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MILITARY STANDARD

MAGNETIC TAPE RECORDER/REPRODUCER FORMATS FOR ASW SENSOR AND SYSTEMS DATA

AMSC N/A FSC 6625

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Magnetic Tape Recorder/Reproducer Formats for ASW Sensor and Systems Data.

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This standard was established at the request of the Chief of Naval Operations (CNO) to foster the compatibility and exchangeability of magnetic tape recordings of sensor data among members of the Anti-Submarine Warfare (ASW) community as a means of improving ASW effectiveness.

2. The lack of a standard governing these sensor data recordings has had a serious and deleterious effect on the accurate and expeditious exchange of information within the ASW community. It is the dedicated purpose of this standard to create a synergistic harmony within the Navy for its conduct of Anti-Submarine Warfare.

3. The prevailing fragments of Navy-wide standardization have caused a substantially increased cost of ownership for its ASW data collection and management network. This situation has brought about inefficient data reduction, difficult logistics support, complex maintenance and excessive training burdens. A key element in achieving relief from these handicaps via real standardization is strict adherence to a unifying standard. This standard is intended to foster a unity whereby the Navy reaps the maximum benefits with minimum impact on the individual effectiveness of its component programs.

4. This standard represents the results of research among users of sensor data in the ASW community. It also reflects comments and ideas from the tape recording industry. This standard is to be used as a baseline for tape recording requirements in the design of all future systems which gather, distribute, or utilize ASW sensor data. Agencies which propose to deviate from this standard are required to support this decision by demonstrating that: the use of each specific aspect of this standard would seriously degrade the performance of their mission as defined by the CNO; and that each proposed deviation will be in the best overall interest of the Navy. Consequently, all elements of the ASW community are counseled to attain as much overall standardization as possible, even where specific deviations are granted.

5. This standard applies to the membership of the ASW community, but may be used by other activities. The ASW community includes acquisition platforms and reconstruction systems, analysis and intelligence centers, training facilities, and agencies which cooperate with these activities.

6. Requests for deviation from specific areas of this standard shall be made via the ASW Tape Recorder Steering Group to the CNO (OP-951) for action and resolution. Such requests shall include technical design criteria as well as justifications which support the desired deviations and planning and funding documents which show how the impact of deviation will be accommodated by the ASW community.

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1. SCOPE

1.1 Scope. This standard covers the magnetic tape recorder configurations to be used to record and reproduce ASW sensor and system data.

1.2 Applicability. This standard is required for the acquisition of new or updated magnetic tape recorder/reproducers format for ASW systems which record and reproduce any quantity of data in any of the following formats:

(a) Analog direct (wideband, 2 megahertz (MHz)).
(b) Analog frequency modulation (FM) (wideband - group II).
(c) Single-track or multi-track serial high density digital (HDDR).
(d) Parallel HDDR.
(e) Mixed analog/digital.
(f) Rotary HDDR.

1.2.1 This standard is applicable to and includes all new air, surface, subsurface, and land-based ASW recording systems. In addition, it applies to all new acquisitions of any quantity of analog FM, analog direct, serial or parallel high density electronics to retrofit existing magnetic tape systems for acquisition and reconstruction of ASW sensor and system data.

1.3 Classification. This standard covers 28-track longitudinal recording using 1-inch (25.4 millimeter (mm)) wide tape and rotary recording using 19 mm magnetic tape. Fourteen-track longitudinal systems are also covered as a subset of 28-track systems.

1.4 Purpose. This standard defines the terminology, standardizes the recorder/reproducer configuration, and defines certain performance limits to assure crossplay compatibility between tapes recorded at one ASW facility or platform and reproduced at another.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications. Unless otherwise specified, the following specifications of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

W-R-175	- Reels and Hubs for Magnetic Recording Tape, General Specification for.
W-R-175/4	- Reels, Precision, Aluminum, with 3-Inch Center Hole (Detail Specification).
W-R-175/6	- Reels, Precision, Glass Flange with Aluminum Hub, 3-Inch Center Hole (Detailed Specification).
W-T-1553	- Tape, Recording, Instrumentation, Magnetic Oxide-Coated.

STANDARDS

MILITARY

MIL-STD-2179 - Helical Digital Recording Format for 19-mm Magnetic Tape Cassette Recorder/Reproducers.

(Copies of specifications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

INTER-RANGE INSTRUMENTATION GROUP (IRIG)

104 - Standard Time Code
106 - Telemetry Standards, AD/A089 90B
118 - Test Methods for Telemetry Systems and Subsystems Vol. III, AD/A121 858.
200 - IRIG Standard Time Formats, TCWG, AD/728 069

(Application for copies should be addressed to Secretariat, Range Commanders Council, White Sands Missile Range, NM 88002.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Aliasing. Aliasing is the generation of spurious frequency components resulting from an insufficiently high sampling rate.

3.2 Areal packing density. Areal packing density is the total number of data bits contained within a specific area on tape, usually expressed in terms of bits per square inch or bits per square centimeter.

3.3 Bandwidth. Bandwidth is the difference between the highest and lowest frequencies at which the amplitude response of the recorder/reproducer is within specified limits. Common practice is to define bandwidth at the points where the frequency response is 3 decibels (dB) below the response at 10 percent of the specified upper frequency limit.

3.4 Baseline restorer. Baseline restorer is a circuit to restore the direct current (dc) component of a signal.

3.5 Bit error. Bit error is the incorrect representation of a binary digit.

3.6 Bit error rate (BER). BER is the rate at which bit errors occur in the data bits during reproduction. BER is usually expressed as the ratio of data bit errors to the total number of data bits processed. It may also be expressed as the ratio of bit errors to either tape length or unit time.

3.7 Bit packing density. Bit packing density is the number of total bits recorded per unit track length unit, usually expressed as kilobits per inch (kb/in) or bits per millimeter (b/mm).

3.8 Bit slip. Bit slip is the error condition in which the phase of a digital signal, with respect to its associated clock, has shifted or changed to such an extent that the correct synchronism between clock and signal is not maintained. Bit slip also occurs when additional data bits have been inserted or deleted from a data bit sequence.

3.9 Bit synchronizer. A bit synchronizer is an electronic circuit that extracts the binary data and the associated bit-rate clock from a pulse code modulated signal that has been reproduced from a tape recording. The extraction process restores and maintains the correct relative timing of the data and the bit-rate clock.

3.10 Carrier frequency. The carrier frequency is the frequency which is modulated by the data in an FM recording system.

3.11 Cross-play. Cross-play is to record and reproduce on the same machine or record on one machine and reproduce on another while maintaining performance within specified limits, or record at one speed and reproduce at the same or different speed while maintaining performance within specified limits on the same or a different machine.

3.12 Cross-talk. Cross-talk is the coupling of unwanted signals from an originating record/reproduce channel to any other channel. The usual practice is to express cross-talk in terms of dB down from the full-scale signal recorded on the originating channel.

3.13 Decoder. A decoder is electronic circuity to perform the inverse of encoding.

3.14 Delayed modulation mark (DM-M) code. DM-M is a serial digital data encoding method where a "one" is represented by a level change at mid-bit time. A "zero" is represented by no transition at mid-bit time. A transition occurs at the start of the bit period between pairs of "zeros." DM-M is also called Miller code, and is a bi-phase mark toggle code.

3.15 Digital recording. Digital recording is a technique of recording in which the data has been coded and recorded as a binary sequence representing "zeros" and "ones" by causing a transition between two magnetic states on tape.

3.16 Digital recording code. Digital recording code is the coding and format of the binary digital data recorded on magnetic tape which corresponds to the input signal to be recorded.

3.17 Direct recording. Direct recording is a method of recording data on magnetic tape in which the electrical input signal is added to a high frequency bias and applied directly to the recording head.

3.18 Dropout. Droput is an abnormal reproduce signal amplitude of such a magnitude that the recorded signal is non-existent, undefined or distorted beyond acceptable limits.

3.19 Encoder. Encoder is the electronic circuitry that accepts a serial binary digital data stream at its input and changes the format to one of those used for digital recording.

3.20 Error detection. Error detection is the process of detecting bit errors.

3.21 Error correction. Error correction is the process of correcting detected bit errors.

3.22 Eye pattern. Eye pattern is the oscilloscope pattern that results when a raw reproduced digital bit stream is applied to the vertical input terminals and the horizontal sweep is synchronized with the reconstructed bit-rate clock.

3.23 Flutter. Flutter is the dynamic variation in tape speed about the average value. Flutter occurs at rates of 0.1 to 500 Hertz (Hz), typically, but may extend over 0.01 Hz to greater than 10 kilohertz (kHz). This variation in tape speed is in the direction of tape motion.

3.24 Flux transition. Flux transition is the reversal of the magnetic pole pattern within the tape medium.

3.25 Flux transition density. Flux transition density is the number of flux transitions per unit track length.

3.26 Frame synchronizer. The frame synchronizer is the electronic circuitry to extract a synchronizing pattern from a reproduced digital bit stream and to generate timing signals which identify frames and subframes.

3.27 Frequency deviation. Frequency deviation is the difference between the instantaneous frequency of a modulated carrier and the unmodulated carrier.

3.28 Frequency deviation limit. Frequency deviation limit is the upper and lower frequencies beyond which a carrier should not be deviated.

3.29 Gap scatter. Gap scatter is the distance between two parallel lines, in the plane of the tape and perpendicular to the head reference surface, which contains the trailing edges of all the gaps in a head stack.

3.30 Head stack azimuth. Head stack azimuth is the angle in the plane of the tape between a perpendicular to the head mounting reference surface and the line connecting the trailing edges of the outermost gaps in a head stack.

3.31 High density digital recording (HDDR). HDDR is the recording of digital data on a magnetic tape with a flux transition density in excess of 15,000 transitions per inch (591 transitions per millimeter) per track.

3.32 High frequency bias. High frequency bias is a symmetrical signal which is added to the data signal during the record process for the purpose of increasing the linearity and dynamic range of the reproducer analog signal.

3.33 Inter-channel time displacement error (ITDE). ITDE is the relative time between any two tracks in a head stack.

3.34 Jitter amplitude. Jitter amplitude is the time difference between the clock or a reference oscillator transition and the reproduced clock or the reproduced reference oscillator transition.

3.35 Jitter rate. Jitter rate is the rate of change of jitter amplitude expressed in Hz.

3.36 Magnetic head. A magnetic head is a transducer used to convert electric current to flux patterns on tapes and to convert flux patterns on tape to electric current.

3.37 Magnetic tape flaw. Magnetic tape flaw is imperfections in the oxide coating usually due to oxide or slitting debris, foreign particulate matter, absence of coating, and other imperfections such as failure to maintain slitting tolerance and failure to calender the base material properly.

3.38 Magnetic tape recorder/reproducer. A magnetic tape recorder/reproducer is a machine which converts electrical signals to magnetic patterns on a magnetic tape during the record process and converts the remanent magnetic patterns on a magnetic tape to electrical signals during the reproduce process.

3.39 Manchester code. The Manchester code is a serial digital data encoding method in which a level change occurs at the center of every bit period. A "one" is represented by a transition from the "one" level to the "zero" level. A "zero" is represented by a transition from the "zero" level to the "one" level. Transitions are caused at the leading edge of a bit-cell as required to satisfy the above.

3.40 Non-return-to-zero level (NRZ-L). NRZ-L is a digital encoding method in which the encoded waveform remains low for a "zero" and high for a "one" for the entire bit-period.

3.41 Overhead bits. Overhead bits are bits added to digital data to facilitate the recovery of the original data subsequent to the record/reproduce, transmission/reception, or other handling of the data.

3.42 Parallel HDDR. Parallel HDDR is the concurrent recording of digital data and a common clock on parallel recording tracks or the reproduction of digital data and a common clock from parallel recorded tracks.

3.43 Parity bit. A parity bit is an extra bit added to a group of message bits to keep the resultant total count of "ones" in the group an odd or an even number.

3.44 Pseudorandom odd parity (PROP) code. A PROP code is an encoding method for use with parallel high density digital recording. For a detailed technical description of this code, see 5.5.5.1.

3.45 Pseudorandom sequences or patterns. Pseudorandom sequences or patterns are periodic sequences exhibiting many of the statistical properties of uniformly distributed random number sequences.

3.46 Rotary HDDR. A technique for recording information in digitized form on magnetic head assembly as well as moving magnetic tape.

3.47 Signal-to-noise-ratio (SNR). SNR is the ratio of signal power to noise power, in a linear system, expressed in dB.

3.48 Synchronization word. A synchronization word is a fixed pattern of bits inserted into a binary sequence to provide a reference for the reconstruction of the original sequence.

3.49 Single track serial HDDR. Single track serial HDDR is the recording of serial digital data on a signal recording track or reproduction of serial digital data from a single recorded track.

3.50 Skew. Skew is a time displacement error in a signal reproduced on one track of a multiple track reproducer relative to a signal reproduced on any other track of the same reproducer. Static skew results from a misalignment of the reproduce heads. Dynamic skew is caused by the method of guiding the tape or anomalies in tape motion.

3.51 Time base error. Time base error is the difference between the servo reference oscillation transitions and the reproduced servo transitions when the system is in servo lock.

3.52 Wideband-group II. Wideband-group II is an IRIG-106 FM recording standard in which the frequency deviation is limited to plus or minus 30 percent of the carrier frequency.

4. GENERAL REQUIREMENTS

4.1 Tape. The media used to record or reproduce ASW sensor and system data shall be 1-inch wide, E-2 oxide, magnetic tape, in accordance with W-T-1553.

4.1.1 Track format. ASW recorder/reproducers shall use the 28-track format as shown on figure 1. Any recorder/reproducer system requiring 14 or fewer tracks shall use the odd-numbered tracks of the 28-track format to permit the reproduction of such data on 28-track reproducers.

4.1.2 Track numbering. The tracks shall be numbered consecutively starting with number 1, from top to bottom across the width of the tape in accordance with IRIG 106. The numbered tape is viewed from the oxide-coated side as if the tape were moving from left to right in the normal record or reproduce mode.

4.1.3 End-of-tape sensing. End-of-tape sensing shall be a function of the recorder/reproducer. End-of-tape sensing shall not require or be dependent on the use of perforations, metallic strips, clear leaders, or clear aperture formed by removal of oxide. Tape shall not be altered to provide end-of-tape sensing. Environmental conditions, such as ambient light or fog, shall not affect end-of-tape sensing. Signals for end-of-tape sensing shall not be recorded on tape.

4.2 Tape packaging system. Tape packaging system shall be as specified in 4.2.1 through 4.2.3.

4.2.1 Reels. ASW recorder/reproducers shall use precision glass flange reels or precision aluminum reels in accordance with W-R-175, and W-R-175/6 or W-R-175/4 respectively. Precision glass flange reels shall be used whenever possible. Reels of 10.5-, 12.5-, 14-, or 15-inch diameter may be used.

4.2.2 Tape oxide orientation. Tape shall be stored, recorded, and reproduced with the oxide surface facing the reel hub.

4.2.3 Tape shipment. Recorded tape shall be shipped, stored, or forwarded for processing in an unrewound condition. Special care shall be taken to assure that the condition of reels remains in accordance with W-R-175. Damaged reels shall not be used.

