METRIC

MIL-STD-188-161D
10 January 1995
SUPERSEDING
MIL-STD-188-161C
30 OCTOBER 1991

MILITARY STANDARD

INTEROPERABILITY AND PERFORMANCE STANDARDS FOR DIGITAL FACSIMILE EQUIPMENT

AMSC N/A

AREA TCSS

DISTRIBUTION STATEMENT A.
Approved for general release; distribution is unlimited.

FOREWORD

1. This military standard (MIL-STD) is approved for use by all departments and agencies of the Department of Defense (DOD).

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data that may be of use in improving this MIL-STD should be addressed to:

Joint Interoperability and Engineering Organization
ATTN: JIEO - TBBC
Fort Monmouth, NJ 07703-5613

by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this MIL-STD, or by letter.

3. In accordance with DOD Instruction 4630.8, DOD's policy is that all forces for joint and combined operations be supported through compatible, interoperable, and integrated command, control, communications, and intelligence (C3I) systems. Furthermore, all C3I systems developed for use by U.S. forces are considered to be for joint use. The Director of the Defense Information Systems Agency (DISA) serves as the DOD single point of contact for developing information technology standards to achieve interoperability and compatibility. All C3I systems and equipment shall conform to technical and procedural standards for compatibility and interoperability, as developed or recommended by DISA.

4. Military standards in the 188 series (MIL-STD-188-XXX) address telecommunications design parameters based on mature technologies and are to be used in all new DOD systems and equipment, or major upgrades thereto, to ensure interoperability. The MIL-STD-188 series is subdivided into a MIL-STD-188-100 series, covering common standards for tactical and long-haul communications; a MIL-STD-188-200 series, covering standards for tactical communications only; and a MIL-STD-188-300 series, covering standards for long-haul communications only. Emphasis is being placed on the development of common standards for tactical and long-haul communications (the MIL-STD-188-100 series). The MIL-STD-188 series may be based on, or make reference to, American National Standards Institute (ANSI) standards, International Telecommunication Union - Telecommunication (ITU-T) recommendations, International Organization for Standardization (ISO) standards, North Atlantic Treaty Organization (NATO) standardization agreements (STANAG), and other standards, wherever applicable.

5. This MIL-STD contains technical parameters for digital facsimile equipment used in tactical and long-haul communications. The parameters contained herein are consistent with the mandatory parameters of NATO STANAG 5000, and of the International Telecommunication Union - Telecommunication (ITU-T) Group 3 equipment as published in FIPs 147 and 148. ITU-T was formerly known as CCITT.

SPECIAL CONSIDERATIONS

1. MIL-STD-188-161D is being issued to provide enhanced protocol capabilities.

2. Department of Defense Instruction (DODI) 5000.2, Part 7c, states that the MIL-STD-188 series, appropriately tailored, will be used for all inter- and intra-DOD component systems and equipment to ensure interoperability and compatibility. The instruction requires that only applicable standards are to be used, and those standards must be tailored to invoke only those requirements suitable for the user. The following guidance is provided for your use:

a. Unclassified operations: The ITU-T Group 3 analog output machine is recommended for users who do not need to send classified information over facsimile equipment.

b. Classified operations: A Type I and/or Type II digital output facsimile machine is recommended for users who are required to transmit classified information. A dual-mode facsimile machine that has Type I and/or Type II and ITU-T Group 3 protocols will satisfy unclassified and classified operations.

c. Users must understand that this MIL-STD covers the minimum requirements. A user must consider the following factors, prior to purchasing facsimile equipment:

(1) Interoperability between U.S. and Allied forces, as required.

(2) Transmission rates required to support all phases of operational requirements (peacetime through war, tactical, and NATO STANAG 5000).

(3) Multipage requirements.

(4) Error correction requirements.

(5) Classified and unclassified processing.

(6) The type of cryptographic equipment being used with the facsimile equipment.

(7) Resolution requirements (low, medium, and high).

(8) Uncompressed mode requirements.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

FIGURES

CONTENTS (Concluded)

TABLES

1. SCOPE

1.1 Purpose. The purpose of this MIL-STD is to establish, in the most economical manner, interoperability and performance parameters necessary to ensure interoperability among long-haul and tactical digital facsimile equipment. The technical parameters established by this MIL-STD represent a set of minimum interoperability and performance characteristics, which may be exceeded to satisfy specific requirements.

This MIL-STD is not intended to serve as a stand-alone, comprehensive reference containing all technical parameters and other details required for the design of new equipment or the preparation of specifications. Therefore, parameters for such items as size and weight limitations, connectors, cable assemblies, or power supplies are not in this MIL-STD. These parameters and other design details have to be established, based on specific requirements, and have to be carefully tailored in accordance with the policies of DODI 5000.2, Part 10c.

The purpose of this MIL-STD is not to inhibit advances in communications technology. Such advances are facilitated by not specifying the technology that should be used in the design and development of digital facsimile systems to meet the required standards.

1.2 Content. This MIL-STD provides technical interoperability and performance parameters for two forms of digital facsimile equipment. The first form is designated Type I and/or Type II, which are interoperable with Type I and Type II NATO tactical digital facsimile equipment, respectively, and provide a digital output signal. The second form is designated ITU-T Group 3 facsimile equipment, in accordance with Federal Information Processing Standard (FIPS) 147 and FIPS 148, and provides an analog output signal.

1.3 Applicability. This MIL-STD is mandatory within DOD in the design, development, and acquisition of facsimile equipment. It is not intended that existing equipment and systems be immediately converted to comply with the provisions of this MIL-STD. New equipment and systems, and those undergoing major modification or rehabilitation, shall also conform to this MIL-STD.

1.3.1 Application guidance. Application of this MIL-STD shall be tailored in accordance with DODI 5000.2. Based on identified requirements, the following applies:

a. Facsimile equipment designated only for digital output shall, at a minimum, comply with Type I and/or Type II requirements.

b. Facsimile equipment designated only for analog output shall, at a minimum, comply with ITU-T Group 3 (FIPS 147 and FIPS 148) requirements.

c. Facsimile equipment designated for both digital and analog output shall, at a minimum, comply with both Type I and/or Type II (see sections 4 and 5) and ITU-T Group 3 (FIPS 147 and FIPS 148) requirements.

d. When a ITU-T Group 3 analog output facsimile requires interface with a digital output facsimile, that interface shall, at a minimum, comply with the Type I and/or Type II requirements.

1.4 System standards and design objective. The parameters and other requirements specified in this MIL-STD are mandatory system standards if the word *shall* is used in connection with the parameter value or requirement under consideration. Nonmandatory design objectives are indicated in parentheses after a standardized parameter value or by the word *should* in connection with the parameter value or requirement under consideration. For a definition of the terms *system standard* and *design objective*, see Federal Standard 1037 (FED-STD 1037).

2. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this MIL-STD to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the current issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplements thereto, cited in the solicitation.

FEDERAL STANDARDS

FED-STD-1037	Glossary of Telecommunication Terms
FIPS 147	Group 3 Facsimile Apparatus for Document Transmission (Note: DOD-adopted)
FIPS 148	Procedures for Document Facsimile Transmission (Note: DOD-adopted)

MILITARY STANDARDS

MIL-STD-188-100	Military Communications Systems Technical Standards, Common Long Haul and Tactical Communications Systems Technical Standards
MIL-STD-188-114	Electrical Characteristics of Digital Interface Circuits
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics

INTERNATIONAL STANDARDS

STANAG 5000	Interoperability of Tactical Digital Facsimile Equipment

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4, Section D, Philadelphia, PA 19111.)

[Copies of federal information processing standards (FIPS) are available to DOD activities from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099. Others must request copies of FIPS from the

National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161-2171.]

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this MIL-STD to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

NTISSI 7000	TEMPEST Countermeasures for Facilities (U) (SECRET)
DODI 5000.2	Defense Acquisition Management Policies and Procedures

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

(Copies of DOD directives are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4, Section D, Philadelphia, PA 19111.)

2.2 Non-Government publications. The following documents form a part of this MIL-STD to the extent specified herein. Unless otherwise specified, the issues of the documents, which are DOD-adopted, are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

Telecommunications Industry Association (TIA)/Electronic Industries Association (EIA)

TIA/EIA-465-A	Group 3 Facsimile Apparatus for Document Transmission
TIA/EIA-466-A	Procedures for Document Facsimile Transmission

(Applications for copies should be addressed to the Telecommunications Industry Association, 2001 Pennsylvania Avenue N.W., Washington, DC 20006.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this MIL-STD and the references cited herein, the text of this MIL-STD shall take precedence. Nothing in this MIL-STD, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Acronyms used in this MIL-STD

ACK	acknowledge
AMSC	Acquisition Management System Control
ANSI	American National Standards Institute
ASCII	American standard code for information interchange
BCH	Bose Chandhuri Hocquenghem code, a cyclic code
BER	bit error ratio
BILP	beginning of intermediate line pair
BOLP	beginning of line pair
bps	bit(s) per second
C3I	command, control, communications, and intelligence
CAP	capabilities
CMD SOM	command SOM
CRC	cyclic redundancy check
DCE	data circuit-terminating equipment
DISA	Defense Information Systems Agency
DOD	Department of Defense
DODI	Department of Defense Instruction
DODISS	Department of Defense Index of Specifications and Standards
DSVT	digital subscriber voice terminal (KY-68)
DTE	data terminal equipment
EMC	electromagnetic compatibility
EIA	Electronic Industries Association
EOL	end of line

EOM	end of message
EOT	end of transmission
FAX	facsimile
FEC	forward error correction
FED-STD	federal standard
FIPS	federal information processing standard
FSA	federal supply area
HDLC	high-level data link control
HSOM	handshake start of message
INFO	information
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ITU-T	International Telecommunication Union - Telecommunication (formerly CCITT)
JIEO	Joint Interoperability and Engineering Organization
JITC	Joint Interoperability Test Command
LSB	least significant bit
LSBP	LSB plane
MIL-STD	military standard
mm	millimeter(s)
MSB	most significant bit
MSBP	MSB plane
msec	millisecond(s)
NATO	North Atlantic Treaty Organization
NSA	National Security Agency
NTISSI	National Telecommunications and Information Systems Security Instruction

OCONUS	outside the continental United States
PDS	protected distribution system
PEL	picture element
PN	pseudorandom noise
PSTN	public switched telephone network
RSP SOM	response SOM
RTC	return to control
SDLC	synchronous data link control
SOM	start of message
STANAG	standardization agreement (NATO)
STU-III	secure telephone unit, third generation
TIA	Telecommunications Industry Association

3.2 Definitions used in this MIL-STD

3.2.1 Terms. Definitions of terms used in this MIL-STD shall be as specified in the current edition of FED-STD-1037. In addition, the following definitions are applicable for the purpose of this MIL-STD.

3.2.2 Type I facsimile equipment. Facsimile equipment, as defined in this MIL-STD, which provides for the transmission and reception of black-and-white information.

3.2.3 Type II facsimile equipment. Facsimile equipment, as defined in this MIL-STD, which provides for the transmission and reception of gray-scale information, as well as black-and-white information.

3.2.4 ITU-T Group 3 facsimile equipment. Facsimile equipment that provides for the transmission and reception of black-and-white information, as defined in ITU-T Recommendations T.4 and T.30 (FIPS 147 and FIPS 148). (This is an abbreviated definition for comparison with Type I and Type II definitions given above. For the complete definition, see FED-STD-1037.)

3.2.5 Digital facsimile equipment. Facsimile equipment that employs digital techniques to encode the image detected by the scanner.

3.2.6 Secured path. Communications path which is encrypted or is a protected distribution system (PDS).

3.2.7 Unsecured path. Communications path which is not encrypted nor is a PDS.

3.3 Type I and Type II facsimile mode definitions

3.3.1 Non-handshake mode. In non-handshake mode, no handshake is exchanged between transmitting and receiving facsimiles.

3.3.2 Handshake mode. In handshake mode, a handshake is exchanged between transmitting and receiving facsimiles before black-and-white or gray-scale information is sent. This is a normal method of operation for ITU-T Group 3 facsimile equipment.

4. GENERAL REQUIREMENTS

4.1 Interoperability. The requirements specified in this MIL-STD are intended to ensure facsimile interoperability among all Services and agencies within the DOD. STANAG 5000 requirements are specified for those DOD users who require interoperability with U.S. NATO allies.

a. Digital signal output. Facsimile equipment designated for digital output shall, at a minimum, comply with the requirements for Type I and/or Type II, as stated herein. (These requirements are consistent with STANAG 5000 parameters.)

b. Analog signal output. Facsimile equipment designated for analog output shall, at a minimum, comply with ITU-T Group 3 requirements, as documented in FIPS 147 and FIPS 148.

c. Dual-mode signal output. Facsimile equipment designated for both digital and analog output shall, at a minimum, comply with both ITU-T Group 3 and Type I and/or Type II requirements, as stated in a and b above.

d. ITU-T Group 3 interface for digital transmissions. ITU-T Group 3 analog output facsimile equipment requiring a digital output shall, at a minimum, comply with Type I or Type II facsimile requirements in this MIL-STD.

4.1.1. Dual-mode protocols. Type I and/or Type II protocols should always be used between terminals implementing both ITU-T Group 3 and Type I and/or Type II protocols. Receiving dual-mode terminals shall be able to recognize and differentiate between ITU-T Group 3 and Type I and/or Type II transmissions. (NOTE: No requirement exists for ITU-T Group 3 protocols and Type I and/or Type II protocols to interoperate.)

4.1.2. Facsimile security. When facsimile equipment is used for processing classified information, such equipment shall not allow classified traffic to pass through an unsecured path.

4.2 TEMPEST. The facsimile equipment, when provided for secure operations, shall meet the applicable requirements of National Telecommunications and Information Systems Security Instruction (NTISSI) 7000(U)(SECRET).

4.3 NATO interoperability. When NATO interoperability is required between facsimile equipment with digital signal outputs, then the equipment shall conform to NATO STANAG 5000.

4.4 Electromagnetic compatibility (EMC) requirements. The facsimile equipment shall comply with the applicable requirements of MIL-STD-461. Test methods and measurements taken to determine equipment electromagnetic interference characteristics shall be accomplished in accordance with the requirements of MIL-STD-462.

5. DETAILED REQUIREMENTS

5.1 General. This section includes detailed requirements for Type I and Type II digital facsimile equipment. To obtain detailed information on ITU-T Group 3 analog facsimile equipment, see FIPS 147 and 148.

5.1.1 Transmission rates. The facsimile equipment, excluding the modem, shall be able to operate bit-by-bit asynchronously at data rates of 2400 bps, 4800 bps, and 9600 bps, with timing provided by an external clock. Additional standard rates specified in MIL-STD-188-100 may be implemented as required. NATO interoperability requires 2400 bps and 16,000 bps, in accordance with STANAG 5000. The phase relationship between external clock pulses and the data transmission rate of the digital facsimile shall be in accordance with MIL-STD-188-100, paragraph 4.3.1.6.3.

5.1.2 Digital interfaces. The electrical characteristics of all digital interfaces for data, control, and timing signals shall comply with the applicable requirements as stated in MIL-STD-188-114.

5.1.3 Interchange circuits. The interchange circuits shown in Table I are mandatory. Other circuits may be provided for specific applications.

TABLE I. Functional interchange circuits.

CIRCUIT	DIRECTION
Request to Send	from DTE to DCE
Clear to Send	from DCE to DTE
Receive Input Control	from DTE to DCE
Send Data	from DTE to DCE
Receive Data	from DCE to DTE
Send Timing	from DCE to DTE
Receive Timing	from DCE to DTE
Loss of Sync	from DTE to DCE
Send Common*	Return
Receive Common*	Return
Signal Ground	Ground

* For applicability see MIL-STD-188-114, paragraphs 5.4.2.8 and 5.4.2.9.

5.1.4 Synchronization codewords and signaling sequences. The codewords and signaling sequences used in Type I and Type II facsimiles shall be as defined in Table II.

TABLE II. Codewords and signaling sequences for Type I and Type II.

NAME	COMPOSITION
Beginning of Intermediate Line Pair (BILP)	00000000000000011
Beginning of Line Pair (BOLP)	00000000000000010
End of Line (EOL)	000000000001
End of Message (EOM)	Minimum of 16 consecutive S_1 codewords
NOT End of Message ($\overline{EOM}$)	Minimum of 16 consecutive inverted S_1 codewords
End of Transmission (EOT)	Minimum of 16 consecutive S_0 codewords
Return to Control (RTC)	EOL EOL EOL EOL EOL EOL
Start of Message (SOM)	S_1 S_0 *X* clock periods, S_0 S_1 (where *X* is the number of clock periods between the pairs of codewords)
S_0	111100010011010
S_1	111101011001000
Fill	Variable-length string of 0's
Stuffing	Variable-length string of 1's
Preamble	Variable-length string of all 1's or all 0's

5.2 Type I facsimile equipment

5.2.1 Image parameters

5.2.1.1 Tolerance. The tolerance for the image parameters listed in 5.2.1.2 and 5.2.1.3 shall be ±1 percent.

5.2.1.2 Scan line length. The scan line length shall be 215 mm. Other, optional, scan-line lengths may be implemented by the employment of appended protocols (see 5.2.5.4.2 and 5.2.5.4.3).

5.2.1.3 Resolution. The facsimile equipment shall implement the medium resolution. The low and high resolutions, defined below, are optional. Other optional resolutions may be implemented by the employment of appended protocols (see 5.2.5.4.2 and 5.2.5.4.3).

a. Medium. 3.85 lines per mm (vertical) by 1728 black-and-white picture elements (pels) along the horizontal scan line. (NOTE: This is a nominal medium resolution of 100 by 200 lines per inch.)

b. Low. 3.85 lines per mm (vertical) by 864 black-and-white pels along the horizontal scan line. (NOTE: This is a nominal low resolution of 100 by 100 lines per inch.)

c. High. 7.7 lines per mm (vertical) by 1728 pels along the horizontal scan line. (NOTE: This is a nominal high resolution of 200 by 200 lines per inch.)

5.2.1.4 Scanning direction. Scanning direction shall be from left to right and from top to bottom.

5.2.1.5 Scanned line transmission time. The minimum scanned line transmission time shall be 20 msec. Other, optional, minimum scanned-line transmission times may be implemented by the employment of appended protocols (see 5.2.5.4.2 and 5.2.5.4.3).

5.2.1.6 Contrast levels. The contrast levels shall be black and white.

5.2.2 Document dimensions

5.2.2 Document dimensions. Input of documents up to a maximum of 215 mm wide by 1000 mm long shall be accepted. Documents up to 230 mm wide may be accepted into the scanner, but only 215 mm of the document shall be scanned. Other, optional, scanned widths may be implemented by the employment of appended protocols (see 5.2.5.4.2 and 5.2.5.4.3).

5.2.3 Image coding modes. The facsimile equipment shall implement the compressed mode and compressed with forward error correction (FEC) mode. When NATO interoperability is required or severely degraded transmission conditions are expected (worse than can be handled by FEC), the facsimile equipment shall also implement the uncompressed mode. (Simplified block diagrams reflecting the image coding modes are shown in Appendix A.)

5.2.3.1 Uncompressed mode. In the uncompressed mode, facsimile data shall be transmitted pel by pel, with logic 1 representing black. Each line of the output data shall consist of a synchronization code followed by a number of pels, as specified in 5.2.1.3. The synchronization code shall be a sequence of two S_0 codewords.

5.2.3.2 Compressed mode. In the compressed mode, facsimile data shall be transmitted after compression by the redundancy reduction algorithm. A line of data shall be composed of a series of variable-length codewords. Each codeword represents a run-length of either all white or all black. White runs and black runs shall alternate. All data lines shall begin with a white run-length codeword to ensure that the receiver maintains color synchronization. A white run-length of zero shall be sent if the actual scan line begins with a black run. Black or white run-lengths, up to a maximum length of one scanning line (1728 pels), are defined by the codewords in Tables III and IV. The codewords are of two types: terminating codewords and make-up codewords. Each run-length shall be represented by either one terminating codeword, or one make-up codeword followed by a terminating codeword.

