Range Commanders Council

IRIG STANDARD 106-93

TELEMETRY GROUP

TELEMETRY STANDARDS

WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ELECTRONIC PROVING GROUND
COMBAT SYSTEMS TEST ACTIVITY

ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION NEWPORT

30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR FORCE DEVELOPMENT TEST CENTER
AIR FORCE WEAPONS AND TACTICS CENTER
SPACE AND MISSILE SYSTEMS CENTER,
SPACE TEST AND EXPERIMENTATION PROGRAM OFFICE

IRIG STANDARD 106-93

TELEMETRY STANDARDS

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ACRONYMS AND INITIALISMS

ADARIO	Analog/Digital/Adaptable/Recorder Input/Output
AFC	automatic frequency control
AGC	automatic gain control
ALC	automatic level control
AM	amplitude modulation
APC	automatic phase control
BCD	binary coded decimal
BEP	bit error probability
BER	bit error rate
BiØ-L	bi-phase level
BM	block marker
BMD	block marker division
BW	bandwidth
CHP	channel parameter
CR	carriage return
CSR	clock slip rate
CW	continuous wave
dBm	decibels referenced to 1 milliwatt
DSB	double sideband
ENR	excess noise ratio
EOF	end of file
EIRP	effective isotropic radiated power
FDM	frequency division multiplex
FET	field effect transistor
FFI	frame format identification
FM	frequency modulation
G/T	gain/temperature
HDD	high density digital
HDDR	high density digital recording
HE	high energy
HR	high resolution
IF	intermediate frequency
IM	intermodulation
IMD	intermodulation distortion
IP	intercept point
ips	inches per second
ITDE	interchannel time displacement error

ACRONYMS AND INITIALISMS

kHz	kilohertz
ks	kiloseconds
LF	line feed
LIFO	last in first out
LO	local oscillator
log	logarithm
LSB	least significant bit
Mbps	megabits per second
MC	master clock
MCS	master clock source
MCT	manufacturer's centerline tape
MGC	manual gain control
MHz	megahertz
MSB	most significant bit
MSCT	manufacturer's secondary centerline tape
N	newton
NNT	notch noise test
NPR	noise power ratio
NPRF	noise power ratio floor
NRZ-L	non return to zero-level
OQPSK	offset quadrature phase shift keying
p-p	peak-to-peak
PAM	pulse-amplitude modulation
PCM	pulse-code modulation
PLL	phase-lock loop
PM	phase modulation
PRN	pseudo random noise
PSK	phase shift keying
PW	partial word
PWS	partial word status
QPSK	quadrature phase shift keying
RF	radio frequency
RH	relative humidity
rms	root mean square
RNRZ-L	randomized non return to zero-level
SNR	signal-to-noise ratio
SSB	single sideband
SST	session start time
ST	subterminal
STA	subterminal address
SWR	standing wave ratio

ACRONYMS AND INITIALISMS

TBE	time base error
TC	tachometer constant
TD	time delay
TMATS	Telemetry Attributes Transfer Standard
TTL	transistor-transistor logic
UBE	upper band edge
VCO	voltage controlled oscillator
WC	word count

CHAPTER 1

INTRODUCTION

1.1 General

The Telemetry Group (TG) of the Range Commanders Council (RCC) has prepared this document to foster the compatibility of telemetry transmitting, receiving, and signal processing equipment at the member ranges under the cognizance of the RCC. The range commanders highly recommend that telemetry equipment operated by the ranges and telemetry equipment used in programs that require test range support, conform to these standards.

1.2 Scope

These standards do not necessarily define the existing capability of any test range, but constitute a guide for the orderly implementation and application of telemetry systems for both the ranges and range users. The scope of capabilities attainable with the utilization of these standards requires a careful consideration of tradeoffs. Guidance concerning these tradeoffs is provided in the text.

1.3 Purpose

These standards provide the necessary criteria on which to base equipment design and modification. The ultimate purpose is to ensure efficient spectrum utilization, interference-free operation, interoperability between ranges, and compatibility of range user equipment with the ranges.

1.3.1 A companion series, RCC document 118-XX, *Test Methods for Telemetry Systems and Subsystems*, and RCC document 119-88, *Telemetry Applications Handbook*, have been published in conjunction with this standard.

1.3.2 The policy of the Telemetry Group is to update the telemetry standards and test methods as required to be consistent with advances in the state of the art. To determine the current revision status, contact the RCC Secretariat at the White Sands Missile Range, New Mexico.

1.4 Reference Documents

Reference documents are identified at the point of reference.

1.5 Definitions

Commonly used terms are defined in standard reference glossaries and dictionaries. Definitions of terms with special applications are included when the term first appears. Radio frequency terms are defined in the *Manual of Regulations and Procedures for Federal Radio Frequency Management*. Copies of this manual may be obtained from the following address:

Executive Secretary, IRAC
U.S. Department of Commerce, NTIA
Room 1605, HCHB Building
14th & Constitution Ave., N.W.
Washington, D.C. 20230

1.6 General Statements and Requirements

General statements and requirements are contained in each chapter of this document and the appendixes.

CHAPTER 2

TRANSMITTER AND RECEIVER SYSTEMS

2.1 Radio Frequency Standards for Telemetry

These standards provide the criteria to determine equipment and frequency use requirements and are intended to ensure efficient use of equipment and interchange of operations and data between test ranges. Systems not conforming to these standards require justification upon application for frequency allocation, and the use of such systems or frequencies is highly discouraged.

2.2 VHF Band

The frequency band from 225 to 260 Mhz is allocated to government fixed and mobile communications service. Telemetry operations on this band were not allocated after 1969 in favor of the UHF bands described in paragraph 2.3. Allocations for operation in the VHF band are granted only upon a showing that the UHF frequencies intended for that purpose are unacceptable. As such, allocations are granted on a secondary, nonprotected basis only. Standards pertaining to VHF telemetry operation have been deleted from this edition.

2.3 UHF Bands

The bands used for telemetry are described unofficially as the L-Band from 1435 to 1535 MHz, the S-Band from 2200 to 2300 MHz, and the Upper S-Band from 2310 to 2390 MHz. While these band designations are common in telemetry parlance, they may have no specific meaning to anyone else. Telemetry assignments are made for testing[1] of manned and unmanned aircraft, missiles, space vehicles, rocket sleds and systems carried on such sleds for testing, or their major components. See appendix A for channel assignments for specific bandwidths.

2.3.1 Allocation of the L-Band (1435 to 1535 MHz). This band is allocated in the U.S. and its possessions for government and nongovernment aeronautical telemetry use on a shared basis.

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[1]A telemetry system as defined here is not critical to the operational (tactical) function of the system.

2.3.1.1 1435 to 1535 MHz Channels. The frequencies in this range will be assigned for aeronautical telemetry and associated remote-control operations[2] for testing of manned or unmanned aircraft, missiles, rocket sleds, and other vehicles or their major components. Permissible usage includes telemetry associated with launching and reentry into the Earth's atmosphere as well as any incidental orbiting prior to reentry of manned or unmanned vehicles undergoing flight tests. The following frequencies are shared with flight telemetering mobile stations: 1444.5, 1453.5, 1501.5, 1515.5, 1524.5, and 1525.5 MHz.[3]

2.3.1.2 1530 to 1535 MHz Channels. In the frequency range from 1530 to 1535 MHz, the Maritime Mobile-Satellite Service is the only primary service after 1 January 1990 with telemetry as a secondary user.

2.3.2 Allocation of the S-Band (2200 to 2300 MHz). Frequencies in this range are for telemetering other than manned vehicles.

2.3.2.1 2200 to 2290 MHz Channels. These channels are shared equally with the government's fixed, mobile, and space research services. These frequencies include telemetry associated with launch vehicles, missiles, upper atmosphere research rockets, and space vehicles regardless of their trajectories.

2.3.2.2 2290 to 2300 MHz Channels. Allocations in this range are for deep-space research telemetry on a shared basis with fixed and mobile service. Telemetry for other than deep-space uses may not be assigned on these frequencies.

2.3.3 Allocation of the Upper S-Band (2310 to 2390 MHz). This band is allocated in the U.S. for government and nongovernment telemetry use on a co-equal shared basis with radio-location service in a manner similar to that of the L-Band. Telemetry assignments are made for flight testing of manned or unmanned aircraft, missiles, space vehicles, or their major components.

2.4 UHF Telemetry Transmitter Systems

Air- and space-ground telemetry is accommodated in the appropriate allocated UHF bands 1435 to 1535, 2200 to 2300, and 2310 to 2390 MHz as described in paragraph 2.3.

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[2]The word used for remote control operations in this band is *telecommand*.

[3]Frequency management terminology for weather balloons.

2.4.1 Center Frequency Tolerance. Unless otherwise specified for a particular usage, frequency tolerance for a telemetry transmitter shall be ±5 percent of the authorized bandwidth to a maximum of ±200 kHz. For standard bandwidth channels (see appendix A for definitions), frequency tolerance is thus ±50 kHz or approximately ±0.003 percent for L-band systems and ±0.002 percent for S-band.

NOTE

Between 1 and 5 seconds after initial turn on, the unmodulated transmitter frequency shall remain within twice the specified limits for the assigned radio frequency. After 5 seconds, the standard frequency tolerance is applicable for any and all operations where the transmitter power output is -25 dBm or greater (or produces a field strength greater than 500 μV/M at a distance of 30 meters from the transmitting antenna in any direction.)

Between turn on and 1 second following turn on, the unmodulated transmitter output frequency shall be within the bandwidth assigned for the modulated signal at any time when the transmitter output power exceeds -25 dBm.

Specific uses may dictate tolerances more stringent than those stated.

2.4.2 Channel Spacing. Standard bandwidth channels are spaced at increments of 1 MHz, beginning 500 kHz above the lower edge of each band (1435.5, 1436.5...1529.5, 2200.5, 2201.5...). Wider bandwidths are permitted (see appendix A, subparagraph 4.3.3), centered on standard bandwidth channels which do not allow the resulting spectrum to fall outside the bands; narrow-bandwidth channels may be assigned between standard channels for multiple-carrier uses upon a showing with the application. Under no circumstances will such channels be separated in center frequency by less than 100 kHz. Narrow-bandwidth channels are spaced at integral tenths of MHz within the "split" channel used (2201.1, 2201.2, 2201.3...).[4]

[4]The use of narrow-band channels requires receiver capabilities that may not be available at all test ranges.

2.4.3 Output Power. The output power of a telemetry transmitter (and the effective isotropic radiated power [EIRP], if substantially different) shall be the minimum possible required for the specific application, and in no circumstances should radiated power exceed 25 watts EIRP in any direction.[5]

2.4.4 Modulation Polarity. An increasing voltage at the input of an FM transmitter shall cause an increase in output carrier frequency. An increase in voltage at the input of a PM transmitter shall cause an advancement in the phase of the output carrier. An increasing voltage shall cause an increase in the output power of an AM transmitter.

2.4.5 Spurious Emission and Interference Limits. Spurious emissions from the transmitter case, through input and power leads, and at the transmitter RF output and antenna-radiated spurious emissions are to be within required limits when measured by the methods and equipment shown in MIL-STD-461, *Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference* and MIL-STD-462, *Electromagnetic Interference Characteristics, Measurement,* or other applicable military standards and specifications.

2.4.5.1 Transmitter-Antenna System Emissions. Emissions from the antenna are of primary importance. A tuned antenna may or may not attenuate spurious frequency products produced by the transmitter, and an antenna or multitransmitter system may generate spurious outputs[6] when a pure signal is fed to its input. The transmitting pattern of such spurious frequencies is generally different from the pattern at the desired frequency. Spurious and harmonic outputs in the transmitter output line shall be limited to -25 dBm. Antenna-radiated spurious and harmonic outputs shall be no greater than 320 μV/meter at 30 meters in any direction.

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[5]An exemption from this power limit will be considered on application.

[6]For purposes of this standard, a signal or emission is spurious (that is, unwanted or unnecessary) whether it is caused by harmonics or not related to the transmitter frequency.

NOTE

Radiated tests will be made in lieu of transmitter output tests only when the transmitter is inaccessible. Radiated tests may still be required if the antenna is intended to be part of the filtering of spurious products from the transmitter or is suspected of generating spurious products by itself or in interaction with the transmitter and feedlines. The tests should be made with normal modulation with FM, PM, SSB or DSB systems.

2.4.5.2 Conducted and Radiated Interference. Interference (and the RF output itself) radiated from the transmitter or fed back into the transmitter power, signal, or control leads may interfere with the normal operation of the transmitter or the antenna system to which the transmitter is connected. All signals conducted by the transmitter's leads (other than the RF output cable) in the range of 150 kHz to 25 MHz, and all radiated fields in the range of 150 kHz to 10 GHz (or other greater frequency ranges as specified) must be within the limits of the applicable military standards or specifications.

2.4.6 Operational Flexibility. Each transmitter shall be capable of operating at all frequencies within its allocated band without design modification.

2.4.7 Modulated Transmitter Bandwidth. Refer to appendix A for standards for emission outside authorized bandwidths.

2.5 UHF Telemetry Receiver System

As a minimum, UHF receiver systems shall have the following characteristics.

2.5.1 Spurious Emissions. The RF energy, radiated from the receiver itself or fed back into power, RF input, output, and control leads in the range from 150 kHz to 10 GHz shall be within the limits specified in MIL-STD 461 and tested in accordance with MIL-STD 462 or RCC document 118-XX, volume II, ***Test Methods for Telemetry RF Subsystems***.

2.5.2 Frequency Tolerance. The accuracy of all local oscillators within the receiver shall be such that a conversion accuracy at each stage and overall is within ±0.001 percent of the indicated tuned frequency under all operating conditions for which the receiver is specified.

2.5.3 Spurious Responses. Reception of any frequency other than the one to which the receiver is tuned shall be a minimum of 60 dB below the desired signal over the range 150 kHz to 10 GHz.

2.5.4 Operational Flexibility. All ground-based receivers shall be capable of operating over the entire band for which they are constructed. External downconverters may be either intended for the entire band or a small portion thereof but capable of retuning anywhere in the band without modification.