4.3 Heads. Heads shall be as specified in 4.3.1 through 4.3.10.

4.3.1 Head configuration. Head sets shall be located in two separate head stacks, which incorporate 14 heads in each stack. Two record head stacks shall be used to record tracks of 28-track tape and two reproduce head stacks shall be used to reproduce tracks of 28-track tape, as shown on figure 2. For 28-track tape, where 14 or fewer tracks are being used, only the odd record and reproduce head stack shall be used.

4.3.2 Head stack mounting. The two stacks of a 28-track head stack pair (record or reproduce) shall be mounted so that the center lines through the head gaps of each stack are parallel and spaced 1.500 ± 0.00025 inches (38.1 ± 0.0062 mm) apart for fixed head stacks (see figure 2). Where azimuth adjustment of the reproduce head stack is required, the stack spacing shall be 1.500 ± 0.002 inches (38.1 ± 0.051 mm) between gap center lines (including maximum azimuth adjustment) to meet system performance requirements.

4.3.3 Head location. For 28-track tape, each magnetic head in a stack shall be located within plus or minus 0.0015 inch (0.038 mm) of the nominal positions required to match the track locations. Track locations are shown on figure 1.

4.3.4 Head stack tilt. The plane tangent to the front surface of the head stack at the center line of the head gaps shall be perpendicular to the head mounting plate within plus or minus 1 minute (plus or minus 0.29 milliradian (mrad)) of arc (see figure 3).

4.3.5 Individual gap azimuth. Each individual gap azimuth in the record head stack shall be perpendicular to the head mounting plate within plus or minus 1 minute of arc, as shown on figure 4. The individual gap azimuth in the reproduce head stack, as specified in IRIG 106, shall match that of the record head stack as indicated by reproducing an upper band edge (UBE) frequency signal on a selected track and setting or adjusting the reproduce head stack azimuth for maximum output. At this azimuth setting, the output of any other track in the reproduce head stack shall be within 2 dB of the output at its own optimum azimuth setting.

4.3.6 Head stack azimuth. The reproduce head stack azimuth shall be adjustable over a range of plus or minus 0 degrees 5 minutes of arc (plus or minus 1.45 milliradians). The record head stack azimuth shall be fixed at 90 degrees (1.57 radians (rad)) plus or minus 1 minute of arc, in accordance with figure 5.

4.3.7 Gap scatter. Gap scatter shall be 100 microinches (μin) (0.00254 mm) or less, in accordance with figure 6.

4.3.8 Record head gap. For 28-track analog tape, the record head gap length shall be 80 ± 10 μin (2.03 micrometers (μm)). For 28-track tape parallel HDDR, the record gap shall be 20 ± 5 μin.

4.3.9 Head stack numbering. Head stack number 1 of a pair of stacks (record or reproduce) shall be the first stack over which an element of tape passes when moving in the normal record or reproduction direction. Head stack number 2 shall be the second (record or reproduce) stack over which an element of tape passes.

4.3.10 Head number. Numbering of a record or reproduce head shall correspond to the track number on the magnetic tape which that head normally records or reproduces. Stack number 1 of a pair shall contain the odd-numbered heads, and stack number 2 shall contain the even-numbered heads.

4.3.11 Individual head polarity. Individual head polarity shall be as specified in 4.3.11.1 and 4.3.11.2.

4.3.11.1 Record head. Each record head winding shall be connected to its respective record amplifier so that a positive-going pulse, with respect to system ground, at the recording system input results in the generation of a specific magnetic pattern on a segment of tape passing the record head in the normal direction of tape motion. The resulting magnetic pattern shall consist of a polarity sequence of south-north-north-south.

4.3.11.2 Reproduce head. Each reproduce head winding shall be connected to its respective amplifier so that a segment of tape exhibiting a south-north-north-south magnetic pattern shall produce a positive-going pulse, with respect to system-ground, at the output of the reproduce system.

4.4 Tape speed, stability and accuracy. Tape speed, stability and accuracy shall be as specified in 4.4.1 through 4.4.5.

4.4.1 Analog/hybrid speeds. The standard tape speeds specified herein shall be used to record and reproduce analog (direct or FM), serial digital, and hybrid (analog/digital) data. The standard tape speeds shall be 15/16 inch per second (in/sec) (23.8 millimeters per second (mm/sec)), 1.875 in/sec (47.6 mm/sec), 3.75 in/sec (95.2 mm/sec), 7.5 in/sec (190.5 mm/sec), 15 in/sec (381 mm/sec), 30 in/sec (762 mm/sec), 60 in/sec (1524 mm/sec), and 120 in/sec (3048 mm/sec).

4.4.2 Parallel digital recording speed. Tape speed may vary during the recording of parallel digital data in order to effect a constant bit packing density on tape. This approach shall be allowable when no analog or serial data is being recorded. Standard octave speeds may also be used above 15/16 in/sec. The allowable range of speeds for parallel digital recording shall be 1.875 to 120 in/sec (47.6 to 3048 mm/sec).

4.4.3 Speed selection. The slowest speed for a given recording mode which will accommodate the required data frequency response shall be selected. Where more than one speed is required for various data types, the higher speed shall be used when these data are recorded simultaneously, and the recorder default condition shall be the higher speed.

4.4.4 Tape speed accuracy and stability. Tape speed accuracy and stability shall be as specified in 4.4.4.1 through 4.4.4.4.2.

4.4.4.1 Record tape speed. For analog, serial digital and parallel digital standard speed formats, the record speed shall be within plus or minus 0.1 percent of the standard tape speed specified in 4.4.1 over any 10-second interval when operated under capstan tachometer servo control.

4.4.4.2 Interchannel time displacement error (ITDE). For all formats at 7.5 in/sec (190.5 mm/sec), the effective ITDE due to all causes, including dynamic skew caused by all motion of the tape, shall not exceed 40 microseconds (μs) (3 sigma) for 1-inch tape over any 10-second period. The maximum error limit shall be proportionally larger or smaller at slower or faster tape speeds, respectively.

4.4.4.3 Cumulative flutter. Cumulative flutter for all formats shall not exceed 0.5 percent when measured in accordance with IRIG 118. This measurement uses a direct reading flutter meter (Ampex TU-40 or equivalent) designed to read peak-to-peak flutter amplitude and ignore occasional random peaks, provided that the value read is exceeded less than 5 percent of the time.

4.4.4.4 Flutter components. Spectral components resulting from the movements of tape during the record/reproduce process shall not exceed a maximum flutter envelope. The amplitude of spectral components of flutter are determined by spectral analysis using a 0.1 Hz filter resolution, an 8-ensemble average, and Hanning weighting. Test signals for flutter component measurements shall be recorded at the standard record level.

4.4.4.4.1 Spectral flutter. Artifacts generated around data tones within the data bandwidth at any speed shall not exceed the maximum allowable flutter envelope when referred to a 1-kHz test tone. The equipment specification may impose more stringent requirements. Based on a test tone of 1 kHz, the generated flutter artifacts shall not exceed a level of minus 35 dB from the test tone to plus or minus 3 Hz about the test tone. From plus or minus 3 Hz to plus or minus 300 Hz the maximum flutter envelope follows a negative slope of 6 dB per octave. At frequencies exceeding plus or minus 300 Hz above the test tone, the generated artifacts shall not exceed minus 75 dB.

4.4.4.4.2 Spectral artifacts. Artifacts in the spectral noise floor due to all causes shall not exceed minus 75 dB, except within plus or minus 300 Hz of a test tone.

4.4.5 Time base reference. Analog and serial digital recorders shall record a coherent sinusoidal reference signal simultaneously with the data on each of the servo tracks specified in table I. At 7.5 in/sec (190.5 mm/sec), the reference signal shall be 12.500 kHz. The reference signal shall be derived from a crystal oscillator that has long-term and short-term accuracy and stability errors that are less than 1 part per million. The reference signal frequency shall be directly proportional to tape speed.

4.5 Analog/serial digital channel. Analog/serial digital channel shall be in accordance with 4.5.1 through 4.5.2.5.

4.5.1 Frequency response. Frequency response shall be as follows:

(a) FM. FM data channel parameters shall be as specified in table II.
(b) Direct. Data channel frequency response shall be as specified in table III.

4.5.2 Track assignments. Track assignments shall be as specified in 4.5.2.1 through 4.5.2.5.

4.5.2.1 Analog and serial digital data. Analog and serial digital data may be assigned to any data track specified in table I.

4.5.2.2 Parallel digital data. Track assignments for parallel digital data shall be as specified in table IV.

4.5.2.3 Digital annotation and low rate digital data. Magnetic anomaly detection and digital annotation data shall be bias-recorded on track 3 using Manchester code.

4.5.2.4 Voice. Clear voice shall be direct-recorded on track 1 only. As an alternative, voice may be multiplexed with time code data and direct recorded on track 27. Track 1 shall then be a data track.

4.5.2.5 Time code. The format time code, as specified in IRIG 200 and shown on figure 7, shall be direct-recorded on track 27.

5. DETAILED REQUIREMENTS

5.1 Recording method. Recording methods shall be to wideband direct, wideband-group II FM, serial and parallel HDDR. These methods may be used in combination subject to the track assignments of 4.5.2. Rotary HDDR shall be as defined in 5.6

5.2 Analog recording. Analog recording shall be as specified in 5.2.1 through 5.2.2.1.

5.2.1 FM recording. The input data signal shall cause the frequency of an oscillator to deviate as a linear function of the amplitude of the input data signal.

5.2.1.1 Carrier center frequency. The carrier center frequency shall be as specified in table II.

5.2.1.2 Carrier frequency deviation. The frequency deviation limits shall be plus or minus 30 percent. A positive-going signal voltage shall cause a positive carrier deviation (increased frequency) and a negative-going voltage shall cause a negative carrier deviation (lower frequency) (see table II).

5.2.1.3 Bias frequency. The bias frequency shall be greater than 3.4 times the highest frequency necessary to convey the fully deviated FM signal. Bias shall be used with all FM recording. Bias shall be added to the output of the FM voltage controlled oscillator (VCO) and the resultant sum applied to the record head.

5.2.1.4 Recorded bias level. The record bias current shall be adjusted for a maximum reproduce output level of the carrier center frequency as specified in table II.

5.2.2 Direct recording. The input signal shall be appropriately conditioned and added to the high frequency bias signal and the resultant sum applied to the record head so that the signal is recorded in unaltered form.

5.2.2.1 Recorded bias level. The recorded bias level shall be as shown in table III.

5.3 HDDR. Detailed requirements for single-track serial and parallel HDDR formats shall be as specified in 5.3.1 and 5.3.2.

5.3.1 Digital data codes. The binary code for single track serial HDDR shall be delayed modulation-mark (DM-M) and shall be bias-recorded. The binary code for parallel HDDR shall be PROP and shall be non-bias recorded.

5.3.2 HDDR track assignments. The usually higher quality center tracks shall be used for serial high density digital data. This type of recording is more sensitive to tape flaws and slitting debris than direct or FM data. Serial digital data may be assigned to any data track identified in table I. Parallel digital data may be recorded on any track identified in 5.5.2 for digital data use.

5.3.3 Data input and output (I/O). The NRZ-L input and output digital data at the recorder/reproducer interface shall be coded with accompanying zero degree clock. The clock is defined as a 50 ± 5 percent duty cycle and positive-going within 3 percent of the data bit period beginning. Clock jitter rate shall not exceed 0.5 percent.

5.3.4 Data sense. The positive logic definition of data I/O logical sense is that a high (positive direction) voltage signal equals a logic "one" and a low (negative direction) voltage signal equals a logic "zero". To preserve data sense between interchange parties, the relationship between data I/O and the encoded symbols on tape must be controlled. The recorder/reproducer shall not invert the data sense nor the clock sense when the input of a recorder/reproducer is compared to its output.

5.3.5 Serial digital servo reference tracks. There shall be a minimum of one servo reference track to minimize reproduced time-base error. If both head stacks of a 28-track system are dedicated to digital service, the servo reference shall be recorded on track 8 of the even stack. In a 14-track system, the servo reference shall be recorded on track 7 of the odd stack. If more than one servo reference signal is used, the track assignments shall be as specified in table I.

5.4 Serial HDDR. Single track serial HDDR provides a means for recording a bi-level digital stream on a single recording track. Multiple digital streams may be recorded on multi-track wideband recorders as long as each digital stream is recorded on a separate track. Multiple digital streams do not necessarily have or use a common synchronous clock. Because of the DM-M code wave forms, the bit packing density, and related minimum performance standards, the maximum BER is specified to be 1 in 10^6 bits.

5.4.1 Record elements. The record side of a digital recorder has the following elements:

(a) Encoder. The encoder accepts a serial NRZ-L digital bit stream and its clock at its input and converts it to a series of level changes in accordance with the DM-M code algorithm.

(b) Record amplifier. The record amplifier accepts encoded signals at its input and produces current in the record head. Record head current is of one polarity for a high level and of the opposite polarity for a low level.

(c) Record head. The record head leaves flux patterns on tape in response to current input. Each record head and record amplifier shall be connected so that a positive going pulse, with respect to system ground at the record amplifier input, will result in the generation of a flux pattern consisting of a polarity sequence of south-north-north-south.

5.4.2 Synchronization for DM-M. The DM-M encoding method used for serial coding on tape shall be as shown on figure 8. For DM-M coding, the middle of a bit cell must be distinguished in order to regenerate the clock in the proper phase. A 1-0-1 sequence produces a 2 bit cell transition spacing. All other bit sequences produce lesser transition spacings. DM-M decoders shall have 1-0-1 detectors to establish the regenerated clock in the proper phase and to synchronize the binary message. The input data stream shall be framed into a known number of bit intervals, all of equal duration, unless special identification bits within the stream are required. The number of bit intervals per frame shall remain fixed from frame to frame. The length of a frame shall not exceed 1,024 bit intervals including the bits devoted to the synchronization pattern. The synchronization pattern shall consist of a digital word not longer than 33 consecutive bits, which shall be rich in 1-0-1 pattern segments, and repeated not less frequently than every 512 bits.

5.4.3 Bit packing density. The single track bit rate, including synchronization bits, shall be 256 (plus or minus 5 percent) kilobits per second (kb/sec) at a tape speed of 7.5 in/sec. This corresponds to 34,133.33 (plus or minus 5 percent) bits per track-inch for DM-M encoding. The bit rate shall be proportional at other tape speeds.

5.4.4 Recording technique. The DM-M pattern shall be recorded on the specified tape using wideband direct analog recording techniques with integral, symmetrical waveform, high frequency bias. The bias frequency shall be at least 3.4 times the highest recording channel signal frequency for which the recorder/reproducer system is designed. The bias shall not contain even harmonics. The bias current setting shall produce a peak-to-peak reproduce head output maximum at a signal frequency corresponding to one-half the maximum DM-M bit rate when record current is set for peak output at band edge. If the record signal used to set bias is a single frequency sine wave, the record head current is reduced from the level which produces the peak-to-peak maximum until the reproduce head output decreases 4 dB. If the record signal used to set bias is a single frequency square wave, the record head current is not readjusted.