5.2.3.2.1 Short runs. Run-lengths in the range of 0 through 63 pels shall be encoded with the appropriate terminating codeword. (NOTE: The black run-length codewords and the white run-length codewords are in separate lists.)

5.2.3.2.2 Long runs. Run-lengths in the range of 64 through 1728 pels shall be encoded first by the make-up codeword representing the run-length equal to or shorter than that required. The make-up codeword shall be followed by the terminating codeword representing the difference between the required run-length and the run-length represented by the make-up codeword.

5.2.3.2.3 End of line (EOL). The EOL codeword shall follow each line of facsimile data. (NOTE: This is a unique codeword that can never be found within a valid line of data. Therefore, resynchronization after an error burst is possible.) In addition, the EOL codeword shall also be sent prior to the first data line of a page.

5.2.3.2.4 Fill. Fill may be placed in the data flow to generate a pause. Fill may be inserted between a line of data and an EOL, but never within a line of data. Fill shall be added to ensure that the transmission time of each total coded scan line is not less than the minimum. To prevent premature disconnects, the maximum transmission time of any total coded scan line should be less than the interval specified in the loss of synchronization specifications. (NOTE: Fill format is a variable-length string of 0's.)

TABLE III. Terminating codes.

WHITE RUN LENGTH	CODEWORD	BLACK RUN LENGTH	CODEWORD
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100

TABLE III. Terminating codes. (Concluded)

WHITE RUN LENGTH	CODEWORD	BLACK RUN LENGTH	CODEWORD
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

NOTE: These codes are identical to those of ITU-T Recommendation T.4.

TABLE IV. Make-up codes.

WHITE RUN LENGTH	CODEWORD	BLACK RUN LENGTH	CODEWORD
64	11011	64	0000001111
128	10010	128	000011001000
192	010111	192	000011001001
256	0110111	256	000001011011
320	00110110	320	000000110011
384	00110111	384	000000110100
448	01100100	448	000000110101
512	01100101	512	0000001101100
576	01101000	576	0000001101101
640	01100111	640	0000001001010
704	011001100	704	0000001001011
768	011001101	768	0000001001100
832	011010010	832	0000001001101
896	011010011	896	0000001110010
960	011010100	960	0000001110011
1024	011010101	1024	0000001110100
1088	011010110	1088	0000001110101
1152	011010111	1152	0000001110110
1216	011011000	1216	0000001110111
1280	011011001	1280	0000001010010
1344	011011010	1344	0000001010011
1408	011011011	1408	0000001010100
1472	010011000	1472	0000001010101
1536	010011001	1536	0000001011010
1600	010011010	1600	0000001011011
1664	011000	1664	0000001100100
1728	010011011	1728	0000001100101
EOL	000000000001	EOL	000000000001

NOTE: These codes are identical to those of ITU-T Recommendation T.4.

5.2.3.2.5 Return to control (RTC). A minimum of two contiguous RTC signals shall be sent to indicate the end of message (EOM) transmission. (NOTE: Each RTC consists of six consecutive EOLs.) Following the RTC signals, the transmitter shall send post-message commands.

5.2.3.3 Compressed with forward error correction. In the compressed with FEC mode, facsimile data shall be further processed by a channel coder and bit interleaving buffer to provide FEC. The channel coder shall use a Bose Chandhuri Hocquenghem (BCH) FEC code with the capability to correct two errored bits per block. A BCH (63,51) code, defined by the generator polynomial $G = X^{12} + X^{10} + X^8 + X^5 + X^4 + X^3 + 1$, shall be used. Table V lists the syndromes of the BCH code that shall be used.

5.2.3.3.1 Encoder. An encoder shall be provided in the facsimile transmitter to encode the facsimile data using the BCH code. For information on possible implementation of the encoder, see Appendix A.

5.2.3.3.2 Decoder. A decoder shall be provided in the facsimile receiver to decode the received facsimile data. For information on possible implementation of the decoder, see Appendix A.

5.2.3.3.3 Interleaving buffer. An interleaving buffer shall be used to improve the error-correcting capability of the channel encoder, especially considering transmission bit errors clustered in bursts. The buffer shall be a matrix of 63 x 5 = 315 bits. Figure 1 shows the interleaving buffer configuration on the transmitting side. [NOTE: The figure labeling follows STANAG 5000 format; hence, the long side of the matrix is designated N (N = 63) and the short side is designated W (W = 5).] Data input shall be line-by-line; data output shall be column-by-column. The data input sequence shall be

$$D_0,\ D_1, \ldots,\ D_{313},\ D_{314}$$

Accordingly, the data output sequence shall be

$$D_0,\ D_{63},\ D_{126},\ D_{189},\ D_{252},\ D_1,\ D_{64}, \ldots,\ D_{188},\ D_{251},\ D_{314}$$

At the receiving side, the data input and data output sequence shall be the reverse of the transmitting side (as shown in Figure 2).

5.2.3.3.4 Synchronization. The transmitting BCH-encoder and interleaving buffer, respectively, shall be synchronized with the receiving BCH-decoder and interleaving buffer, before starting to transmit encoded facsimile data. The FEC control block shall be

TABLE V. Syndromes of the BCH decoder.

	r11	r10	r9	r8	r7	r6	r5	r4	r3	r2	r1	r0
R1	1	0	0	0	0	0	0	0	0	0	0	0
R2	1	1	0	0	0	0	0	0	0	0	0	0
R3	1	0	1	0	0	0	0	0	0	0	0	0
R4	1	0	0	1	0	0	0	0	0	0	0	0
R5	1	0	0	0	1	0	0	0	0	0	0	0
R6	1	0	0	0	0	1	0	0	0	0	0	0
R7	1	0	0	0	0	0	1	0	0	0	0	0
R8	1	0	0	0	0	0	0	1	0	0	0	0
R9	1	0	0	0	0	0	0	0	1	0	0	0
R10	1	0	0	0	0	0	0	0	0	1	0	0
R11	1	0	0	0	0	0	0	0	0	0	1	0
R12	1	0	0	0	0	0	0	0	0	0	0	1
R13	0	0	1	0	1	0	0	1	1	1	0	0
R14	1	1	0	1	0	1	0	0	1	1	1	0
R15	1	0	1	0	1	0	1	0	0	1	1	1
R16	0	0	1	1	1	1	0	0	1	1	1	1
R17	0	1	1	1	0	1	1	1	1	0	1	1
R18	0	1	0	1	0	0	1	0	0	0	0	1
R19	0	1	0	0	0	0	0	0	1	1	0	0
R20	1	1	1	0	0	0	0	0	0	1	1	0
R21	1	0	1	1	0	0	0	0	0	0	1	1
R22	0	0	1	1	0	0	0	1	1	1	0	1
R23	0	1	1	1	0	0	0	1	0	0	1	0
R24	1	1	1	1	1	0	0	0	1	0	0	1
R25	0	0	0	1	0	1	0	1	1	0	0	0
R26	1	1	0	0	1	0	1	0	1	1	0	0
R27	1	0	1	0	0	1	0	1	0	1	1	0
R28	1	0	0	1	0	0	1	0	1	0	1	1
R29	0	0	1	0	0	0	0	0	1	0	0	1
R30	0	1	1	1	1	0	0	1	1	0	0	0
R31	1	1	1	1	1	1	0	0	1	1	0	0
R32	1	0	1	1	1	1	1	0	0	1	1	0
R33	1	0	0	1	1	1	1	1	0	0	1	1
R34	0	0	1	0	0	1	1	0	0	1	0	1
R35	0	1	1	1	1	0	1	0	1	1	1	0
R36	1	1	1	1	1	1	0	1	0	1	1	1
R37	0	0	0	1	0	1	1	1	0	1	1	1
R38	0	1	1	0	0	0	1	0	0	1	1	1
R39	0	1	0	1	1	0	0	0	1	1	1	1
R40	0	1	0	0	0	1	0	1	1	0	1	1
R41	0	1	0	0	1	0	1	1	0	0	0	1
R42	0	1	0	0	1	1	0	0	0	1	0	0
R43	1	1	1	0	0	1	1	0	0	0	1	0
R44	1	0	1	1	0	0	1	1	0	0	0	1
R45	0	0	1	1	0	0	0	0	0	1	0	0
R46	1	1	0	1	1	0	0	0	0	0	1	0
R47	1	0	1	0	1	1	0	0	0	0	0	1
R48	0	0	1	1	1	1	1	1	1	1	0	0
R49	1	1	0	1	1	1	1	1	1	1	1	0
R50	1	0	1	0	1	1	1	1	1	1	1	1
R51	0	0	1	1	1	1	1	0	0	0	1	1
R52	0	1	1	1	0	1	1	0	1	1	0	1
R53	0	1	0	1	0	0	1	0	1	0	1	0
R54	1	1	1	0	1	0	0	1	0	1	0	1
R55	0	0	0	1	1	1	0	1	0	1	1	0
R56	1	1	0	0	1	1	1	0	1	0	1	1
R57	0	0	0	0	1	1	1	0	1	0	0	1
R58	0	1	1	0	1	1	1	0	1	0	0	0
R59	1	1	1	1	0	1	1	1	0	1	0	0
R60	1	0	1	1	1	0	1	1	1	0	1	0
R61	1	0	0	1	1	1	0	1	1	1	0	1
R62	0	0	1	0	0	1	1	1	0	0	1	0
R63	1	1	0	1	0	0	1	1	1	0	0	1

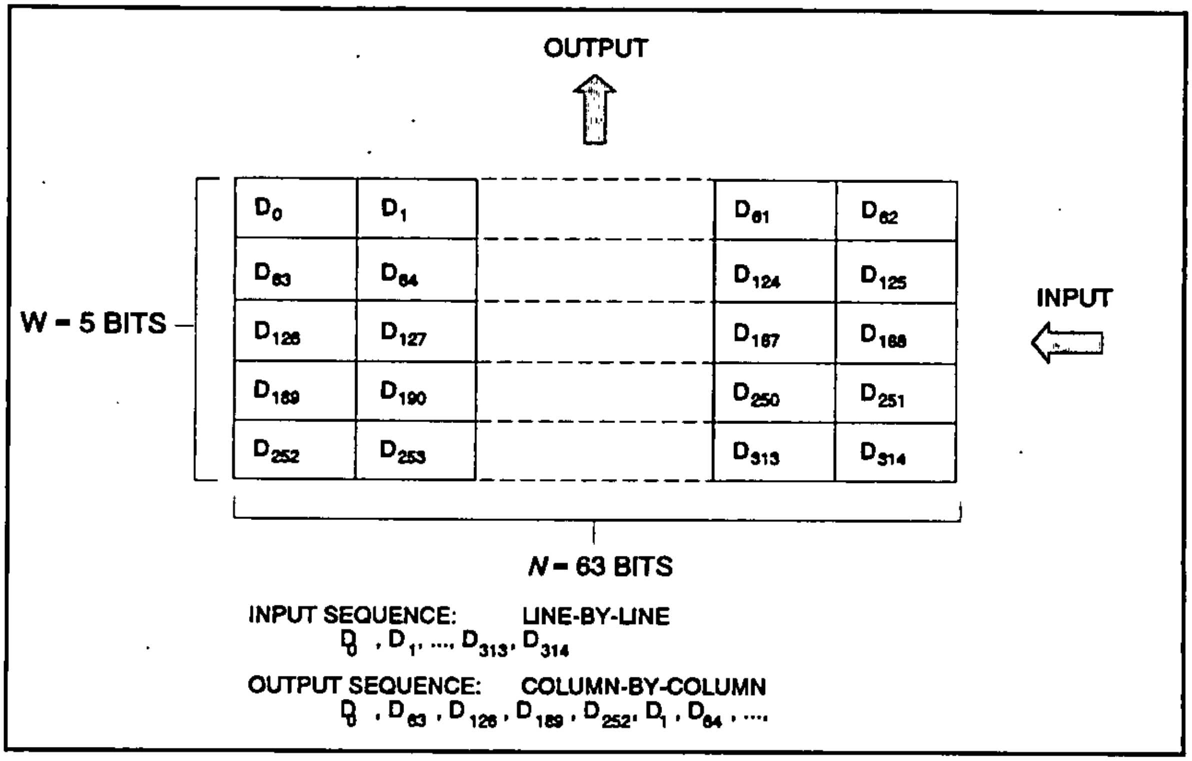


Figure 1. Interleaving buffer at the transmitter.

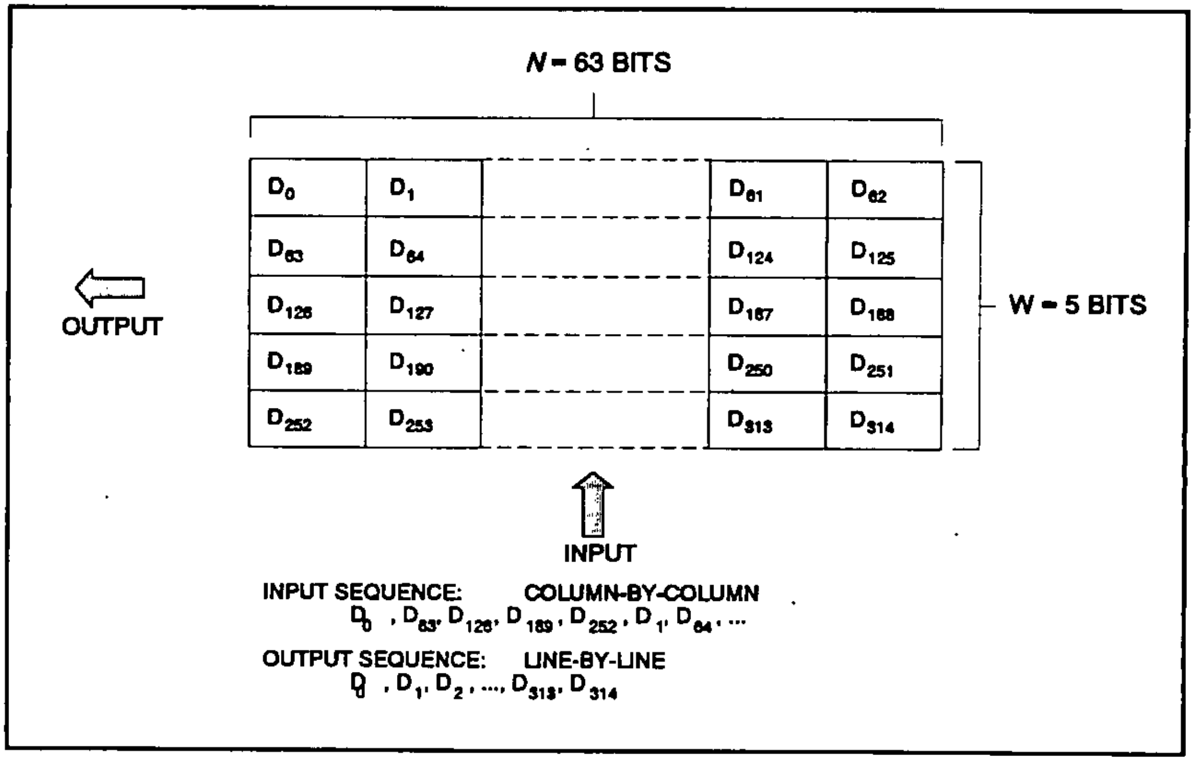


Figure 2. Interleaving buffer at the receiver.

the synchronization SOM sequence when the BCH-encoder and interleaving buffer are used. Figure 3 illustrates the format for the synchronization SOM sequence. The synchronization process shall be as follows:

a. The transmitter shall send the synchronization SOM sequence without using the BCH-encoder and interleaving buffer. Immediately after the synchronization SOM sequence, the transmitter uses the BCH-encoder and interleaving buffer to send encoded facsimile data.

b. At the receiver, the incoming signal shall be initially monitored bit-by-bit without using the BCH-decoder and interleaving buffer. When the first synchronization SOM sequence is detected, synchronization is achieved and, thereafter, the BCH-decoder and interleaving buffer shall be used. Block synchronization can be achieved at any of the three points illustrated in Figure 3. After the detection of any block synchronization point, incoming data shall pass through the BCH-decoder/corrector and the interleaving buffer to the facsimile decoder.

5.2.4 Loss of synchronization. In the event of the loss of the synchronization signal, the receiver shall be able to detect loss of synchronization. At any time following detection of the first synchronization signal, the receiver shall declare a loss of synchronization if a line synchronization code or an EOM has not been detected within a time-out period. This period shall be sufficiently long to preclude false declaration of loss of synchronization. The signal indicating the loss shall be an "ON" state, as defined by MIL-STD-188-114, applied to the loss of synchronization interchange circuit. (NOTE: In addition, criteria for declaring loss of synchronization, based on incorrectly decoded lines, may be applied. Implementation of this feature is a performance factor and does not bear directly on interoperability.)

5.2.5 Signaling protocols. Signaling protocol frames shall be used to coordinate message transmission. The parameters to be used for each transmission shall be signaled to the receiver by using SOM frames, and the termination of the facsimile transmission shall be signaled by an EOM sequence. The receive facsimile shall be able to detect and correct inverted data. [NOTE: Type I and Type II protocol signals have been specifically designed to provide extremely high assurance of correct receiver operation (automatic start, mode setup, and automatic stop) in error environments as high as a 10^{-2} bit error ratio (BER). This means that a return acknowledgment is not necessary for the non-handshake mode.]

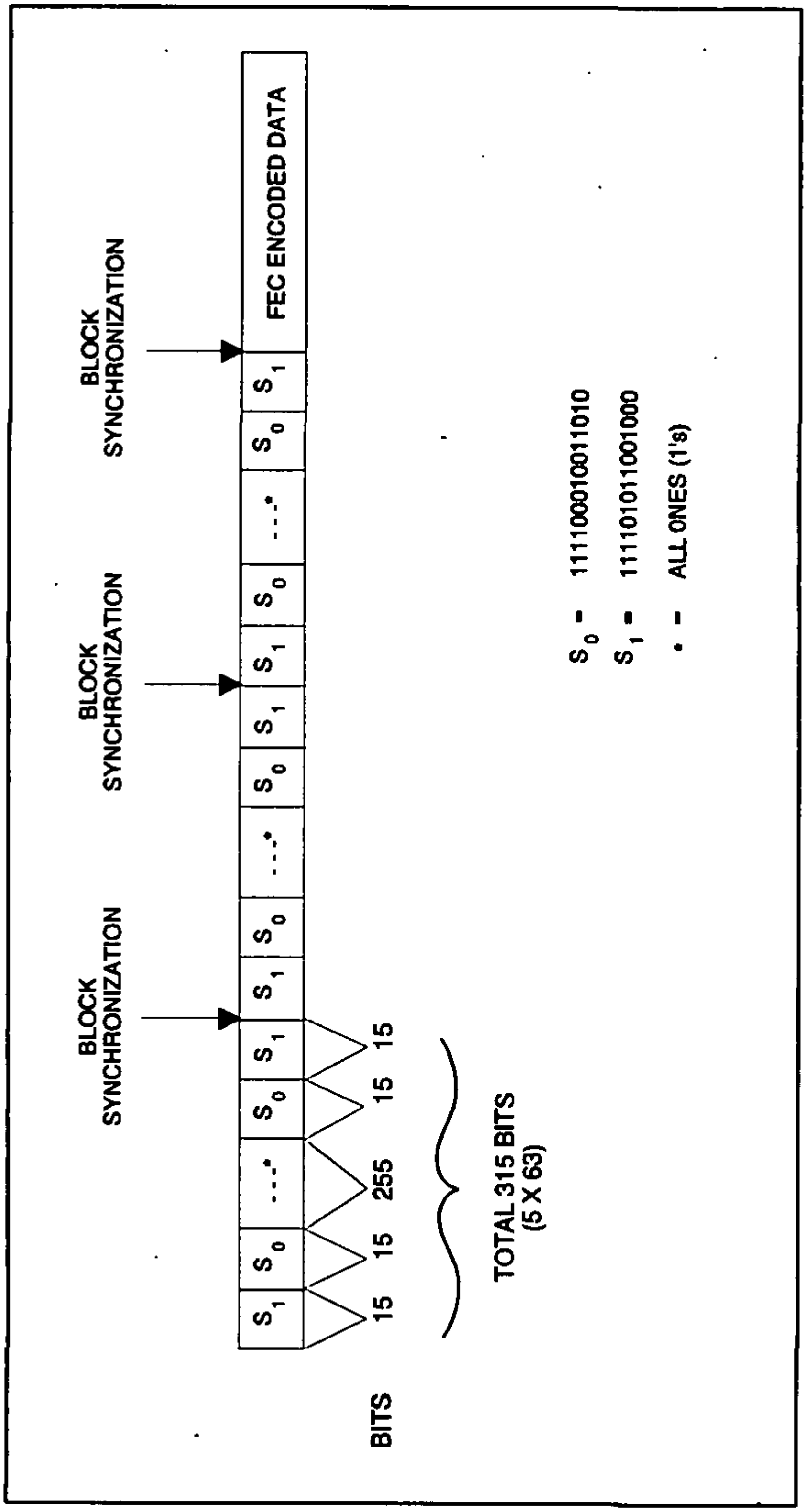


Figure 3. Synchronization SOM sequence for BCH coder and interleaver.