2.5.5 Intermediate Frequency Bandwidths. The standard receiver IF bandwidths are shown in table 2-1. These bandwidths are separate from, and should not be confused with, post-detection low-pass filtering that receivers provide, although the two interact.[7]

TABLE 2-1. STANDARD RECEIVER IF BANDWIDTHS

12.5 kHz†	300 kHz‡	1.5 MHz★	6 MHz★
25.0 kHz†	500 kHz‡	2.4 MHz★	10 MHz★
50.0 kHz†	750 kHz‡	3.3 MHz★	15 MHz★
100.0 kHz†	1000 kHz	4.0 MHz★	20 MHz★

NOTE

The IF bandwidth for most purposes should be selected in such a way that 90 to 99 percent of the transmitted spectrum is received. In most cases, the bandwidth used for optimal reception will be narrower than the bandwidth measured by any method in accordance with appendix A.

[7]In most instances, the output low-pass filter should *not* be used to "clean up" the receiver output prior to use with demultiplexing equipment.

NOTES

1. Bandwidths are expressed at the points where response is 3 dB below the response at the design center frequency, assuming that passband ripple is minimal, which may not necessarily be the case. The 3 dB bandwidth is chosen because it matches closely the noise bandwidth of a "brick-wall" filter of the same bandwidth. Because the term "bandwidth" has several meanings, the bandwidth required for a specific purpose may be other than that stated here. Ideal IF filter response is symmetrical about its center frequency; in practice, this may not be the case.

2. Not all bandwidths must be available on all receivers or at all test ranges. In addition to the bandwidths listed, receivers may have other bandwidths available.

3. (†)Bandwidths are for use with narrow-band channels. Narrow-band channels require greater transmitter and receiver stability than those required in the standards to operate properly.

4. (‡)Bandwidths are for use with standard bandwidth channels.

5. (★)Bandwidths are for wide-band systems only. Bandwidths greater than about 5 MHz are not obtainable on receivers with 10 MHz IF center frequency.

CHAPTER 3

FREQUENCY DIVISION MULTIPLEXING TELEMETRY STANDARDS

3.1 General

In frequency division multiplexing, each data channel makes use of a separate subcarrier which occupies a defined position and bandwidth in the modulation baseband of the RF carrier. Two types of frequency modulation (FM) subcarrier formats may be used. The data bandwidth of one format type is proportional to the subcarrier center frequency, while the data bandwidth of the other type is constant, regardless of subcarrier frequency.

3.2 FM Subcarrier Characteristics

In these systems, one or more subcarrier signals, each at a different frequency, are employed to frequency modulate (FM) or phase modulate (PM) a transmitter in accordance with the RF conditions specified in chapter 2. The following subparagraphs set forth the standards for utilization of FM frequency division multiplexing.

3.2.1 Each of the subcarriers conveys measurement data in FM form. The number of data channels may be increased by modulating one or more of the subcarriers with a time-division multiplex format such as pulse-code modulation (PCM) or pulse-amplitude modulation (PAM).

3.2.2 The selecting and grouping of subcarrier channels depend upon the data bandwidth requirements of the application at hand and upon the necessity to ensure adequate guard bands between channels. Combinations of both proportional-bandwidth channels and constant-bandwidth channels may be used.

3.3 FM Subcarrier Channel Characteristics

The following subparagraphs describe the characteristics of proportional-bandwidth and constant-bandwidth FM subcarrier channels.

3.3.1 Proportional-Bandwidth FM Subcarrier Channel Characteristics. Table 3-1 lists the standard proportional-bandwidth FM subcarrier channels. The channels identified with letters permit ±15 or ±30 percent subcarrier deviation rather than ±7.5 percent deviation but use the same frequencies as the 12 highest numbered channels. The channels shall be used within the limits of maximum subcarrier deviation. See appendix B for expected performance tradeoffs at selected combinations of deviation and modulating frequency.

TABLE 3-1. PROPORTIONAL-BANDWIDTH FM SUBCARRIER CHANNELS

±7.5% CHANNELS

Channel	Center Frequencies (Hz)	Lower Deviation Limit (Hz)	Upper Deviation Limit (Hz)	Nominal Frequency Response (Hz)	Nominal Rise Time (ms)	Maximum Frequency Response (Hz)	Minimum Rise Time (ms)
1	400	370	430	6	58	30	11.7
2	560	518	602	8	44	42	8.33
3	730	675	785	11	32	55	6.40
4	960	888	1032	14	25	72	4.86
5	1300	1202	1398	20	18	98	3.60
6	1700	1572	1828	25	14	128	2.74
7	2300	2127	2473	35	10	173	2.03
8	3000	2775	3225	45	7.8	225	1.56
9	3900	3607	4193	59	6.0	293	1.20
10	5400	4995	5805	81	4.3	405	.864
11	7350	6799	7901	110	3.2	551	.635
12	10 500	9712	11 288	160	2.2	788	.444
13	14 500	13 412	15 588	220	1.6	1088	.322
14	22 000	20 350	23 650	330	1.1	1650	.212
15	30 000	27 750	32 250	450	.78	2250	.156
16	40 000	37 500	43 000	600	.58	3000	.117
17	52 500	48 562	56 438	788	.44	3938	.089
18	70 000	64 750	75 250	1050	.33	5250	.06
19	93 000	86 025	99 975	1395	.25	6975	.050
20	124 000	114 700	133 300	1860	.19	9300	.038
21	165 000	152 625	177 375	2475	.14	12 375	.029
22	225 000	208 125	241 875	3375	.10	16 875	.021
23	300 000	277 500	322 500	4500	.08	22 500	.016
24	400 000	370 000	430 000	6000	.06	30 000	.012
25	560 000	518 000	602 000	8400	.04	42 000	.008

See notes at end of table.

TABLE 3-1 (CONT'D). PROPORTIONAL-BANDWIDTH FM SUBCARRIER CHANNELS

±15% CHANNELS

Channel	Center Frequencies (Hz)	Lower Deviation Limit (Hz)	Upper Deviation Limit (Hz)	Nominal Frequency Response (Hz)	Nominal Rise Time (ms)	Maximum Frequency Response (Hz)	Minimum Rise Time (ms)
A	22 000	18 700	25 300	660	.53	3300	.106
B	30 000	25 500	34 500	900	.39	4500	.078
C	40 000	34 000	46 000	1200	.29	6000	.058
D	52 500	44 625	60 375	1575	.22	7875	.044
E	70 000	59 500	80 500	2100	.17	10 500	.033
F	93 000	79 500	106 950	2790	.13	13 950	.025
G	124 000	105 400	142 600	3720	.09	18 600	.018
H	165 000	140 240	189 750	4950	.07	24 750	.014
I	225 000	191 250	258 750	6750	.05	33 750	.010
J	300 000	255 500	345 000	9000	.04	45 000	.008
K	400 000	340 000	460 000	12 000	.03	60 000	.006
L	560 000	476 000	644 000	16 800	.02	84 000	.004

TABLE 3-1 (CONT'D). PROPORTIONAL-BANDWIDTH FM SUBCARRIER CHANNELS

±30% CHANNELS

Channel	Center Frequencies (Hz)	Lower Deviation Limit (Hz)	Upper Deviation Limit (Hz)	Nominal Frequency Response (Hz)	Nominal Rise Time (ms)	Maximum Frequency Response (Hz)	Minimum Rise Time (ms)
AA	22 000	15 400	28 600	1320	.265	6600	.053
BB	30 000	21 000	39 000	1800	.194	9000	.038
CC	40 000	28 000	52 000	2400	.146	12 000	.029
DD	52 500	36 750	68 250	3150	.111	15 750	.022
EE	70 000	49 000	91 000	4200	.083	21 000	.016
FF	93 000	65 100	120 900	5580	.063	27 900	.012
GG	124 000	86 800	161 200	7440	.047	37 200	.009
HH	165 000	115 500	214 500	9900	.035	49 500	.007
II	225 000	157 500	292 500	13 500	.026	67 500	.005
JJ	300 000	210 000	390 000	18 000	.019	90 000	.004
KK	400 000	280 000	520 000	24 000	.015	120 000	.003
LL	560 000	392 000	728 000	33 600	.010	168 000	.002

Round off to nearest Hz.

The indicated maximum data frequency response and minimum rise time is based on the maximum theoretical response that can be obtained in a bandwidth between the upper and lower frequency limits specified for the channels. See appendix B for determining possible accuracy versus response tradeoffs.

Channels A through L may be used by omitting adjacent lettered and numbered channels. Channels 13 and A may be used together with some increase in adjacent channel interference.

Channels AA through LL may be used by omitting every four adjacent double lettered and lettered channels and every three adjacent numbered channels. Channels AA through LL may be used by omitting every three adjacent double lettered and lettered channels and every two adjacent numbered channels with some increase in adjacent channel interference.

3.3.2 Constant-Bandwidth FM Subcarrier Channel Characteristics. Table 3-2 lists the standard constant-bandwidth FM subcarrier channels. The letters A, B, C, D, E, F, G, and H identify the channels for use with maximum subcarrier deviations of ±2, ±4, ±8, ±16, ±32, ±64, ±128, and ±256 kHz, along with maximum frequency responses of 2, 4, 8, 16, 32, 64, 128, and 256 kHz. The channels shall be used within the limits of maximum subcarrier deviation. See appendix B for expected performance tradeoffs at selected combinations of deviation and modulating frequencies.

3.4 Tape Speed Control and Flutter Compensation

Tape speed control and flutter compensation for FM/FM formats may be accomplished as indicated in subparagraph 6.8.4, chapter 6. The standard reference frequency used shall be in accordance with the criteria in table 3-3 when the reference signal is mixed with data.

A CHANNELS Deviation limits = ± 2 kHz Nominal frequency response = 0.4 kHz Maximum frequency response = 2 kHz	B CHANNELS Deviation limits = ± 4 kHz Nominal frequency response = 0.8 kHz Maximum frequency response = 4 kHz	C CHANNELS Deviation limits = ± 8 kHz Nominal frequency response = 1.6 kHz Maximum frequency response = 8 kHz	D CHANNELS Deviation limits = ± 16 kHz Nominal frequency response = 3.2 kHz Maximum frequency response = 16 kHz	E CHANNELS Deviation limits = ± 32 kHz Nominal frequency response = 6.4 kHz Maximum frequency response = 32 kHz	F CHANNELS Deviation limits = ± 64 kHz Nominal frequency response = 12.8 kHz Maximum frequency response = 64 kHz	G CHANNELS Deviation limits = ± 128 kHz Nominal frequency response = 25.6 kHz Maximum frequency response = 128 kHz	H CHANNELS Deviation limits = ± 256 kHz Nominal frequency response = 51.2 kHz Maximum frequency response = 256 kHz
Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)	Center Frequency (kHz)
8	16	32	64	128	256	512	1024
16	32	64	128	256	512	1024	2048
24	48	96	192	384	768	1536	3072
32	64	128	256	512	1024	2048	
40	80	160	320	640	1280	2560	
48	96	192	384	768	1536	3072	
56	112	224	448	896	1792	3584	
64	128	256	512	1024	2048		
72	144	288	576	1152	2304		
80	160	320	640	1280	2560		
88	176	352	704	1408	2816		
96	192	384	768	1536	3072		
104	208	416	832	1664	3328		
112	224	448	896	1792	3584		
120	240	480	960	1920	3840		
128	256	512	1024	2048			
136	272	544	1088	2176			
144	288	576	1152	2304			
152	304	608	1216	2432			
160	320	640	1280	2560			
168	336	672	1344	2688			
176	352	704	1408	2816			

The constant bandwidth channel designation shall be the channel center frequency in kilohertz and the channel letter indicating deviation limit; for example, 16A, indicating fc = 16 kHz, deviation limit of ± 2 kHz. See appendix F for former subcarrier nomenclature.

The indicated maximum frequency is based upon the maximum theoretical response that can be obtained in a bandwidth between deviation limits specified for the channel. See discussion in appendix B for determining practical accuracy versus frequency response trade offs.

Prior to using a channel outside the enclosed area, the user should verify the availability of range assets to support the demodulation of the channel selected. Very limited support is available above 2 MHz.

Table 3-2. Constant Bandwidth FM Subcarrier Channels.

TABLE 3-3. REFERENCE SIGNAL USAGE
Reference Frequencies for Tape Speed and Flutter Compensation
Reference Frequency (kHz ±0.01%)
960[1]
480[1]
240[1]
200
100
50
25
12.5
6.25
3.125

[1]These frequencies are for flutter compensation only and not for capstan servo speed control. In addition, the 240 kHz reference signal may be used as a detranslation frequency in a constant-bandwidth format.

If the reference signal is recorded on a separate tape track, any of the listed reference frequencies may be used provided the requirements for compensation rate of change are satisfied.

If the reference signal is mixed with the data signal, consideration must be given to possible problems with intermodulation sum and difference frequencies. Also, sufficient guard band must be allowed between the reference frequency and any adjacent data subcarrier.

CHAPTER 4

PULSE CODE MODULATION STANDARDS

4.1 General

Pulse Code Modulation (PCM) data are transmitted as a serial bit stream of binary-coded time-division multiplexed words. These standards define pulse train structure and system design characteristics for the implementation of PCM telemetry formats. Additional information and recommendations are provided in appendix C and in RCC document 119-88, ***Telemetry Applications Handbook***. The following general terms are defined.

4.1.1 Class I and Class II Distinctions. Two classes of PCM formats are covered in this chapter: the basic (and simpler) type is class I, and the more complex applications are class II. The use of any class II technique requires concurrence of the range involved. All characteristics described in these standards are class I except the following which are class II:

- formats including more than 512 data words,
- variable frame length (see subparagraph 4.3.2.2),
- word lengths in excess of 16 bits,
- fragmented words (see subparagraph 4.2.2.2),
- format changes (see paragraph 4.3),
- asynchronous embedded formats (see paragraph 4.4),
- bit rates greater than 5 megabits per second (Mbps),
- tagged data formats (see paragraph 4.5),
- formats involving more than one independent subframe (see subparagraph 4.2.3.9),
- unevenly spaced supercommutation (see subparagraph 4.2.3.11), and
- formats with data content other than unsigned straight binary or complement arithmetic representation for negative numbers such as floating point variables.