5.4.5 Track 3 annotation. Track 3 shall be reserved for digital annotation of the acoustic ASW tape. Only the word and block formats presented herein shall be used. The following digital annotation parameters are defined herein:

Data Word Format
Data Block Format
Recorded Data Protocol
Interface Definition
Recording Method

Figure 9 shows those areas of the digital annotation recording scheme which are covered herein.

The following is a list of all the annotation data words that can be uniquely defined with a four-bit function code:

Word		Function Code (MSB LSB)
	Not used	0000
	Mandatory	
Header		1001
Zulu time		0100
	Assigned	
RF/Track assignment		1000
Sonobuoy latitude		1101
Sonobuoy longitude		1110
	Platform unique	
----		1111
----		1100
	Available for assignment	
TBD		0001
TBD		0010
TBD		0011
TBD		0110
TBD		0111
TBD		1010
TBD		1011

Formats for each data word are provided on figures 10 through 17 and the definition of each data bit is contained in table VII. Spare bits in any defined data word may be assigned specific additional data which does not effect the existing data bits or their meaning. No defined data bit meaning may be altered. Other unique words desired by the individual user may be recorded using Function Code 1111 or 1100 (see figures 16 and 17).

5.4.5.1 Data word format. Recorded words shall be 36 bits in length. The 36-bit word shall be formatted as shown on figure 10. Bit 0 (the first bit written to tape) shall be a '1'. Bit 35 (the last bit written to tape) shall give the 36-bit word odd one's parity.

5.4.5.2 Block format. Blocks of data shall be recorded incorporating various quantities of data words, depending on the quantity of changes in the system configuration, the tactical situation and system status since the last block of words. Each block of data words shall begin with the header word. The limitations on the block shall be the following:

(a) It shall contain as a minimum the header word.
(b) The time word shall be recorded at least once each second.
(c) The maximum block size is 150 words.
(d) Sonobuoy latitude and longitude, if recorded, shall be preceded immediately by the RF/track assignment word, since the Sonobuoy latitude and longitude words by themselves do not identify the sonobuoy they pertain to.
(e) If a tape track does not have an RF assigned, the RF field bits (bits 12-5) shall be 0000 0000.

5.4.5.3 Data protocol. The number of data words in an individual block shall be determined by the platform's needs. Any number greater than the minimum may be recorded, up to 150 words. The first word of each data block shall be the header word. After each data word has been recorded, a minimum of 36 zeros shall be recorded before the next data word. After the last data word of the block has been recorded, zeros shall be recorded until a new header word is received. Figure 18 shows the format for a typical data block.

5.4.5.4 Interface definition. The acoustic tape recorder shall accept digital annotation data from the platform's data bus via an interface device. The interface device shall reformat the annotation data to conform to this standard.

5.4.5.5 Recording method. The annotation data shall be recorded using a standard wideband direct data channel and the standard bias recording method. Annotation data shall be recorded using Manchester coding (see figures 8 and 19). The packing density shall be constant at 5.555 kb/in. The record data rate shall be determined by multiplying 5.555 kb/in by the record tape speed (see 4.4.1 for allowable tape speeds). For instance, data rate at 7-1/2 in/sec is 5.555 kb/in x 7.50 in/sec = 41.66 kb/sec.

5.4.5.6 Word format. Formats for the words specified in 5.4.5 are shown on figures 10 through 17. Spare words may be assigned data bits as required. Spare bits in any defined data word may be assigned specific additional data bits which do not affect the existing data bits or their meaning. No defined data bit meaning may be altered.

5.4.6 High rate data streams. If a digital data stream rate exceeds the bit rate of a single track, a higher tape speed shall be used or parallel HDDR shall be used.

5.4.7 BER. The maximum uncorrected BER shall be 1 in 10^6 bits.

5.5 Parallel HDDR. Parallel HDDR provides a means to record and reproduce multiple bi-level digital streams which are synchronous to a common clock. Parallel HDDR is intended for ASW applications where maximum record time is needed or the data to be recorded is primarily digital. When parallel HDDR is used the recorder/reproducers shall be optimized for that mode.

5.5.1 Intrinsic tape recorder performance. To obtain the full range of bit packing densities and other performance levels of this standard, the recorder shall meet the minimum performance requirements specified in section 4. In addition, parallel HDDR recorder/reproducers shall provide for speed and servo control by external sources.

5.5.2 Track allocation. Those systems which require 14 or fewer tracks shall use the odd numbered head stacks of the 28-track system.

5.5.2.1 14-track systems. For 14-track systems, specific tracks shall be reserved as follows:

(a) Track 1 - time code direct.
(b) Track 3 - parallel data error correction.

All other tracks shall be used for high density digital data.

5.5.2.2 28-track systems. For 28-track systems, specific tracks shall be reserved as follows:

(a) Track 1 - time code direct.
(b) Track 3 - parallel data error correction for the odd numbered tracks.
(c) Track 2 - spare direct.
(d) Track 4 - parallel data error correction for the even numbered tracks.

All other tracks shall be used for high density digital data.

5.5.2.3 Parity track inputs. When an even number of tracks are required for the parallel HDDR, an odd pseudorandom sequence shall be used to generate the parity track signal. When an odd number of tracks are required for the parallel HDDR, an even pseudorandom sequence shall be used to generate the parity track signal.

5.5.2.4 Digital word format. In those cases where raw data is most readily available in a parallel word format, it may be advantageous to record and reproduce the data in that format. Past experience shows that the center tracks are generally cleaner than the edge tracks. Therefore, the most significant bits shall be recorded on the center tracks whenever practical.

The preferred track allocations for the bits of parallel words shall be as shown in table IV. In no case shall parallel digital data words be split between head stacks. If a parallel word contains more bits than can be recorded in parallel on one stack, the data words shall be buffered and segmented for recording. The track allocation for the bits of each segment shall follow the sequence shown in table IV.

5.5.3 Data sense. The definition of data I/O logical sense indicates that a high (positive direction) voltage signal equals a logic "one" and low (negative direction) voltage signal equals a logic "zero." The HDDR shall not invert the data sense nor the clock sense when the input of the recorder system is compared to the output of the system. For the PROP coding, a positive logic interpretation shall be used. The code used to randomize the data for parallel recording shall be as shown in tables V and VI.

5.5.4 Parallel digital recording systems element functions. Parallel high density digital recorder/reproducers shall contain the following elements:

(a) Parallel encoders. Parallel encoders shall accept a digital bit stream which is synchronous to an accompanying clock. The stream shall be encoded and formatted for output to a record amplifier. The encoding shall consist of pseudorandomizing each 7-bit segment of the input bit stream and adding parity bits and synchronization bits.

(b) Parallel record amplifiers. Parallel record amplifiers shall accept the output of the parallel encoder and produce current in the record head. Record head current is one polarity for a high level encoder output and the opposite polarity for low level encoder output.

(c) Parallel record heads. Parallel record heads shall leave flux patterns on tape in response to current input. Each record head and record amplifier shall be connected so that a positive-going pulse, with respect to system ground at the record amplifier input, will result in the generation of a flux pattern consisting of a polarity sequence of south-north-north-south.

(d) Parallel reproduce heads. Each reproduce head shall be connected to its reproduce amplifier so that a segment of tape exhibiting a south-north-north-south polarity sequence shall result in a positive-going pulse, with respect to system ground, at the output of the amplifier.

5.5.5 On-tape parallel recording code. Pseudorandom odd parity non-return-to-zero level (PROP NRZ-L) on-tape coding shall be used for parallel high density digital recording. To ensure data interchange, a positive logic sense shall be applied.

5.5.5.1 PROP code format. To form a parallel format, each track of NRZ-L data shall be arranged in synchronous frames as shown on figure 20. Each frame consists of 504 bits where 24 bits are a de-skew synchronization pattern (001111000011110000111100), 60 bits are odd parity (1 for each 7 data bits), and 420 bits are data. The data bits are collected into 60 groups (that is, words) of 7 data bits plus an added eighth odd parity bit. Only the data portion (the 420 data bits) of the frame shall be randomized. Parity shall be formed on each randomized word. The randomization consists of modulo-two additions of the data bits and a $(2^6 -1)$ pseudorandom sequence. The sequence shall be modified by repeating every sixth bit from the sequence generator. The sequence generator shall be reset at data bit 7 of each new frame. Two different stages of the sequence generator are used: one for the odd-numbered parallel channels and another for even-numbered channels. The resulting randomizing codes shall be as shown in tables V and VI. Maximum security against repeated data patterns shall be as provided by combining the parity bits with randomized data. The frame sync word pattern is an even pattern versus data words which are always odd patterns. Hence, the synchronization pattern is unique and cannot appear in the data portion of the frame. The data word parity bit shall be both a guarantor of a minimum transition rate and an error indicator independent of the data stream. During reproduce/decoding, the data shall be de-skewed and realigned to synchronize with a regenerated clock. Synchronization bits, parity bits, and randomization bits shall be removed and the data restored to replicas of their original form without time gaps.

5.5.6 Recording technique. Parallel high density digital data shall be direct-recorded without bias. The maximum uncorrected BER shall be 1 in 10^6 bits when recorded on one machine and reproduced on another. E-2 type tape, as specified in W-T-1553, and ring type heads (20 ± 5 µin record gap length) shall be used. Optimal signal output with the highest resolution and packing density shall be obtained by setting the record head to the level that creates the highest head field gradient, which creates the narrowest possible transition zone on the tape. Best results are normally obtained by setting the record current gain for a maximum reproduce head output at a signal frequency 0.6 times the input data bit rate for the PROP code. The record signal used to set record current gain shall be a single frequency square wave at a level equal to the peak-to-peak amplitude of the PROP encoder output.

5.5.7 Recorded bit packing density. The recorded bit packing density on tape shall be from 16 to 33.3 kb/in. The recorded bit packing density includes user data, parity, and synchronization bits.

5.5.8 BER. The corrected BER shall not exceed 1 in 10^8 bits.

5.5.8.1 Error correction. Across-tracks odd-parity data streams shall be formed and recorded for the purpose of correcting errors in the reproduced data. One data stream shall be formed for each head stack. The error correcting data stream shall be recorded on track 3 for the odd-numbered stack and on track 4 for the even-numbered stack. The error correcting data streams shall be formed from the input data streams prior to encoding and shall be encoded and recorded in the same manner as the input data. Error correction shall be performed after data is de-skewed and realigned (that is, decoded). Across-tracks parity shall be reformed and rechecked against the reproduced parity for each across-track group. If these parity checks do not agree, then at least one track has an error at this precise bit position. Individual reproduce dropout detectors shall be used to locate which track has the error. As long as only one track dropout exists within a group, the bit error shall be corrected by inversion of the data bit prior to outputting the data. The error correcting logic shall be capable of correcting all single track burst errors or all isolated single track errors resulting from signal loss of 20 dB or less.

5.5.8.2 Control of bit error sources. The specified corrected bit error rate performance can be achieved with available magnetic tapes only when tape flaws are the single remaining source of bit errors. The specified bit error rate requires a reproduced post equalization, SNR, which shall be at least 25 dB, and a decoder which shall be capable of reading through flaws as severe as a 15 to 20 dB dropout without error. Sources of bit errors within the recorder/reproducer (for example, poorly adjusted recording, bit pattern sensitivity within the decoder, and spurious noise spikes) shall be minimized to the levels controlled by the hardware specification.

5.5.9 Signal monitoring. Where frequencies permit, critical signal test points shall be provided for monitoring on an oscilloscope while the system is operating. Such monitoring shall not interfere with normal operation. As a minimum, waveform and level monitoring shall be included for the following:

(a) Each input channel to the parallel encoders.
(b) Each input channel to the record head drivers.
(c) Each equalizer reproduced output from the reproduce head amplifiers.
(d) Each data, clock, dropout signal from the bit synchronizer, decoders, and base-line compensation logic circuits.
(e) Any other critical timing and control waveforms needed during signal electronic alignment and system test debugging.

5.5.9.1 Status displays. The system shall include the following signal and operating status displays: illuminated indicators for each active digital channel for reproduce signal (loss), frame sync (loss), and parity (error). In addition, a master (system) synchronization visual indicator shall be provided.

5.5.10 Transport bypass capability. The ability to operate the parallel HDDR system without transporting tape is required to validate each encoder/decoder operation while watching the status lights (data, sync, error).

5.6 Rotary HDDR. High rate digital data recorded utilizing rotary head recording methods shall be accomplished as defined by MIL-STD-2179 in its entirety.

5.7 Tests.

5.7.1 General test considerations. An acceptable measure of digital recorder/reproducer system performance shall involve determination of reproduced individual bit errors. However, because system design responses shall be as dependent on the test method used as upon the performance specifications themselves, both must have equal emphasis. The two basic sources of bit errors are systemic hardware deficiencies and magnetic tape dropouts. The deleterious effects of dropouts are somewhat dependent on the system hardware since one type of decoder scheme might tolerate signal amplitude variation better than another. A means shall be developed to isolate, correlate, and test for each type of error to provide a good overall measurement of system performance. Three methods of bit error testing are included in this standard: a pseudorandom bit sequence test, a pseudorandom word test, and a pattern sensitivity test. Each test has been selected to expose digital recorder/reproducer system deficiencies significant to successful system operation. Each test shall establish the relationship of bit errors to accurate locations on tape. Therefore, an error printer shall be used in conjunction with a tape footage counter or a time code generator/reader. The objective of the test method shall be to examine the following areas:

(a) The statistics of tape-related errors on a given track and across tracks.
(b) The statistics of pattern sensitivity-related errors, format-related errors, and data-related (not code) errors.
(c) The statistics of hardware related errors: spurious noise, spectral, Gaussian and other systemic sources.

The test shall describe one track and one recorder/reproducer at a time. Adequate system validation shall require that the test include all digital tracks and the case where a signal has been commutated among tracks. To validate the system, a tape made on the recording system shall be transferred to the reproduce system and reproduced to validate that both systems meet the applicable requirements of this standard. Each of the tests specified in 5.7.1.1 through 5.7.1.3 shall require a test stream generator on the record side. The reproduce side shall require a bit error detector capable of reconstructing the test stream and counting bit errors as they occur.

5.7.1.1 Pseudorandom bit error. A pseudorandom sequence shall be used to mimic a continuous data stream. When a long sequence (at least 2,047 bits) is used, an acceptable representation of random data response is provided. However, it has little regard to pattern sensitivity or the particular implementation of the encoder/decoder scheme. A principal utility of the test shall be to determine error sensitivity to tape dropouts and to gross malfunctions within the hardware. If the bit sample is at least 10^7 bits, a good estimate of the bit error rate shall result from accumulating the errors and dividing by the sample. When the sample is increased to 10^8 and the errors accumulated, correlation with dropouts along the tape becomes possible. If a means is included to detect the amount of signal reduction when error bursts occur, correlation of errors with dropout points along the tape becomes possible. If the system is performing properly, the characteristic of the error printout shall be occasional as a result of sporadic error bursts. If, in addition to these sporadic bursts (associated with dropouts), there is a cyclic (more or less continuous) accumulation of errors, then some equipment inadequacy, malfunction, or high spurious noise bursts shall be indicated. If error bursts associated with tape flaws are significantly longer than the observed flaw period (greater than 100 or so bits), the ability of the bit synchronizer to recover from bit slip is questionable.