5.2.5.1 Protocol elements and frames

5.2.5.1.1 Synchronization codewords. Two special synchronization codewords shall be used, in various combinations, to generate all protocol requirements. The codewords are designated S_0 and S_1. Each codeword shall be made up of a 15-bit pseudorandom noise (PN) sequence, as shown in Table II. The composition of the protocol elements in terms of the synchronization codewords shall be as shown in Table VI. (NOTE: This lists the probability of detection, P_d, of each protocol element in a noise environment of 10^{-2} BER. All elements have detection probabilities in excess of 99.99 percent in this environment.)

[NOTE: If either of the PN sequences (codewords) is compared, bit-by-bit, with any cyclical shift of the sequence, the number of agreements differs from the number of disagreements by 1, except at the autocorrelation peak where there are 15 agreements. Consequently, the correlation improvement for exact synchronization is 15 to 1 for noise-free operation, and is reduced by 1 for every bit perturbed by noise. A significant correlation improvement is achieved, even in extremely noisy environments.]

5.2.5.1.2 Start of message (SOM). Each SOM frame shall consist of two pairs of synchronization codewords, S_0 and S_1, separated by an interval measured in clock periods, as shown in Figure 4. The mode shall be indicated by the number of clock periods (X) between two pairs of codewords. The data bit corresponding to each of these clock periods shall be logic 1. The binary value allocations for the command SOM frame shall be as shown in Figure 4. The value of X, to denote the interoperability modes, and the corresponding 8-bit binary designators, shall be as shown in Table VII. The SOM frame shall be transmitted three times, but detection by the receiver of any one frame shall be sufficient. Use of these signals is described in 5.2.5.2.

NOTE: The value of X can be calculated from the binary value allocations. For example, to obtain the X value corresponding to black-and-white operation, a resolution of 3.85 lines/mm times 1728 pels/scanline, and compressed mode, assemble the binary designator from the following binary value allocation:

00---001	black and white
00-01---	3.85 lines/mm x 1728 pels/scanline
000-----	compressed mode

The binary designator 00001001 is then converted to its decimal equivalent, 9, to get the X value.

TABLE VI. Protocol elements.

PROTOCOL ELEMENT	COMPOSITION	P_d AT 10^{-2} BER	TRANSMISSIONS REQUIRED	DETECTIONS REQUIRED
SOM	S_1 S_0 X S_0 S_1	0.999945	3	1
EOM	S_1	0.99995	16 minimum	4 in sequence

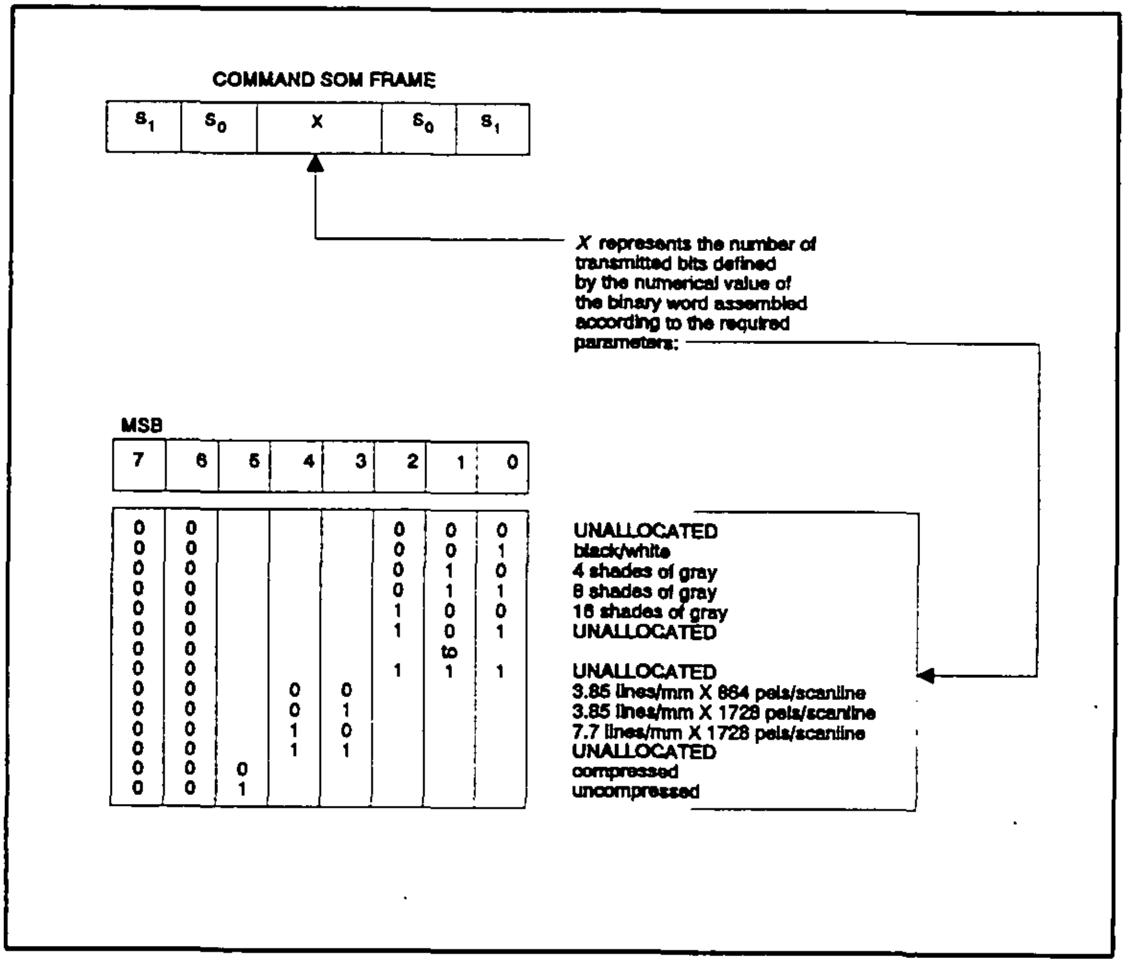


Figure 4. Value allocations for the Type I and Type II command SOM frame.

TABLE VII. X values with corresponding binary designator.

CMD SOM FRAME PARAMETERS				BINARY DESIGNATOR							
SHADES OF GRAY	RESOLUTION	COMPRESSION	NUMBER OF CLOCK PERIODS (X)	7	6	5	4	3	2	1	0
Black/White	3.85 x 864 (100 x 100)	C	1	0	0	0	0	0	0	0	1
4			2	0	0	0	0	0	0	1	0
8			3	0	0	0	0	0	0	1	1
16			4	0	0	0	0	0	1	0	0
Black/White	3.85 x 1728 (100 x 200)		9	0	0	0	0	1	0	0	1
4			10	0	0	0	0	1	0	1	0
8			11	0	0	0	0	1	0	1	1
16			12	0	0	0	0	1	1	0	0
Black/White	7.7 x 1728 (200 x 200)		17	0	0	0	1	0	0	0	1
4			18	0	0	0	1	0	0	1	0
8			19	0	0	0	1	0	0	1	1
16			20	0	0	0	1	0	1	0	0
Black/White	3.85 x 864 (100 x 100)	U	33	0	0	1	0	0	0	0	1
4			34	0	0	1	0	0	0	1	0
8			35	0	0	1	0	0	0	1	1
16			36	0	0	1	0	0	1	0	0
Black/White	3.85 x 1728 (100 x 200)		41	0	0	1	0	1	0	0	1
4			42	0	0	1	0	1	0	1	0
8			43	0	0	1	0	1	0	1	1
16			44	0	0	1	0	1	1	0	0
Black/White	7.7 x 1728 (200 x 200)		49	0	0	1	1	0	0	0	1
4			50	0	0	1	1	0	0	1	0
8			51	0	0	1	1	0	0	1	1
16			52	0	0	1	1	0	1	0	0

TABLE VII. X values with corresponding binary designator. (Concluded)

FEC CONTROL SOM FRAME PARAMETERS	NUMBER OF CLOCK PERIODS (X)	BINARY DESIGNATOR							
		7	6	5	4	3	2	1	0
FEC USED	255	1	1	1	1	1	1	1	1
FEC NOT USED	254	1	1	1	1	1	1	1	0

RESPONSE SOM FRAME PARAMETERS	NUMBER OF CLOCK PERIODS (X)	BINARY DESIGNATOR							
		7	6	5	4	3	2	1	0
ACK - EQUIPMENT READY TO RECEIVE	129	1	0	0	0	0	0	0	1
NAK - EQUIPMENT NOT READY	130	1	0	0	0	0	0	1	0
ILL - AN ILLEGAL SOM WAS RECEIVED	131	1	0	0	0	0	0	1	1

5.2.5.1.3 End of message (EOM). The EOM frame shall consist of at least 16 S_1 codewords transmitted in sequence. When 4 consecutive S_1 codewords have been detected by the receiver, EOM shall be declared.

5.2.5.2 Signaling sequence and timing

5.2.5.2.1 Compressed, forward error correction (FEC) not used. Figure 5 illustrates the signaling sequence for the compressed mode without FEC. At the start of a message transmission, a short pattern of data shall be sent to establish the data channel (such as modem training and encryption synchronization). The data transmitted shall conform with the definition of stuffing. With the data communications channel established, the signaling sequence shall begin with at least 16 inverted S_1 codewords. (NOTE: This enables the receiver to correct a channel inversion.) Three command (CMD) SOM frames with an appropriate *X* value shall be sent next, followed by 3 FEC control SOM frames with an *X* value of 254, signifying that FEC will not be used. Stuffing shall be inserted as needed, before and after the FEC control SOM frames. The facsimile data shall start with an EOL codeword no less than 2 seconds and no more than 3 seconds after the end of the third CMD SOM frame. At the end of the message, the facsimile data stream shall end with at least two contiguous RTC signals. Following RTC, an EOM shall signify the end of the current transmission. Stuffing should be inserted, as required, between RTC and EOM.

5.2.5.2.2 Compressed, FEC used. Figure 6 illustrates the signaling sequence for the compressed mode with FEC. The data communications channel shall be established as described in 5.2.5.2.1. Inverted S_1 codewords shall be sent as defined in 5.2.5.2.1. Three CMD SOM frames with an appropriate *X* value shall then be sent, followed by 3 FEC control SOM frames with an *X* value of 255 to synchronize the FEC system. The insertion and timing of the start of facsimile data shall be as described in 5.2.5.2.1. At the end of the message, the facsimile data shall end with at least 2 contiguous RTC signals. To allow freedom of implementation, EOM shall be sent both before the end and after the end of FEC coding. To ensure that the first EOM can be decoded correctly, the FEC block containing the final bit shall be transmitted in full. Stuffing bits shall be inserted, as required, between RTC and EOM. The second EOM (outside of FEC) shall not begin earlier than 500 msec after the end of the FEC block containing the final bit of RTC. Further signaling may then begin immediately after the second EOM.

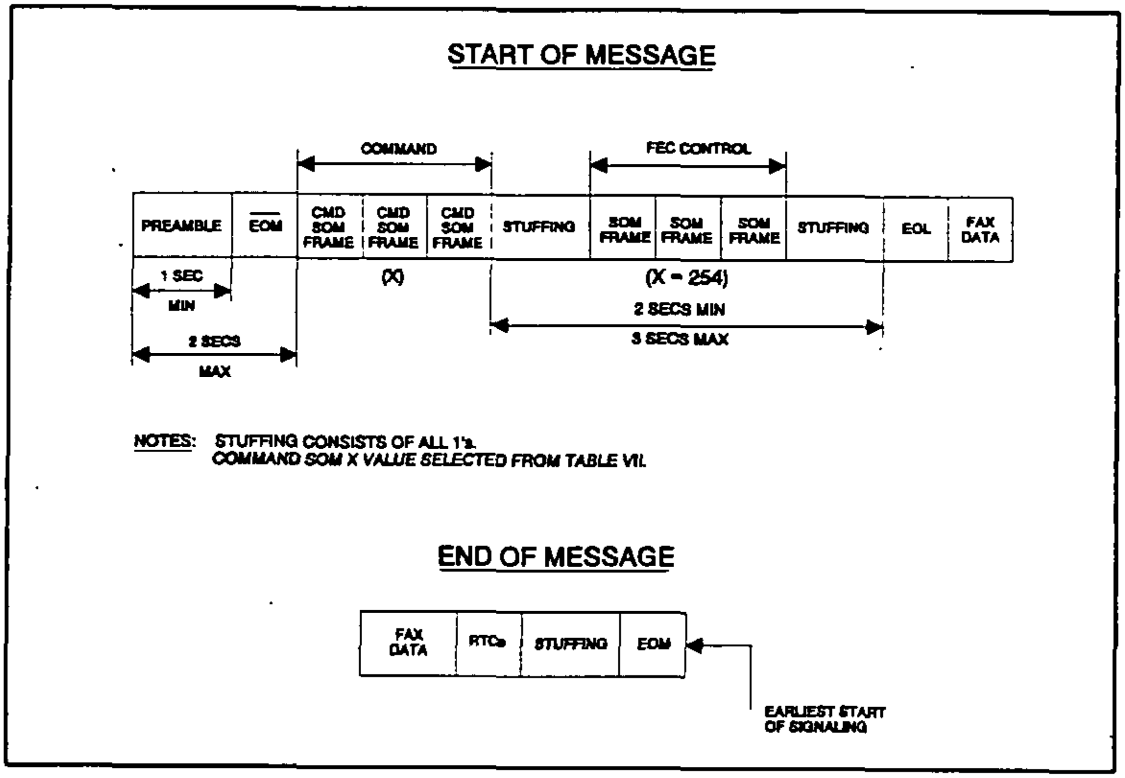


Figure 5. Signal timing, compressed mode, FEC not used.

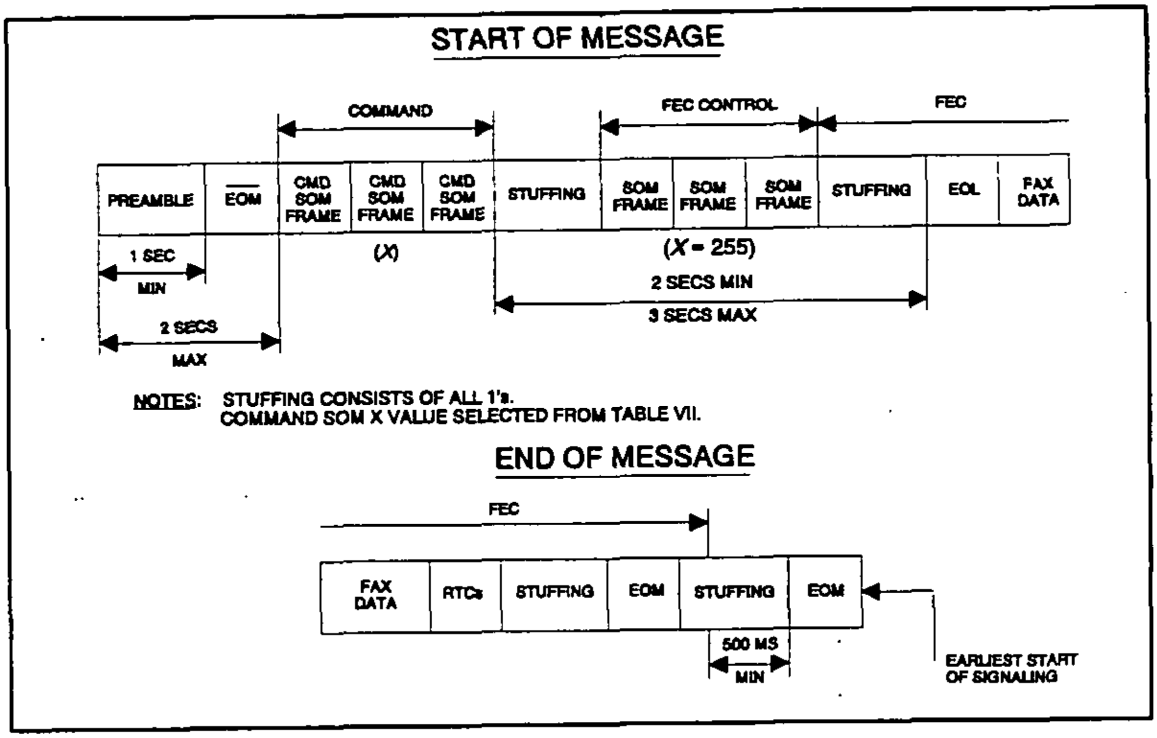


Figure 6. Signal timing, compressed mode, FEC used.

5.2.5.2.3 Uncompressed. Figures 7 and 10 illustrate signaling for the uncompressed mode. The data communications channel shall be established as described in 5.2.5.2.1. A minimum of 16 inverted S_1 codewords shall be sent, followed by 3 CMD SOM frames with an appropriate *X* value. Facsimile data shall follow no less than 2 seconds and no more than 3 seconds after the end of the last command SOM. At the end of the message, the facsimile data stream shall end with a minimum of 2 seconds of S_1 codewords. Further signaling may begin immediately after the S_1 codewords. Whenever the receiver does not detect EOM within 15 seconds after the last line synchronization code, the receiver shall assume that the transmission has terminated and proceed as if it had received an EOM.

5.2.5.3 Handshake mode protocols. This subparagraph provides the details of the handshaking protocols needed for interoperation in the handshake mode. Table VII shows the *X* value assignments for the handshake SOM (HSOM) frame.

5.2.5.3.1 Timing. Timing in the handshake mode is more complicated because the sending station shall interrupt transmission after sending the command SOM frames to listen for an acknowledgment. The FEC control SOM frames shall be sent after receiving acknowledgment. Figures 8 and 9 illustrate the timing required to transmit HSOM (with FEC enabled or disabled, respectively) when the receiving equipment's transmitter is in the standby mode. Figures 11 and 12 illustrate the timing required to insert the HSOM within a line of facsimile data when the receiving unit is also transmitting data.

5.2.5.3.2 Format. The signal format for the handshake mode shall be the same as described in 5.2.5.2.1 up to the end of the third CMD SOM frame. At this point, the transmitter shall prepare to receive an acknowledgment. The signal format of the receiver response acknowledging HSOM shall be the same as the command SOM, except for the X values defined in Table VII. The binary value allocations for the response SOM frame shall be as shown in Figure 13.

5.2.5.3.3 Acknowledgment. When satisfactory acknowledgment is received in a period extending from 2 to 15 seconds from the end of the first CMD SOM frame, then the transmission of facsimile data, including the FEC-control SOM frames, shall begin no less than 2 seconds after the detection of a response SOM frame or no more than 3 seconds from the last response SOM frame.