NOTE

The use of fixed frame formats has been common practice but does not fit all requirements. The capabilities to demultiplex some of the allowed class II features in this standard may not be available or have limited availability at test ranges. A verification of range capabilities should be made prior to incorporation of these features into a telemetry system.

4.2 Fixed Formats

Bit- and word-oriented formats will conform to the following definitions and requirements.

4.2.1 Bit-Oriented Definitions and Requirements. The following definitions and requirements are addressed to bit characteristics.

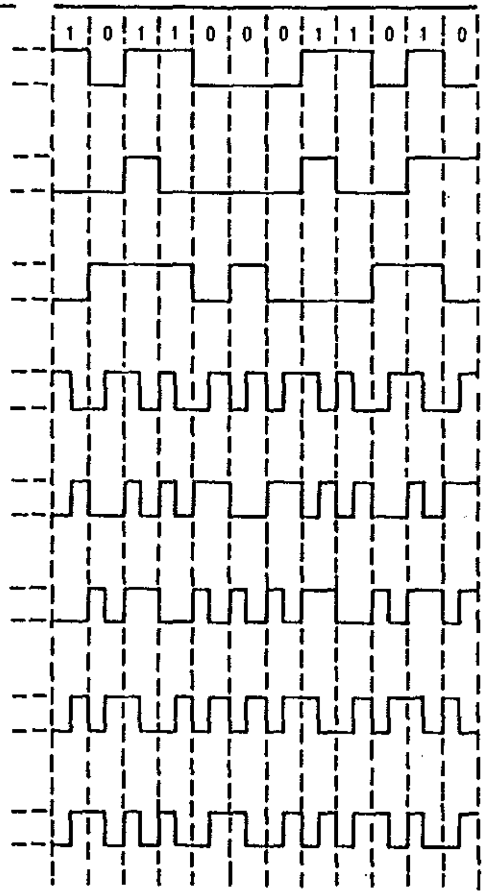
4.2.1.1 Binary Bit Representation. The following code conventions for representing serial binary ones and zeros are the only permissible representations:

NRZ-L	RNRZ-L	BiØ-L
NRZ-M	DBiØ-M	BiØ-M
NRZ-S	DBiØ-S	BiØ-S

Graphic and written descriptions of these conventions are shown in figure 4-1. Randomized NRZ-L (RNRZ-L) is described in appendix D. Only one convention shall be used in a single PCM bit stream.

4.2.1.2 Serial Bit Stream Transitions. The transmitted or recorded bit stream shall be continuous and shall contain sufficient transitions to ensure bit acquisition and continued bit synchronization, taking into account the binary representation chosen. (See recommendation in paragraph 1.3, appendix C.)

4.2.1.3 Bit Rate (Class I and II). The maximum bit rate is limited only by the requirements in chapter 2. Receiver intermediate-frequency (IF) bandwidths should be selected from table 2-1. The minimum bit rate shall be 10 bps. Bit rates greater than 5 Mbps are class II.



CODE DESIGNATION	LOGIC WAVEFORM LEVELS	CODE DEFINITIONS
NRZ-L	1 / 0	NON-RETURN-TO-ZERO-LEVEL "ONE" IS REPRESENTED BY ONE LEVEL "ZERO" IS REPRESENTED BY THE OTHER LEVEL
NRZ-M	1 / 0	NON-RETURN-TO-ZERO-MARK "ONE" IS REPRESENTED BY A CHANGE IN LEVEL "ZERO" IS REPRESENTED BY NO CHANGE IN LEVEL
NRZ-S	1 / 0	NON-RETURN-TO-ZERO-SPACE "ONE" IS REPRESENTED BY NO CHANGE IN LEVEL "ZERO" IS REPRESENTED BY A CHANGE IN LEVEL
BIϕ-L(1)	1 / 0	BI-PHASE-LEVEL (SPLIT PHASE) LEVEL CHANGE OCCURS AT CENTER OF EVERY BIT "ONE" IS REPRESENTED BY A "ONE" LEVEL WITH TRANSITION TO THE "ZERO" LEVEL "ZERO" IS REPRESENTED BY A "ZERO" LEVEL WITH TRANSITION TO THE "ONE" LEVEL
BIϕ-M	1 / 0	BI-PHASE-MARK LEVEL CHANGE OCCURS AT THE BEGINNING OF EVERY BIT PERIOD "ONE" IS REPRESENTED BY A MIDBIT LEVEL CHANGE "ZERO" IS REPRESENTED BY NO MIDBIT LEVEL CHANGE
BIϕ-S	1 / 0	BI-PHASE SPACE LEVEL CHANGE OCCURS AT THE BEGINNING OF EVERY BIT PERIOD "ONE" IS REPRESENTED BY A NO MIDBIT LEVEL CHANGE "ZERO" IS REPRESENTED BY MIDBIT LEVEL CHANGE
DBIϕ-M(1)	1 / 0	DIFFERENTIAL-BI-PHASE-MARK LEVEL CHANGE OCCURS AT THE CENTER OF EACH BIT PERIOD "ONE" IS REPRESENTED BY NO LEVEL CHANGE AT THE BEGINNING OF THE BIT PERIOD "ZERO" IS REPRESENTED BY A LEVEL CHANGE AT THE BEGINNING OF THE BIT PERIOD
DBIϕ-S(1)	1 / 0	DIFFERENTIAL-BI-PHASE-SPACE LEVEL CHANGE OCCURS AT THE CENTER OF EACH BIT PERIOD "ONE" IS REPRESENTED BY A LEVEL CHANGE AT THE BEGINNING OF THE BIT PERIOD "ZERO" IS REPRESENTED BY NO LEVEL CHANGE AT THE BEGINNING OF THE BIT PERIOD

(1) These codes may be derived from the corresponding NRZ codes by inverting the level for the last half of each bit interval

Figure 4-1. PCM code definitions.

4.2.1.4 Bit Rate Accuracy and Stability. During any period of desired data, the bit rate shall not differ from the specified nominal bit rate by more than 0.1 percent of the nominal rate.

4.2.1.5 Bit Jitter. The bit jitter shall not exceed ±0.1 bit interval referenced to the expected transition time with no jitter. The expected transition time shall be based on the measured average bit period as determined during the immediately preceding 1000 bits.

4.2.1.6 Bit Numbering. To provide consistent notation, the most significant bit in a word shall be numbered "one." Less significant bits shall be numbered sequentially within the word.

4.2.2 Word-Oriented Definitions and Requirements. The following definitions and requirements are addressed to word characteristics.

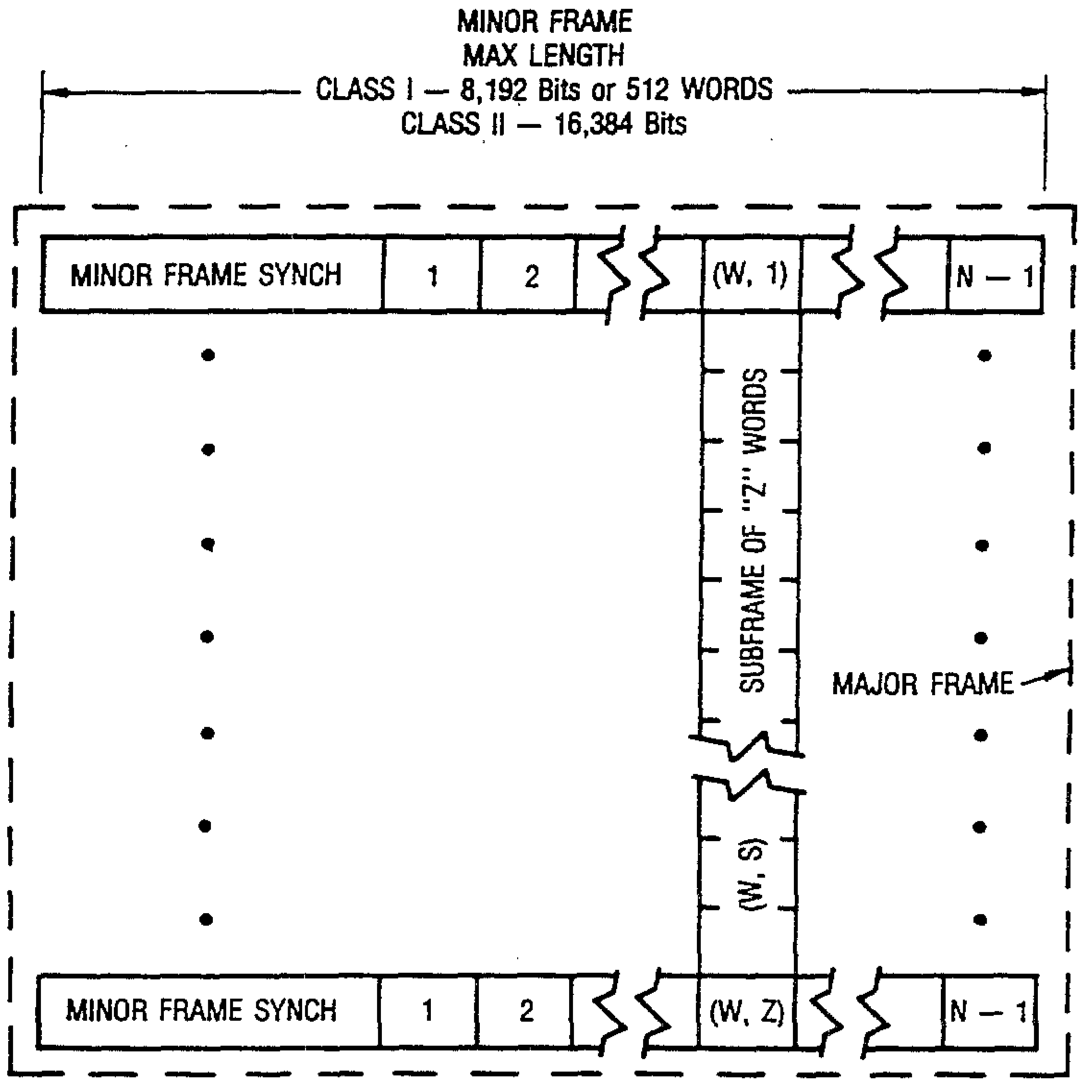
4.2.2.1 Word Length (Class I and II). Individual words may vary in length from 4 bits to not more than 16 bits in class I and not more than 64 bits in class II. Words of different length may be multiplexed in a single minor frame. The length of a word in any identified word position within a minor frame shall be constant, except as allowed in paragraph 4.3 (class II).

4.2.2.2 Fragmented Words (Class II). A fragmented word is defined as a word divided into no more than eight segments and located in various locations within a minor frame. The locations need not be adjacent. No more than four such words are allowed per minor frame. All word segments used to form a data word are constrained to the boundaries of a single minor frame. Fragmented synchronization words are not allowed.

4.2.2.3 Word Numbering. To provide consistent notation, the first word after synchronization shall be numbered "one" (see figure 4-2). Each subsequent word shall be numbered sequentially within the minor frame. Numbering within a subframe (see subparagraph 4.2.3.8) shall be "one" for the word in the same minor frame as the initial counter value for subframe synchronization and sequentially thereafter. Notation of W and S shall mean the W word position in the minor frame and S word position in the subframe.

4.2.3 Frame Structure. The PCM data shall be formatted into fixed length frames as defined in these sections regarding frame structure and in figure 4-2. Frames shall contain a fixed number of equal duration bit intervals.

4.2.3.1 Minor Frame. The minor frame is defined as the data structure in time sequence from the beginning of a minor frame synchronization pattern to the beginning of the next minor frame synchronization pattern.



- BY DEFINITION A MAJOR FRAME CONTAINS N * Z WORDS.
  "Z" = THE NUMBER OF WORDS IN LONGEST SUBFRAME. (Max.256)
  "N" = THE NUMBER OF WORDS IN MINOR FRAME.
- MINOR FRAME SYNCH IS CONSIDERED ONE WORD, REGARDLESS OF LENGTH.

Figure 4-2. PCM frame structure.

4.2.3.2 Minor Frame Length (Class I and II). The minor frame length is the number of bit intervals from the beginning of the frame synchronization pattern to the beginning of the next synchronization pattern. The length of a minor frame shall not exceed 8192 bits or 512 words in class I and shall not exceed 16 384 bits in class II.

4.2.3.3 Minor Frame Composition. The minor frame shall contain the minor frame synchronization pattern, data words, and subframe synchronization words, if used. Other words such as frame format identifiers may be needed within class II formats (see paragraph 4.3).

4.2.3.4 Minor Frame Synchronization. The minor frame synchronization information shall consist of a fixed digital word not longer than 33 consecutive bits and not shorter than 16 bits. Recommended synchronization patterns are given in appendix C.

4.2.3.5 Major Frame. A major frame contains the number of minor frames required to include one sample of every parameter in the format.

4.2.3.6 Major Frame Length. Major frame length is defined as minor frame length times the number of minor frames in the major frame. The maximum number of minor frames per major frame shall not exceed 256 minor frames.

4.2.3.7 Supercommutation and Subcommutation. Defined as data sampling at rates which are multiples (supercommutation) or submultiples (subcommutation) of the minor frame rate.

4.2.3.8 Subframe. A subframe is defined as one cycle of the parameters from a commutator whose rate is a submultiple of the minor frame rate.

4.2.3.9 Independent Subframe. Defined as a subframe which is not synchronous with and not an integer submultiple of other subframes in a major frame. Each independent subframe must have its own subframe counter.

4.2.3.10 Dependent Subframe. Defined as a subframe which is synchronous with and thus an integer submultiple of, or equal in length to, an independent subframe in the major frame.

4.2.3.11 Supercommutation (Class I and II). Supercommutation (supercom) is defined as data sampling at a rate which is a multiple of the minor frame rate. For class I, supercommutated samples shall be evenly spaced. In class II, supercommutated samples should be as evenly spaced in the minor frame as practical. Supercommutation occurs as multiple samples of the same parameter: (a) in each minor frame or (b) in a subframe ("supercom on a subframe").

4.2.3.12 Subframe Synchronization Method. The standard method for subframe synchronization is to use a subframe counter. This binary counter counts sequentially up or down at the minor frame rate. The counter shall be located in a fixed position in each and every minor frame. Preferably the start of a major frame should be synchronized with the minimum counter value when counting up or the maximum value when counting down.

