American National Standard

Adopted for Use by the Federal Government

FIPS PUB 16-1
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for bit sequencing of the american national standard code for information interchange in serial-by-bit data transmission

american national standards institute, inc.
1430 broadway, new york, new york 10018

X3.15-1976

This standard has been adopted for Federal Government use.

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ANSI®
X3.15-1976
Revision of
X3.15-1966

American National Standard for Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

Secretariat

Computer and Business Equipment Manufacturers Association

Approved June 25, 1976

American National Standards Institute, Inc

American National Standard

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Foreword

(This Foreword is not a part of American National Standard for Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission, X3.15-1976.)

This standard specifies means of bit sequencing for the transmittal of the American National Standard Code for Information Interchange, X3.4-1968 (ASCII) and the codes invoked when applying the American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange, X3.41-1974, for serial-by-bit, serial-by-character data transmission at the interface between data processing terminal equipment and data communication equipment. It is a revision of American National Standard for Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission, X3.15-1966.

This standard is one of a series developed by Task Group X3S3.3 on Data Communication Formats under the coordination of the X3S3 Subcommittee on Data Communications of American National Standards Committee on Computers and Information Processing, X3. Task Group X3S3.3, which was organized late in 1962 and held its first meeting in January 1963, is charged with the responsibility for standardizing character format, data transmission of characters within a hierarchy of groupings (that is, words, blocks, messages, etc) including group error control, and the order or sequence of bits within characters (including parity).

Other standards prescribe the character structure, the sense (odd or even) of parity bits, the formats for parallel-by-bit, serial-by-character data transmission, and other parameters vital to the transmission of information between the types of equipment previously mentioned.

Suggestions for improvement of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Computers and Information Processing, X3. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the X3 Committee had the following members:

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Contents

American National Standard for Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

1. Scope

1.1 This standard specifies the bit sequencing of the American National Standard Code for Information Interchange, X3.4-1968 (ASCII) and the codes invoked when applying the American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange, X3.41-1974, for serial-by-bit, serial-by-character data transmission.

1.2 This standard applies to general information interchange in the ASCII and extended ASCII, at the interface between data processing terminal equipment (such as data processors, data media input-output devices, and office machines) and data communication equipment (such as data sets and modems).

2. Standard Bit Sequence

The bit sequence for an ASCII character shall be least significant bit first to most significant bit -- in terms of the 7-bit ASCII nomenclature (American National Standard Code for Information Interchange, X3.4-1968) b_1 through b_7 in ascending (consecutive) order, or in terms of the 8-bit nomenclature (American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character set of American National Standard Code for Information Interchange, X3.41-1974) a_1 through a_8 in ascending (consecutive) order.

3. Character Parity

In a 7-bit environment a character parity bit, if transmitted, shall follow the most significant bit, b_7, of the character to which it applies. No character parity bit is provided in an 8-bit environment.

4. Qualifications

4.1 This standard does not specify that a character parity bit shall or shall not be transmitted, nor does it specify the total number of bits per character, the bit rate, the character rate, or the transmission technique.

4.2 This standard does not apply to parallel-by-bit, serial-by-character data transmission.

5. Revision of American National Standards Referred to in This Document

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply:

American National Standard Code for Information Interchange, X3.4-1968 (ASCII)

American National Standard Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange, X3.41-1974

Appendix

(This Appendix is not a part of American National Standard for Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission, X3.15-1976, but is included for information purposes only.)

Criteria, Considerations, and Conclusions

A1. Introduction

This Appendix contains criteria pertinent to the selection of the bit sequencing in serial-by-bit data transmission. Not all of the listed criteria have been entirely satisfied. Some are conflicting, and the selected bit sequence was based upon a detailed analysis and weighing of these divergent criteria. The final choice of transmission bit sequence represents an acceptable compromise.

A2. Specific Criteria

NOTE: The following criteria are not mutually consistent and are not listed in order of importance.

A2.1 The transmission bit sequence should be in consecutive numerical order (ascending or descending), in terms of ASCII nomenclature.

A2.2 The transmission bit sequence should minimize the amount and complexity of existing and future hardware.