5.7.1.2 Pseudorandom word. The input signal shall be a repeated sequence consisting of a formatted frame. The frame shall include a sync pattern and a time-division multiplex of randomized data words. The frame length shall be chosen to match (or nearly so) the operating frame length. The randomized word lengths shall be chosen to match (or nearly so) the bit length of the operating words. In addition to the framing formatter, on the input record side is a frame synchronizer capable of synchronizing the frame and outputting selected data words to a bit error counter and printer. The output sample rate shall, of necessity, be reduced to the selected word rate, and the amount of tape used may be increased to obtain a statistically significant sample. However, a long-term bit error rate established by this test shall be indicative of performance for the operating system. The test shall reveal any undue sensitivity to the planned operating format.

5.7.1.3 Pattern sensitivity test. The worst case direct current (dc) (base line wander) offset pattern for DM-M is the sequence ...101, 101, 101, 1011, 101, 101.... The worst case synchronization pattern shall be a sequence with no isolated zeros (for example, 10001, 10001, and so forth) for which the decoder is denied the necessary ...101... pattern it must have in order to self-synchronize. Either, or both, patterns can be generated by circulating shift registers of appropriate length. An alternative method shall be to form a serial bit stream based on a binary counter with a sufficient number of stages to simulate the expected worst case combination of data words. In the counter method, the counter shall be allowed to accumulate continually at a controlled rate to create a digital ramp. During the test, the counter sequence shall be repeated and sampled several hundred times at each level and an associated bit error rate established. Inability to read through such patterns in the absence of deep (greater than 20 dB) flaws shall indicate inadequate baseline compensation and inadequate ability to maintain synchronization within the encoder/decoder.

5.7.2 Parallel test requirements. Parallel tests shall be as specified in 5.7.2.1 and 5.7.2.2.

5.7.2.1 General considerations. An acceptable measure of parallel digital recorder/reproducer system performance shall involve determination of reproduced individual bit errors. Special measures have been built into the PROP code to immunize against system sensitivity to data patterns and to enhance margins against tape flaws. Nevertheless, two basic sources of bit errors need to be addressed: systemic hardware deficiencies and magnetic tape dropouts. A means shall be found to isolate, correlate, and test for each type of error source to obtain a good overall measure of system performance. In addition, the relationship of bit errors to locations on tape must be accurately established. Therefore, an error printer shall be used in conjunction with tape footage counter or a time code generator/reader. The objective shall be to measure the following areas:

- (a) Quantity, location and dropout level for tape-related errors for individual tracks and for the aggregate of all tracks, both with and without error correction.
- (b) Hardware-related errors.
- (c) Capability to:
  - (1) Record and reproduce on the same or a different machine.
  - (2) Record at one speed and reproduce at the same or a different speed.
  - (3) Operate consistently without adjustment between routine specified maintenance cycles.

Because the PROP code parallel HDDR method has incorporated special measures to eliminate pattern sensitivity, the pseudorandom tests (5.7.1.1 and 5.7.1.2) shall be sufficient.

5.7.2.2 High rate serial data testing. A single serial input data stream shall be distributed by means of a serial-to-parallel conversion process to the parallel data channel inputs for recording. After resynchronization, realignment, and overhead removal during the reproduction process, the output parallel channels shall be multiplexed (that is, a parallel-to-serial conversion process) to reform a replica of the input serial stream. This stream shall be applied to a bit error detector equipped with an error printer. The serial rate is always N (the number of active parallel data channels) times the channel bit rate. For the tape track assignments of 5.5.2.1 and 5.5.2.2, N is 12 (for 14-track systems) or 24 (for 28-track systems).

6. NOTES

6.1 Changes from previous issue. Asterisks or vertical lines are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.2 Subject term (key word) listing.

Analog direct
Analog frequency
Baseline restorer
Magnetic tape
Track format
Word format

Custodians:
Army - CR
Navy - SH
Air Force - 99

Review activities:
Navy - NV, OM
Air Force - 82
DLA - ES

User activity:
Navy - AS

Preparing activity:
Navy - SH
(Project 6625-0689)

TABLE I. 28-track standard track assignments.

Odd[1]	Even
1 - ICS (Voice)[2] or data	2 - Data
3 - Digital annotation track	4 - Data
5 - Data	6 - Data
7 - Servo	8 - Servo
9 - Data	10 - Data
11 - Data	12 - Data
13 - Data	14 - Data
15 - Data	16 - Data
17 - Data	18 - Data
19 - Data	20 - Data
21 - Data	22 - Data
23 - Servo	24 - Servo
25 - Data	26 - Data
27 - Time code[2] or MPX voice[3]	28 - Data

[1] For a 14-track machine used on a 28-track format, only the odd head stack shall be used, with the track assignments listed for the odd tracks.

[2] Track 1 shall be voice if clear voice is being used but shall be a data track if voice is multiplexed. If multiplexed voice is being used, track 27 shall contain time code plus multiplexed voice.

[3] Up to 5 FM subcarriers are permissible: 3B-32 kHz, 5B-48 kHz, 7B-64 kHz, 9B-80 kHz, 11B-96 kHz. Subcarrier modulation method shall be in accordance with table 3-2 of IRIG 106.

TABLE II. Wideband (FM) parameters - group II (30 percent).

Tape speed (in/sec)	Carrier center frequency (kHz)	Carrier plus deviation (kHz)	Carrier minus deviation (kHz)	Data channel frequency response[1] (kHz)
15/16	7.03125	9.1405	4.922	dc to 3.91
1-7/8	14.0625	18.281	9.844	dc to 7.81
3-3/4	28.125	36.562	19.688	dc to 15.6
7-1/2	56.250	73.125	39.375	dc to 31.2
15	112.50	146.25	78.75	dc to 62.5
30	225.0	292.50	157.5	dc to 125.0
60	450.0	585.0	315.0	dc to 250.0
120	900.0	1170.0	630.0	dc to 500.0

[1] Frequency response limits shall be plus 1, minus 3 dB referred to 100 Hz output for carrier center frequency of 7.03125 kHz, and referred to 1000 Hz output for carrier center frequency of 14.0625 kHz and above.

TABLE III. Direct-record parameters.

Tape speed (in/sec)	Plus or minus 3 db passband[1]	Record bias set frequency[2] (kHz)	Record level[2] set frequency (kHz)
120	400-2,000,000	2,000	200
60	400-1,000,000	1,000	100
30	400-500,000	500	50
15	400-250,000	250	25
7-1/2	400-125,000	125	12.5
3-3/4	400-62,500	62.5	6.25
1-7/8	400-31,250	31.25	3.13
15/16	400-15,625	15.625	1.56

[1] Passband response reference shall be the output amplitude of a sinusoidal signal at the record level set frequency recorded at standard record level. The record level set frequency shall be 10 percent of the upper band edge (UBE) frequency (0.1 UBE).

[2] When setting record bias level, a UBE frequency input signal shall be employed. The signal input level shall be set 5 to 6 dB below standard record level to avoid saturation effects which could result in erroneous bias level settings. The record bias current shall be adjusted for a maximum reproduce output level and then increased until the output level decreases by 2 dB.

TABLE IV. Track assignments for parallel words.

Odd head stack		Even head stack	
Bit	Track no.	Bit	Track no.
MSB	13	MSB	14
MSB-1	17	MSB-1	18
MSB-2	11	MSB-2	12
MSB-3	19	MSB-3	20
MSB-4	9	MSB-4	10
MSB-5	21	MSB-5	22
MSB-6	7	MSB-6	8
MSB-7	23	MSB-7	24
MSB-8	5	MSB-8	6
MSB-9	25	MSB-9	26
MSB-10	15	MSB-10	16
MSB-11	27	MSB-11	28

NOTE:
(1) Tracks 3 and 4 reserved for parallel error correction.
(2) Track 1 is reserved for time code direct and 2 is "spare direct" and do not have PROP encoded data.

TABLE V. PROP randomizing code, odd sequence.

Data word	Data bit	X1	X2	X3	X4	X5	X6	X7	Data word	Data bit	X1	X2	X3	X4	X5	X6	X7
1	1- 7	0	0	1	1	0	1	0	31	211-217	0	0	0	1	0	0	1
2	8- 14	0	0	0	0	0	0	1	32	218-224	1	1	0	0	1	0	1
3	15- 21	1	1	1	1	1	0	1	33	225-231	0	0	1	0	0	0	0
4	22- 28	1	1	1	1	0	0	1	34	232-238	0	0	0	1	1	1	1
5	29- 35	1	1	1	0	1	0	1	35	239-245	1	1	0	1	1	1	1
6	36- 42	1	1	0	0	0	0	1	36	246-252	0	0	0	1	1	1	0
7	43- 49	0	0	1	1	1	0	0	37	253-259	1	1	0	1	1	0	0
8	50- 56	0	0	1	1	0	1	1	38	260-266	0	0	0	1	0	1	1
9	57- 63	0	0	1	0	0	1	0	39	267-273	1	1	0	0	0	1	1
10	64- 70	0	0	0	1	0	0	1	40	274-280	0	0	1	1	0	1	0
11	71- 77	1	1	0	0	1	0	1	41	281-287	0	0	1	0	0	0	1
12	78- 84	0	0	1	0	0	0	0	42	288-294	0	0	0	1	1	0	0
13	85- 91	0	0	0	1	1	1	1	43	295-301	1	1	0	1	0	1	0
14	92- 98	1	1	0	1	1	1	1	44	302-308	0	0	0	0	0	0	1
15	99-105	0	0	0	1	1	1	0	45	309-315	1	1	1	1	1	0	1
16	106-112	1	1	0	1	1	0	0	46	316-322	1	1	1	1	0	0	1
17	113-119	0	0	0	1	0	1	1	47	323-329	1	1	1	0	1	0	1
18	120-126	1	1	0	0	0	1	1	48	330-336	1	1	0	0	0	0	1
19	127-133	0	0	1	1	0	1	0	49	337-343	0	0	1	1	1	0	0
20	134-140	0	0	1	0	0	0	1	50	344-350	0	0	1	1	0	1	1
21	141-147	0	0	0	1	1	0	0	51	351-357	0	0	1	0	0	1	0
22	148-154	1	1	0	1	0	1	0	52	358-364	0	0	0	1	0	0	1
23	155-161	0	0	0	0	0	0	1	53	365-371	1	1	0	0	1	0	1
24	162-168	1	1	1	1	1	0	1	54	372-378	0	0	1	0	0	0	0
25	169-175	1	1	1	1	0	0	1	55	379-385	0	0	0	1	1	1	1
26	176-182	1	1	1	0	1	0	1	56	380-392	1	1	0	1	1	1	1
27	183-189	1	1	0	0	0	0	1	57	393-399	0	0	0	1	1	1	0
28	190-196	0	0	1	1	1	0	0	58	400-406	1	1	0	1	1	0	0
29	197-203	0	0	1	1	0	1	1	59	407-413	0	0	0	1	0	1	1
30	204-210	0	0	1	0	0	1	0	60	414-420	1	1	0	0	0	1	1

TABLE VI. PROP randomizing code, even sequence.

Data word	Data bit	X1	X2	X3	X4	X5	X6	X7	Data word	Data bit	X1	X2	X3	X4	X5	X6	X7
1	1- 7	1	1	1	0	1	0	0	31	211-217	0	0	1	0	0	1	1
2	8- 14	0	0	0	0	0	1	1	32	218-224	0	0	0	1	0	1	0
3	15- 21	1	1	1	1	0	1	1	33	225-231	1	1	0	0	0	0	0
4	22- 28	1	1	1	0	0	1	1	34	232-238	0	0	1	1	1	1	1
5	29- 35	1	1	0	1	0	1	1	35	239-245	0	0	1	1	1	1	0
6	36- 42	0	0	0	0	0	1	0	36	246-252	0	0	1	1	1	0	1
7	43- 49	1	1	1	1	0	0	0	37	253-259	0	0	1	1	0	0	0
8	50- 56	1	1	1	0	1	1	0	38	260-266	0	0	1	0	1	1	1
9	57- 63	1	1	0	0	1	0	0	39	267-273	0	0	0	0	1	1	0
10	64- 70	0	0	1	0	0	1	1	40	274-280	1	1	1	0	1	0	0
11	71- 77	0	0	0	1	0	1	0	41	281-287	1	1	0	0	0	1	0
12	78- 84	1	1	0	0	0	0	0	42	288-294	0	0	1	1	0	0	1
13	85- 91	0	0	1	1	1	1	1	43	295-301	0	0	1	0	1	0	0
14	92- 98	0	0	1	1	1	1	0	44	302-308	0	0	0	0	0	1	1
15	99-105	0	0	1	1	1	0	1	45	309-315	1	1	1	1	0	1	1
16	106-112	0	0	1	1	0	0	0	46	316-322	1	1	1	0	0	1	1
17	113-119	0	0	1	0	1	1	1	47	323-329	1	1	0	1	0	1	1
18	120-126	0	0	0	0	1	1	0	48	330-336	0	0	0	0	0	1	0
19	127-133	1	1	1	0	1	0	0	49	337-343	1	1	1	1	0	0	0
20	134-140	1	1	0	0	0	1	0	50	344-350	1	1	1	0	1	1	0
21	141-147	0	0	1	1	0	0	1	51	351-357	1	1	0	0	1	0	0
22	148-154	0	0	1	0	1	0	0	52	358-364	0	0	1	0	0	1	1
23	155-161	0	0	0	0	0	1	1	53	365-371	0	0	0	1	0	1	0
24	162-168	1	1	1	1	0	1	1	54	372-378	1	1	0	0	0	0	0
25	169-175	1	1	1	0	0	1	1	55	379-385	0	0	1	1	1	1	1
26	176-182	1	1	0	1	0	1	1	56	386-392	0	0	1	1	1	1	0
27	183-189	0	0	0	0	0	1	0	57	393-399	0	0	1	1	1	0	1
28	190-196	1	1	1	1	0	0	0	58	400-406	0	0	1	1	0	0	0
29	197-203	1	1	1	0	1	1	0	59	407-413	0	0	1	0	1	1	1
30	204-210	1	1	0	0	1	0	0	60	414-420	0	0	0	0	1	1	0

TABLE VII. Annotation data format.