4.2.3.13 Transmitted Frame Counter. The frame counter provides a natural binary count corresponding to the minor frame number in which the frame count word appears. It is recommended that such a counter be included in all minor frames whether class I or class II and is especially desirable in class II formats to assist with data processing. The frame counter should be of nominal format word length and reset to start upcounting again after reaching maximum value. In class I formats where subcommutation is present, the subframe counter can serve as the frame counter.

4.3 Format Change (Class II)

Defined as changes with regard to frame structure, word length or location, commutation sequence, sample interval or change in measurement listing. Format changes shall occur only on minor frame boundaries and may not have a definable major frame length since these formats may not have periodic data content locations. Bit synchronization shall be maintained and fill bits used instead of intentional dead periods. Format changes are inherently disruptive to test data processing and fixed format methods are preferred. In cases where there is necessity for varying format, the methods shall conform to the characteristics described in the following sections.

4.3.1 Frame Format Identification. A frame format identification (FFI) is a word that shall uniquely identify a single format. In formats where change is required, the frame format identification shall be placed in every minor frame, not just those near the time of a change. The format identifier shall be the same length as the most common word length in the format or multiples thereof, but no longer than 16 bits and shall occur in a fixed position relative to minor frame synchronization. The FFI shall identify the format applicable to the current minor frame. Frame synchronization pattern, FFI location, bit rate, and binary bit representation code shall not be changed. The FFIs shall be constructed such that, as a minimum, a single bit error shall not produce another valid FFI. The number of unique formats allowed shall not exceed 16.

4.3.2 Format Change Implementation Methods. The following subparagraphs describe format change implementation methods.

4.3.2.1 Measurement List Change. This method of format change consists of a modification in data content only and not format structure. The format structure consists of major and minor frames and subframes with only the measurements contained in the format being changed.

4.3.2.2 Format Structure Change. Defined as a format change where there is a total departure in frame structure and data content. Lengthy resynchronization periods may be incurred when using this type of change. This term would apply where no traditional subframe and major frame definitions are applicable for the selected format.

4.4 Asynchronous Embedded Format (Class II)

Defined as a secondary data stream which has major frame characteristics, an asynchronous embedded format is inserted into a host major frame in a manner which does not allow predicting the location of embedded synchronization information based only on host format timing. The embedded frame segments shall be inserted as an integral number of words in every host minor frame. In this combined format, specific word positions in the host minor frame shall be dedicated to the embedded asynchronous format. No more than two asynchronous embedded formats shall be allowed per major frame. Embedded formats shall have only class I characteristics.

4.5 Tagged Data Format (Class II)

Defined as a fixed frame length format having no applicable subframe or major frame definitions and characterized as a stream of data words, or blocks of words, with associated identifiers (tags). These formats consist of frame synchronization patterns, identifiers, data words, and fill words as required.

4.5.1 Alternating Tag and Data. This tagged data format consists of frames containing tag words alternating in time sequence with data words or blocks of words identified by the tags.

4.5.2 Bus Data MIL-STD-1553[1]. Telemetering of MIL-STD-1553 formatted information, if not restructured to conform to other methods in this standard, shall

- conform to the serial signal characteristics of subparagraph 4.2.1 (including the removal of the 3-bit-period word synchronization);

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[1]Defined in USAF Systems Command "MIL-STD-1553", ***Multiplex Applications Handbook***.

- have an unaltered order of words per bus (except in an overflow case);
- have a fixed frame length using fill words as necessary and maintain fixed word boundaries (see subparagraph 4.2.3.3);
- provide identifier bits contiguous to each word (for such purposes as status, data and command distinction, indication of an inserted time word, and bus origin where multiple buses have been word merged); and
- provide any other necessary identifier bits for the specific application (for example, overflow indicators for bit rates chosen lower than basic bus rate).

4.6 Premodulation Filtering

Premodulation filtering is recommended to confine the radiated RF spectrum (see appendix A).

CHAPTER 5

PULSE AMPLITUDE MODULATION STANDARDS

5.1 General

This standard defines the recommended pulse train structure and design characteristics for the implementation of PAM telemetry systems. The PAM data are transmitted as time division multiplexed analog pulses with the amplitude of the information channel pulse being the analog-variable parameter.

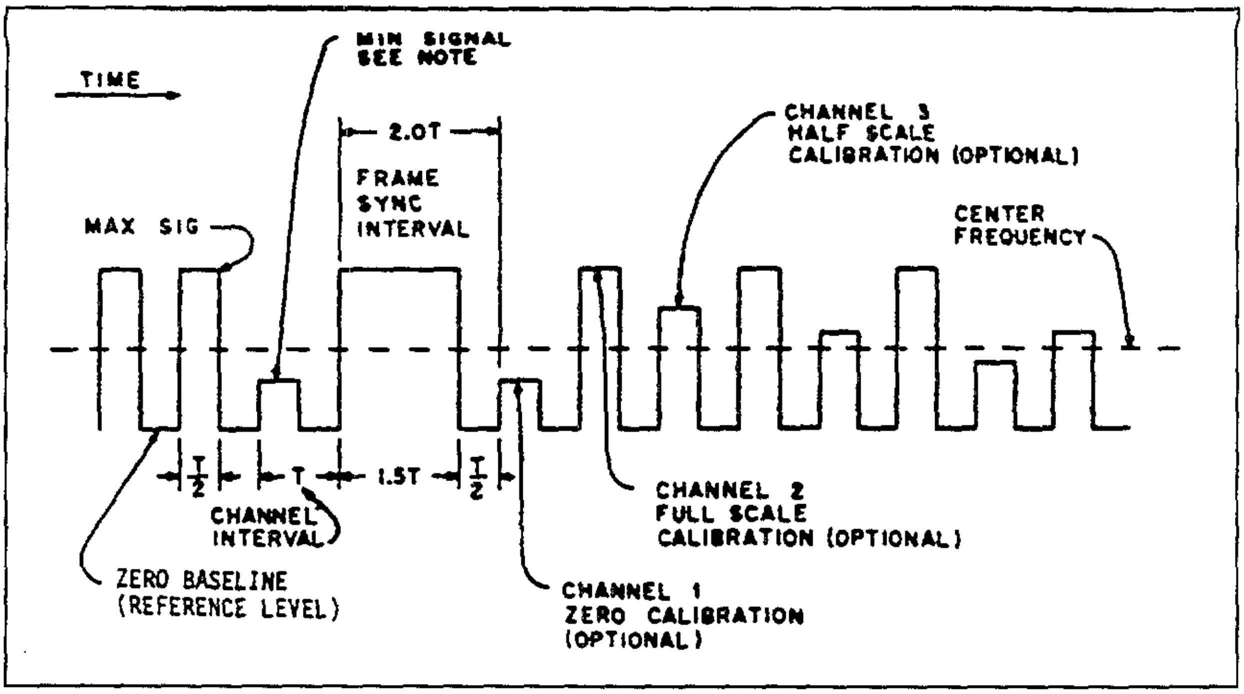
5.2 Frame and Pulse Structure

Each frame consists of a constant number of time-sequenced channel intervals. The maximum frame length shall be 128 channel time intervals per frame, including the intervals devoted to synchronization and calibration. The pulse and frame structure shall conform to either figure 5-1 or 5-2.

5.2.1 Commutation Pattern. The information channels are allocated equal and constant time intervals within the PAM frame. Each interval ("T" in figures 5-1 and 5-2) contains a sample pulse beginning at the start of the interval and having amplitude determined by the amplitude of the measurand of the corresponding information channel according to a fixed relationship (usually linear) between the minimum level (zero amplitude) and the maximum level (full-scale amplitude). For a 50 percent duty cycle (RZ-PAM), the zero level shall be 20 to 25 percent of the full amplitude level as shown in figure 5-1. The pulse width shall be the same in all time intervals except for the intervals devoted to synchronization. The duration shall be either 0.5T ±0.05, as shown in figure 5-1, or T ±0.05, as shown in figure 5-2.

5.2.2 In-Flight Calibration. It is recommended that in-flight calibration be used and channels 1 and 2, immediately following the frame synchronization interval, be used for zero and full-scale calibration. For RZ-PAM, channel 3 may be used for an optional half-scale calibration, and for NRZ-PAM, the channel interval preceding channel 1 may be used for half-scale calibration if set to 50 percent.

5.2.3 Frame Synchronization Interval. Each frame is identified by the presence within it of a synchronization interval.



NOTE

A 20 to 25 percent deviation reserved for pulse synchronization is recommended.

Figure 5-1. 50-percent duty cycle PAM with amplitude synchronization.

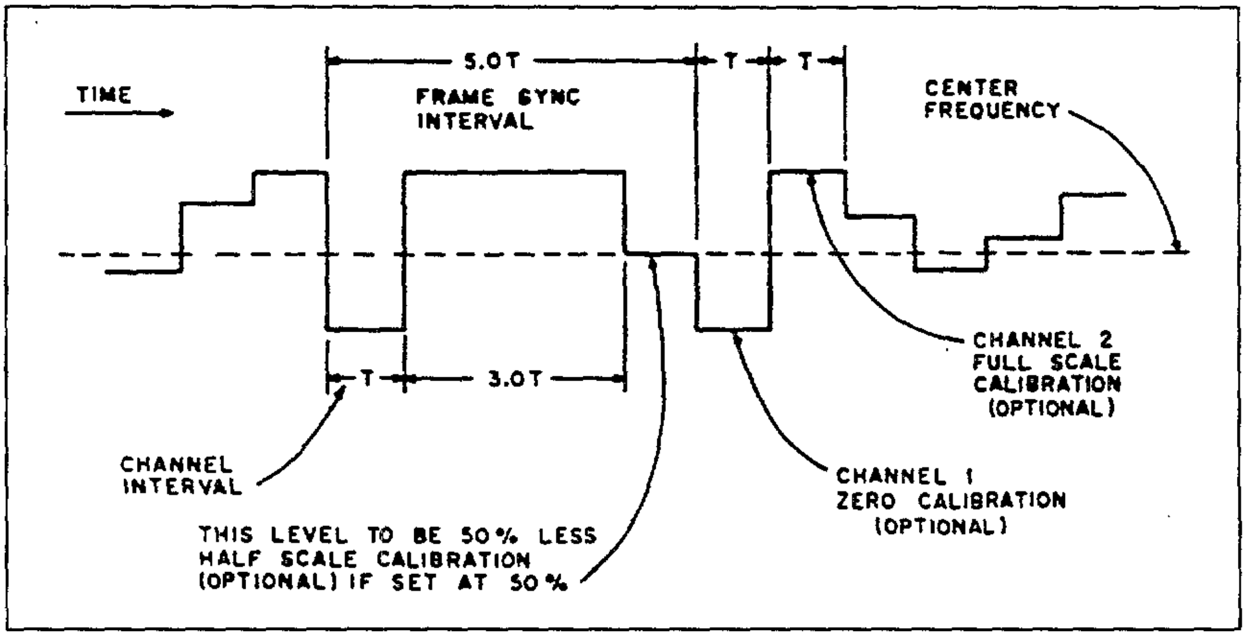


Figure 5-2. 100-percent duty cycle PAM with amplitude synchronization.

5.2.3.1 Fifty Percent Duty Cycle (RZ-PAM). The synchronization pattern interval shall have a duration equal to two information channel intervals (2T) and shall be full-scale amplitude for 1.5T followed by the reference level or zero baseline for 0.5T (see figure 5-1).

5.2.3.2 One Hundred Percent Duty Cycle (NRZ-PAM). The synchronization pattern is in the order given: zero level for a period of T, full-scale amplitude for a period of 3T, and a level not exceeding 50 percent full-scale amplitude for a period T (see figure 5-2).

5.2.4 Maximum Pulse Rate. The maximum pulse rate should not be greater than that permitted by the following subparagraphs.

5.2.4.1 PAM/FM/FM. The reciprocal of the shortest interval between transitions in the PAM pulse train shall not be greater than one-fifth of the total (peak-to-peak) deviation specified in chapter 3 and tables 3-1 and 3-2 for the FM subcarrier selected.

5.2.4.2 PAM/FM. The reciprocal of the shortest interval between transitions in the PAM pulse train shall be limited by whichever is the narrower of the following:

5.2.4.2.1 One-half of the 3 dB frequency of the premodulation filter when employed.

5.2.4.2.2 One-fifth of the intermediate frequency (IF) bandwidth (3 dB points) selected from the IF bandwidths which are listed in table 2-1.

5.3 Frame and Pulse Rate

The frame and pulse parameters listed below may be used in any combination:

- a minimum rate of 0.125 frames per second, and
- a maximum pulse rate as specified in subparagraph 5.2.4.

5.3.1 Long Term Accuracy and Stability. During a measured period of desired data, the time between the occurrence of corresponding points in any two successive frame synchronization intervals should not differ from the reciprocal of the specified nominal frame rate by more than 5 percent of the nominal period.

5.3.2 Short Term Stability. During a measured period, P, containing 1000-channel intervals, the time between the start of any two successive channel intervals (synchronization intervals excepted) should not differ from the average channel interval established by the formula $T_{avg} = \frac{P}{1000}$ by more than 1 percent of the average interval.

5.4 Multiple and Submultiple Sampling Rates

Data multiplexing at sampling rates which are multiples and submultiples of the frame rate is permissible.

5.4.1 Submultiple Frame Synchronization. The beginning of the longest submultiple frame interval is identified by the transmission of a synchronization pattern. All other submultiple frames have a fixed and known relationship to the identified submultiple frames.

5.4.1.1 Fifty Percent Duty Cycle (RZ). The synchronization pattern has a full-scale amplitude pulse in two successive occurrences of channel intervals allocated to data channels of the identified submultiple frame. The first such pulse has a duration equal to the channel interval; the second pulse immediately follows the first pulse and has a duration nominally one-half the channel interval. There is no return to zero between the two pulses.

5.4.1.2 One Hundred Percent Duty Cycle (NRZ). The synchronization pattern has information in five successive occurrences of a channel interval allocated to data channels of the identified submultiple frame. The amplitude of the data channels assigned for synchronization is shown in the following subparagraphs.