A2.3 The transmission bit sequence should be selected to minimize adverse consequences of equipment or system malfunction.

A2.4 The transmission of a binary bit stream should not be precluded.

A2.5 The transmission of encrypted material should not be precluded.

A2.6 There should be a correspondence between media track (channel or row) designation, ASCII bit number, and transmission bit sequence, in order to minimize training and reduce confusion of operating, maintenance, and engineering personnel.

A2.7 The transmission bit sequence should allow a logical extension to supersets of ASCII.

A2.8 The transmission bit sequence of any subset or superset of ASCII should provide that any designated bit be immutable in its position in the transmission sequence as well as in its logical order and media representation.

A2.9 The character parity bit should be positioned to allow it to be generated "on the fly," following the data bits.

A2.10 The transmission bit sequence should allow maximum design flexibility in future systems utilizing ASCII.

A3. Considerations

A3.1 Considerations of the various possible bit sequences for serial-by-bit, serial-by-character data transmission produced the following two choices for further study:

(1) Low-order bit first to high-order bit
(2) High-order bit first to low-order bit

The basic structure of ASCII – that is, the separation of graphics and controls, and the location of the symbols, digits, and alphabet within the graphic portion – favored a consecutive bit sequence.

A3.2 There is unanimity of opinion that the character parity bit, where included on a per-character basis, should appear last in the bit sequence so that this bit can be generated "on the fly."

A3.3 These two bit-sequencing choices, A3.1(1) and A3.1(2), were then subjected to an exhaustive investigation to determine their influence on data interchange from the following points of view:

(1) Flexibility of hardware design
(2) Hardware efficiency
(3) Ease of maintenance
(4) Contraction of ASCII to subsets
(5) Expansion of ASCII to supersets
(6) Error consequences

A3.4 With the low-order bit transmitted first, the first data pulse can correspond to ASCII bit b_1, the second

to bit b_2, etc. Thus "third" will mean the third data pulse as well as bit b_3. It can also mean the third track (or channel or row) in media. This simple, orderly relationship between media track number, pulse number, and bit designation number is desirable in the maintenance of communication equipment, especially in discussions between remote technicians and between technicians and engineers. This arrangement is as follows:

Media track:	1	2	3	4	5	6	7	8
ASCII bit:	b_1	b_2	b_3	b_4	b_5	b_6	b_7	P
Data pulse number:	1	2	3	4	5	6	7	8

where P is the character parity bit.

A3.5 The 7 bits of ASCII are designated b_1 through b_7 in increasing order of significance. Thus, additional high-order bits may be added and designated b_8, b_9, etc, in an orderly manner. It is desirable, from the transmission standpoint, to have a code "open-ended" at the end of a character bit sequence rather than at the start. Compatibility between equipments using different size sets is less difficult, since each numbered bit always appears in a given position with respect to the start of the character sequence.

A3.5.1 Terminals using a subset of ASCII need only operate with the appropriate numbers of bits at the beginning of the character.

A3.5.2 Terminals transmitting supersets of ASCII need only append the additional (b_8, b_9, etc) bits to the ASCII.

A3.5.3 In all cases, the character parity bit then maintains its defined position as the last bit of the character to be transmitted.

A3.6 Low-order bit first is in agreement with recently established standards, such as bit sequencing of ASCII in Military Standard MIL-STD-188 C, Military Communication System Technical Standards, Nov 24, 1969.[1]

A3.7 High-order bit first allows future systems and hardware to be designed to take advantage of the unique organization of ASCII into control character columns and graphic columns; this could, for example, reduce the bit storage requirement in simple input-output (I/O) printers and control mechanisms.

A3.8 If the transmission sequence is high-order bit first, the implementation of ASCII into present-day, 6-bit character based processors and into upper-lower I/O typewriters can be simplified, resulting in hardware reduction.

A3.9 The only criterion pertinent to character parity is that it can be capable of generation "on the fly." This implies that it be transmitted later than all data bits. This does not contradict any of the criteria for the sequence of data bits.

A3.10 The error rate of a system is not dependent on the choice of bit sequencing. The consequence of an error is influenced by the choice of bit sequence; however, no definite conclusions could be drawn as to which bit sequence resulted in the least harmful error condition.