Record word	Data field bit numbers	Explanation	Function code
			Bit no. 4 Bit no. 1
Not used	----	----	0000
TBD	----	----	0001
TBD	----	----	0010
TBD	----	----	0011
Zulu time	32-5	Greenwich mean time in 1/64 seconds (see figure 12)	0100
TBD	----	----	0101
TBD	----	----	0110
TBD	----	----	0111
RF/track assignments	32-31	Unit: Denotes recorder/reproducer unit when more than one acoustic recorder is used. Bit 32 Bit 31 0 0 - First recorder 0 1 - Second recorder 1 0 - Third recorder 1 1 - Fourth recorder	1000
	30-25	Buoy type Bit 30 Bit 25 000000 - None, channel free 000001 - Bathythermal (BT) 000010 - Low frequency analysis recording (LOFAR) 000011 - Range only (RO) 000100 - Directional Frequency Analysis & Recording (DIFAR) 000101 - Vertical Line Array (VLA) 000110 - Command Activated Multi-Beam Sonobuoy (CAMBS)	

TABLE VII. Annotation data format. - Continued

Record word	Data field bit numbers	Explanation	Function code
			Bit no. 4 Bit no. 1
RF/track assignments	30-25	000111 - Low cost sonobuoy 001000 - Generic (country assignable) 001001 - BARRA 001010 - Expendable Reliable Acoustic Path Sonobuoy (ERAPS) 001011 - Air Transportable Acoustic Communication (ATAC) 001100 - Vertical Line Array DIFAR (VLAD) 001101 - Spare 001110 - Ambient Noise Measurement Calibration 001111 - Directional Command Activated Sonar System (DICASS) Others - TBD	
	24-17	Tape track number Denotes the tape track to which the RF channel (bits 12-5) has been assigned. If more than one recorder is being used on the mission the recorder to which the RF channel has been assigned is contained in the unit data field (bits 32-31). Bit 24 Bit 17 00000001 - Track 1 00000010 - Track 2 00000011 - Track 3 . . . 00011011 - Track 27 00011100 - Track 28	

TABLE VII. Annotation data format. - Continued

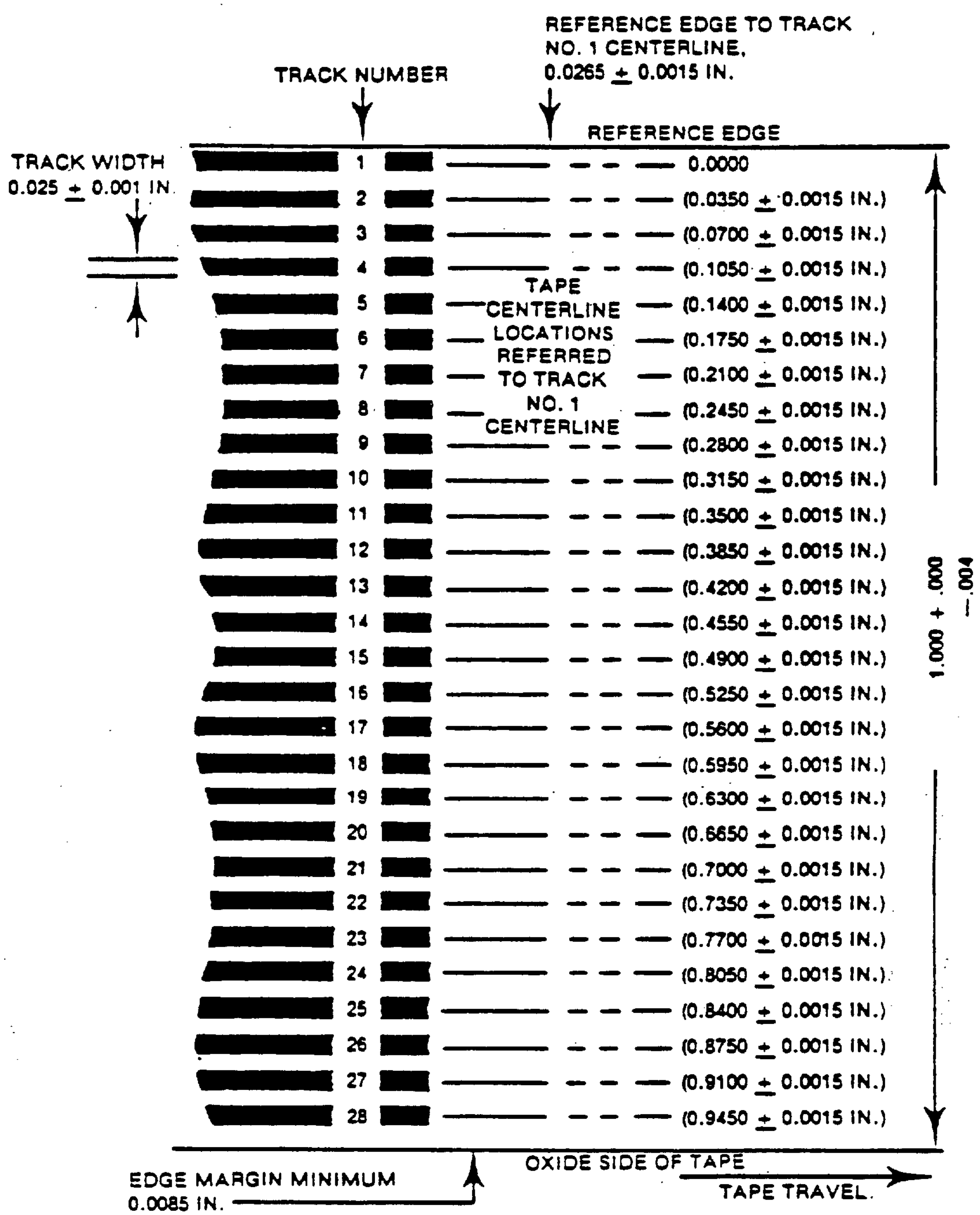
Record word	Data field bit numbers	Explanation	Function code
RF/track assignments	16-13	<u>Hydrophone depth*</u> Bit 16 Bit 13 0000 - No entry 0001 - Shallow 0010 - Medium 0011 - Deep *Actual value depends on buoy type	Bit no. 4 Bit no. 1
	12-5	<u>Sonobuoy RF channel</u> Bit 12 Bit 5 00000000 - No RF assigned 00000001 - RF channel 1 00000010 - RF channel 2 00000011 - RF channel 3 . . . 01100010 - RF channel 98 01100011 - RF channel 99	
Header	32-18	Spare	1001
	17-10	<u>Block size</u> Denotes number of words to follow (binary number) Bit 17 Bit 10 0000 0000 - Not used 0000 0001 - 1 word 0000 0010 - 2 words 0000 0011 - 3 words . . . 1001 0100 - 148 words 1001 0101 - 149 words 1001 0110 - Not used . . .	
	9-5	Spare	

TABLE VII. Annotation data format. - Continued

Record word	Data field bit numbers	Explanation	Function code
			Bit no. 4 Bit no. 1
TBD	----	----	1010
TBD	----	----	1011
Platform unique	32-5	Unique data Bits 32-5 may be used in any manner desired by the individual user.	1100
Sonobuoy longitude	32	Direction Denotes N/S latitude 0 = North 1 = South	1101
	31-6	Latitude Denotes latitude expressed in BAMS with a precision of 5.3644×10^{6}°. Although latitude does not exceed 90 degrees, the most significant bit (bit 31) has the same weight as bit 31 in the longitude word (180 degrees). South latitude (negative numbers) is expressed in two's complement notation.	
	5	Status* Denotes buoy deployment status 0 = Redundant position 1 = Initial deployment/new position *Status bit is set when the buoy is deployed/inserted or when the position is corrected. The bit is zero at all other times.	
Sonobuoy longitude	32	Direction Designates E/W longitude 0 = East 1 = West	1110

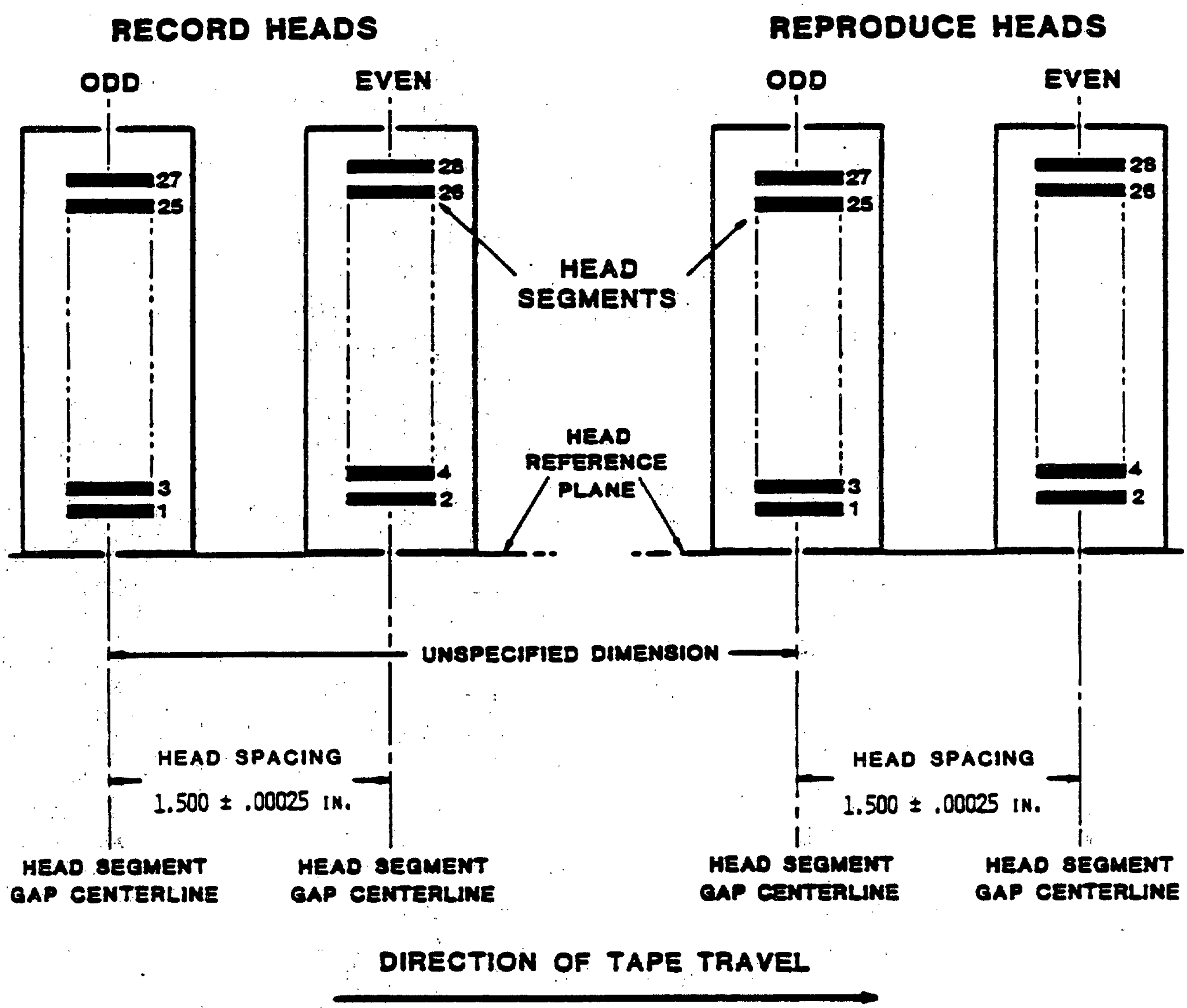
TABLE VII. Annotation data format. - Continued

Record word	Data field bit numbers	Explanation	Function code
			Bit no. 4 Bit no. 1
Sonobuoy longitude	31-6	Longitude Denote longitude expressed in BAMS with a precision of $5.3644 \times 10^{6\circ}$. West longitude (negative values) is expressed in two's complement notation.	
	5	Status* Denotes buoy deployment status 0 = Reducdant position 1 = Initial deployment/new position *Status bit is set when the buoy is deployed/inserted or when the position is corrected. The bit is zero at all other times.	
Platform unique	32-5	Unique data Bits 32-5 may be used in any manner desired by the individual user.	1111



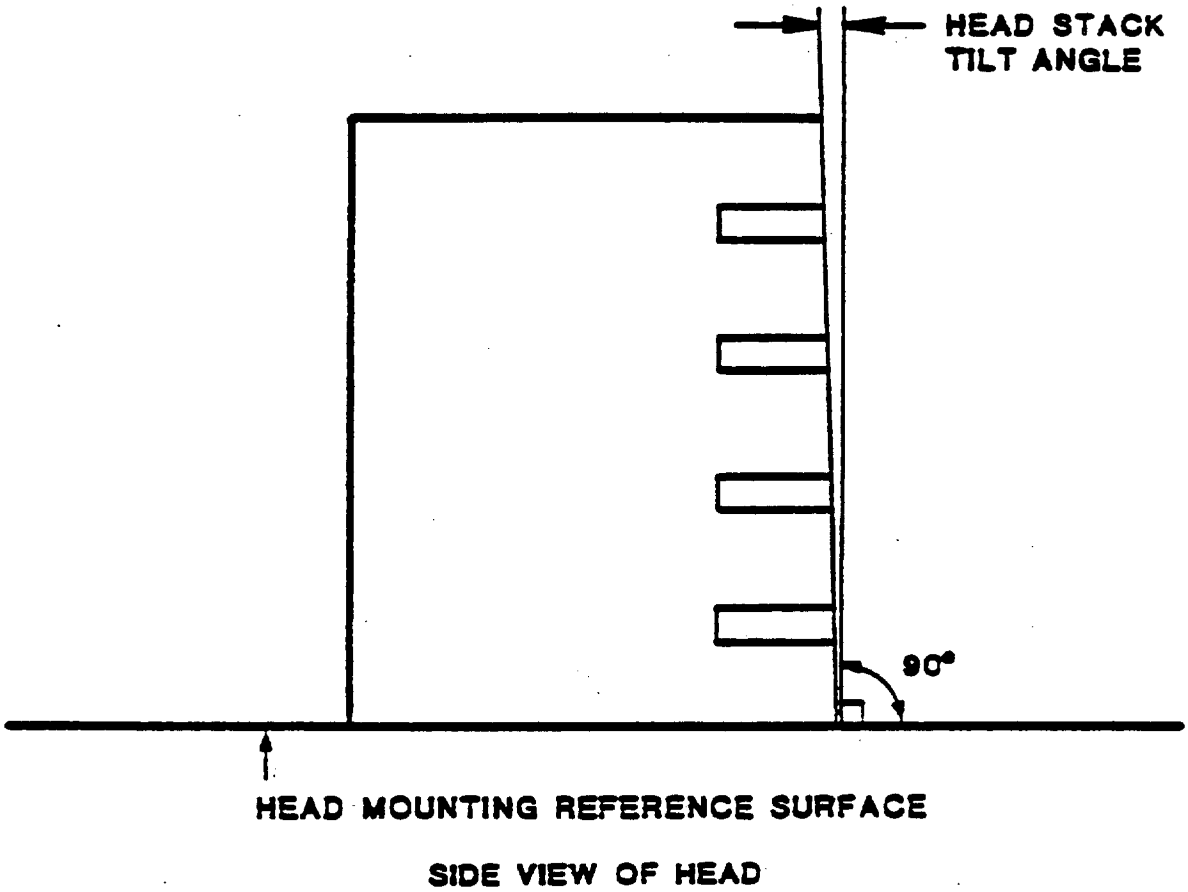
SH 13202734

FIGURE 1. 28-track recorded tape format.