5.4.1.2.1 First occurrence - zero amplitude.

5.4.1.2.2 Second, third, and fourth occurrences - full-scale amplitude.

5.4.1.2.3 Fifth occurrence - not more than 50 percent of full-scale amplitude.

5.4.2 Maximum Submultiple Frame Length. The interval of any submultiple frame, including the time devoted to synchronizing information, shall not exceed 128 times the interval of the frame in which it occupies a recurring position.

5.5 Frequency Modulation

The frequency deviation of an FM carrier or subcarrier, which represents the maximum and minimum amplitude of a PAM waveform, should be equal and opposite with respect to the assigned carrier or subcarrier frequency. The deviation should be the same for all occurrences of the same level.

5.6 Premodulation Filtering

A maximally linear phase response, premodulation filter, is recommended to restrict the radiated spectrum (see appendix A).

CHAPTER 6

MAGNETIC TAPE RECORDER AND REPRODUCER STANDARDS

6.1 Introduction

These standards define terminology for longitudinal fixed-head recorder and reproducer systems and establish the recorder and reproducer configuration required to ensure crossplay compatibility between tapes recorded at one facility and reproduced at another. A standard for 19 millimeter digital cassette helical scan recording is also included. Acceptable performance levels and a minimum of restrictions consistent with compatibility in interchange transactions are delineated. While the standards may serve as a guide in the procurement of magnetic tape recording equipment, they are not intended to be employed as substitutes for purchase specifications. Other standards have been prepared by the American National Standards Institute (ANSI) and the International Standards Organization (see paragraph 1.0, appendix D).

Wherever feasible, quantitative performance levels are given which must be met or exceeded to comply with these standards. Standard test methods and measurement procedures shall be used to determine such quantities, including those contained in volume III of RCC document 118-XX, *Test Methods for Recorder/Reproducer Systems and Magnetic Tape*.

United States (U.S.) engineering units are the original dimension in these standards. Conversions from U.S. engineering units (similar to British Imperial Units) to Systeme International d' Unites (SI) units have been done according to ANSI Z210.1-1976 (and International Standards Organization 370) Method A, except as noted. Standards applying to magnetic tapes are contained in chapter 7 of this document.

6.2 Definitions

6.2.1 Bias Signal, High Frequency. A high-frequency sinusoidal signal linearly added to the analog data signal in direct recording to linearize the magnetic recording characteristic.

6.2.2 Bi-Phase. A method of representing "one" or "zero" levels in PCM systems where a level change is forced to occur in every bit period. In bi-phase recording, the bi-phase level (split-phase) method is employed.

6.2.3 Bit Error. In PCM systems, a bit error has occurred when the expected bit value is not present; for example, a zero is present when a one is expected, or a one is present when a zero is expected.

6.2.4 Bit Error Rate. Number of bits in error in a predetermined number of bits transmitted or recorded, for example, 1 in 10^6 or a BER of 10^{-6}.

6.2.5 Bit Packing Density, Linear. Number of bits recorded per inch or per millimeter of tape length. For serial PCM recording, the number of bits per unit length of a single track.

6.2.6 Bit Slip. The increase or decrease in detected bit rate by one or more bits with respect to the actual bit rate.

6.2.7 Crossplay. Reproducing a previously recorded tape on a recorder and reproducer system other than that used to record the tape.

6.2.8 Crosstalk. Undesired signal energy appearing in a reproducer channel as a result of coupling from other channels.

6.2.9 Data Azimuth (Dynamic). The departure from the head segment gap azimuth angles (static) because of the dynamic interface between the heads and the moving tape.

6.2.10 Data Scatter. The distance between two parallel lines (as defined under Gap Scatter) in the plane of the tape, which contains all data transitions recorded simultaneously with the same head at the same instant of time.

6.2.11 Data Spacing. For interlaced head systems, the distance on tape between simultaneous events recorded on odd and even heads.

6.2.12 Direct Recording (ac Bias Recording). A magnetic recording technique employing a high-frequency bias signal which is linearly added to the data signal. The composite signal is then used as the driving signal to the record-head segment. The bias signal, whose frequency is well above the highest frequency that can be reproduced by the system, transforms the recording of the data signal so that it is a more nearly linear process.

6.2.13 Double-Density Recording. Direct, FM, or PCM recording on magnetic tape at bandwidths equal to those used in wide-band instrumentation recording, but at one-half the wide-band tape speeds specified in IRIG standard 106-80 and earlier telemetry standards. Special record and reproduce heads and high output tapes (see chapter 7) are required for double-density recording.

6.2.14 Dropout. An instantaneous decrease in reproduce signal amplitude of a specified amplitude and duration.

6.2.15 Edge Margin. The distance between the outside edge of the highest number track and the tape edge (see figure 6-1).

6.2.16 Edge Margin Minimum. The minimum value of edge margin.

6.2.17 FM Recording. Recording on magnetic tape using frequency-modulated record electronics to obtain response from dc to an upper specified frequency. The FM systems forfeit upper bandwidth response of direct record systems to obtain low frequency and dc response not available with direct recording.

6.2.18 Flux Transition. A 180-degree change in the flux pattern of a magnetic medium brought about by a reversal of poles within the medium.

6.2.19 Flux Transition Density. Number of flux transitions per inch or per millimeter of track length.

6.2.20 Flutter. Undesired changes in the frequency of signals during the reproduction of a magnetic tape produced by speed variations of the magnetic tape during recording or reproducing.

6.2.21 Gap Length (Physical). The dimension between leading and trailing edges of a record or reproduce head-segment gap measured along a line perpendicular to the leading and trailing edges of the gap.

6.2.22 Gap Scatter (Record Head). The distance between two parallel lines is defined in the following subparagraphs.

6.2.22.1 The two lines pass through the geometric centers of the trailing edges of the two outermost head segment gaps within a record head. The geometric centers of the other head segment gap trailing edges lie between the two parallel lines.

6.2.22.2 The two parallel lines lie in the plane of the tape and are perpendicular to the head reference plane (see figure 6-3).

6.2.23 Gap Scatter (Reproduce Head). Defined the same as for record-head gap scatter except that the reference points for reproduce heads are the geometric centers of the center lines of the head segment gaps (see figure 6-3).

6.2.24 Head (Record or Reproduce). A group of individual head segments mounted in a stack.

6.2.25 Head Designation. For interlaced heads, the first head of a record or reproduce pair over which the tape passes in the forward direction contains odd-numbered head segments and is the odd head. The second head containing even-numbered head segments is the even head. For noninterlaced heads, that is, in-line heads, both odd- and even-numbered head segments are contained within a single head.

6.2.26 Heads, In-Line. A single record head and a single reproduce head are employed. Odd and even record-head segment gaps are in-line in the record head. Odd and even reproduce-head segment gaps are in-line in the reproduce head.

6.2.27 Head Reference Plane. The plane, which may be imaginary, is parallel to the reference edge of the tape and perpendicular to the plane of the tape. For purposes of this definition, the tape shall be considered as perfect (see figures 6-2 and 6-3).

6.2.28 Head Segment, Record or Reproduce. A single transducer that records or reproduces one track (see figure 6-3).

6.2.29 Head Segment Gap Azimuth (Record or Reproduce Heads). The angle formed in the plane of the tape between a line perpendicular to the head reference plane and a line parallel to the trailing edge of the record-head segment gap or parallel to the center line of the reproduce-head segment gap.

6.2.30 Head Segment Gap Azimuth Scatter. The angular deviations of the head segment gap azimuth angles within a head.

6.2.31 Head Segment Numbering. Numbering of a head segment corresponds to the track number on the magnetic tape on which that head segment normally operates. For interlaced heads, the odd head of a pair contains all odd-numbered segments, while the even head will contain all even-numbered segments (see figure 6-2). In-line heads will contain odd and even segments in the same head stack.

6.2.32 Head Spacing. For interlaced head systems, the distance between odd and even heads.

6.2.33 Head Tilt. The angle between the plane tangent to the front surface of the head at the center line of the head segment gaps and a line perpendicular to the head reference plane (see figure 6-3).

6.2.34 Heads, Interlaced. Two record heads and two reproduce heads are employed. Head segments for alternate tracks are in alternate heads.

6.2.35 High-Density Digital Recording. Recording of digital data on a magnetic medium resulting in a flux transition density in excess of 590 transitions per millimeter (15 000 transitions per inch) per track.

6.2.36 Individual Track Data Azimuth Difference. Angular deviation of the data azimuth of an individual odd or even recorded track from the data azimuth of other odd or even tracks. The difficulty in making direct optical angular measurements requires this error to be expressed as a loss of signal amplitude experienced when the tape is reproduced with an ideal reproducing head, whose gap is aligned to coincide with the data azimuth of all tracks in one head as compared to the azimuth which produces maximum signal for an individual track (see figure 6-3).

6.2.37 Non Return to Zero-Level. A binary method of representation for PCM signals where one is represented by one level, and zero is defined as the other level in a bi-level system.

6.2.38 Record Level Set Frequency. Frequency of a sinusoidal signal used to establish the standard record level in direct-record systems. Normally, 10 percent of the upper band edge (UBE) frequency.

6.2.39 Reference Tape Edge. When viewing a magnetic tape from the oxide surface side with the earlier recorded portion to the observer's right, the reference edge is the top edge of the tape (see figure 6-1).

6.2.40 Reference Track Location. Location of the center line of track number 1 from the reference edge of tape.

6.2.41 Standard Record Level. For a magnetic tape recorder meeting IRIG standards and operating in the direct record mode, the input signal level produces 1 percent third harmonic distortion of the record level set frequency.

6.2.42 Tape Skew. Motion of a magnetic tape past a head such that a line perpendicular to the tape reference edge has an angular displacement (static or dynamic) from the head gap center lines.

6.2.43 Tape Speed, Absolute. The tape speed during recording and reproducing. The peripheral velocity of the capstan minus any tape slip, regardless of tape tension and environment.

6.2.44 Tape Speed, Effective. The tape speed modified by the effects on tape of operating conditions such as tension, tape materials, thickness, temperature, and humidity. The effective tape speed should be equal to the selected speed of the recorder, for example, 1524 mm/s (60 ips), 3048 mm/s (120 ips), regardless of operating conditions.

6.2.45 Tape Speed Errors. Errors are the departures of the effective speed from the selected tape speed.

6.2.46 Track Location. Location of the nth track center line from the reference track center line.

6.2.47 Track Numbering. The reference track is designated as track number 1. Tracks are numbered consecutively from the reference track downward when viewing the oxide surface of the tape with the earlier recorded portion of the tape to the observer's right (see figure 6-1).

6.2.48 Track Spacing. Distance between adjacent track center lines on a magnetic tape (see figure 6-1).

6.2.49 Track Width. The physical width of the common interface of the record-head segment at the gaps. This definition does not include the effects of fringing fields which will tend to increase the recorded track width by a small amount.

6.3 General Consideration for Longitudinal Recording

Standard recording techniques, tape speeds, and tape configurations are required to provide maximum interchange of recorded telemetry magnetic tapes between the test ranges. Any one of the following methods of information storage or any compatible combination may be used simultaneously: direct recording, predetection recording, FM recording, or PCM recording. Double-density recording may be used when the length of recording time is critical; however, it must be used realizing that performance parameters such as signal-to-noise ratio, crosstalk, and dropouts may be degraded (see paragraph 2.0, appendix D).

6.3.1 Tape Speeds. The standard tape speeds for instrumentation magnetic tape recorders are shown in table 6-1.

6.3.2 Tape Width. The standard nominal tape width is 25.4 mm (1 in.) (see table 7-1, Tape Dimensions).

6.3.3 Record and Reproduce Bandwidths. For the purpose of these standards, two system bandwidth classes are designated: wide-band and double-density (see table 6-1). Interchange of tapes between the bandwidth classes is **NOT** recommended.

6.4 Recorded Tape Format

The parameters related to recorded tape format and record and reproduce head configurations determine compatibility between systems that are vital to interchangeability (crossplay) of recorded magnetic tapes. Refer to the definitions in paragraph 6.2, figures 6-1 through 6-4 and tables 6-2 through 6-4. See appendix D for configurations not included in these standards.

6.4.1 Track Width and Spacing. Refer to figure 6-1 and tables 6-2 through 6-4.

6.4.2 Track Numbering. The tracks on a tape are numbered consecutively from track 1 through track n with track 1 located nearest the tape reference edge as shown in figure 6-1.

6.4.3 Data Spacing. For interlaced formats, the spacing on tape between simultaneous events on odd and even tracks is nominally 38.1 mm (1.5 in.) (see paragraph 6.4.4.1).

6.4.4 Head Placement. The standard technique for wide band and 28-track double density is to interlace the heads, both the record and the reproduce, and to provide alternate tracks in separate heads. Thus, to record on all tracks of a standard width tape, two interlaced record heads are used; to reproduce all tracks of a standard width tape, two interlaced reproduce heads are used. For 14-track double density, the standard technique uses one in-line record head and one in-line reproduce head.

6.4.4.1 Head Placement, Interlaced. Two heads comprise the record-head pair or the reproduce-head pair. Mounting of either head pair is done in such a manner that the center lines drawn through the head gaps are parallel and spaced 38.10 mm ±0.05 (1.500 in. ±0.002) apart, as shown in tables 6-2 and 6-4, for systems that include head azimuth adjustment. The dimension between gap center lines includes the maximum azimuth adjustment required to meet system performance requirements. For systems with fixed heads, that is, heads without an azimuth adjustment, the spacing between gap center lines shall be 38.10 mm ±0.03 (1.500 in. ±0.001) (see figure 6-2).

6.4.4.2 Head Identification and Location. A head segment is numbered to correspond to the track number that segment records or reproduces. Tracks 1, 3, 5, . . . are referred to as the "odd" head segments. Tracks 2, 4, 6, . . . are referred to as the even head segments. For interlaced heads, the head containing the odd numbered segments (odd head) is the first head in a pair of heads (record or reproduce) over which an element of tape passes when moving in the forward record or reproduce direction (see figure 6-2).