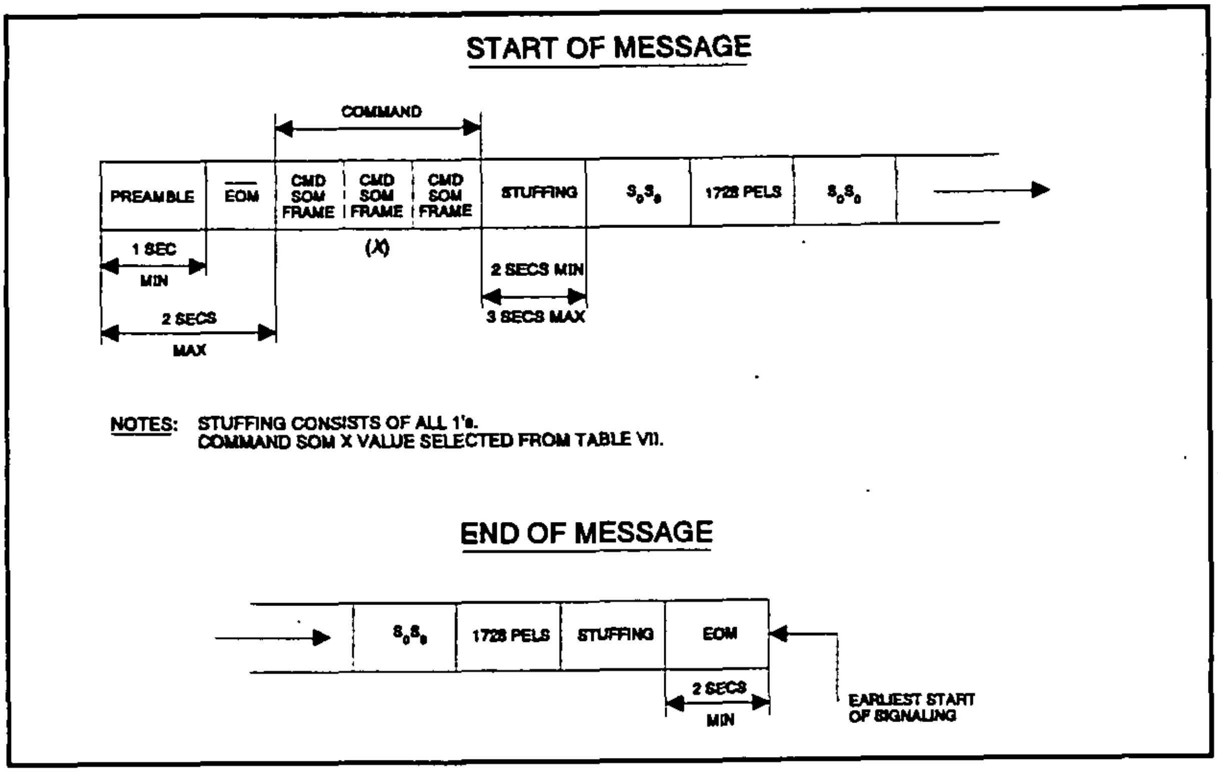


Figure 7. Signal timing, uncompressed mode.

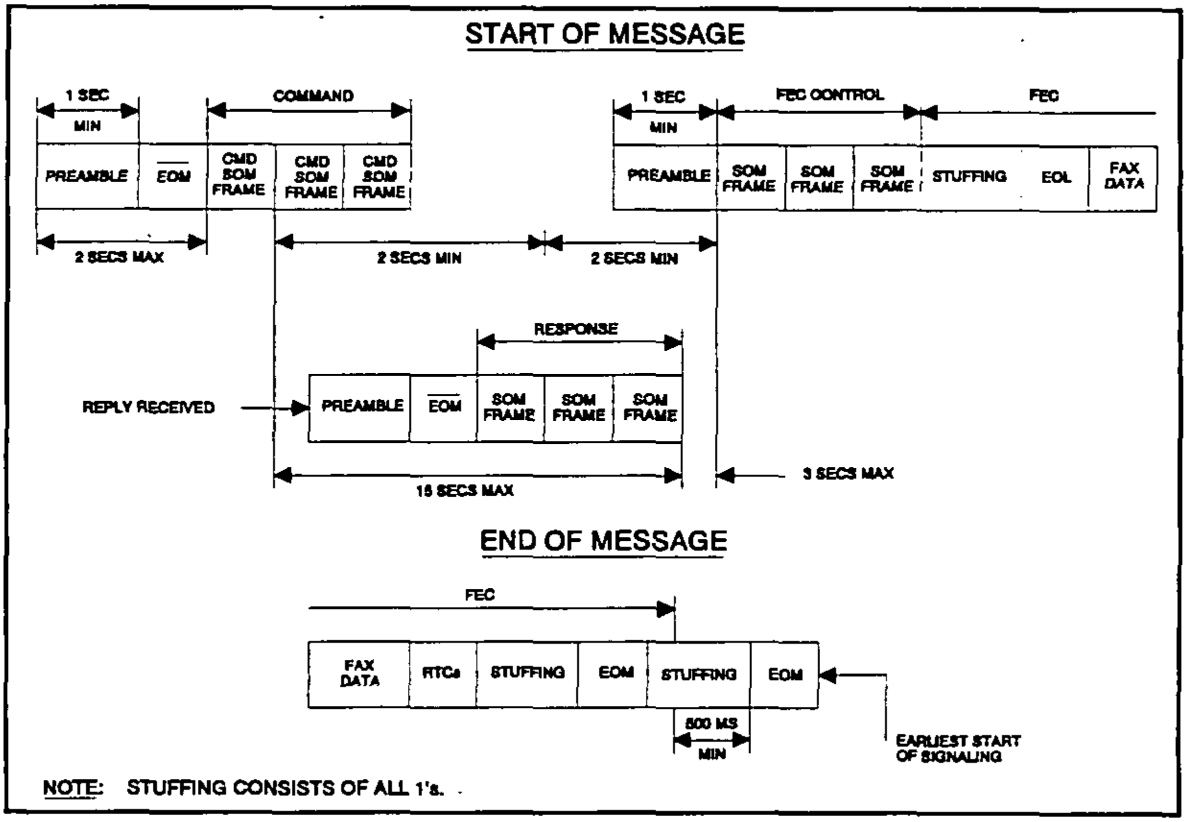


Figure 8. Signal timing, handshake mode, FEC used.

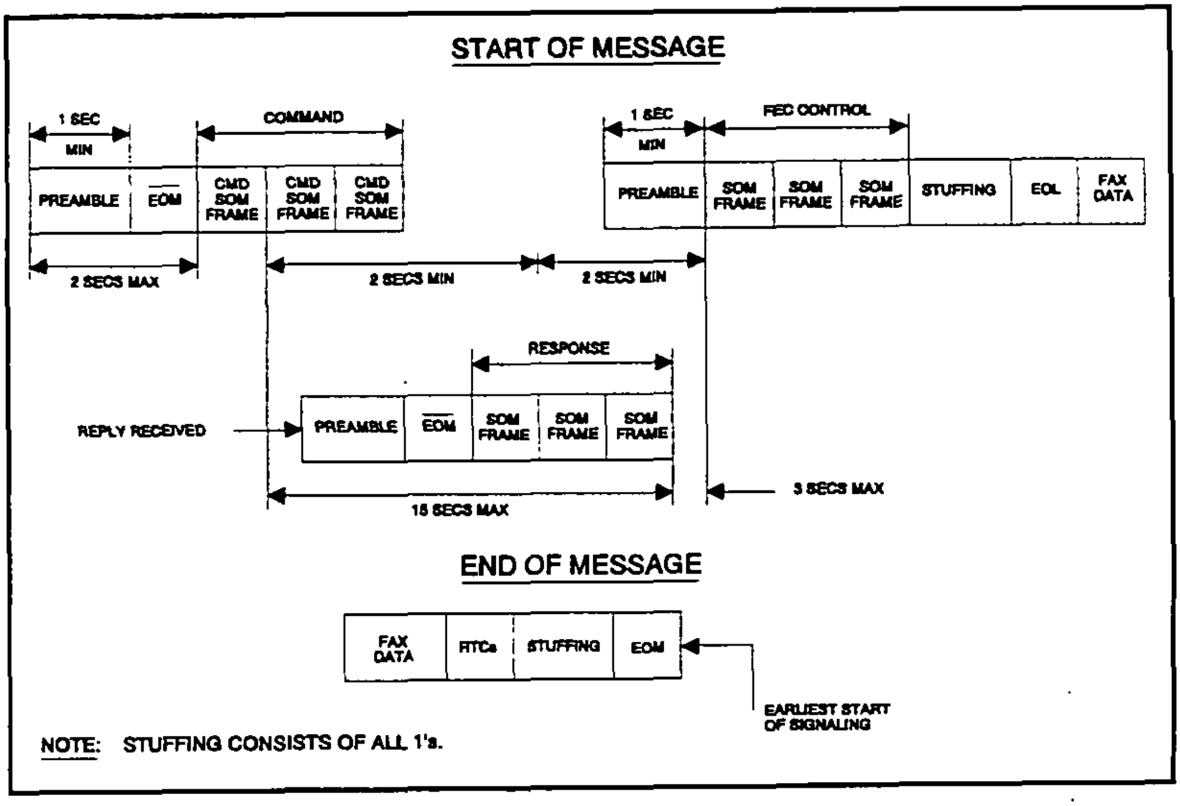


Figure 9. Signal timing, handshake mode, FEC not used.

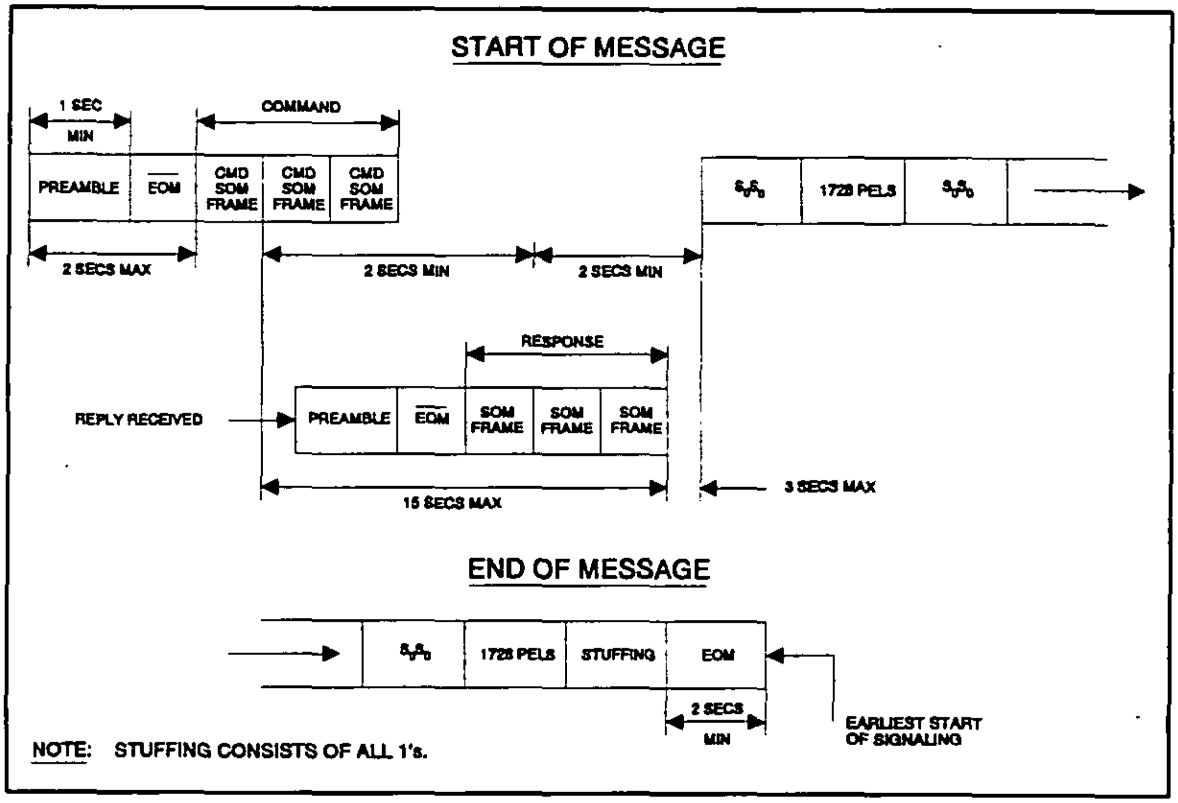


Figure 10. Signal timing, handshake mode, uncompressed mode.

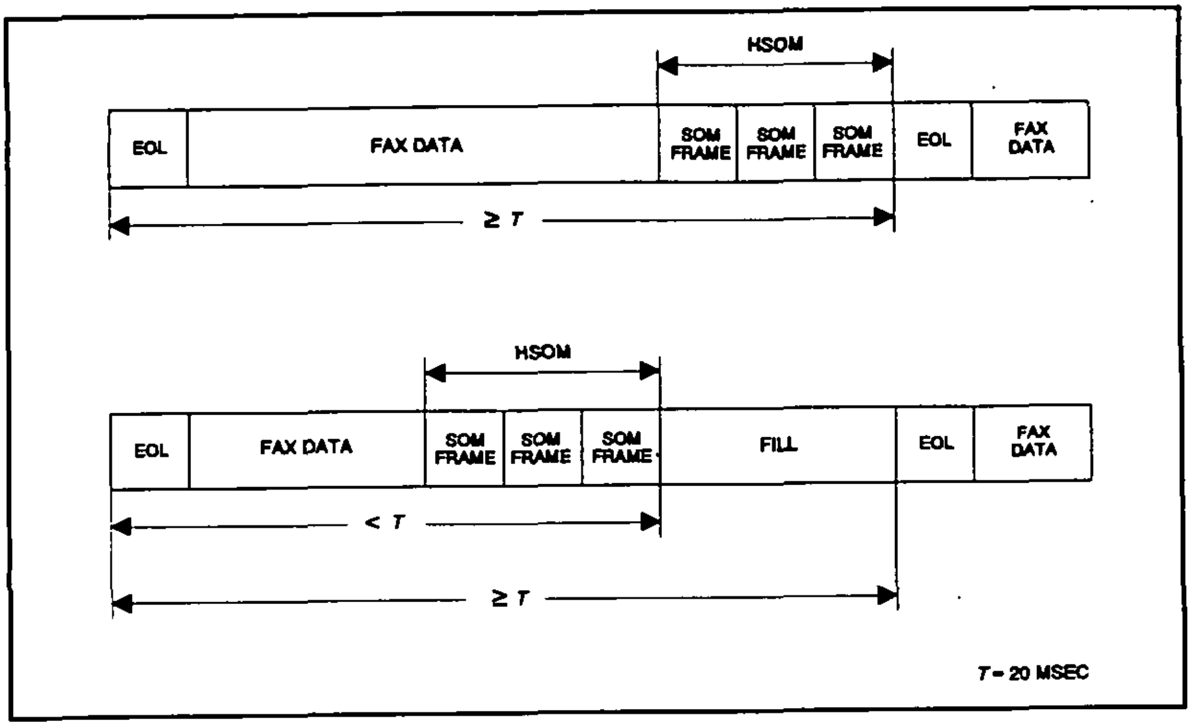


Figure 11. Transmission of the HSOM within a line of black-and-white compressed data.

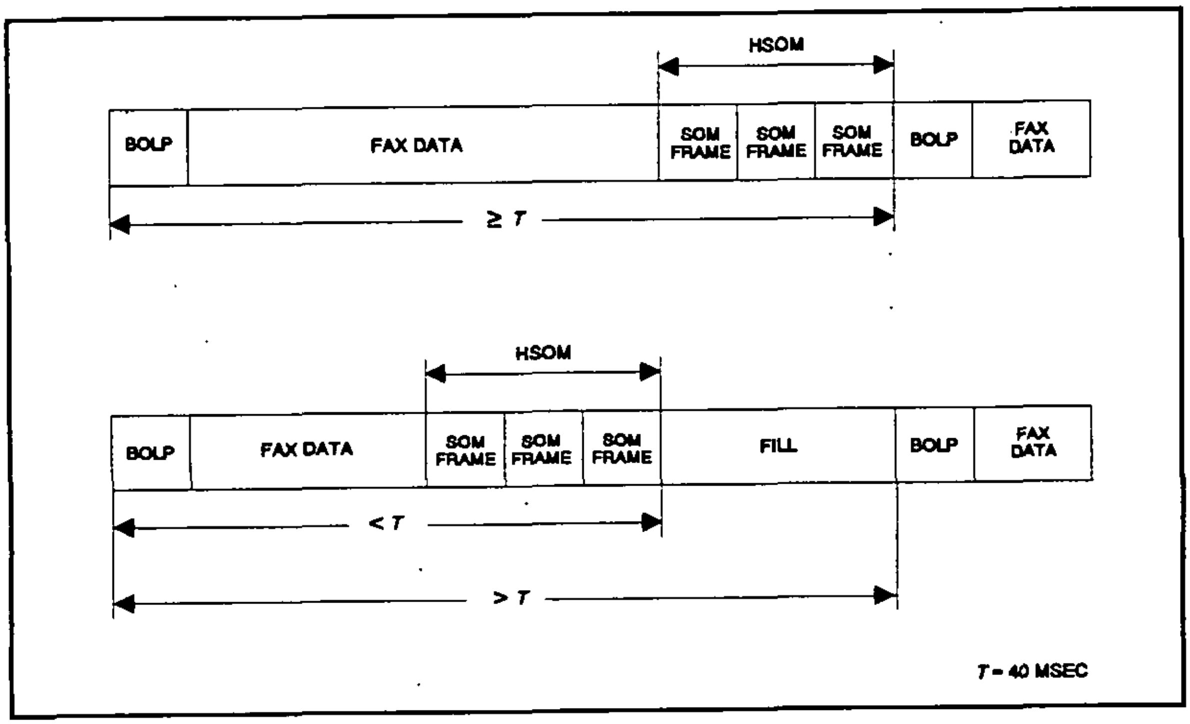


Figure 12. Transmission of the HSOM within a line of gray-scale compressed data.

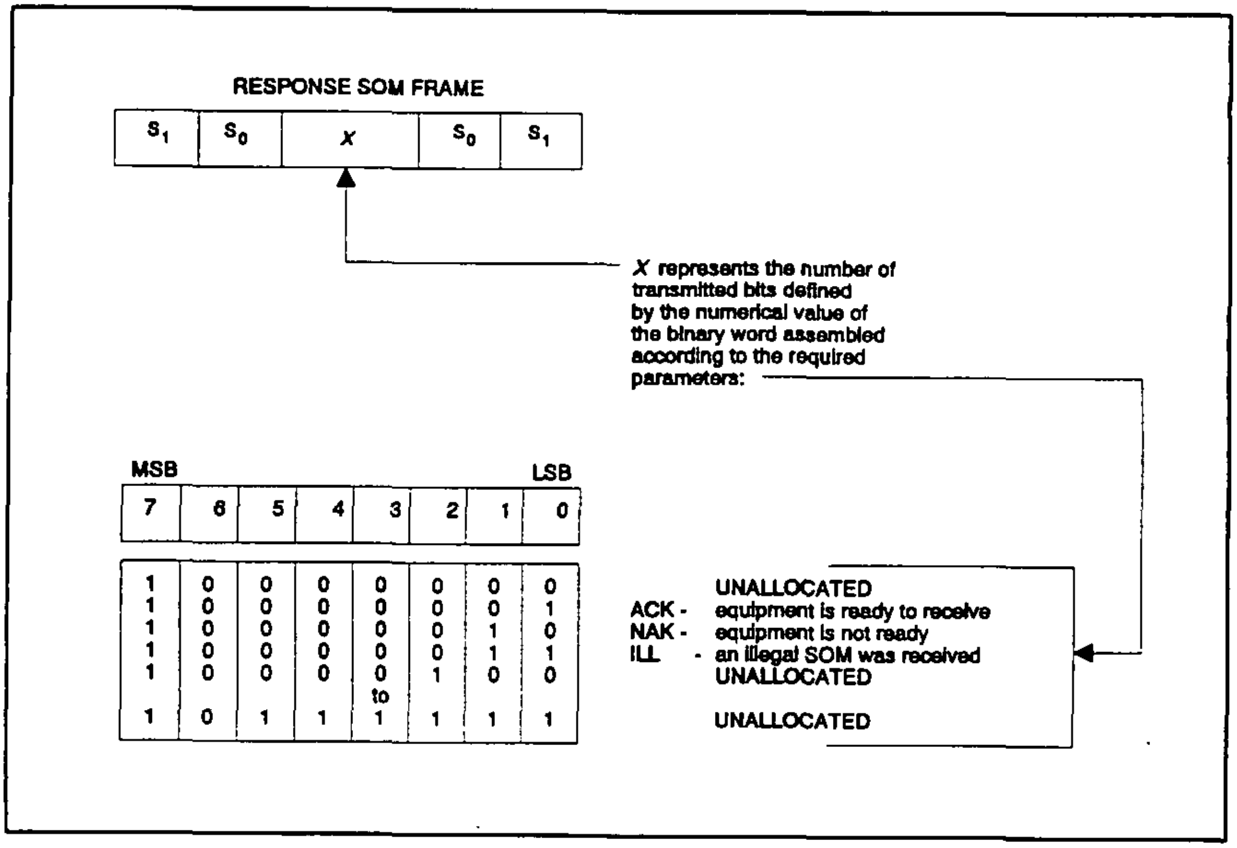


Figure 13. Value allocations for the response SOM frame.