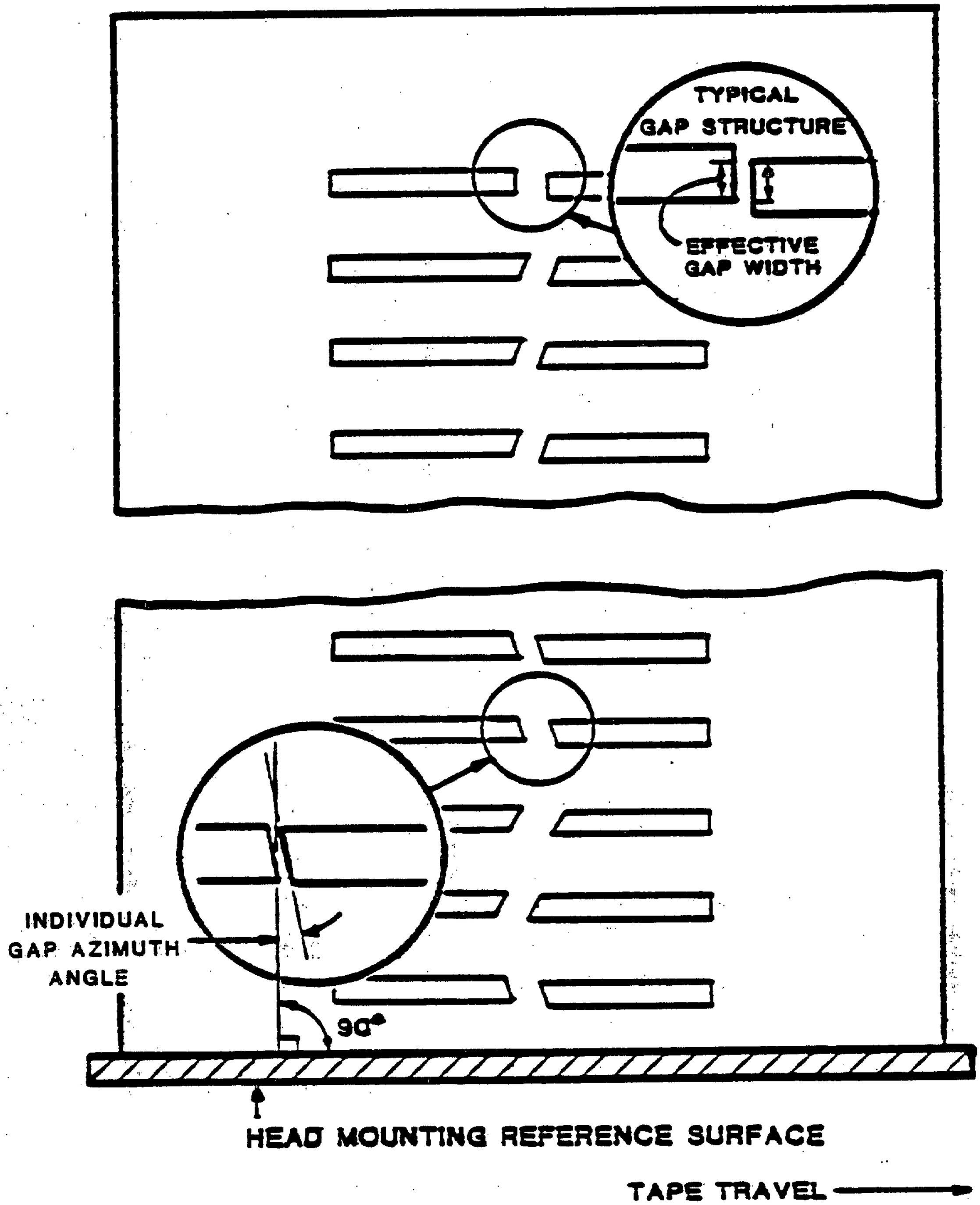
SH 13202735

FIGURE 2. 28-track head and stack configuration.



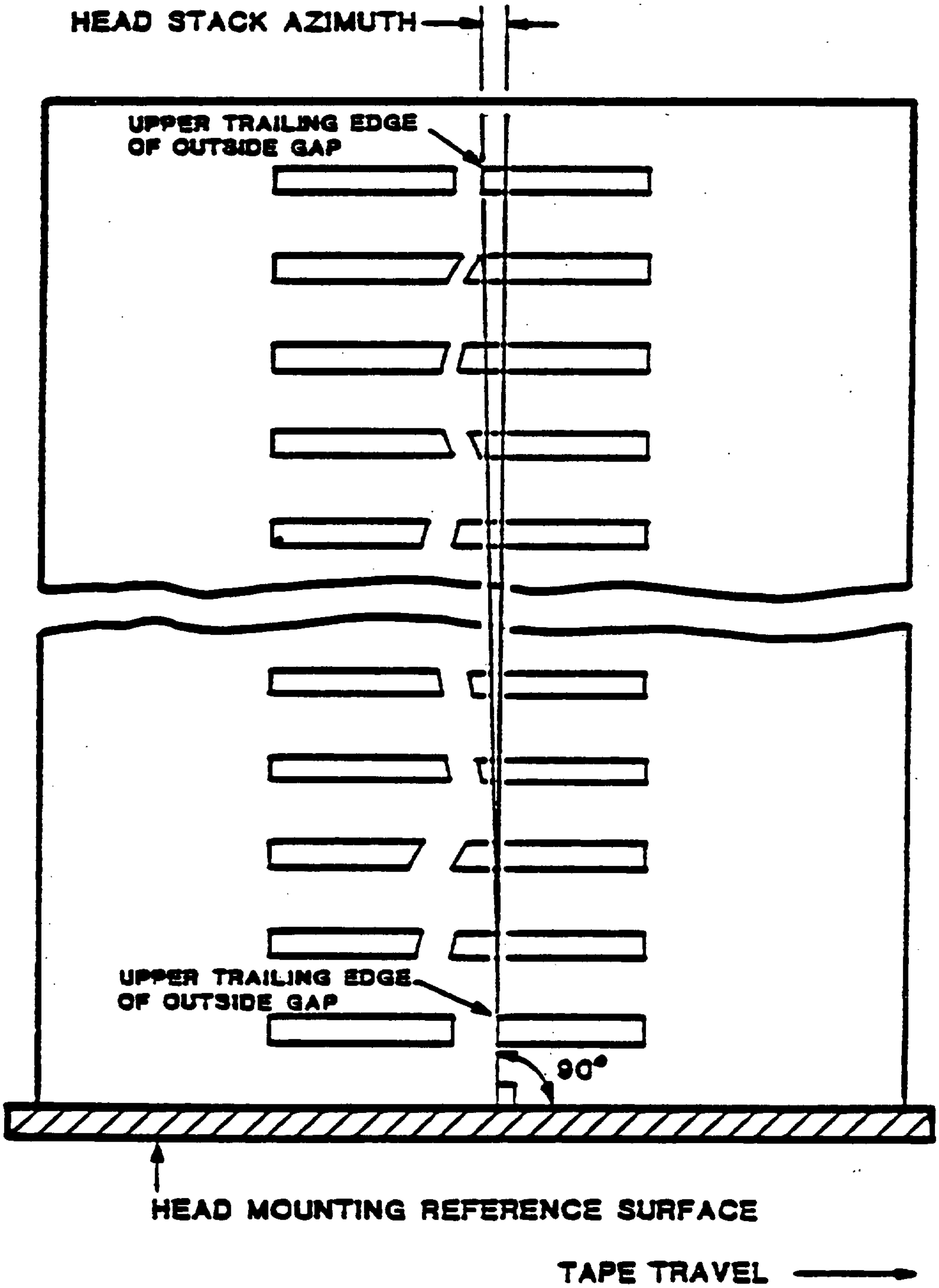
SH 13202736

FIGURE 3. Head stack tilt angle.



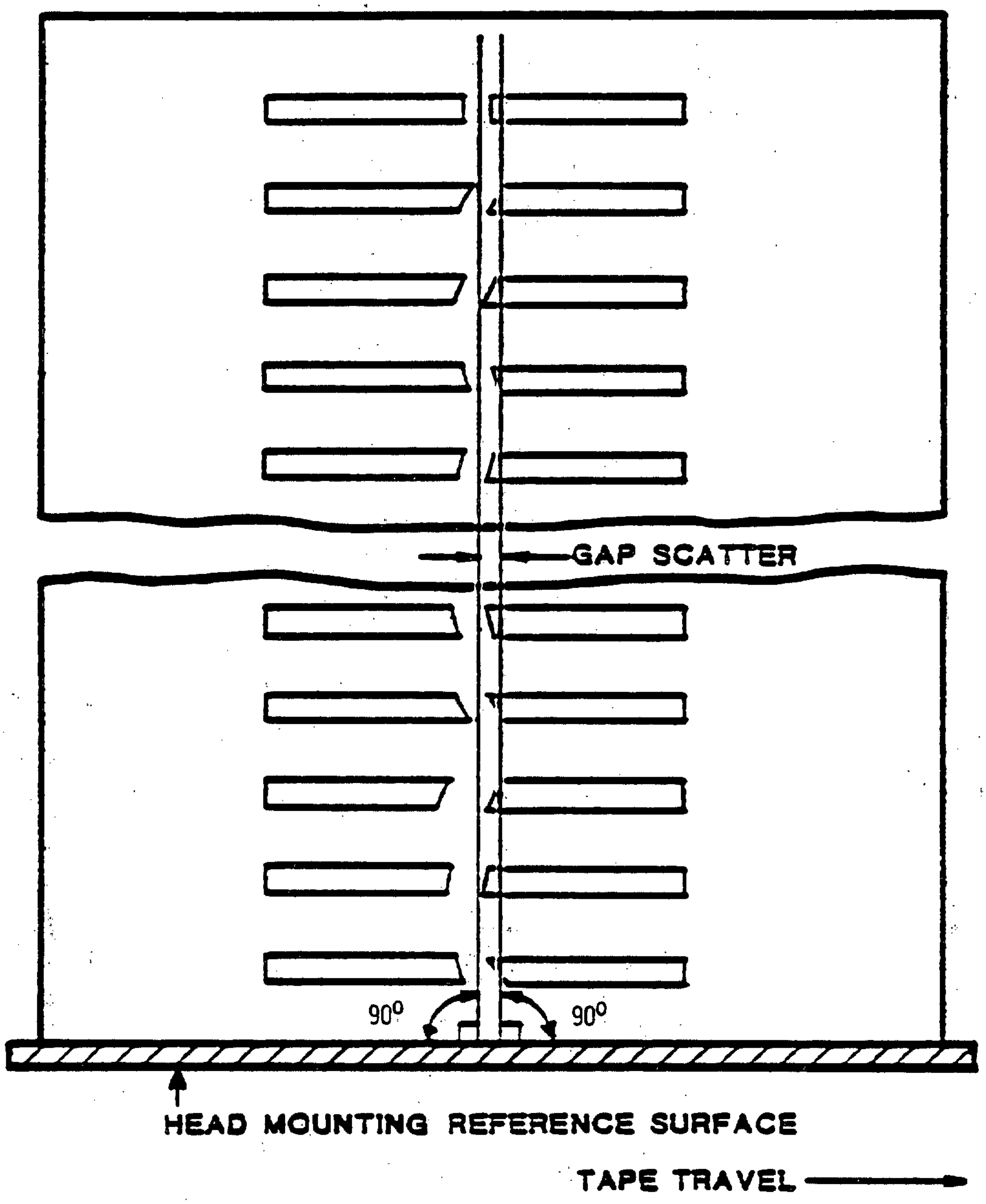
SH 13202737

FIGURE 4. Head stack gap azimuth, effective gap width.



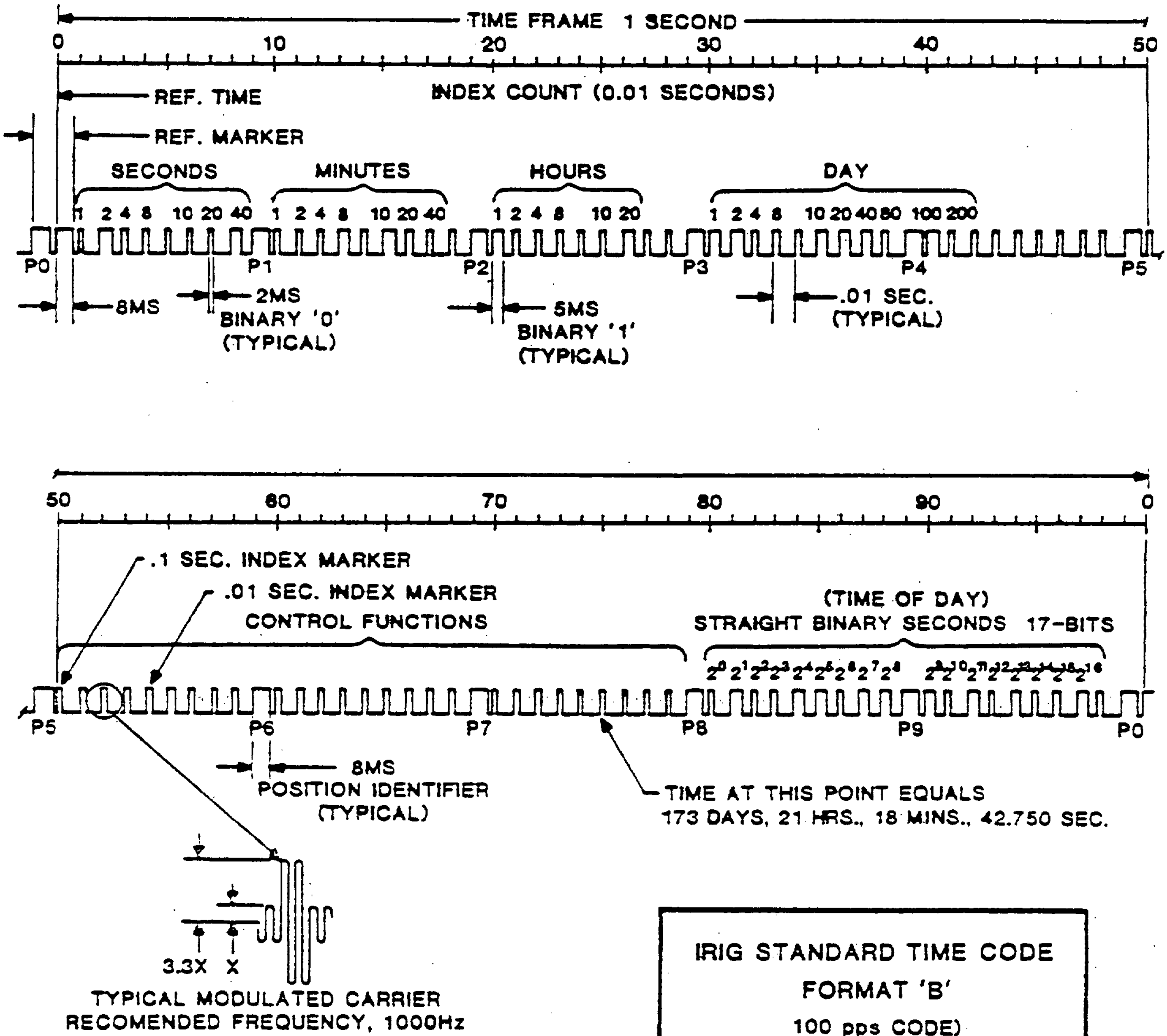
SH 13202738

FIGURE 5. Head stack azimuth.



SH 13202739

FIGURE 6. Gap scatter.