6.4.4.3 In-Line Head Placement. An in-line head shall occupy the position of head number 1 in an interlaced system.

6.4.4.4 Head Segment Location. Any head segment within a head shall be located within ±0.05 mm (±0.002 in.) of the nominal (dimension from table without tolerances) position required to match the track location as shown in figure 6-1 and tables 6-2 through 6-4.

TABLE 6-1. RECORD AND REPRODUCE PARAMETERS

Tape Speed mm/s (ips)	±3 dB Reproduce Passband kHz[1]	Direct Record Bias Set Frequency (UBE) kHz[2]	Direct Record Level Set Frequency (10% of UBE) kHz
WIDE BAND		**(OVERBIAS 2dB)**	
6096.0 (240)	0.8-4000	4000	400
3048.0 (120)	0.4-2000	2000	200
1524.0 (60)	0.4-1000	1000	100
762.0 (30)	0.4- 500	500	50
381.0 (15)	0.4- 250	250	25
190.5 (7-1/2)	0.4- 125	125	12.5
95.2 (3-3/4)	0.4- 62.5	62.5	6.25
47.6 (1-7/8)	0.4- 31.25	31.25	3.12
DOUBLE DENSITY		**(OVERBIAS 2 dB)**	
3048.0 (120)	2 -4000	4000	400
1524.0 (60)	2 -2000	2000	200
762.0 (30)	2 -1000	1000	100
381.0 (15)	2 - 500	500	50
190.0 (7-1/2)	1 - 250	250	25
95.2 (3-3/4)	0.5- 125	125	12.5

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

[2]When setting record bias level, a UBE frequency input signal is employed. The signal input level is 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 is adjusted for maximum reproduce output level and then increased until the output level decreases by the number of dB indicated in the table (see paragraph 4.1.3.3 of volume III, RCC document 118-XX).

TABLE 6-2. DIMENSIONS - RECORDED TAPE FORMAT, 14 TRACKS INTERLACED ON 25.4 mm (1 in.) WIDE TAPE (REFER TO FIGURE 6-1.)

Parameters	Millimeters		Inches
	Maximum	Minimum	
Track Width	1.397	1.143	0.050 ±0.005
Track Spacing	1.778		0.070
Head Spacing:			
Fixed Heads	38.125	38.075	1.500 ±0.001
Adjustable Heads	38.151	38.049	1.500 ±0.002
Edge Margin, Minimum	0.279		1.011
Reference Track Location	1.168	1.067	0.044 ±0.002
Track Location Tolerance	0.051	-0.051	±0.002

Track Number	Location of nth track: Millimeters		Inches
	Maximum	Minimum	
1 (Reference)	0.000	0.000	0.000
2	1.829	1.727	0.070
3	3.607	3.505	0.140
4	5.385	5.283	0.210
5	7.163	7.061	0.280
6	8.941	8.839	0.350
7	10.719	10.617	0.420
8	12.497	12.395	0.490
9	14.275	14.173	0.560
10	16.053	15.951	0.630
11	17.831	17.729	0.700
12	19.609	19.507	0.770
13	21.387	21.285	0.840
14	23.165	23.063	0.910

TABLE 6-3. DIMENSIONS - RECORDED TAPE FORMAT, 14 TRACKS IN-LINE ON 25.4 mm (1 in.) WIDE TAPE (REFER TO FIGURE 6-1.)

Parameters	Millimeters		Inches
	Maximum	Minimum	
Track Width	0.660	0.610	0.25 ±0.001
Track Spacing	1.778		0.070
Head Spacing	N/A		N/A
Edge Margin, Minimum[1]	1.118	0.044	
Reference Track Location	0.698	0.622	0.0260 ±0.0015
Track Location Tolerance	0.038	-0.038	±0.0015

	Location of nth track		
Track Number	Millimeters		Inches
	Maximum	Minimum	
1 (Reference)	0.000	0.000	0.000
2	1.816	1.740	0.070
3	3.594	3.518	0.140
4	5.372	5.296	0.210
5	7.150	7.074	0.280
6	8.928	8.852	0.350
7	10.706	10.630	0.420
8	12.484	12.408	0.490
9	14.262	14.186	0.560
10	16.040	15.964	0.630
11	17.818	17.742	0.700
12	19.596	19.520	0.770
13	21.374	21.298	0.840
14	23.152	23.076	0.910

[1] Track location and spacing are the same as the odd tracks of the 28-track interlaced format (see table 6-4). Edge margin for track 1 is only 0.229 mm (0.009 in.).

TABLE 6-4. DIMENSIONS - RECORDED TAPE FORMAT, 28 TRACKS INTERLACED ON 25.4 mm (1 in.) WIDE TAPE (REFER TO FIGURE 6-1.)

Parameters	Millimeters		Inches	
	Maximum	Minimum		
Track Width	0.660	0.610	0.025	±0.001
Track Spacing	0.889		0.035	
Head Spacing:				
Fixed Heads	38.125	38.075	1.500	±0.001
Adjustable Heads	38.151	38.049	1.500	±0.002
Edge Margin, Minimum	0.229		0.009	
Reference Track Location	0.699	0.622	0.0260	±0.0015
Track Location Tolerance	0.038	-0.038		±0.0015
	Location of nth track			
Track Number	Millimeters		Inches	
	Maximum	Minimum		
1 (Reference)	0.000	0.000	0.000	
2	0.927	0.851	0.035	
3	1.816	1.740	0.070	
4	2.705	2.629	0.105	
5	3.594	3.518	0.140	
6	4.483	4.407	0.175	
7	5.372	5.296	0.210	
8	6.261	6.185	0.245	
9	7.150	7.074	0.280	
10	8.039	7.963	0.315	
11	8.928	8.852	0.350	
12	9.817	9.741	0.385	
13	10.706	10.630	0.420	
14	11.595	11.519	0.455	
15	12.484	12.408	0.490	
16	13.373	13.297	0.525	
17	14.262	14.186	0.560	
18	15.151	15.075	0.595	
19	16.040	15.964	0.630	
20	16.929	16.853	0.665	
21	17.818	17.742	0.700	
22	18.707	18.631	0.735	
23	19.596	19.520	0.770	
24	20.485	20.409	0.805	
25	21.374	21.298	0.840	
26	22.263	22.187	0.875	
27	23.152	23.076	0.910	
28	24.041	23.965	0.945	

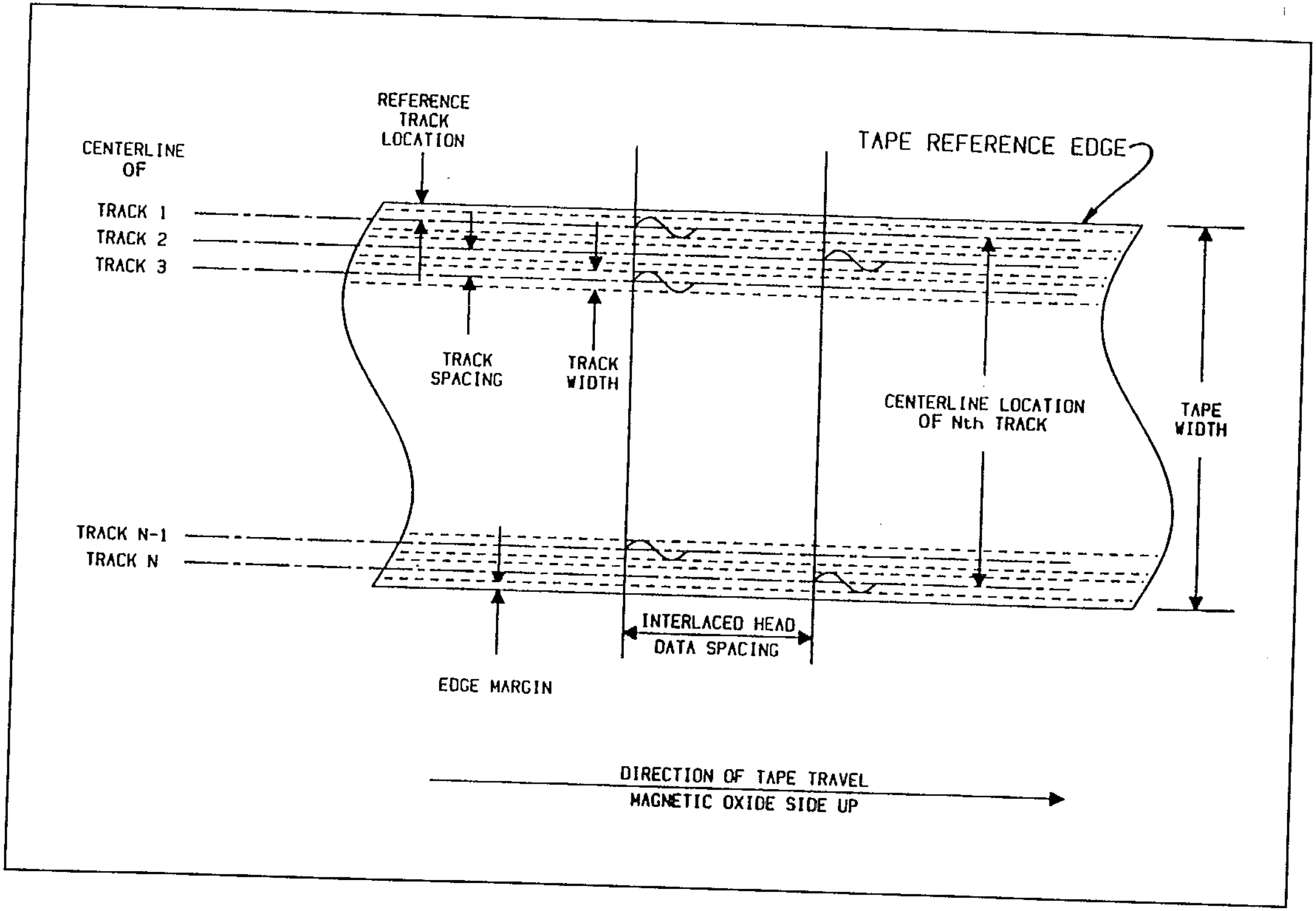


Figure 6-1. Recorded tape format.

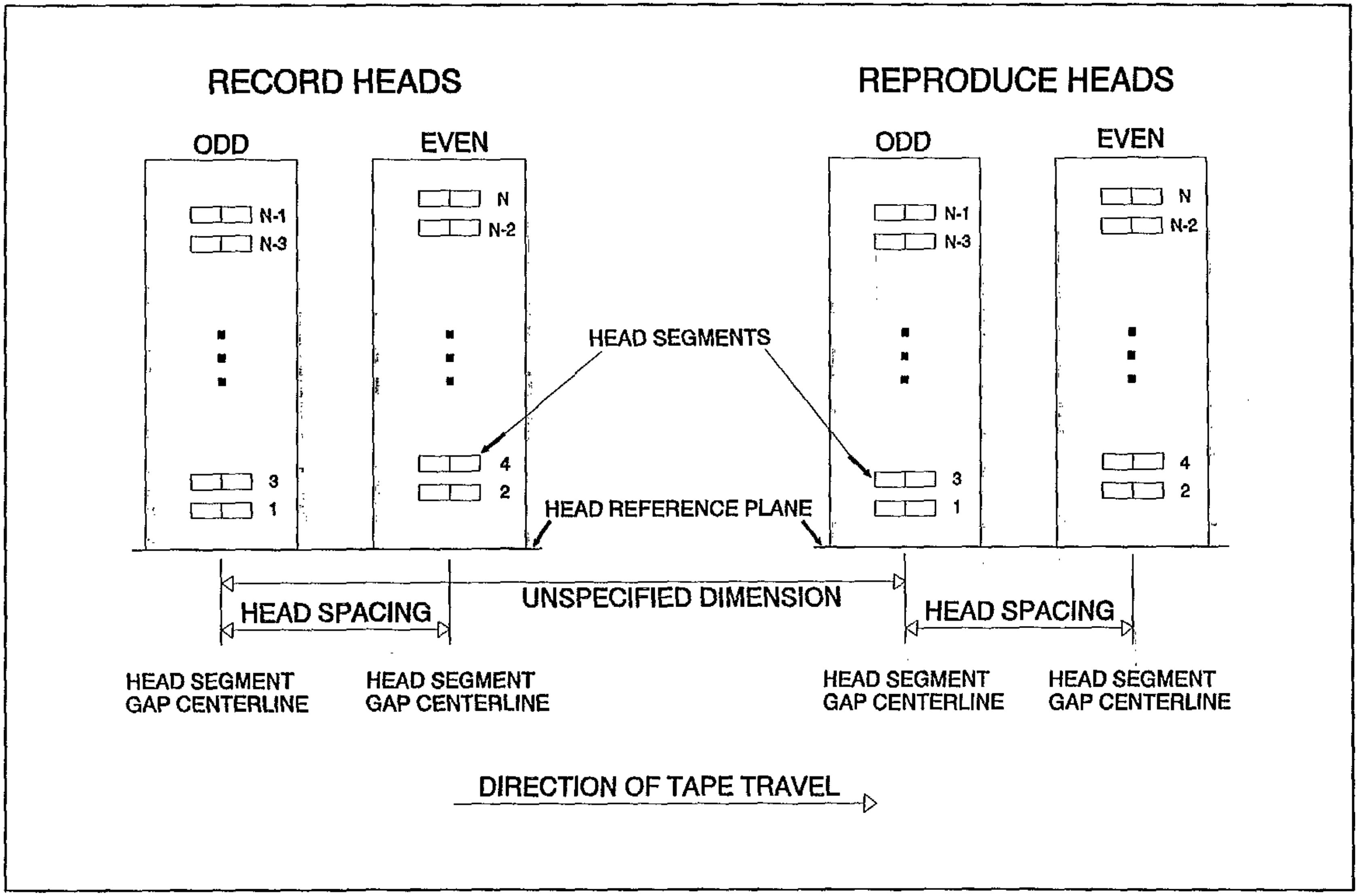


Figure 6-2. Record and reproduce head and head segment identification and location (N-track interlaced system).