A4. Conclusions

A4.1 The question of bit sequence resolves itself into a choice between the following two specific interests:

(1) Low-order bit first offers the advantage of convenient expansion to 8-bit supersets, allows direct correspondence between the ASCII bit designators in media and the transmitted bit sequence, eases maintenance and training, and is consistent with international and military standards.

(2) High-order bit first offers the possibility of more economical implementation of ASCII by present-day 6-bit processors and by simple I/O printers and typewriters.

A4.2 The conclusion reached is that the known advantages of low-order bit first outweigh the possible advantages of high-order bit first.

[1] Available from Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120.

American National Standards on Computers and Information Processing

X3.1-1976 Synchronous Signaling Rates for Data Transmission

X3.2-1970 (R1976) Print Specifications for Magnetic Ink Character Recognition

X3.3-1970 (R1976) Bank Check Specifications for Magnetic Ink Character Recognition

X3.4-1968 Code for Information Interchange

X3.5-1970 Flowchart Symbols and Their Usage in Information Processing

X3.6-1965 (R1973) Perforated Tape Code for Information Interchange

X3.9-1966 FORTRAN

X3.10-1966 Basic FORTRAN

X3.11-1969 Specification for General Purpose Paper Cards for Information Processing

X3.12-1970 Vocabulary for Information Processing

X3.14-1973 Recorded Magnetic Tape for Information Interchange (200 CPI, NRZI)

X3.15-1976 Bit Sequencing of the American National Standard Code for Information Interchange in Serial-by-Bit Data Transmission

X3.16-1976 Character Structure and Character Parity Sense for Serial-by-Bit Data Communication in the American National Standard Code for Information Interchange

X3.17-1974 Character Set and Print Quality for Optical Character Recognition (OCR-A)

X3.18-1974 One-Inch Perforated Paper Tape for Information Interchange

X3.19-1974 Eleven-Sixteenths-Inch Perforated Paper Tape for Information Interchange

X3.20-1967 (R1974) Take-Up Reels for One-Inch Perforated Tape for Information Interchange

X3.21-1967 Rectangular Holes in Twelve-Row Punched Cards

X3.22-1973 Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI)

X3.23-1974 Programming Language COBOL

X3.24-1968 Signal Quality at Interface between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission

X3.25-1976 Character Structure and Character Parity Sense for Parallel-by-Bit Communication in the American National Standard Code for Information Interchange

X3.26-1970 Hollerith Punched Card Code

X3.27-1969 Magnetic Tape Labels for Information Interchange

X3.28-1976 Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links

X3.29-1971 Specifications for Properties of Unpunched Oiled Paper Perforator Tape

X3.30-1971 Representation for Calendar Date and Ordinal Date for Information Interchange

X3.31-1973 Structure for the Identification of the Counties of the United States for Information Interchange

X3.32-1973 Graphic Representation of the Control Characters of American National Standard Code for Information Interchange

X3.34-1972 Interchange Rolls of Perforated Tape for Information Interchange

X3.36-1975 Synchronous High-Speed Data Signaling Rates between Data Terminal Equipment and Data Communication Equipment

X3.37-1974 Programming Language APT

X3.38-1972 Identification of States of the United States (Including the District of Columbia) for Information Interchange

X3.39-1973 Recorded Magnetic Tape for Information Interchange (1600 CPI, PE)

X3.40-1976 Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE)

X3.41-1974 Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange

X3.42-1975 Representation of Numeric Values in Character Strings for Information Interchange

X3.44-1974 Determination of the Performance of Data Communication Systems

X3.45-1974 Character Set for Handprinting

X3.46-1974 Unrecorded Magnetic Six-Disk Pack (General, Physical, and Magnetic Characteristics)

X3.49-1975 Character Set for Optical Character Recognition (OCR-B)

X3.50-1976 Representations for U.S. Customary, SI, and Other Units to Be Used in Systems with Limited Character Sets

X3.51-1975 Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange

X3.52-1976 Unrecorded Single-Disk Cartridge (Front Loading, 2200 BPI), General, Physical, and Magnetic Requirements

X3.53-1976 Programming Language PL/I

X3.54-1976 Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording)

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