5.2.5.3.4 Response. When a response SOM frame is not received within the defined period (see 5.2.5.3.3), or if a response SOM is received that is not a positive acknowledgment SOM, the equipment shall return to a mode in which it is ready to respond to CMD SOM frames. Similarly, if a facsimile line synchronization code has not been received within 15 seconds after transmitting the final response SOM frame, the receiver shall return to the mode where it can respond to CMD SOM frames.

5.2.5.3.5 End of message. The end of message signal format is the same as in 5.2.5.1.3 or 5.2.3.2.5.

5.2.5.3.6 Full-duplex mode. Full-duplex operation is optional. When operating in full-duplex mode and a transmission is being sent in the opposite direction, the response SOM shall be inserted in the data stream at the end of a line (or a line pair) of data prior to fill and the line synchronization codeword.

5.2.5.4 Special protocols. Some equipment may require additional protocols for the exchange of status, information, and capabilities in excess of those provided by the standard CMD SOM.

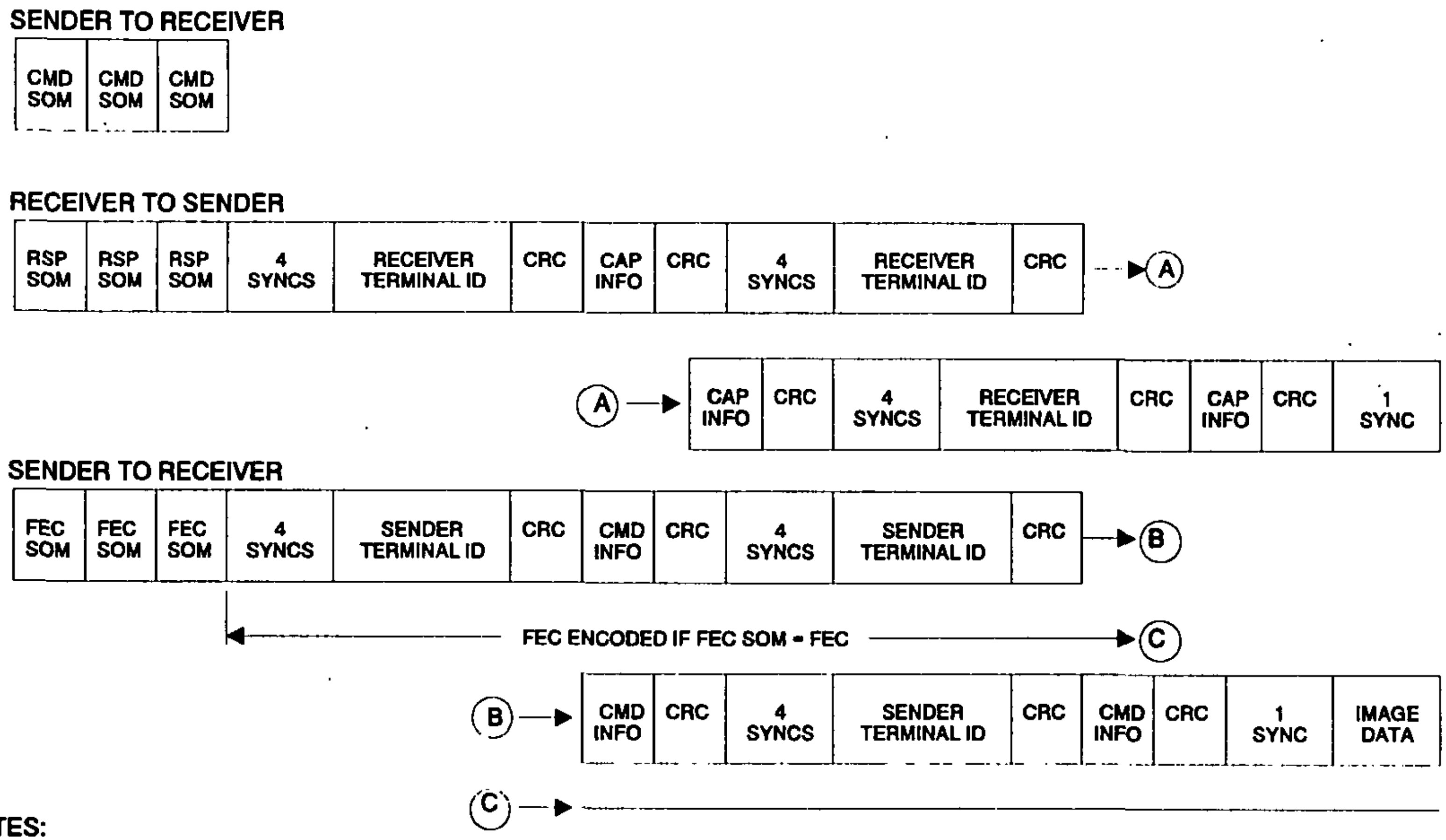
5.2.5.4.1 Extended command SOM protocols (optional capability). The CMD SOM protocol may be extended to provide the capacity to exchange facsimile status, information, and equipment capabilities. The regular CMD SOM frame, shown in Figure 4, has bits 0, 1, and 2 reserved for the gray-scale protocols, bits 3 and 4 for the resolution protocols, and bit 5 for the compression protocols; while bit 6 is set to "0". When set to 1, bit 6 shall identify the extended CMD protocols, indicating the transmission of supplemental CMD SOM frames that contain additional facsimile information. In each of the supplemental CMD SOM frames bit 6 shall be set to "1". The precise code allocations for these protocols are not a concern of this MIL-STD at this time.

5.2.5.4.2 Appended protocols (optional capability). The appended protocols expand the capabilities of this MIL-STD to include:

- Terminal ID exchange
- Page acknowledgment
- Capabilities interchange
- Alert other operator
- Future capabilities enhancements

The appended protocols will not interfere with existing protocols and equipment.

For equipment that requires appended protocols for the exchange of status, the appended protocol is added to the existing response (RSP) SOM and to the existing FEC SOM. The appended messages are shown in Figure 14.



NOTES:

1. SYNCs are 8 bits of ASCII SYN code of 0 x 16.
2. IDs are 20 8-bit ASCII codes with unused code set to SPACE (0 x 20).
3. ASCII codes are transmitted LSB first.
4. Capabilities (CAP) and response (RSP) information fields are 40 bits (5 bytes) long.
5. Cyclic redundancy checks (CRC) are 16 bits long and cover the ID and INFO. The same CRC code is used as in SDLC/HDLC (no 0-bit insertion will occur). See TIA/EIA-466-A Standard, paragraph 4.3.7, for definition.

Figure 14. Appended protocol messages.

5.2.5.4.2.1 Terminal ID exchange

a. General

- The sender sends the CMD SOM, as defined by this MIL-STD. In case the enhanced handshake is unsuccessful, the SOM value shall default to the non-enhanced operation.

- These enhancements cannot be used in conjunction with a CMD SOM specifying the uncompressed mode, since no FEC SOM exists in those modes.

- If an enhanced CMD information (INFO) message is sent, the image transmission shall be as specified by the CMD INFO rather than as specified in the CMD SOM. The enhanced protocol shall be repeated for each message in a multi-message transmission.

b. Handshake mode. In the handshake mode, an enhanced receiver shall make its ID and capabilities known in this extension. An enhanced sender can then match its capabilities and the sending operator's wishes with the receiver's capabilities and specify the transmission parameters it will use. If the sender is un-enhanced, the enhanced capabilities will not be detected, it shall not send an enhanced CMD frame, and the transmission shall proceed according to this MIL-STD. Likewise, if the receiver is un-enhanced, it shall not send an enhanced capability message. The sender shall not send an enhanced CMD frame. Again, the transmission shall take place as defined in this MIL-STD.

c. Broadcast mode. In the broadcast mode, the sender terminal ID can still be made known. If the CMD INFO specifies capabilities other than those defined in this MIL-STD, the operator should confirm the receiver's capabilities by voice and send only CMD INFO that is appropriate for the receiver (that is, not request a send in 300 x 300 unless the receiver is known to be able to receive 300 x 300).

5.2.5.4.2.2 Page acknowledgment. In a multi-page transmission, the receiver may indicate to the sender the quality of reception by using the acknowledge bits of the capabilities (CAP) INFO field of the RSP SOM for the next page. In response to an EOT signal, an enhanced receiver responds with an additional RSP SOM, indicating the quality of reception of the previous page. If the receiver has indicated PAGE acknowledge (ACK) capability in the previous RSP SOM, then the receiver must send the additional message within 12 seconds. Bits 23 and 24 of the receiver capabilities frame provide page acknowledgment information to the transmitter. Four responses are possible:

a. No page acknowledgment capability. Indicates that the receiver provides no page acknowledgment to a page transmission.

b. Good. Indicates that a complete page has been received and that additional pages may follow.

c. Acceptable. Indicates that a complete page has been received with errors and that additional pages may follow.

d. Unacceptable. Indicates that the previous page has not been satisfactorily received. However, further receptions may be possible, provided adjustments are made to improve the noise margins.

5.2.5.4.2.3 Capabilities interchange. In addition to the information exchanged during Terminal ID, a new message detection protocol tells the system where to insert the enhanced message. The SOM format was designed so that correct synchronization could be achieved even when some bits of the synchronization codes (S_0 and S_1) have been damaged by noise (see 5.2.5.1.1). In contrast, if any bits of a synchronization code are damaged in protocols like SDLC or BISYNC, the result will be a failure to receive the message. Typically these protocols are used in a fast turnaround environment in conjunction with "ACK/NAK" and "retransmit until successful" schemes. The RSP SOM and the FEC SOM are used for synchronization. Once the SOM has been detected, the receiver is synchronized to the incoming data stream except that it may not know which of the three receptions of the SOM it has detected. It will also know the exact length of the received SOM. From this it can make one of the following three assumptions:

a. If it has detected the third repetition, then the enhanced message will directly follow the detected SOM.

b. If it has detected the second repetition, then the enhanced message will directly follow the detected SOM by the number of bits in the detected SOM.

c. If it has detected the first repetition, then the enhanced message will directly follow the detected SOM by twice the number of bits in the detected SOM. The receiver can then look for synchronization bytes and calculate CRC based on those three assumptions. In addition, the three repetitions of the enhanced message may be majority-voted bit by bit, based on each of those three assumptions. The result may then be inspected for correct SYNC bytes and CRC. Synchronization should be based on the SOM, as described above, rather than on searching bit by bit for the SYNC codes.

5.2.5.4.2.4 Alert. A bit is provided in both the CAP and CMD INFO frames for alert. It may be used by either the sender or the receiver to indicate a desire to alert the operator of the other facsimile of some abnormal condition. No mandatory action to the reception of this condition is specified.

5.2.5.4.2.5 Future capabilities enhancements. Unallocated bits in each section have been reserved for future capabilities expansion.

5.2.5.4.3 Capabilities and command information fields. Table VIII provides the specific information required for the CAP and CMD INFO fields.

5.2.5.5 Inter-message timing. Further signaling may begin immediately after the final EOM (see Figures 5, 6, 7, 8, 9, and 10 for the point marked EARLIEST START OF SIGNALING). The receiving facsimile shall be able to accept the preamble for the next message immediately after the final EOM.

5.2.5.6 Multi-page transmissions (optional capability). Multi-page transmissions shall be accomplished by repeating the single-message signaling sequence and timing to form a multi-page transmission.

a. Facsimile equipment with multi-page capability shall maintain interoperability with Type I and Type II facsimile equipment defined by this MIL-STD.

b. After sending the last data-line of the final page, the transmitting facsimile shall timeout for 15 seconds, or more, before starting the message preamble and NOT EOM of a new message. A multi-page transmission may also be terminated by an end of transmission (EOT) signal.

5.2.5.6.1 Timeout. For a multi-page transmission, the facsimile shall send the next page's preamble and NOT EOM within 12 seconds of the end of the previous page's final facsimile data line (see Figures 15 and 16). If a subsequent page's preamble and NOT EOM are received within 15 seconds of receiving the last data line of the previous page, then the subsequent page shall be considered another page of the previous transmission. Otherwise, it shall be considered the first page of a new transmission.

TABLE VIII. Capabilities and command information fields.

BIT NUMBER (IN ORDER OF TRANSMISSION)	CAPABILITY	COMMAND
	Resolution	
1	R4 x 3.85[1]	R4 x 3.85
2	R8 x 3.85[2]	R8 x 3.85
3	R8 x 7.7 and/or 200 x 200[3]	R8 x 7.7 and/or 200 x 200
4	R8 x 15.4	R8 x 15.4
5	300 x 300[4]	300 x 300
6	R16 x 15.4 and/or 400 x 400[5]	R16 x 15.4 and/or 400 x 400
7	Future capability	
8	Future capability	
9	Inch-based preferred	Inch-based resolution
10	Metric-based preferred	
	Coding	
11	One- or two-dimensional coding	Two-dimensional coding[6]
12	Future capability	

NOTES:

1 R4 is the horizontal resolution of this standard's low resolution, 864 pels/215 mm.

2 R8 is the horizontal resolution of this standard's medium and high resolution, 1728 pels/215 mm or 2048 pels/255 mm or 2432 pels/303 mm.

3 200 is an inch-based horizontal resolution 200 pels/inch or 1728 pels/219.46 mm or 2048 pels/260.10 mm or 2432 pels/308.46 mm.

4 300 is an inch-based horizontal resolution 300 pels/inch or 2592 pels/219.46 mm or 3072 pels/260.10 mm or 3648 pels/308.46 mm.

5 400 is an inch-based horizontal resolution 400 pels/inch or 3456 pels/219.46 mm or 4096 pels/260.10 mm or 4864 pels/308.46 mm.

6 See TIA/EIA-465-A Standard, Table 3, for run-lengths greater than 1728 and paragraph 4.2.1.3 for two-dimensional coding.

TABLE VIII. Capabilities and command information fields. (Concluded)

BIT NUMBER (IN ORDER OF TRANSMISSION)	CAPABILITY	COMMAND
	Page Width	
13,14 (0,0)	Max width = 215 mm	Width = 215 mm
(0,1)	Max width = 303 mm	Width = 303 mm
(1,0)	Max width = 255 mm	Width = 255 mm
15	Future capability	
16	Future capability	
	Minimum Scan-line Time	
17,18,19 (0,0,0)	20 ms (7.7 = 3.85)	20 ms
(0,0,1)	40 ms (7.7 = 3.85)	40 ms
(0,1,0)	10 ms (7.7 = 3.85)	10 ms
(0,1,1)	5 ms (7.7 = 3.85)	5 ms
(1,0,0)	10 ms (7.7 - ½ 3.85)	
(1,0,1)	20 ms (7.7 - ½ 3.85)	
(1,1,0)	40 ms (7.7 - ½ 3.85)	
(1,1,1)	0 ms (7.7 = 3.85)	0 ms
20	15.4 or 400 = ½ 7.7	
21	Future capability	
22	Future capability	
	Page Acknowledgment Capability	
23,24 (0,0)	No page acknowledge capability	
(0,1)	Good	
(1,0)	Acceptable	
(1,1)	Unacceptable	
	Miscellaneous Capabilities	
25	Alert	Alert
26	Unlimited recording length	Unlimited recording length
27 - 40	Future capability	Future capability

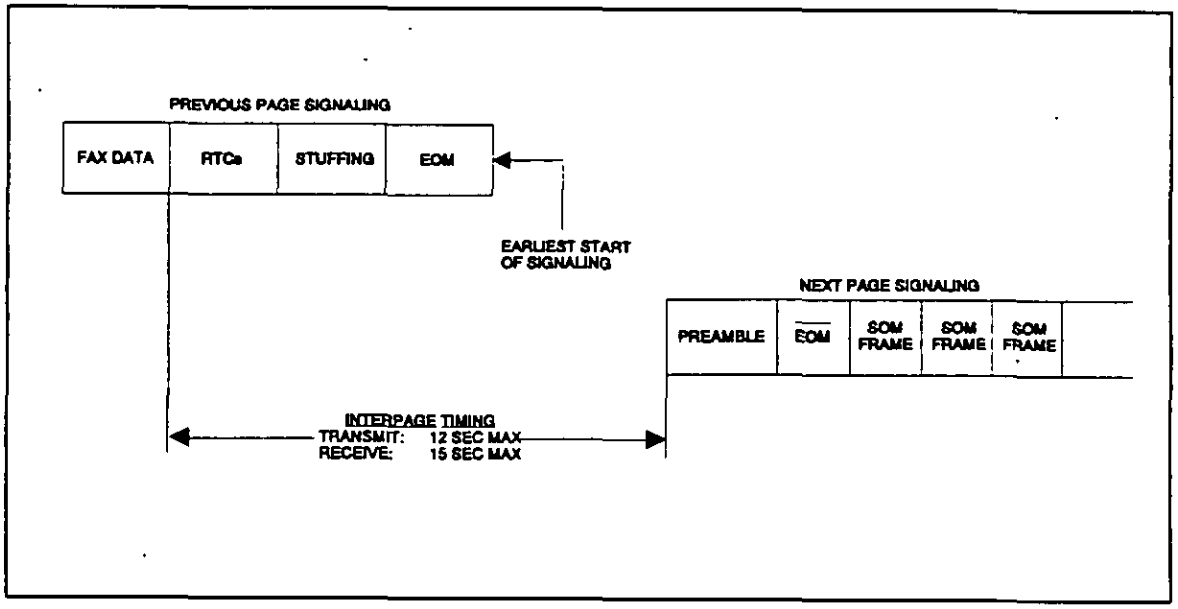


Figure 15. Signal timing for multiple-page transmission (compressed and compressed with FEC).