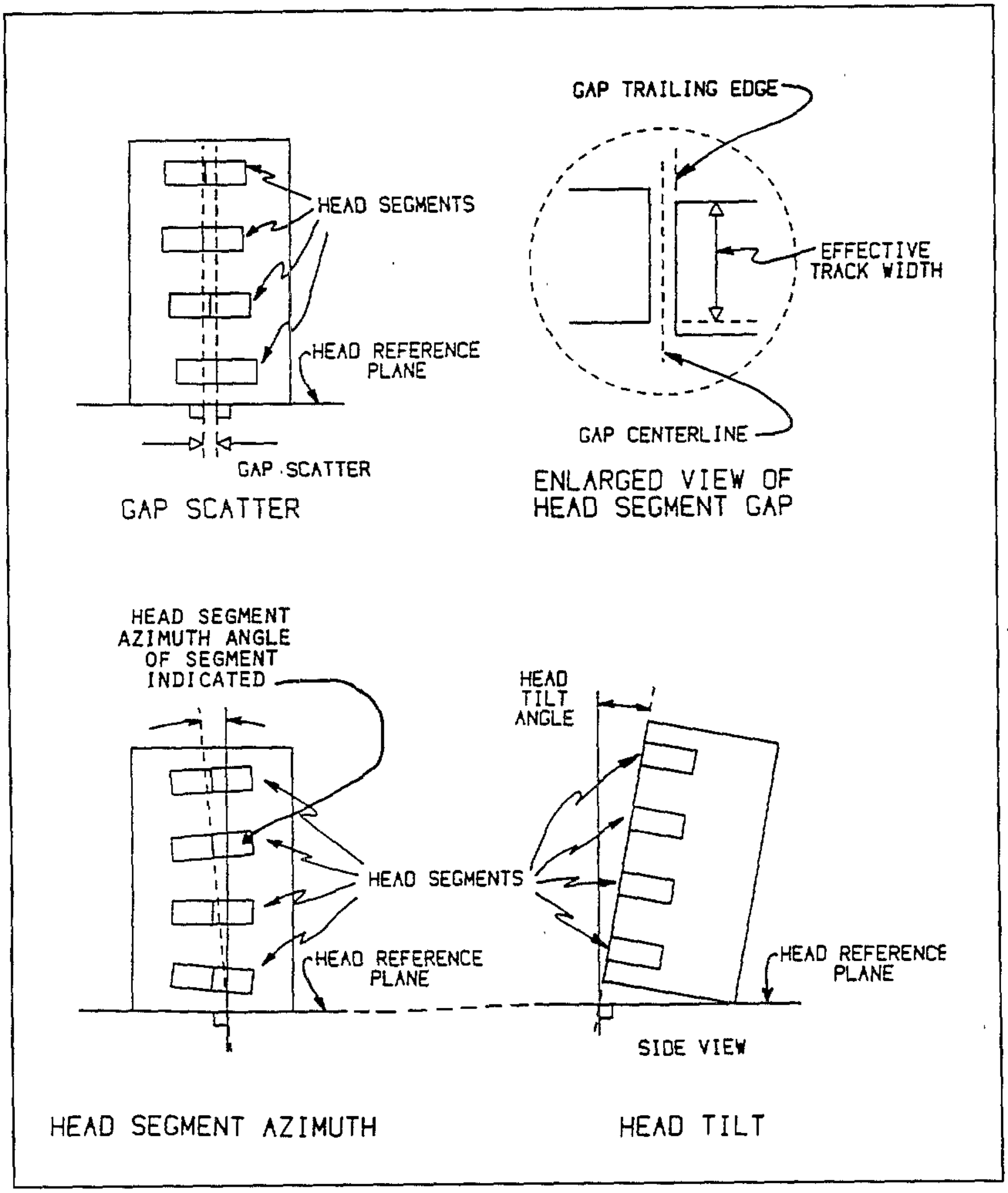


Figure 6-3. Head and head segment mechanical parameters.

6.5 Head and Head Segment Mechanical Parameters

The following subparagraphs describe the mechanical parameters of the head and head segments.

6.5.1 Gap Scatter. Gap scatter shall be 0.005 mm (0.0002 in.) or less for 25.4 mm (1 in.) tape (see figure 6-3 and subparagraph 4.1, appendix D).

6.5.2 Head Segment Gap Azimuth Alignment. The head segment gap azimuth shall be perpendicular to the head reference plane to within ±0.29 mrad (±1 minute of arc).

6.5.3 Head Tilt. The plane tangent to the front surface of the head at the center line of the head segment gaps shall be perpendicular to the head reference plane within ±0.29 mrad (±1 minute of arc) for wide band and double-density recorders (see figure 6-3).

6.5.4 Record-Head Segment Gap Parameters. The parameters for the length and azimuth alignment are described in the following subparagraphs.

6.5.4.1 Record-Head Segment Gap Length. The record gap length (the perpendicular dimension from the leading edge to the trailing edge of the gap) shall be 2.16 μm ±0.5 (85 microinch ±20) for wide-band recorders and 0.89 μm ±0.12 (35 microinch ±5) for double-density recorders (see figure 6-3 and paragraph 6.0, appendix D).

6.5.4.2 Record-Head Stack Gap Azimuth Alignment. The record-head stack azimuth shall be perpendicular to the head reference surface to within ±0.29 mrad (±1 minute of arc). See paragraph 1.2, volume III, RCC document 118-XX for suggested test procedure.

6.5.4.3 Reproduce-Head Segment Gap Azimuth Alignment. The reproduce-head segment azimuth alignment shall match that of the record-head segment as indicated by reproducing an UBE frequency signal on a selected track and setting the reproduce head azimuth for the maximum output. At this azimuth setting, the output of any other track in the reproduce head shall be within 2 dB of the output at its own optimum azimuth setting (see paragraph 1.3, volume III, RCC document 118-XX).

6.6 Head Polarity

See chapter 1, volume III, RCC document 118-XX and subparagraph 4.2, appendix D of this document for additional information.

6.6.1 Record-Head Segment. Each record-head winding shall be connected to its respective amplifier in such a manner that a positive going pulse referenced to system ground at the record amplifier input will result 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.

6.6.2 Reproduce-Head Segment. Each reproduce-head segment winding shall be connected to its respective amplifier in such a manner that an area of a tape track exhibiting a south-north-north-south magnetic pattern will produce a positive going pulse with respect to system ground at the output of the reproducer amplifier.

6.7 Magnetic Tape and Reel Characteristics

Magnetic tape and reel characteristics are specified in chapter 7. It is recommended that all recorder and reproducer systems at a particular range be calibrated for operational use against a reference tape of the type used by the range for each bandwidth class of recorder and reproducer system. Additional supplementary procurement specifications may be required to meet a particular operational requirement of the ranges.

6.7.1 Tape Width. The standard nominal tape width is 25.4 mm (1 in.) (see table 7-1, Tape Dimensions).

6.7.2 Tape Guiding. The tape guidance system restricts the tape angular motion to ±0.15 mrad (±30 seconds of arc) as measured by the interchannel time displacement error (ITDE) of outer tracks on the same head stack. Make sure the guidance system does not damage the tape.

6.8 Direct-Record and Reproduce Systems

Direct recording is a method of recording information signals on magnetic tape using high-frequency ac bias recording (see paragraph 6.2, Definitions). Two classes of systems, wide-band and double-density, are included in these standards (see table 6-1).

6.8.1 Direct-Record Parameters. The following subparagraphs describe the direct-record parameters.

6.8.1.1 The input impedance for wide-band and double-density recorders shall be 75 ohms nominal across the specified band.

6.8.1.2 Input gain adjustment shall be provided to permit sine-wave signals of 0.35 to 3.5 V rms to be adjusted to produce standard record level.

6.8.1.3 Ideally, the recorded flux level on tape versus frequency should be constant. To approach this ideal, the record amplifier transfer characteristic is basically a constant current versus frequency with a superimposed compensation characteristic to correct only for loss of recording efficiency with frequency. Results of the test described in paragraph 4.8, volume III, RCC document 118-XX, with the output amplitude at the 2 percent upper band edge (UBE) frequency used as the 0 dB reference, shall be no greater than the following:

Percent of UBE Frequency	dB Difference
10	0.5
50	1.0
80	1.6
100	2.0

6.8.1.4 Record bias setting information is contained in table 6-1. The bias frequency shall be greater than 3.5 times the highest direct record frequency for which the recorder and reproducer system is designed (see appendix D).

6.8.2 Standard Record Level. The standard record level for direct record systems is the input level of the record level set frequency which produces an output signal containing 1 percent third harmonic distortion. The conditions necessary to establish the standard record level include appropriate selection of the sinusoidal reference frequency (record level set frequency) as indicated in table 6-1 and proper reproduce amplifier termination as defined in figure 4-2, volume III, RCC document 118-XX. A 1 percent third harmonic distortion content is achieved when the level of the third harmonic of the record level set frequency is 40 dB ±1 below the level of a sinusoidal signal of 30 percent of UBE frequency which is recorded at the standard record level (see paragraph 5.0, appendix D for information regarding standard test and operating practices).

6.8.3 Reproduce Parameters. The following subparagraphs describe the reproduce parameters.

6.8.3.1 For wide-band and double-density recorders, the output impedance shall be 75 ohms nominal across the specified passband.

6.8.3.2 When reproducing a signal at the record level set frequency (recorded at the standard record level), the output level shall be a minimum of 1 V rms with a third harmonic distortion of 1 percent and a maximum second harmonic distortion of 0.5 percent when measured across a resistive load of 75 ohms. Lack of proper output termination will not cause the reproduce amplifier to oscillate.

6.8.4 Tape Speed and Flutter Compensation. The average or long-term tape speed must be the same during record and reproduce to avoid frequency offsets which may result in erroneous data. To minimize this problem, a reference signal may be applied to the tape during record and the signal used to servo-control the tape speed upon reproduce. However, because servo-control systems have limited correction capabilities and to minimize the amount of equipment required at the ranges, tape speeds and servo-control signals shall conform to the following standards.

6.8.4.1 The effective tape speed throughout the reel or any portion of the reel (in absence of tape-derived servo-speed control) shall be within ±0.2 percent of the standard speed as measured by the procedures described in chapter 2, volume III, RCC document 118-XX.

6.8.4.2 Sinusoidal or square wave speed-control signals are recorded on the tape for the purpose of servo-control of tape speed during playback. The operating level for speed-control signals shall be 10 dB ±5 below standard record level when mixed with other signals or standard record level when recorded on a separate track.

6.8.4.3 The constant-amplitude speed-control signal shall be used on a separate track for optimum servo-speed correction. The speed-control signal may be mixed with other signals if recording requirements so demand and system performance permits. Mixing of the speed-control signal with certain types of signals may degrade system performance for tapes which are to be reproduced on tape transports with low time-base error capstan drive systems (refer to manufacturer). Table 6-5 lists speed-control signal frequencies. The speed-control signal may also be used as a flutter correction signal.

6.8.4.4 Signals to be used for discriminator flutter correction systems are listed in tables 3-3 and 6-5. See subparagraph 6.8.4.3 and table 3-3 for restrictions on use of flutter correction signals.

6.9 Timing, Predetection, and Tape Signature Recording

Described in the following subparagraphs are timing signal, predetection, and tape signature recording.

6.9.1 Timing Signal Recording. Modulated-carrier, time-code signals (IRIG-A, IRIG-B and IRIG-G) are widely used and other formats are available. When recording IRIG-B time-code signals, care must be taken to ensure that low-frequency response to 100 Hz is provided. The direct-record, low-frequency cutoff of most wide-band recorders is 400 to 800 Hz. For these systems, IRIG-B time-code signals should be recorded on an FM track or on an FM subcarrier. The widest bandwidth subcarrier available should be employed to minimize time delay[3]. For double-density systems, all time-code signals should be recorded on an FM track or an FM subcarrier.

6.9.2 Predetection Recording. Predetection signals are signals which have been translated in frequency but not demodulated. These signals will be recorded by direct (high frequency bias) recording. Parameters for these signals are in table 6-6.

6.9.3 Tape Signature Recording. For data processing using wide-band and double-density recorders and reproducers, a tape signature recorded before or after the data, or both before and after the data, provides a method of adjusting the reproducer head azimuth and reproduce equalization. A means is also provided for verifying the proper operation of equipment such as playback receivers and bit synchronizers used to retrieve the recorded data. A pulse code modulation (PCM) signature is recommended where primarily PCM data is recorded. A swept-frequency or white-noise signature may be used for other data such as frequency division multiplexing (FDM) or wide-band FM. The procedures for recording and using these signatures are given in paragraph 7.0, appendix D. A recommended preamble/postamble signal for recorder/reproducer alignment is included in paragraph 6.12.

6.10 FM Record Systems

For these FM record systems, the input signal modulates a voltage-controlled oscillator, and the output is delivered to the recording head. High-frequency bias may be used but is not required. The following standards shall apply.

6.10.1 Tape and Reel Characteristics. Paragraph 7.1 and all related subparagraphs shall apply.

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[3]Timing code formats are found in IRIG standard 200-89, *Time Code Formats* and IRIG standard 205-87, *Parallel Binary and Parallel Binary Coded Decimal Time Code Formats*.

TABLE 6-5. CONSTANT-AMPLITUDE SPEED-CONTROL SIGNALS[1]					
Tape Speed		Frequency[2] kHz			
mm/s	ips				
6096	(240)	400	±0.01%	800	±0.01%
3048	(120)	200	±0.01%	400	±0.01%
1524	(60)	100	±0.01%	200	±0.01%
762	(30)	50	±0.01%	100	±0.01%
381	(15)	25	±0.01%	50	±0.01%
190.5	(7-1/2)	12.5	±0.01%	25	±0.01%
95.5	(3-3/4)	6.5	±0.01%	12.5	±0.01%
47.6	(1-7/8)	3.125	±0.01%	6.25	±0.01%

NOTE

Caution should be used when multiplexing other signals with the speed-control signal. In the vicinity of the frequency of the speed-control signal (fsc ±10 percent), the level of individual extraneous signals including spurious, harmonics and noise must be 40 dB or more below the level of the speed-control signal. A better procedure is to leave one octave on either side of the speed-control signal free of other signals.

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[1]May also serve as discriminator flutter-correction reference signal (see table 3-3).