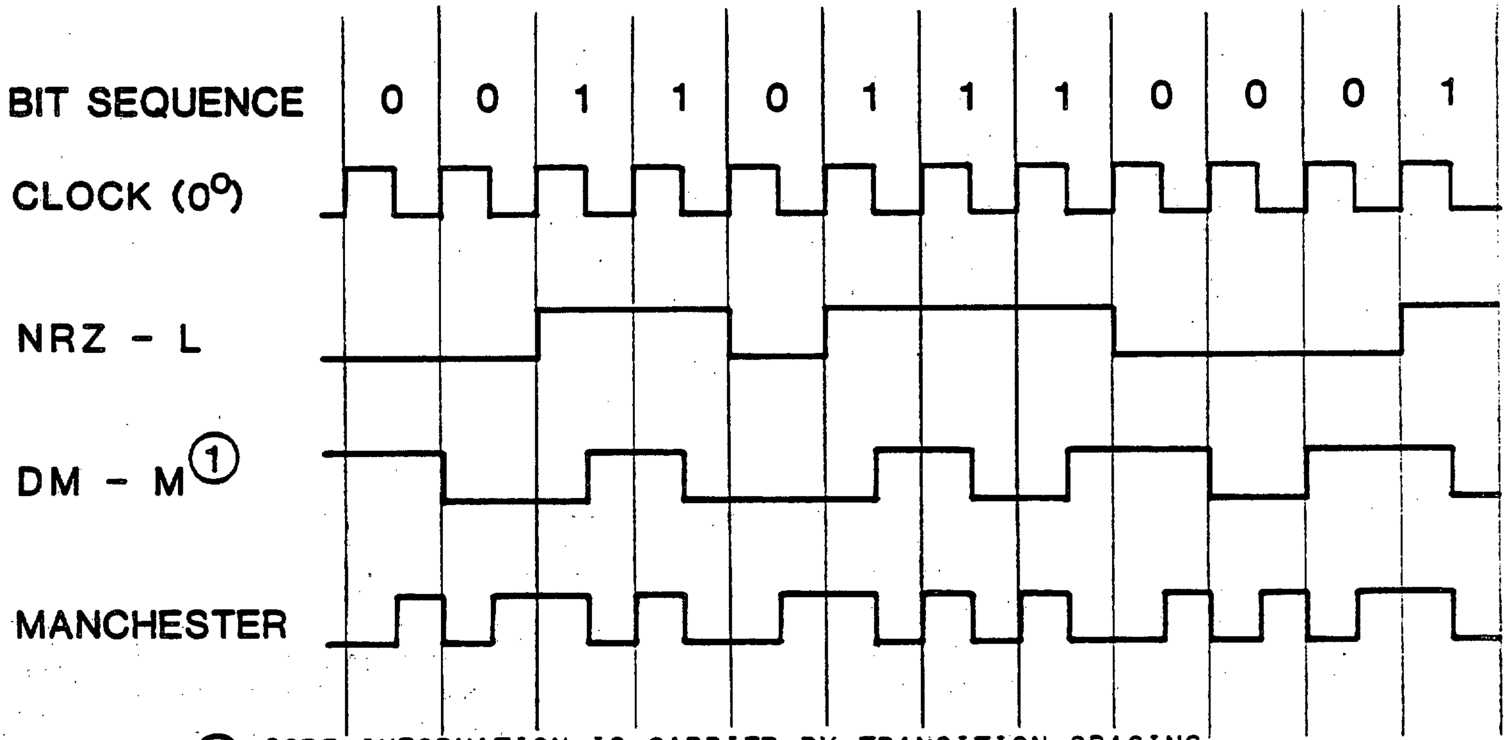
IRIG STANDARD TIME CODE
FORMAT 'B'
100 pps CODE)
Reference IRIG Document 104-70

NOTE:

1. The use of the 17-bit segment representing time of day in binary seconds is optional.

SH 13202740

FIGURE 7. Standard time code, format B.



① CODE INFORMATION IS CARRIED BY TRANSITION SPACING, EXACT VOLTAGE LEVEL IS NOT SIGNIFICANT.

CODE DEFINITIONS:

NRZ - L

A "one" is represented by the "1" level.
A "zero" is represented by the "0" level.

DM - M

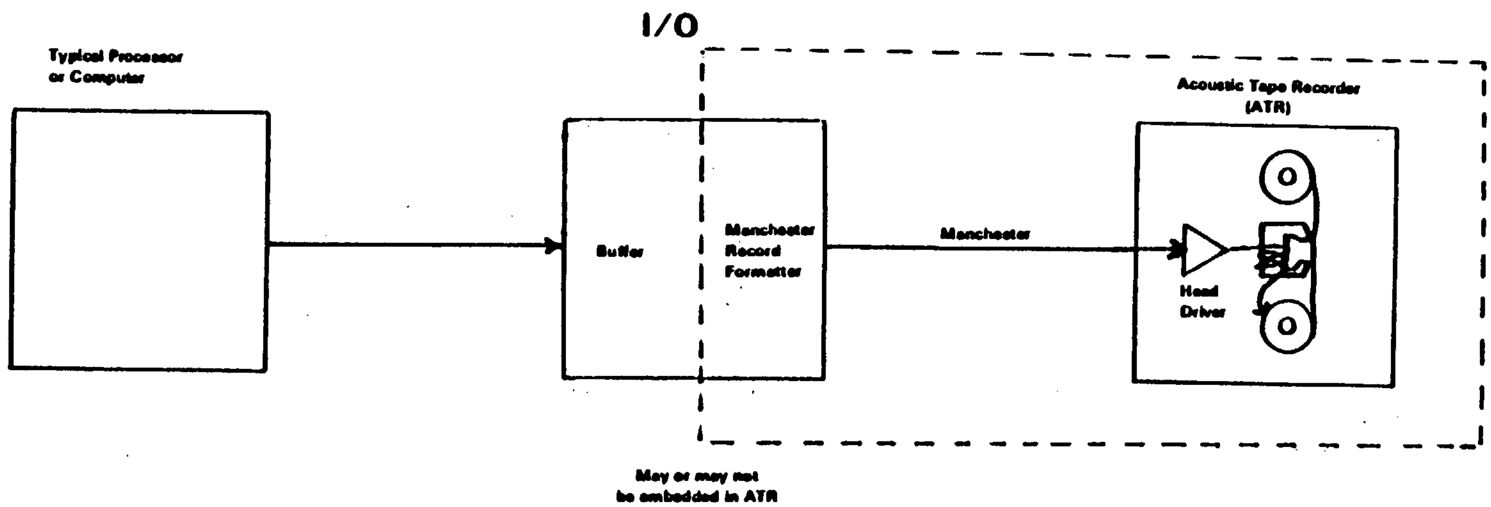
A "one" is represented by a level change at the mid-bit time.
A "zero" is represented by no transition at mid-bit time. A transition occurs at the start of the bit period between pairs of adjacent "zeros".

MANCHESTER

A "one" is represnted by a transition from the "one" level to the "zero" level.
A "zero" is represented by a transition from the "zero" level to the "one" level.

SH 13202741

FIGURE 8. Single track code waveforms and definitions.



Areas surrouned by the dotted line are covered by this standard. This standard covers the format of data *recorded on tape only*, not the specific I/O interface.

SH 13202744

FIGURE 9. Scope of MIL-STD-1610A digital annotation.

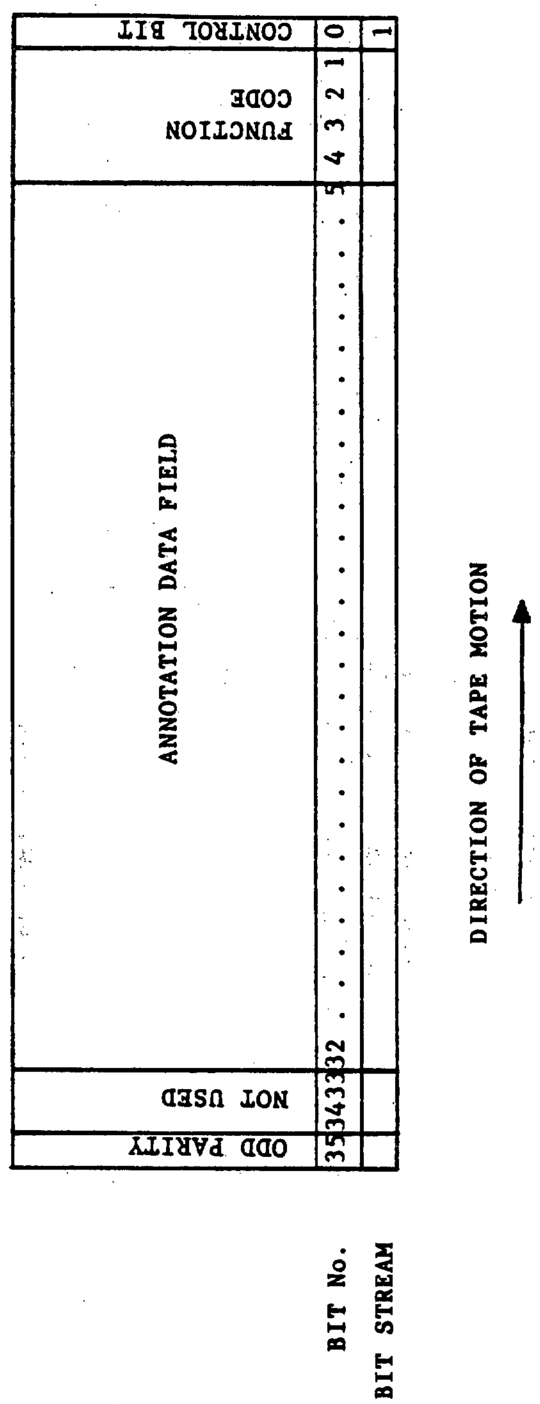


FIGURE 10. Typical data word format.

SH 13202745

	ODD PARITY	NOT USED	SPARE	HEADER FIELD: BLOCK SIZE	SPARE	FUNCTION CODE	CONTROL BIT
BIT No.	35	34 33	32 18	17 10	9 . . . 5	4 3 2 1	0
BIT STREAM		0 0				1 0 0 1	1

DIRECTION OF TAPE MOTION →

SH 13202746

FIGURE 11. Header word format.

Field	Column	BIT No.	BIT STREAM
ODD PARITY		35	1
NOT USED		34	0
NOT USED		33	0
ZULU TIME DATA FIELD	2097152 Seconds	32	0
ZULU TIME DATA FIELD	1048576 Seconds	31	0
ZULU TIME DATA FIELD	524288 Seconds	30	0
ZULU TIME DATA FIELD	262144 Seconds	29	0
ZULU TIME DATA FIELD	131072 Seconds	28	0
ZULU TIME DATA FIELD	65536 Seconds	27	0
ZULU TIME DATA FIELD	32768 Seconds	26	0
ZULU TIME DATA FIELD	16384 Seconds	25	0
ZULU TIME DATA FIELD	8192 Seconds	24	1
ZULU TIME DATA FIELD	4096 Seconds	23	0
ZULU TIME DATA FIELD	2048 Seconds	22	1
ZULU TIME DATA FIELD	1024 Seconds	21	1
ZULU TIME DATA FIELD	512 Seconds	20	0
ZULU TIME DATA FIELD	256 Seconds	19	0
ZULU TIME DATA FIELD	128 Seconds	18	1
ZULU TIME DATA FIELD	64 Seconds	17	1
ZULU TIME DATA FIELD	32 Seconds	16	0
ZULU TIME DATA FIELD	16 Seconds	15	0
ZULU TIME DATA FIELD	8 Seconds	14	0
ZULU TIME DATA FIELD	4 Seconds	13	0
ZULU TIME DATA FIELD	2 Seconds	12	0
ZULU TIME DATA FIELD	1 Second	11	1
ZULU TIME DATA FIELD	1/2 Second	10	0
ZULU TIME DATA FIELD	1/4 Second	9	0
ZULU TIME DATA FIELD	1/8 Second	8	0
ZULU TIME DATA FIELD	1/16 Second	7	0
ZULU TIME DATA FIELD	1/32 Second	6	0
ZULU TIME DATA FIELD	1/64 Second	5	0
FUNCTION CODE		4	0
FUNCTION CODE		3	1
FUNCTION CODE		2	0
FUNCTION CODE		1	0
CONTROL BIT		0	1

DIRECTION OF TAPE MOTION →

TIME DEPICTED IS 11,457 SECONDS
(3 hours, 10 minutes, 57 seconds)

SH 13202747

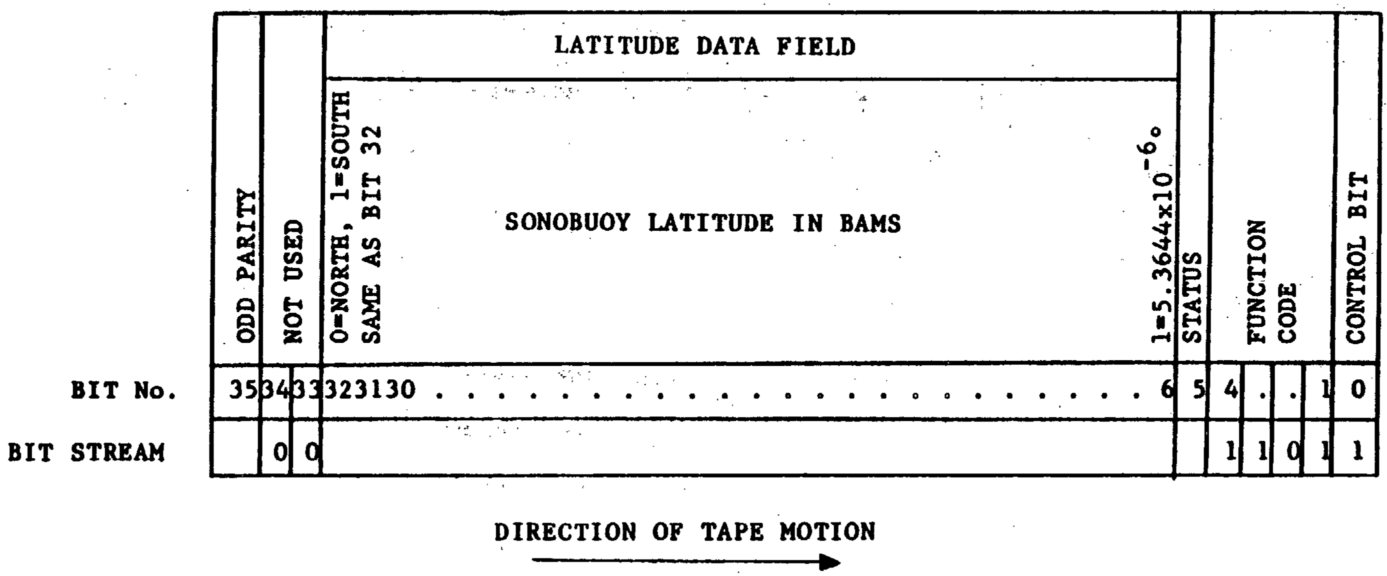
FIGURE 12. Zulu time word format.