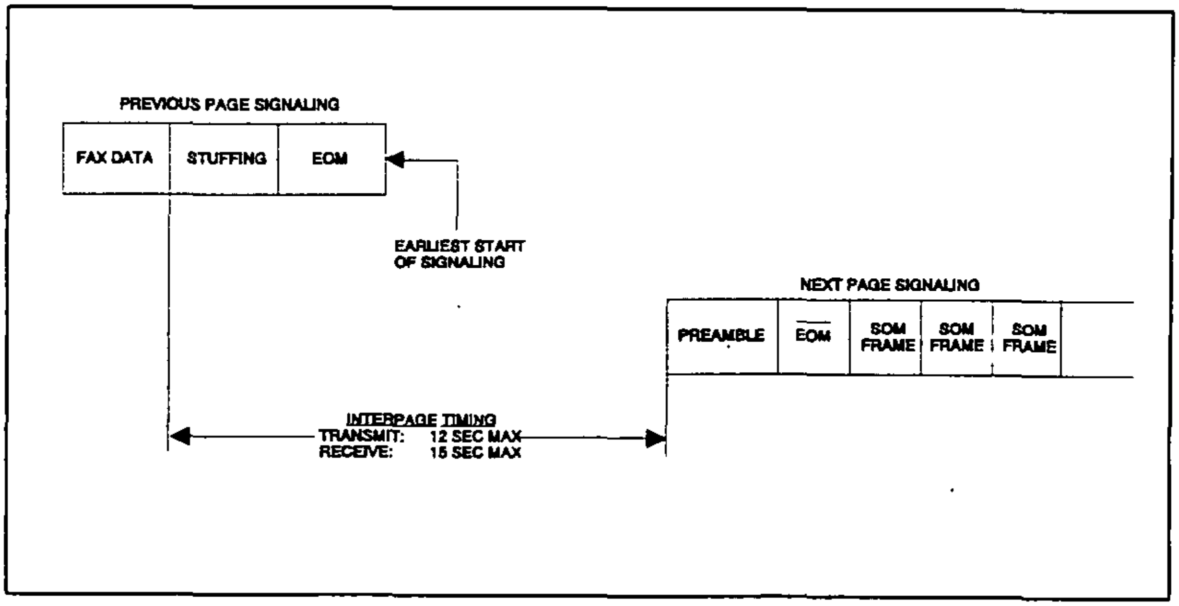


Figure 16. Signal timing for multiple-page transmission (uncompressed).

5.2.5.6.2 End-of-transmission signal. A transmitter may signal the end of a multi-page or a single-page transmission by sending an EOT signal. An EOT shall consist of at least 16 S_0 codewords transmitted in sequence. When the receiver detects four consecutive S_0 codewords, EOT may be declared. The final EOM and the EOT shall be separated by at least 1 second of stuffing (see Figures 17 and 18).

5.2.5.6.3 Polarity. The transmitter shall maintain the same data polarity throughout a multi-page transmission.

5.3 Type II facsimile equipment

5.3.1 Image parameters. The image parameters listed in 5.2.1 apply to Type II facsimile equipment, which shall implement the medium and high resolutions. The low resolution is optional. The minimum transmission time of any scanned line pair shall be 40 msec for all compressed gray-scale modes, and 20 msec per line for all black-and-white and uncompressed gray-scale modes. Other, optional, resolutions and minimum scanned-line transmission times may be implemented by the employment of appended protocols (see 5.2.5.4.2 and 5.2.5.4.3).

5.3.2 Black-and-white operation. All Type II facsimile equipment shall be able to be operated as Type I black-and-white facsimile equipment. All requirements of 5.2 shall apply.

5.3.3 Gray-scale operation. In addition to black-and-white operation, Type II facsimile equipment shall be able to transmit and receive in 4, 8, and 16 shades of gray. The scanned dynamic range (D_{max}/Step 16 to Paper White/Step 1) shall be selected, and the linear distribution of steps between these two shall be determined by the fractional values of Table IX. The recorded dynamic range (D_{max}/Step 16 to Paper White/Step 1) shall be determined by the reprographic process capability. The distribution of steps over the dynamic range shall be determined by the fractional values of Table IX. Recorded gray-shade values shall be in accordance with Table X. (NOTE: The separation of this specification for the scanner and recorder allows a different dynamic range capability for each.)

5.3.3.1 Gray-coding the gray scale. The gray scale shall be processed by initial conversion of each picture element of the scanned signal to a 4-bit, gray-code data unit (image data) representing 1 of the 16 shades of gray. A gray code, in accordance with Table X, shall be used so that only one

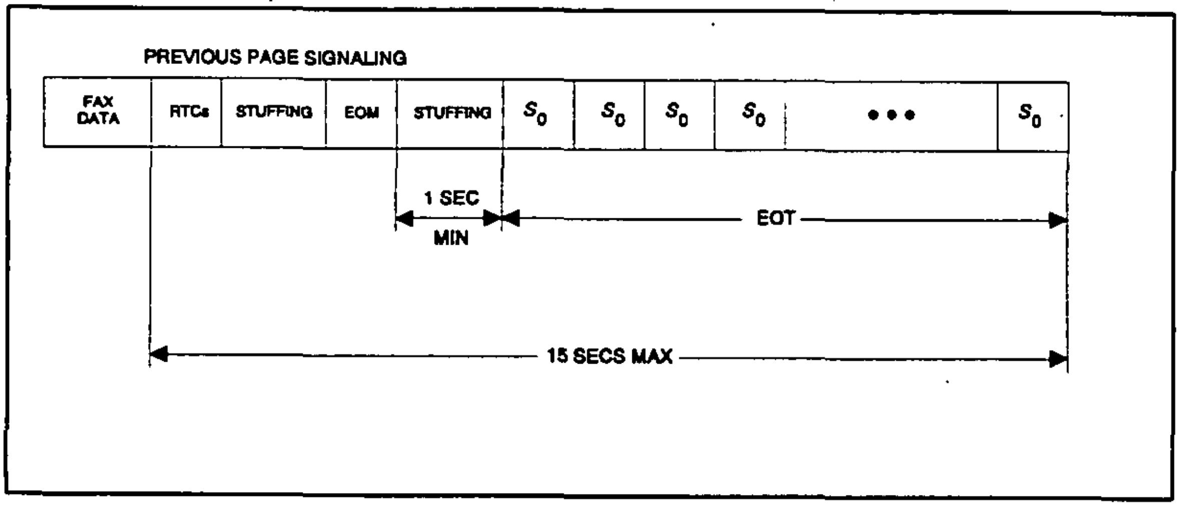


Figure 17. Signal timing for End of Transmission (EOT) signal (compressed and compressed with FEC).

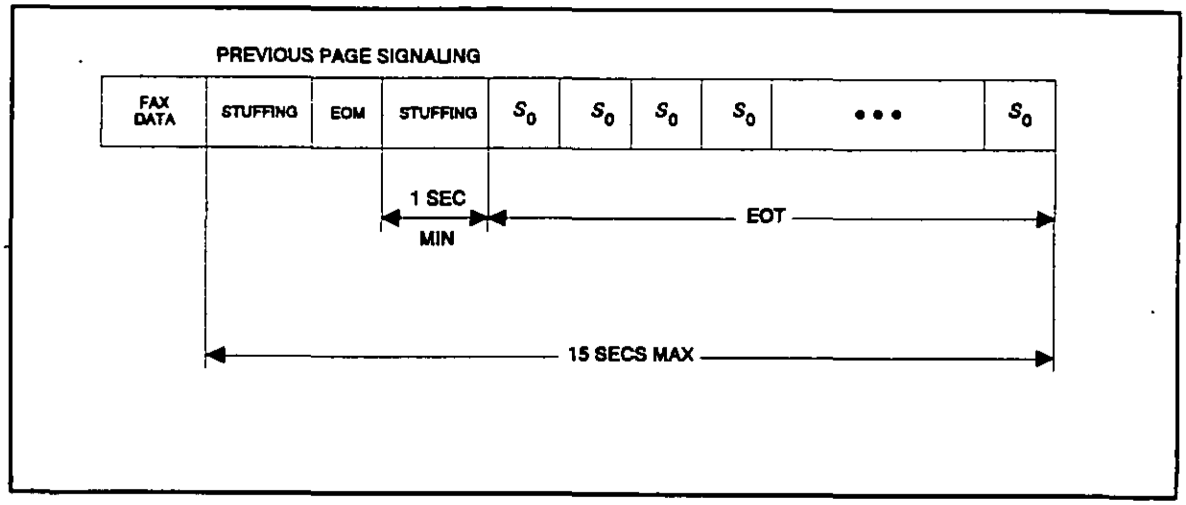


Figure 18. Signal timing for End of Transmission (EOT) signal (uncompressed).

TABLE IX. Normalized gray-scale shades.

	STEP NUMBER	NORMALIZED DENSITY
PAPER WHITE	1	0.000
	2	0.067
	3	0.133
	4	0.200
	5	0.267
	6	0.333
	7	0.400
	8	0.467
	9	0.533
	10	0.600
	11	0.667
	12	0.733
	13	0.800
	14	0.867
	15	0.933
D MAXIMUM	16	1.000

TABLE X. Gray codes for 4, 8, and 16 gray shades.

16 SHADES		8 SHADES		4 SHADES	
STEP	GRAY CODE	STEP	GRAY CODE	STEP	GRAY CODE
1	0000	1	000	1	00
2	0001				
3	0011				
4	0010	4	001		
5	0110				
6	0111	6	011	6	01
7	0101				
8	0100	8	010		
9	1100				
10	1101	10	110		
11	1111				
12	1110	12	111	12	11
13	1010				
14	1011	14	101		
15	1001				
16	1000	16	100	16	10

transition occurs between adjacent gray levels. Gray-coding applies to all 3 image-coding modes (uncompressed, compressed, and compressed with FEC).

5.3.3.2 Bit-plane-encoding the gray scale. After gray-coding, the data shall be processed as bit planes. The most significant bit (MSB) plane (MSBP) contains the MSB of each gray-coded pel. Similarly, plane 2 shall contain the next MSB of each gray-coded pel. (NOTE: Each plane, consisting of black and white pels, can be treated as a black-and-white image.) For 16 gray shades, the 4-bit planes shall be passed directly to the transmission process. For 8 gray shades, bit plane 4, the least significant bit plane (LSBP), shall be discarded by discarding bit 4, and the remaining 3-bit codes representing 8 gray shades shall be passed to the transmission process. Similarly, for 4 gray shades, plane 3 shall be discarded in addition to plane 4. The remaining 2-bit codes represent 4 gray shades, as shown in Table X.

5.3.3.3 Gray-scale transmission. See Appendix A for general information (including block diagrams) relating to the modular make-up of the facsimile transmitter and receiver. Three output modes shall be available:

a. uncompressed facsimile data with line synchronization codes added;

b. compressed facsimile data using a 2-dimensional algorithm; and

c. compressed, as in b, with the addition of FEC using a BCH code and bit interleaving buffer. The scheme selected for a given transmission shall be signaled to the receiver. This signaling protocol shall be the same as covered in 5.2.5.2 and 5.2.5.3.

5.3.3.3.1 Uncompressed. Uncompressed facsimile data shall be transmitted pel-by-pel per bit plane, with logic 1 representing black. Each scan line of the output data shall consist of a synchronization code followed by 1728 pels of the MSB plane followed by the 1728 pels of the next MSB planes, in order, until all bit planes of the line have been transmitted. (NOTE: Each bit plane is made up of black and white pels. The first bit plane contains the MSB of each gray-encoded pel, the second bit plane contains the second MSB of each gray-encoded pel, and the following bit planes are made up in a corresponding manner.) The synchronization codes shall consist of a sequence of two codewords, designated S_0, and shall be identical to the codes used for Type I facsimile uncompressed transmission. See Appendix A for examples of the format used to transmit facsimile data with multiple gray shades.

5.3.3.3.2 Compressed. Compressed facsimile data shall be transmitted after compression by using a 2-dimensional procedure.

5.3.3.3.2.1 Compressed data format. A line pair of compressed data (shown in Figure 19) shall be composed of a series of variable-length codewords that form the bit planes (designated P1 through P4) representing the first 864 picture elements of each of the 2 adjacent horizontal scan lines (1728 total), followed by the second 864 elements of the 2 adjacent horizontal scan lines. Each half-line pair of the output data shall consist of the bit planes in order (MSB plane first); each bit plane shall be separated by a synchronization codeword, EOL (000000000001). (NOTE: EOL is a unique codeword that can never be found within a valid line pair of data. Therefore, resynchronization after an error burst is possible.)

5.3.3.3.2.2 Scan line pair. Each half-line pair of output data shall be preceded by a 3-bit auto resolution codeword (see 5.3.3.3.3). The relative placement of the BOLP and BILP codewords, auto resolution signaling bits, encoded data, EOL, RTC, and fill shall be as illustrated in Figures 19 and 20. (NOTE: Transmission of 16 gray shades is shown. To transmit fewer gray shades, the appropriate bit planes and preceding EOL are not present.)

5.3.3.3.2.3 Wobbled scan lines. The two adjacent scan lines of data shall be "wobbled," bit plane by bit plane, prior to variable-length encoding by combining the spatially related data bits per bit plane in a wobble fashion, as illustrated in Figure 21. (NOTE: L_{11}, L_{12}, L_{13}, ... , represent the sequentially scanned bits derived from line *N*; and L_{21}, L_{22}, L_{23}, ... , represent the sequentially scanned bits derived from line *N* + 1. This produces a combined output of:

$$L_{11},\ L_{21},\ L_{22},\ L_{12},\ L_{13},\ L_{23},\ L_{24},\ L_{14},\ . . .$$

The purpose of this wobble pattern is to take advantage of both horizontal and vertical correlations of adjacent pels. This leads to a higher compression than can be achieved when 1 scan line (thus 1-dimensional coding) is processed at a time).

5.3.3.3.2.4 Variable-length codewords. Each of the variable-length codewords shall represent a run-length of either all white or all black in a bit plane. White and black runs shall alternate. To ensure that the receiver maintains color (black-and-white) synchronization, each of the bit planes for each half of the data line pair shall begin with a white run-length codeword. If an actual half-data line of a bit plane begins with a black run, a white run-length of 0 shall be sent first. Black or white run-lengths, up to a maximum length of 1 half-scan line pair (1728 bits) shall be defined by the Table III terminating codes and Table IV make-up codes for each bit plane presentation of the image.

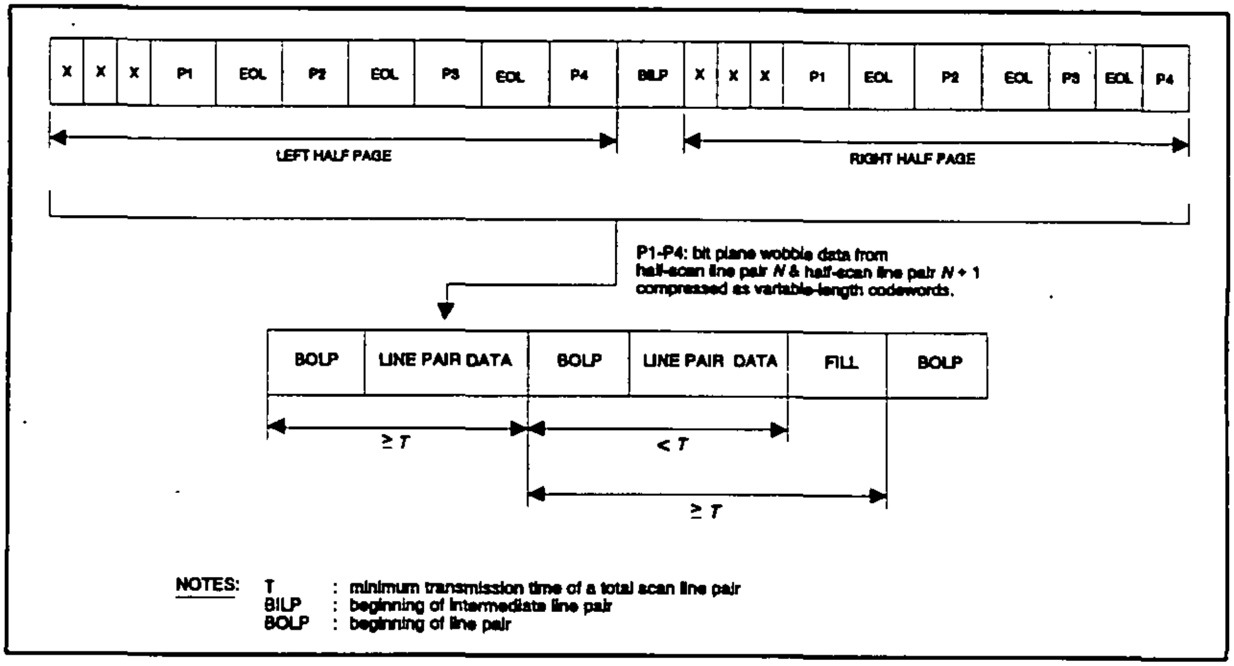


Figure 19. Encoded scan line pair of 16 gray shades starting at the beginning of a page.

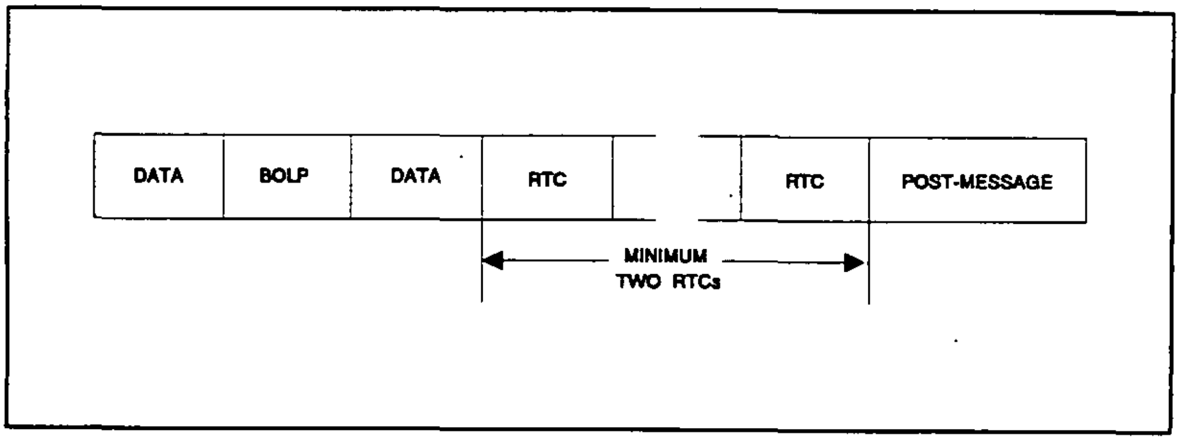


Figure 20. Example of an encoded scan line pair showing the last scan line pair of the last page of a message.

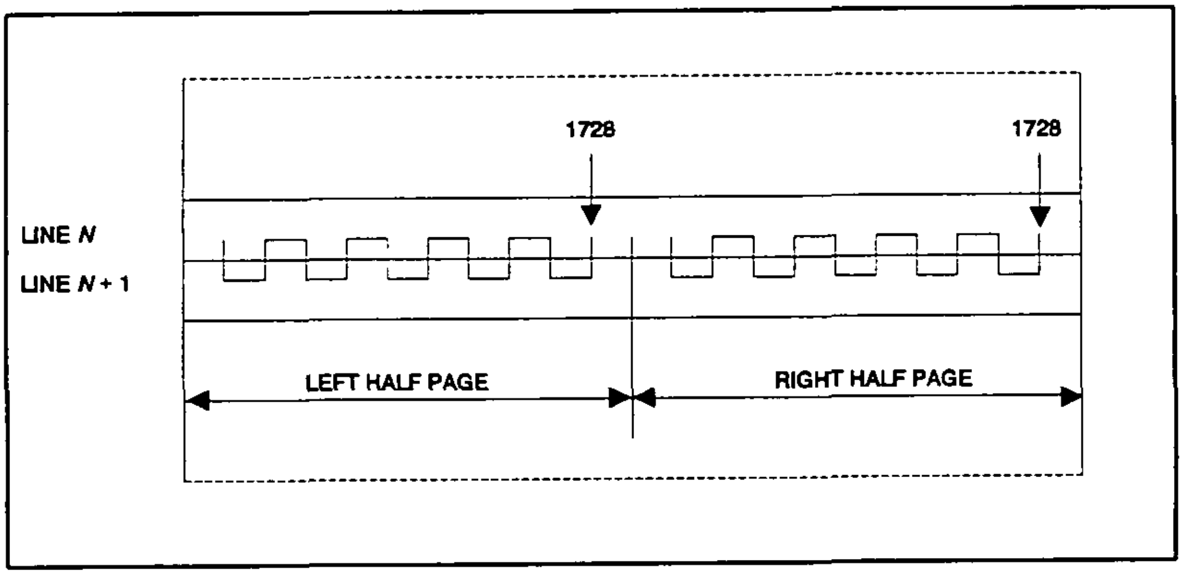


Figure 21. Bit-plane wobble data format.

