Loss Computations

30.4 US Army Communications Command

CCTM-105-50-3	Line of Sight Radio Systems

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- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: ______

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b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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