	ODD PARITY	NOT USED	ANNOTATION DATA FIELD: RECORDER NUMBER	ANNOTATION DATA FIELD: BUOY TYPE	ANNOTATION DATA FIELD: TAPE TRACK NUMBER	ANNOTATION DATA FIELD: HYDROPHONE DEPTH	ANNOTATION DATA FIELD: RF CHANNEL NUMBER	FUNCTION CODE	CONTROL BIT
BIT No.	35	34 33	32 31	30 25	24 17	16 . . 13	12 5	4 . . 1	0
BIT STREAM	1	0 0	0 0	0 0 0 1 0 0	0 0 0 1 0 1 1 0	0 0 1 1	0 1 0 1 1 0 1 0	1 0 0 0	1

DIRECTION OF TAPE MOTION →

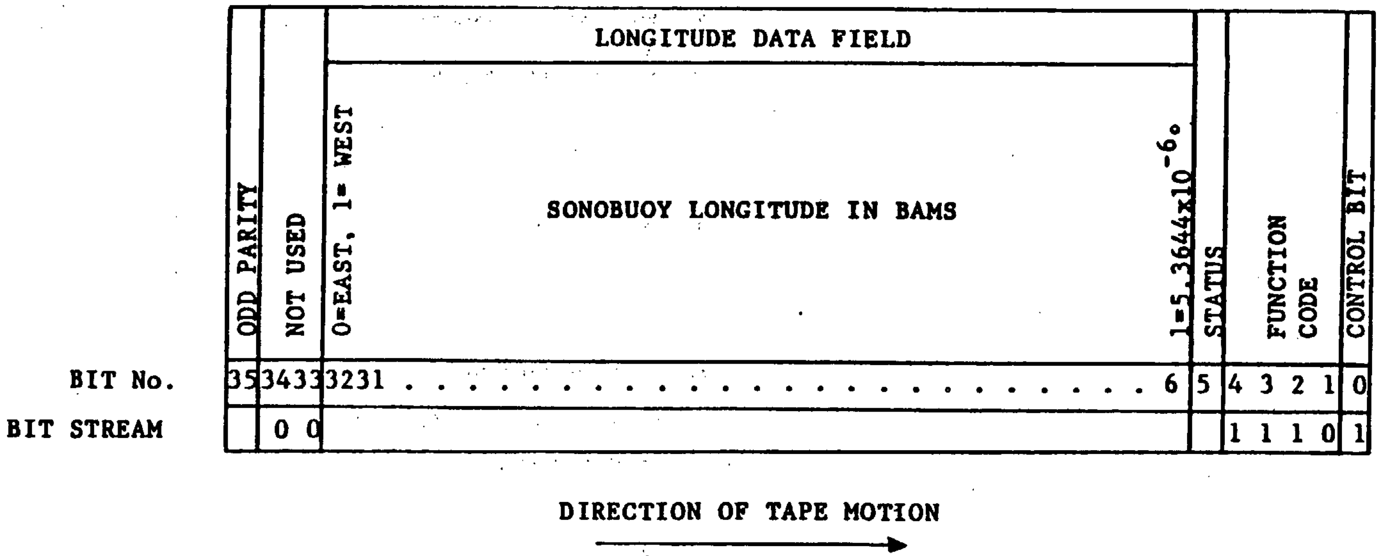
SH 13202748

FIGURE 13. RF/track assignment word format.



SH 13202749

FIGURE 14. Sonobuoy latitude word format.



SH 13202750

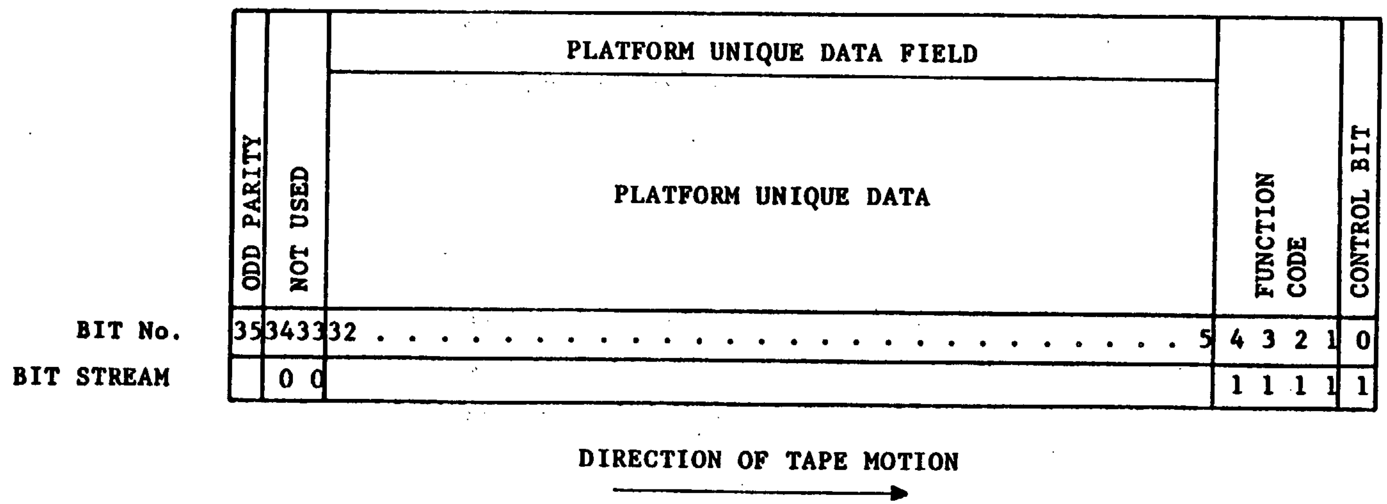
FIGURE 15. Sonobuoy longitude word format.

	ODD PARITY	NOT USED		PLATFORM UNIQUE DATA FIELD: PLATFORM UNIQUE DATA		FUNCTION CODE				CONTROL BIT
BIT No.	35	34	33	32	5	4	3	2	1	0
BIT STREAM		0	0			1	1	0	0	1

DIRECTION OF TAPE MOTION →

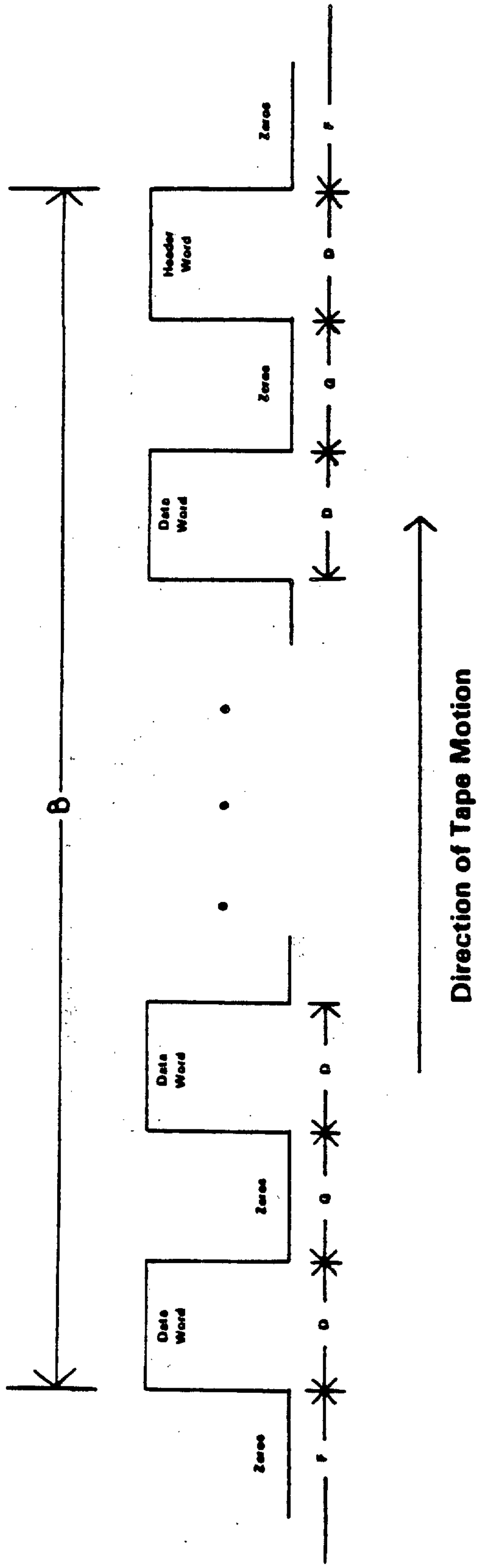
SH 13202751

FIGURE 16. Platform unique data word format.



SH 13202752

FIGURE 17. Platform unique data word format.

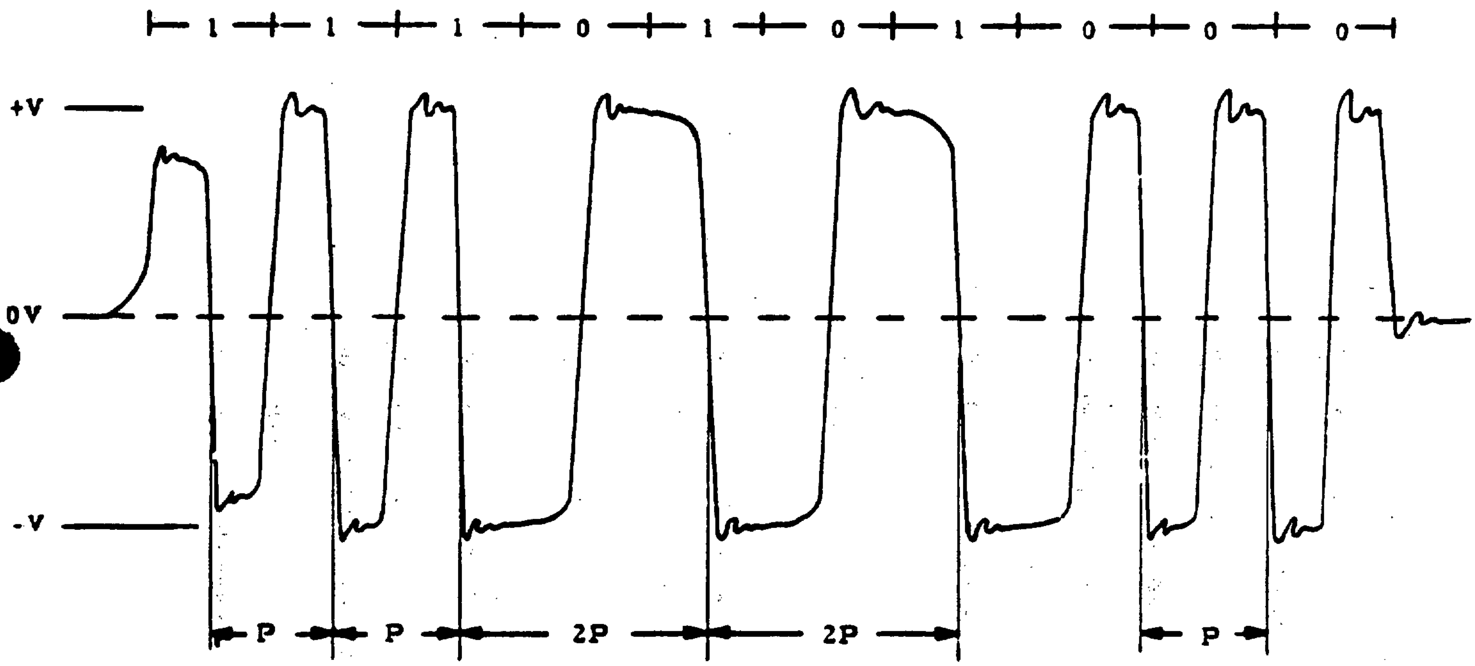


B = Block length ≤ 150 data words
D = 36-bit data word
G = Interword gap between data words. Manchester encoded zeros ≥ 36 bits (zeros)

F = Interrecord gap between data blocks. Manchester encoded zeros ≥ 36 bits (zeros)

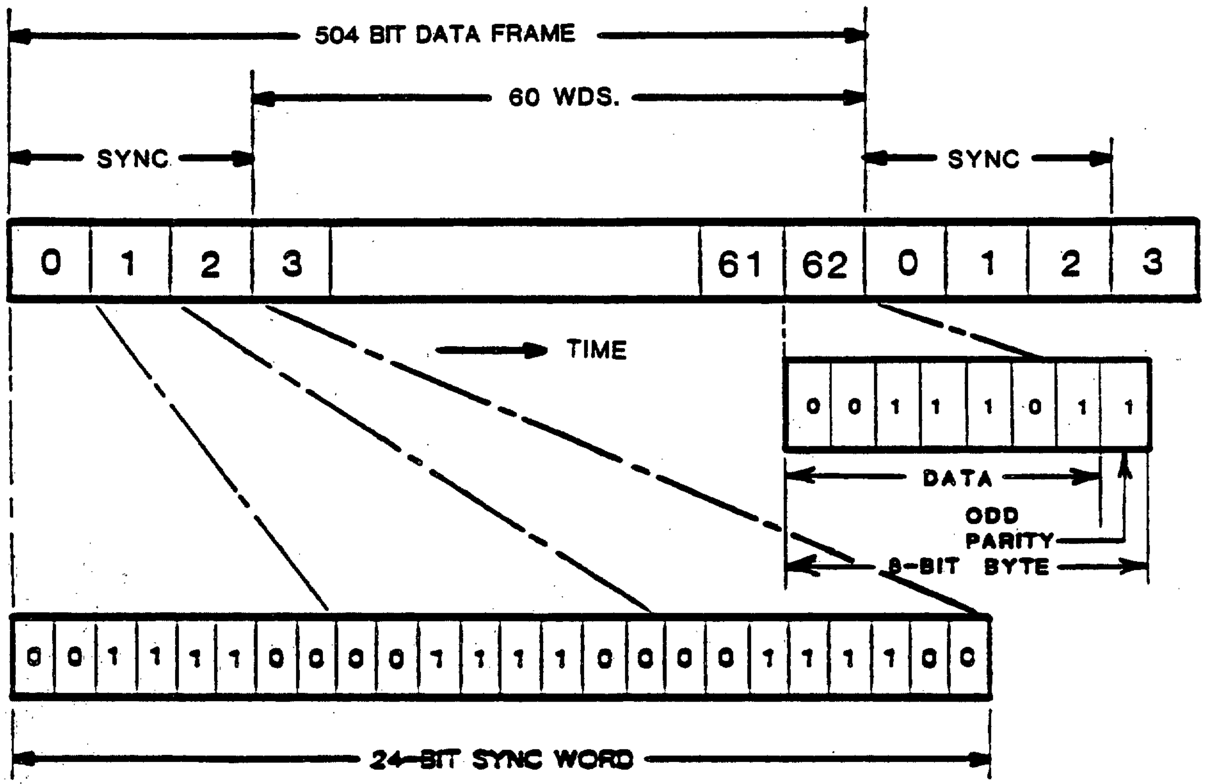
FIGURE 18. Typical data block format.

SH 13202753



SH 13202743

FIGURE 19. Annotation record waveform.



20% OVERHEAD

$$\frac{\text{504 BITS / FRAME}}{\text{420 DATA BITS / FRAME}} = 1.2$$

NRZ - L DEFINITION:

A '1' IS REPRESENTED BY A POSITIVE DIRECTION LEVEL
A '0' IS REPRESENTED BY A NEGATIVE DIRECTION LEVEL

SH 13202742

FIGURE 20. PROP code frame set.