5.3.3.3.2.5 Run-length representation. Each run-length shall be represented by either 1 terminating codeword, or 1 make-up codeword followed by a terminating codeword. (NOTE: Each bit plane represents a black-and-white image, and 4 images constitute a total gray-shade image.) Run-lengths in a range of 0 through 63 pels shall be encoded with their appropriate terminating codeword. Run-lengths in the range of 64 through 1728 pels shall be encoded first by the make-up codeword representing the run-length equal to or shorter than that required. This shall be followed by the terminating codeword representing the difference between the required run-length and the run-length represented by the make-up code.

5.3.3.3.3 Auto resolution. Means shall be provided to implement a half (low) resolution function, by selected bit plane, to increase the achievable compression. (NOTE: This takes advantage of the fact that not all regions of a gray-scale image contain high-resolution information. Lower-order bit planes have little effect on the perceived resolution and, consequently, may be transmitted at a lower resolution in regions of slow-intensity variations.) Bit-plane activity shall be determined and low-resolution operation shall be automatically applied by half-scan line pair (bit plane) when the number of transitions of a given bit plane is less than 60. (NOTE: The number of transitions is not an issue of interoperability, and a threshold of 60 is a suggested implementation number. The total number of decoded pels for a line pair with auto resolution is 432 decoded pels before expanding for use by the recorder.)

5.3.3.3.3.1 Auto resolution algorithm. The auto resolution algorithm is illustrated in Table XI. When half-resolution processing is applied, a majority logic decision shall take place for each bit-plane group of 4 bits (L_{11}, L_{12}, L_{13}, ...) being read-in prior to run-length encoding. The process shall create a single bit, which represents the average of the 4 bits.

5.3.3.3.3.2 Transmitter. The transmitter performs a majority logic decision such that if 3 or 4 bits are black, a black bit shall be substituted for the group of 4. If 0, 1, or 2 bits are black, a white bit shall be substituted for the group of 4.

5.3.3.3.3.3 Receiver. The receiver shall expand each black data bit, or white data bit, received into 4 identical bits prior to processing the data stream for use by the recorder.

5.3.3.3.3.4 Signaling the auto resolution mode. Auto resolution processing shall be signaled to the receiving unit by half-scan line-pair by preceding each half-scan line pair, as shown in Figure 19, with 1 of the 3 bit codes of Table XII. If the first bit (as a consequence of majority logic decision) of a half-scan line-pair bit plane is black, a white run-length of 0 shall be sent prior to the coded half-line pair of bit plane data.

TABLE XI. Bit plane vs. auto resolution function.

	AUTO RESOLUTION ALGORITHM		
BIT PLANE	16 GRAY SHADES	8 GRAY SHADES	4 GRAY SHADES
1 (MSBP)	Not invoked	Not invoked	Not invoked
2	Automatic decision	Automatic decision	Automatic decision
3	Automatic decision	Automatic decision	Discard
4 (LSBP)	Low resolution Always invoked	Discard	Discard

TABLE XII. Auto resolution - signaling codes.

16 GRAY SHADES		8 GRAY SHADES		4 GRAY SHADES	
CODE	MEANING	CODE	MEANING	CODE	MEANING
110	HHHL	110	HHH	---	---
100	HHLL	100	HHL	100	HH
000	HLLL	000	HLL	000	HL

5.3.3.3.3.5 Beginning of line pair (BOLP). The BOLP codeword shall precede each line pair of coded data (see Figure 12). [NOTE: This unique codeword can never be found within a valid half-line pair of coded data. Therefore, resynchronization after an error burst is possible (BOLP = 0000000000000010).]

5.3.3.3.3.6 Beginning of intermediate line pair (BILP). The BILP codeword shall precede each (right half page) half-line pair of data (see Figure 19). [Note: This unique codeword can never be found within a valid half-line pair of coded data. Therefore, resynchronization after an error burst is possible (BILP = 0000000000000011).]

5.3.3.3.3.7 Fill. A pause may be placed in the message flow by transmitting fill. Fill shall be inserted between a line pair of data and a BOLP, but never within the bit planes. Fill shall be added to ensure that each line pair of data, fill, BOLP, and HSOM (when sent) exceeds the minimum transmission time of a total scan line pair. The minimum scan-line transmission time shall be 40 msec for all compressed gray-scale modes and 20 msec for all black-and-white and uncompressed gray-scale modes (see Figure 19). (NOTE: The maximum transmission time for a single line pair is bounded by the limits set for the loss of synchronization check. See 5.3.4.)

5.3.3.3.3.8 Return to control (RTC). The end of a message transmission shall be indicated by sending at least 2 RTC codewords. Each RTC shall consist of 6 consecutive EOLs. Following the RTC signals, the transmitter shall send the post-message commands. (RTC = EOL codeword 000000000001 repeated 6 times.)

5.3.3.3.4 Compressed with forward error correction (FEC). Since each bit plane of a gray-scale image is in itself a black-and-white image, the requirements for channel coder and decoder, bit interleaving buffer, and synchronization techniques described in 5.2.3.3 shall apply.

5.3.4 Loss of facsimile synchronization. The Type II facsimile shall be able to detect loss of synchronization. The technique used shall be the same as for Type I facsimile (see 5.2.4).

5.3.5 Signaling protocols. The protocol signal structure shall be identical to the protocol signal structure used for Type I facsimile equipment (see 5.2.5).

5.3.5.1 Synchronization codewords. The synchronization codewords to be used for Type II facsimile equipment shall be identical to the words used for Type I facsimile equipment (see 5.2.5.1.1).

5.3.5.1.1 Start of message (SOM). Each SOM frame shall consist of two pairs of synchronization codewords, S_1 S_0 and S_0 S_1, the pairs separated by several (X) clock periods, as shown in Figure 4. The mode shall be indicated by the number of clock periods (X) between the two pairs of synchronization codewords. The values of X that shall be used are shown in Table VII. (NOTE: The polarity of the bits in the X interval is irrelevant, as it is the count of clock intervals between pairs of synchronization codewords that designates the mode.) The data bits transmitted in this interval shall be all 1's. The SOM frame shall be transmitted 3 times, but detecting any 1 frame at the receiver shall be sufficient. Uses of these signals are covered in 5.2.5.2.

5.3.5.1.2 End of message (EOM). EOM shall consist of at least 16 S_1 codewords transmitted in sequence. When 4 consecutive S_1 codewords have been detected at the receiver, EOM shall be declared. This procedure shall be identical to Type I facsimile equipment, as covered in 5.2.5.1.3.

5.3.5.2 Signaling sequence and timing. The signaling sequences and timing procedures for compressed mode, with and without FEC, and the uncompressed mode shall be identical to signaling sequences and timing procedures described in 5.2.5.2.

5.3.5.3 Handshake mode protocol. The handshake mode protocol shall be identical to the protocol presented in 5.2.5.3.

5.3.5.4 Special protocols. See 5.2.5.4 for additional methods for the exchange of status, information, and capabilities.

5.3.5.5 Intermessage timing. Intermessage timing shall be identical to that described in 5.2.5.5.

5.3.5.6 Multi-page transmissions (optional capability). Multi-page transmissions shall be accomplished as presented in 5.2.5.6.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Subject term (key-word) listing. The following key words and phrases apply to MIL-STD-188-161:

bit plane
codeword
compressed mode
facsimile synchronization
gray code
gray scale
Group 3 facsimile
handshake mode
image coding
military standard (MIL-STD)
non-handshake mode
scan line
signaling protocols
STANAG 5000
Type I facsimile
Type II facsimile
uncompressed mode
wobbled scan

6.2 International standardization agreement. Certain provisions of this MIL-STD are the subject of international standardization agreement (STANAG) 5000. When change notice, revision, or cancellation of this MIL-STD is proposed that will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.3 Changes from previous issue. The margins of this MIL-STD are marked with change bars to indicate where changes from the previous issue were made. This was done as a convenience only, and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this MIL-STD based on the entire content, irrespective of the marginal notations and relationship to the previous issue.

6.4 Facsimile equipment configurations. To ensure end-to-end DOD interoperability, this MIL-STD mandates standards for Type I and/or Type II (digital output), and ITU-T Group 3 (analog output) facsimile equipment. Although other facsimile equipment designs and configurations exist, such as ITU-T Group 3 modified to have a non-standard digital output, these nonstandard configurations are not recommended, and could cause interoperability problems.

6.5 DOD/Industry coordination. DOD coordinates its facsimile standards with the Telecommunications Industry Association's (TIA) TR-29 Facsimile Systems and Equipment Engineering Committee and its subcommittees. This is a cooperative effort between DOD and the industry/commercial standards organizations. The TR-29 committee continues to study new facsimile features for recommended inclusion in this MIL-STD, adopting commercial standards wherever feasible.

6.6 Facsimile conformance and interoperability testing. The Joint Interoperability Test Command (JITC) at Fort Huachuca, AZ, has developed a program to conduct standards conformance testing of Type I digital facsimiles and facsimile controllers. This testing determines their level of compliance to this standard and NATO STANAG 5000. Testing is also being conducted at JITC to certify interoperability of each facsimile with other vendors' facsimile equipment while operating through various combinations of STU-III and other COMSEC equipment. All facsimile testing is conducted on a cost reimbursable basis. The digital facsimiles and controllers certified by the JITC for conformance to this standard and NATO STANAG 5000, as of publication of this standard, are shown in Table XIII. Additional information can be obtained by calling (602) 538-5097/5008 or DSN 879-5097/5008.

TABLE XIII. Type I digital facsimiles and controllers certified by JITC.

Facsimile/Controller	Installed EPROM	MIL-STD-188-161C	NATO STANAG 5000	Remarks
Ricoh SFX80M and SFX80TE Digital Facsimile	Version 3.04	Meets all requirements and following options: 16 kbps operation, low/high resolution, both uncompressed modes, multi-page opn, and EOT Signal.	Meets all requirements and following options: 4.8 and 9.6 kbps operation, low/high resolution, and all handshake modes.	Certified Sep 94. Thermal paper facsimiles. Interface circuits are not totally IAW MIL-STD-188-114. SFX80TE is TEMPEST Version.
Ricoh SFX2800M and SFX2800TE Digital Facsimiles	Version 3.04	Meets all requirements and following options: 16 kbps operation, low/high resolution, both uncompressed modes, multi-page opn, and EOT Signal.	Meets all requirements and following options: 4.8 and 9.6 kbps operation, low/high resolution, and all handshake modes.	Certified Sep 94. Plain paper facsimiles. Interface circuits are not totally IAW MIL-STD-188-114. SFX2800TE is TEMPEST Version.
Ilex 750, 750A, and 750B Digital Facsimiles	Version S	Meets all requirements and following options: 16 kbps operation, high resolution, both uncompressed modes, multi-page opn, and EOT Signal.	Meets all requirements and following options: 4.8 and 9.6 kbps operation, high resolution, and all handshake modes.	Certified Jan 94. Thermal paper facsimiles. One interface circuit is not totally IAW MIL-STD-188-114.
Ilex 760, 760B, 760R, 760S and 760T Digital Facsimiles	Version S	Meets all requirements and following options: 16 kbps operation, high resolution, both uncompressed modes, multi-page opn, and EOT Signal.	Meets all requirements and following options: 4.8 and 9.6 kbps operation, high resolution, and all handshake modes.	Certified Jan 94. Thermal paper facsimiles. One interface circuit is not totally IAW MIL-STD-188-114. 760T is TEMPEST Version.
GTE 90si Controller	Version M1.4	Meets all requirements and following options: multi-page operation and EOT Signal.	Does not meet all requirements - does not operate in uncompressed mode or 16 kbps.	Certified Apr 94 with Lanier Faxwriter 2115 and Okidata 1000 G3 Facsimiles. All interface circuits are IAW RS-232, and not MIL-STD-188-114.
Zenith/Inteq ZFX-100-1 Controller	Version 1.2	Meets all requirements and following options: 16 kbps operation, multi-page operation and EOT Signal.	Does not meet all requirements - does not operate in uncompressed mode.	Certified Jun 94 with Sharp FO-235 and Samsung FX 1505 G3 Facsimiles. All interface circuits are IAW MIL-STD-188-114.
Zenith/Inteq ZFX-100-C Controller/Fax/Modem Card	Version 1.2	Meets all requirements and following options: 16 kbps operation, multi-page operation and EOT Signal.	Does not meet all requirements - does not operate in uncompressed mode.	Certified Jun 94. Card is inserted in a PC. All interface circuits are IAW RS-232, not MIL-STD-188-114.

APPENDIX A

SUGGESTED IMPLEMENTATIONS FOR DIGITAL FACSIMILE

This appendix contains general information in support of this MIL-STD. Appendix A is not a mandatory part of this MIL-STD.

10. GENERAL

10.1 Scope. Tutorial information related to digital facsimile.

20. REFERENCE DOCUMENTS

STANAG 5000	Interoperability of Tactical Digital Facsimile Equipment

30. DEFINITIONS. This section is not applicable to this appendix.

40. GENERAL REQUIREMENTS

40.1 The facsimile shall be implemented with the latest technology available within reasonable cost and time constraints.

50. SPECIFIC REQUIREMENTS

50.1 Transmitter. The general make-up of the facsimile transmitter is shown in block diagram form in Figure A-1. Illustrated are the three outputs: lead A for the uncompressed mode, lead B for the compressed mode, and lead C for the compressed with forward error correction (FEC) mode. These outputs are in agreement with NATO's needs, as covered in STANAG 5000.

50.2 Receiver. The general make-up of the facsimile receiver is illustrated in block diagram form in Figure A-2. The uncompressed mode, compressed mode, and compressed with FEC mode are shown. The mode inputs are depicted by points A, B, and C, respectively.

50.3 Encoder. Figure A-3 illustrates an implementation of the BCH encoder, using a feedback shift register. The length of the feedback shift register is 12 bits, according to the generator polynomial shown in the figure. During 1 cycle of 63 clocks, 1 block of data is sent at the output of the BCH encoder. At the beginning of the cycle, the contents of the feedback shift register (r_0, ..., r_{11}) are equal to 0. Initially, 51 information bits are transmitted from the data input to the output. At the same time, the information bits are running into the feedback loop of the shift register ($C_0 = 1$). After 51 clocks, the contents of the feedback shift register (r_0, ..., r_{11}) are transmitted with 12 clocks, $C_0 = 0$. These 12 bits are the check bits for the block of 63 data bits. After every cycle of 63 clocks, the contents of the feedback shift register should be 0 (r, ..., $r_{11} = 0$). The next 51 information bits can then be encoded.

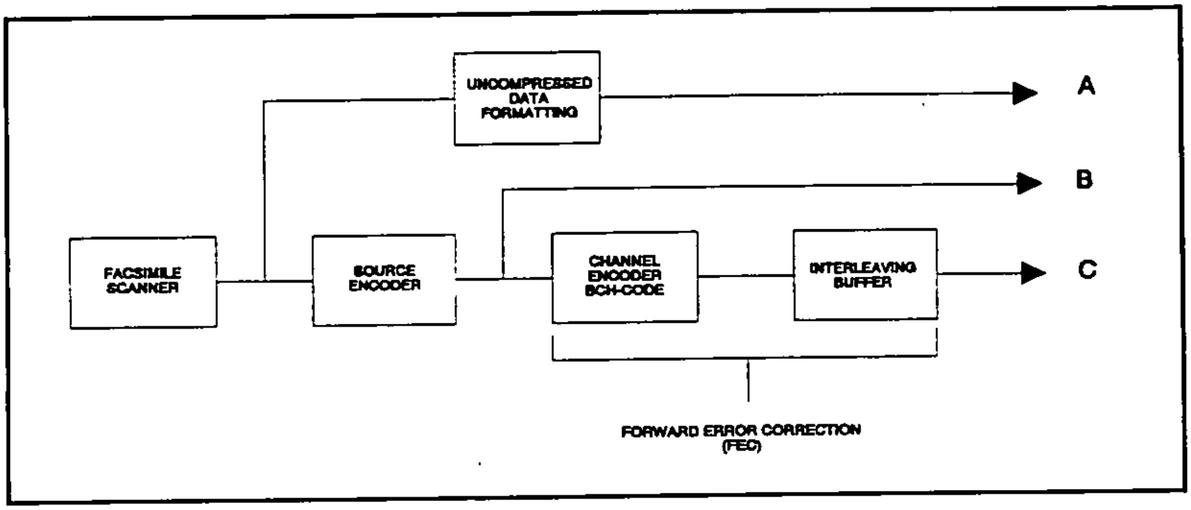


Figure A-1. Block diagram of the encoder.

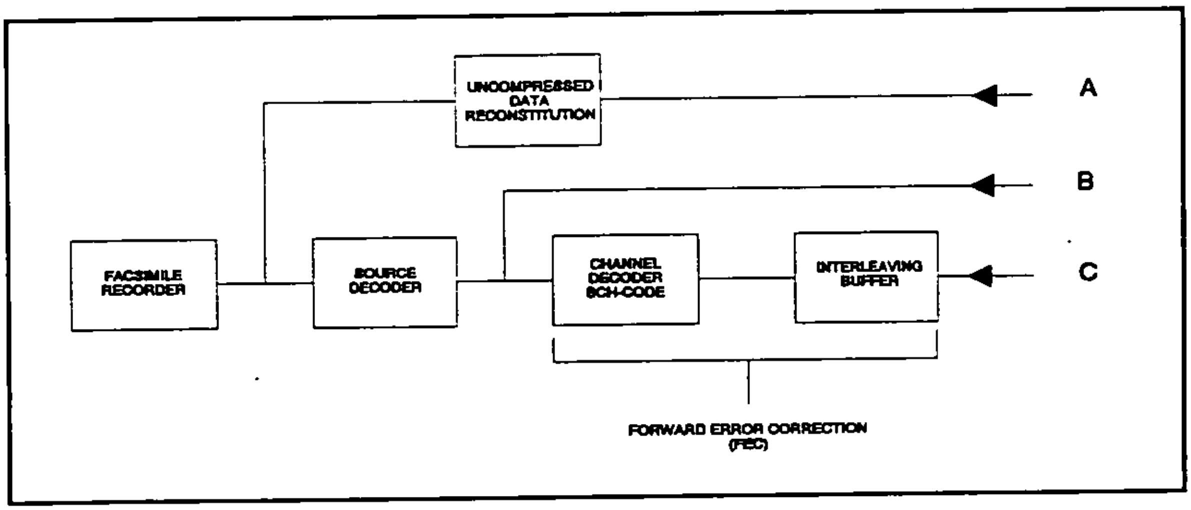


Figure A-2. Block diagram of the decoder.

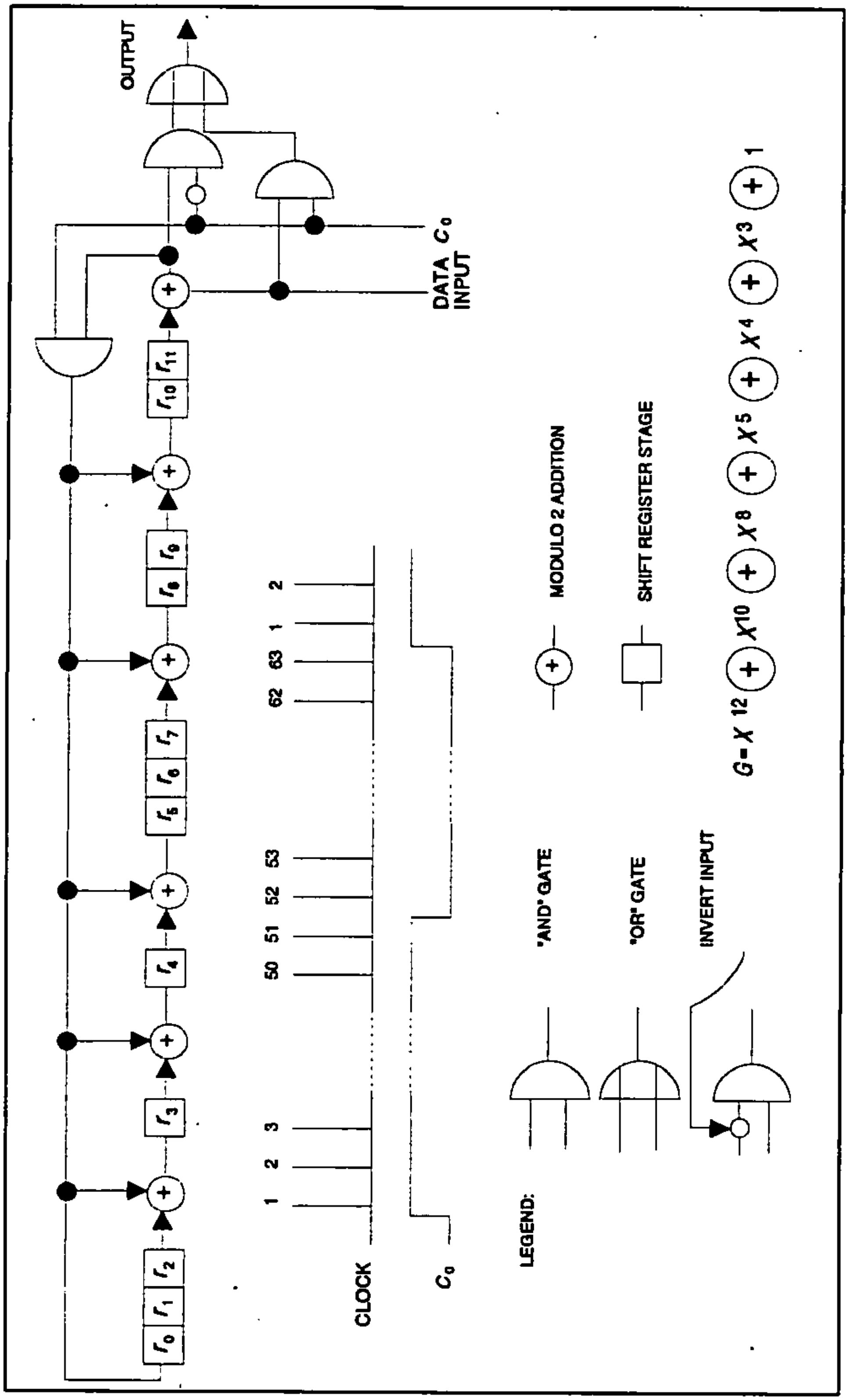


Figure A-3. Block diagram of the BCH encoder.

50.4 Decoder. Figure A-4 illustrates an implementation of the BCH-decoder. The BCH-decoder uses the same feedback shift register as the BCH encoder, plus a 63-bit buffer memory (shift register) and a network. One complete decoding cycle consists of 126 clocks (2 x 63). At the beginning of every cycle, the contents of the feedback shift register (r_0, ..., r_{11}) must be equal to 0. The clock appears at the same time to the feedback shift register and the 63-bit buffer memory. During the first 63 clocks, the block of 63 data bits is written into the 63-bit buffer memory and, at the same time, run into the feedback loop of the shift register ($C_1 = 0$). During the next 63 clocks ($C_1 = 1$) the transmission bit errors are corrected, if there are any. The contents of the feedback shift register (r_0, ..., r_{11}) are analyzed after every clock by the error detection network. If the network detects any 1 of the 12-bit patterns (syndromes) listed in Table V (see 5.2.3.3) as the contents of the feedback shift register, then the position of a transmission bit error is found to be at the output of the 63-bit buffer memory. At that time, the output of the network will correct the transmission bit error by sending a 1 to the modulo 2 adder at the output of the 63-bit buffer memory. Note that only the first 51 bits are information bits. After every cycle of 126 clocks, the feedback shift register must be reset to 0 (r_0, ... , r_{11} = 0), and the next block of 63 data bits can be decoded.

50.5 Scan-line data format. Below is the scan-line data format (codewords plus data) for 16 gray shades, in the uncompressed mode:

	Plane 1	Plane 2	Plane 3	Plane 4
S_0 S_0	1728 bits	1728 bits	1728 bits	1728 bits

Below is the scan-line data format for 8 gray shades (uncompressed):

	Plane 1	Plane 2	Plane 3
S_0 S_0	1728 bits	1728 bits	1728 bits

Below is the scan-line data format for 4 gray shades (uncompressed):

	Plane 1	Plane 2
S_0 S_0	1728 bits	1728 bits

APPENDIX A

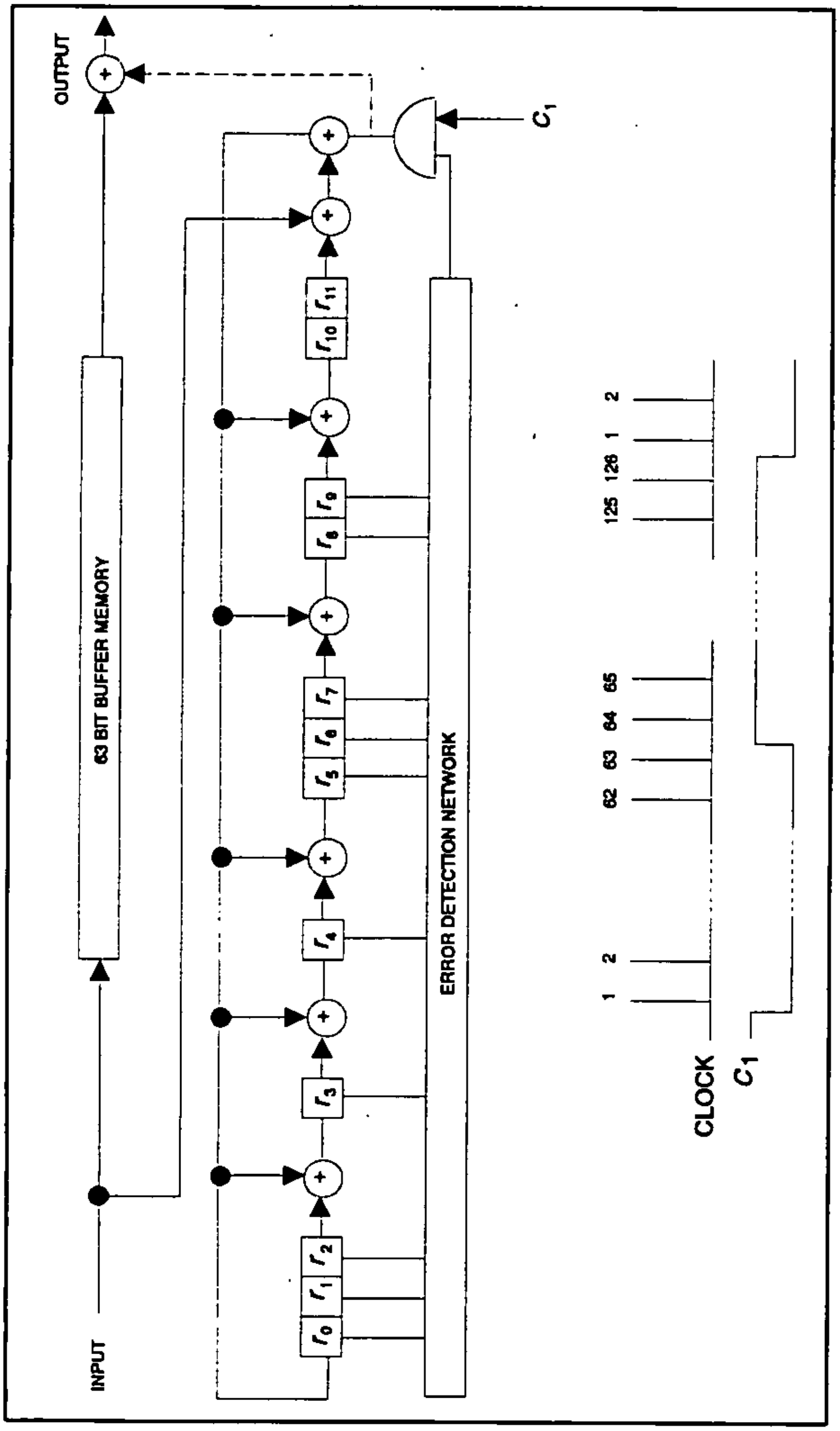


Figure A-4. Block diagram of a BCH decoder.

APPENDIX A

The general format for scan-line data is a pair of S_0 codewords followed by the number of bit planes needed to convey each gray shade being used. Table A-1 presents examples of the information makeup of uncompressed, medium resolution scan-line data. (NOTE: For uncompressed facsimile data, the number of bits in a bit plane corresponds to the number of pels in the scan line.)

TABLE A-1. Examples of the information makeup for uncompressed, medium resolution scan-line data.

GRAY SHADES	BIT PLANES	INFORMATION BITS
16	4	4 x 1728 = 6912
8	3	3 x 1728 = 5184
4	2	2 x 1728 = 3456
Black/White	1	1 x 1728 = 1728

APPENDIX B

TUTORIAL ON FACSIMILE CONFIGURATIONS

This appendix contains general information in support of this MIL-STD. Appendix B is not a mandatory part of this MIL-STD.

APPENDIX B

10. SCOPE. This appendix contains tutorial information related to configurations of facsimile equipment.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. DEFINITIONS. This section is not applicable to this appendix.

40. GENERAL INFORMATION ON CONFIGURATIONS

40.1 Type I and Type II. Type I and Type II digital facsimile equipment is suitable for operation over noisy communications links, such as tactical channels and poor-quality outside the continental United States (OCONUS) public switched telephone networks (PSTN). Type I and Type II equipment is used to provide interoperability with NATO allies, as specified in STANAG 5000. This equipment can operate over various digital interfaces, such as crypto devices, including the Digital Secure Voice Terminal (DSVT) and the Secure Telephone Unit-Third Generation (STU-III). CAUTION: Since STU-III equipment is susceptible to analog-to-digital conversions and channel noise, limitations exist concerning its use over tactical networks.

Type I facsimile equipment provides for the transmission and reception of bi-level (black-and-white) information such as text and graphs. As an option, photographs can be transmitted using electronic halftones. Electronic halftones have lower resolution than Type II gray-scale photographs.

Type II facsimile equipment provides for the transmission and reception of multi-level (gray-scale) information (photographs), as well as bi-level information. In the black-and-white mode, this equipment interoperates with Type I equipment.

40.2 ITU-T Group 3. Facsimile equipment providing for the transmission and reception of bi-level (black-and-white) information is defined in ITU-T Recommendations T.4 and T.30, and in Federal Information Processing Standards (FIPS) 147 and 148. Internally, Group 3 facsimile equipment is digital, but provides only an analog output through a built-in modem for operation over PSTN circuits. Group 3 equipment without an external interface, as described in paragraph 40.3, is not intended for connection to STU-III or other encryption equipment.

40.3 ITU-T Group 3 interfaces for digital transmission. DOD-employed Group 3 facsimile equipment requiring a digital output shall, at a minimum, comply with Type I or Type II requirements. Compliance is usually accomplished through an external interfacing controller (black box). The user's operational requirements determine if use of an external interfacing controller is acceptable.

40.4 ITU-T Group 3, Modified. This is the term commonly used when the modem in Group 3 facsimile equipment is bypassed and nonstandardized protocols are used for digital interfacing. The most common application of such facsimile equipment is operation through the STU-III data port. National Security Agency (NSA) approval of individual facsimile models for operation over STU-III equipment does not indicate interoperability between the different models. These nonstandard configurations are not recommended for new equipment and could cause interoperability problems.

40.5 ITU-T Group 3 - 64 kbps. This digital facsimile standard was approved at the ITU-T plenary meeting in March 1993. The standard provides improved facsimile capabilities for operation over digital networks, such as the Integrated Services Digital Network (ISDN). A DISA/JIEO-sponsored study indicated that Group 3 - 64-kbps is more suitable than Group 4 for military operations. DISA/JIEO plans to add the Group 3 - 64-kbps mode into this MIL-STD.

40.6 ITU-T Group 4. This digital facsimile equipment standard was developed for operation over digital networks. This equipment provides for the transmission and reception of bi-level (black-and-white) information and is defined in ITU-T Recommendation T.503. With the introduction of Group 3 - 64-kbps for ISDN capability (which has many Group 4 capabilities), Group 4 employment is expected to be limited.

40.7 Interoperability of facsimile units. Interoperable facsimile configurations are shown in Figures B-1 through B-5.

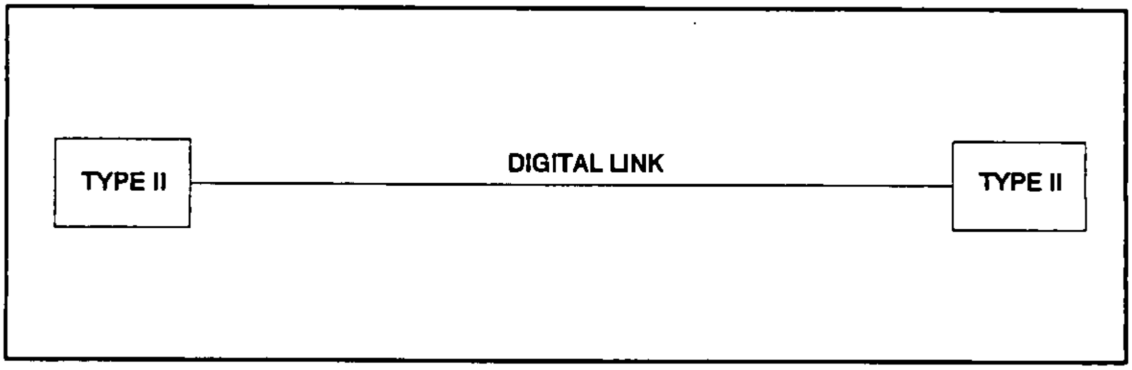


Figure B-1. Unencrypted multi-level digital configuration for photographs.

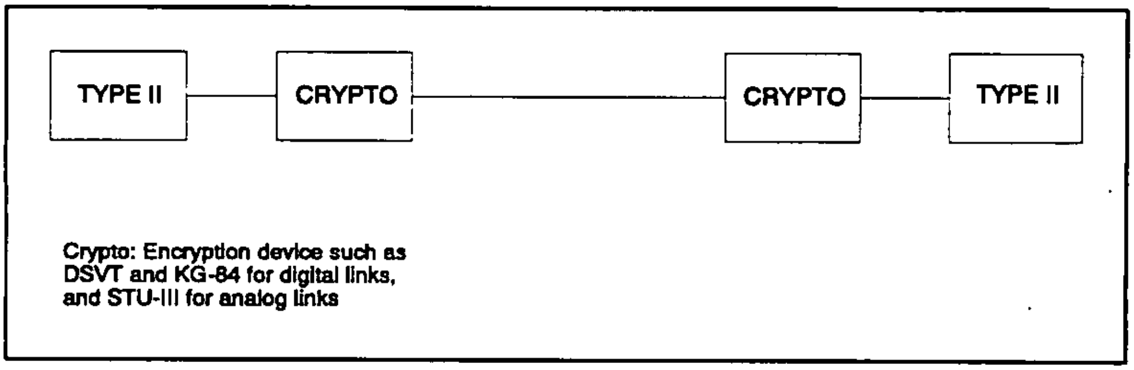


Figure B-2. Encrypted multi-level digital configuration for photographs.

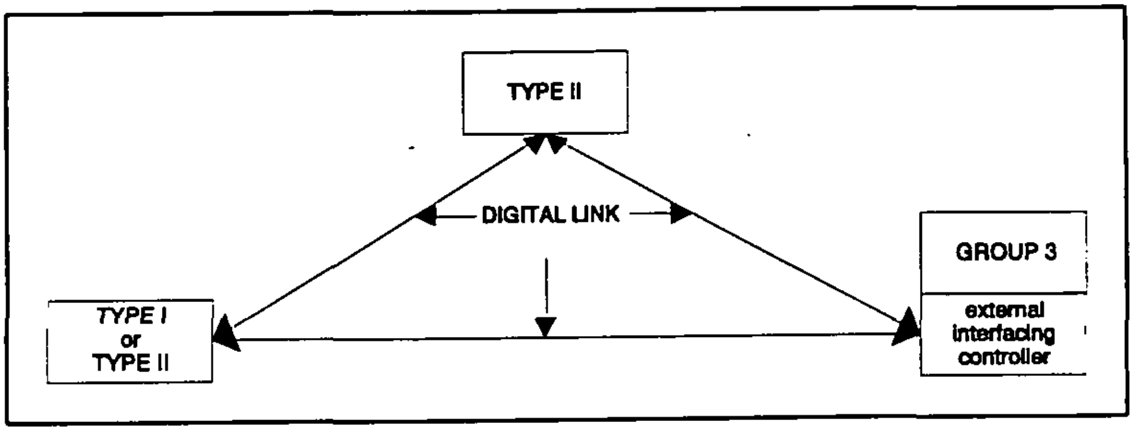


Figure B-3. Unencrypted bi-level digital configuration for text, graphics, and photographs.

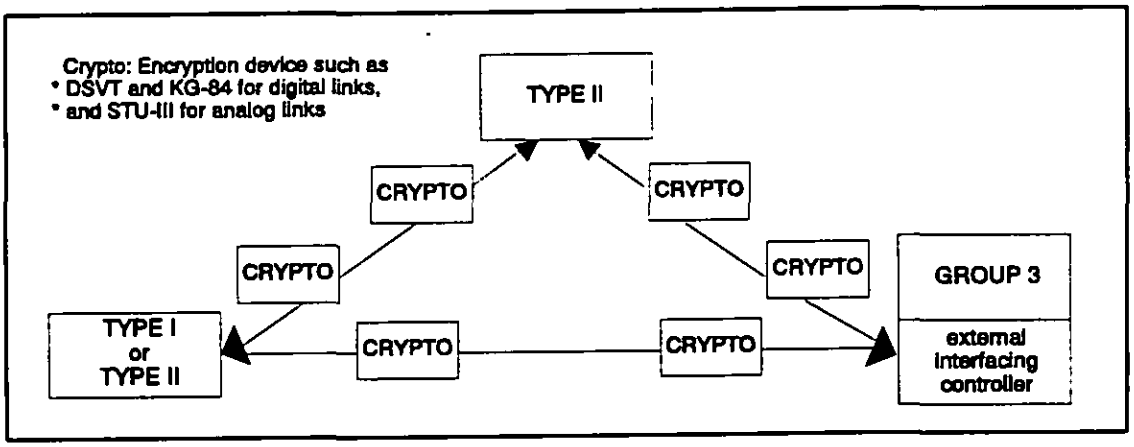


Figure B-4. Encrypted bi-level digital configuration for text, graphics, and photographs.

CONCLUDING MATERIAL

Custodians:
Army - SC
Navy - EC
Air Force - 90
DISA - DC
NSA-NS

Preparing Activity
DISA/JIEO - DC

(Project TCSS-1614)

Review Activities:
Army - CR-1, AC, PT
Navy - OM, MC, NC, TD
Air Force - 02, 17, 93

Other Interests:

Applicable International Organizations
North Atlantic Treaty Organization
EIA/TIA

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER: MIL-STD-188-161D	2. DOCUMENT DATE (YYMMDD) 10 January 1995

3. DOCUMENT TITLE: **Interoperability and Performance Standards for Digital Facsimile Equipment**

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(if applicable)*	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME: DISA-JIEO Center for Standards	b. TELEPHONE *(Include Area Code)* (1) Commercial (908) 532-7715 (2) DSN: 992-7715
c. ADDRESS *(Include Zip Code)* JIEO-TBBC Fort Monmouth, NJ 07703-5613	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340

DD Form 1426, OCT 89 Previous editions are obsolete. 108-290