[2]Either set of speed-control signals may be used primarily with wide-band systems, but only the higher set of frequencies is recommended for double-density systems. When interchanging tapes, care should be taken to ensure that the recorded speed-control signal is compatible with the reproduce system's speed-control electronics.

TABLE 6-6. PREDETECTION CARRIER PARAMETERS					
Tape Speed				Predetection Carrier Center Frequency[1 2] kHz	
mm/s	(ips)	mm/s	(ips)		
Wide-Band		Double-Density		A	B
6096	(240)	3048.0	(120)	1800	2400
3048	(120)	1524.0	(60)	900	1200
1524	(60)	762.0	(30)	450.0	600
762	(30)	381.0	(15)	225.0	300
381	(15)	109.5	(7.5)	112.5	150

6.10.2 Tape Speeds and Corresponding FM Carrier Frequencies. See table 6-7.

6.10.3 FM Record/Reproduce Parameters. See table 6-7.

6.10.4 Speed Control and Compensation. Subparagraph 6.8.4 shall apply. Note that a separate track is always required for speed-control and flutter-compensation signals with a single-carrier FM system.

6.10.5 FM Record Parameters. For FM record systems, an input voltage of 1 to 10 V peak-to-peak shall be adjustable to produce full frequency deviation.

6.10.5.1 Deviation Direction. Increasing positive voltage gives increasing frequency. Predetection recorded tapes may be recorded with reverse deviation direction because of the frequency translation techniques employed.

6.10.5.2 Wide-Band and Double-Density FM Record Systems. Input impedance is 75 ohms ±10 percent at all frequencies in the specified passband.

6.10.6 FM Reproduce Systems. Output levels are for signals recorded at full deviation. In wide-band and double-density FM systems, the output is 2 V peak-to-peak minimum across a load impedance of 75 ohms ±10 percent. Increasing input frequency gives a positive going output voltage.

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[1]The predetection record/playback passband is the carrier center frequency ±66.7 percent.

[2]Use center frequencies in column B when data bandwidth exceeds the capabilities of those in column A.

TABLE 6-7. WIDE-BAND AND DOUBLE-DENSITY FM RECORD PARAMETERS

Double-Density Tape Speed mm/s (ips)	Wide-Band FM Tape Speed mm/s (ips)	Carrier Center Frequency kHz	Carrier Deviation Limits[1] Plus Deviation kHz	Carrier Deviation Limits[1] Minus Deviation kHz	Modulation Frequency kHz	Response Band Limits dB[2]
	Group I					
	47.6 (1-7/8)	6.750	9.450	4.050	dc to 1.250	±1
	95.2 (3-3/4)	13.500	18.900	8.100	dc to 2.500	±1
	190.5 (7-1/2)	27.000	37.800	16.200	dc to 5.000	±1
	381.0 (15)	54.000	75.600	32.400	dc to 10.000	±1
	762.0 (30)	108.000	151.200	64.800	dc to 20.000	±1
	1524.0 (60)	216.000	302.400	129.600	dc to 40.000	±1
	3048.0 (120)	432.000	604.800	259.200	dc to 80.000	±1
Double-Density	**Wide-Band FM**					
	Group II					
	47.6 (1-7/8)	14.062	18.281	9.844	dc to 7.810	±1, -3
	95.2 (3-3/4)	28.125	36.562	19.688	dc to 15.620	±1, -3
95.2 (3-3/4)	190.5 (7-1/2)	56.250	73.125	39.375	dc to 31.250	±1, -3
190.5 (7-1/2)	381.0 (15)	112.500	146.250	78.750	dc to 62.500	±1, -3
381.0 (15)	762.0 (30)	225.000	292.500	157.500	dc to 125.000	±1, -3
762.0 (30)	1524.0 (60)	450.000	585.000	315.000	dc to 250.000	±1, -3
1524.0 (60)	3048.0 (120)	900.000	1170.000	630.000	dc to 500.000	±1, -3
3048.0 (120)	6096.0 (240)	1800.000	2340.000	1260.000	dc to 1000.000	±1, -3

[1]Input voltage levels per subparagraph 6.4.1.

[2]Frequency response referred to 1-kHz output for FM channels 13.5 kHz and above, and 100 Hz for channels below 13.5 kHz.

6.11 PCM Recording

The PCM signals may be successfully recorded using several different methods. Methods included in these standards are predetection recording, post-detection recording, and serial high density digital recording (HDDR). Parallel HDDR methods are not included.

6.11.1 Predetection PCM Recording. This method employs direct recording of the signal obtained by heterodyning the receiver IF signal to one of the center frequencies listed in table 6-6 without demodulating the serial PCM signal (see figure 6-4). The maximum recommended bit rate for predetection recording of NRZ data is equal to the predetection carrier frequency, for example, 900 kb/s for a 900 kHz predetection carrier. The maximum recommended bit rate for predetection recording of bi-phase (BiØ) data is equal to one-half the predetection carrier frequency. For bit rates greater than one-half the maximum recommended rates, the preferred method of detection is to convert the signal to a higher frequency before demodulation.

6.11.2 Post-Detection PCM Recording. The serial PCM signal (plus noise) at the video output of the receiver demodulator is recorded by direct or wide-band FM recording methods without first converting the PCM signal to bi-level form (see figure 6-4). Table 6-8 lists maximum bit rates versus tape speed for these recording methods. The minimum recommended reproduce bit rates are 10 kb/s for post-detection direct BiØ and 10 bits per second for post-detection FM (see paragraph 4.3).

6.11.3 Serial High Density Digital Recording. Serial HDDR is a method of recording PCM data on a magnetic tape which involves applying the data to one track of the recorder as a bi-level signal.

6.11.4 This paragraph deals with standards for direct recording of PCM telemetry data using a wide-band analog instrumentation recorder or reproducer system. Direct recording is described in paragraph 6.8. The recommended PCM codes, maximum bit rates, record and reproduce parameters, and the magnetic tape requirements are also described.

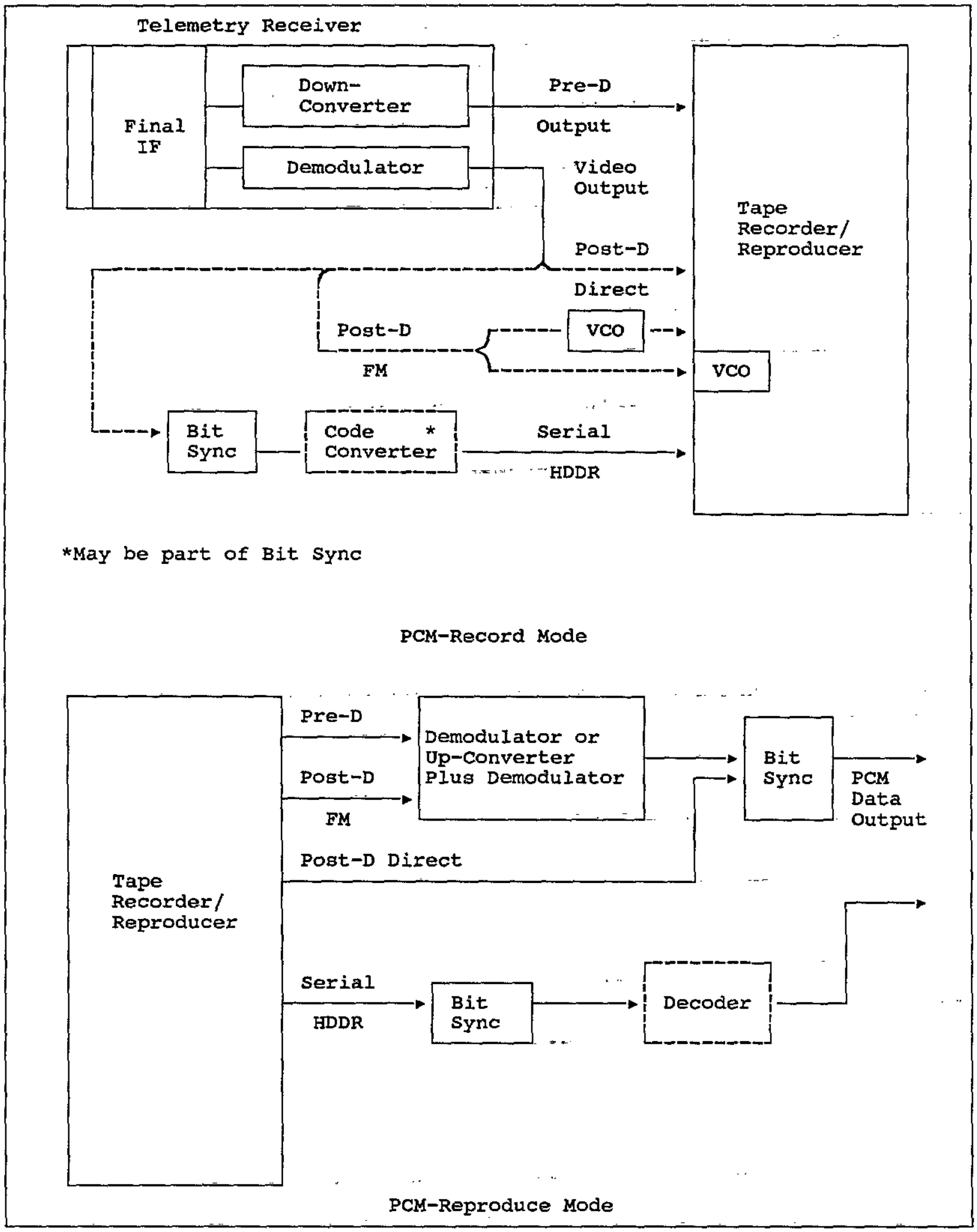

Figure 6-4. PCM record and reproduce configuration.

TABLE 6-8. MAXIMUM RECOMMENDED BIT RATES, POST-DETECTION RECORDING[1]

Tape Speed				Post-D Direct	Post-FM	
m/s	(ips)	mm/s	(ips)	BiØ (kb/s)	BiØ (kb/s)	NRZ (kb/s)
Wide-Band		Double-Density				
6096.0	(240)	3048.0	(120)	1800	900	1800
3048.0	(120)	1524.0	(60)	900	450	900
1524.0	(60)	762.0	(30)	450	225	450
762.0	(30)	381.0	(15)	225	112	225
381.0	(15)	109.5	(7-1/2)	112	56	112
190.0	(7-1/2)	95.2	(3-3/4)	56	28	56
95.2	(3-3/4)	---	---	28	14	28
47.6	(1-7/8)	---	---	14	7	14

6.11.4.1 PCM Codes. The recommended codes for serial high density PCM recording are bi-phase level (BiØ-L) and randomized non return to zero-level (RNRZ-L). The maximum recommended bit packing densities are 590 b/mm (15 kb/in.) for BiØ-L and 980 b/mm (25 kb/in.) for RNRZ-L. Refer to table 6-9 for maximum recommended bit rates versus standard tape speeds. The minimum recommended reproduce bit rates are 5 kb/s for BiØ-L and 200 kb/s for RNRZ-L. Details of the implementation are discussed in paragraph 3.0, appendix D.

6.11.4.2 BiØ-L Code. The BiØ-L code is recommended for direct recording under the following conditions: the bit rate of the data to be recorded does not exceed the maximum bit rates for BiØ-L (see table 6-9), and the amount of tape required for mission recording by this method is not a severe operational constraint.

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[1]Direct recording of NRZ signals is NOT recommended unless the signal format is carefully designed to eliminate low-frequency components for any data expected.

TABLE 6-9. MAXIMUM RECOMMENDED BIT RATES

Tape Speed					
m/s	(ips)	mm/s	(ips)	BiØ-L (kb/s)	RNRZ-L (kb/s)
Wide-Band		Double-Density			
6096.0	(240)	3048.0	(120)	3600	6000
3048.0	(120)	1524.0	(60)	1800	3000
1524.0	(60)	762.0	(30)	900	1500
762.0	(30)	381.0	(15)	450	750
381.0	(15)	190.5	(7-1/2)	225	375
190.5	(7-1/2)	95.2	(3-3/4)	112	187[1]
95.2	(3-3/4)	---	---	56	93[1]
47.6	(1-7/8)	---	---	28	46[1]

6.11.4.3 RNRZ-L Code. The RNRZ-L code is recommended for direct recording under any of the following conditions: the bit rate of the data to be recorded exceeds the maximum recommended bit rates for BiØ-L (see table 6-9) or maximum tape recording time is needed.

6.11.4.3.1 To minimize baseline wander anomalies, RNRZ-L is NOT recommended if the reproduced bit rate is less than 200 kb/s.

6.11.4.3.2 The RNRZ-L shall be implemented using a 15-stage shift register and modulo-2 adders (see figure 6-5). The randomized bit stream to be recorded is generated by adding (modulo-2) the input bit stream to the modulo-2 sum of the outputs of the 14th and 15th stages of the shift register. In the decoder, the randomized bit stream is the input to the shift register (see figure 6-5).

6.11.4.4 Record Parameters. The record parameters are explained in the following subparagraphs.

6.11.4.4.1 High-density PCM data shall be recorded in compliance with the direct record parameters detailed in subparagraph 6.8.1 including the use of an ac bias signal level which produces the required 2 dB overbias condition.

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[1]Reproducing data at bit rates less than 200 kb/s is not recommended when using RNRZ-L (see appendix D for details).

6.11.4.4.2 The peak-to-peak level of the PCM input signal shall be equal to twice the rms value of the signal amplitude used to establish the standard record level with a tolerance of ±25 percent (see subparagraph 6.8.2).

6.11.4.4.3 The signal to be recorded must be bi-level. Bi-level signals are signals where only two levels are present. Therefore, signals containing noise must be converted to bi-level signals before they are recorded.

6.11.4.4.4 To minimize the effects of tape dropouts, serial high-density digital data should not be recorded on the edge tracks of the tape.

6.11.4.5 Reproduce Parameters. All reproduce parameters in subparagraph 6.8.3 shall apply.

6.11.4.5.1 PCM Signature. A PCM signature should be recorded before or after or both before and after the data to provide a method for adjusting the reproduce head azimuth and the reproducer equalizers. The data rate of the PCM signature should be the same as the rate of the data to be recorded (see paragraph 7.0, appendix D for tape signature recording).

6.11.4.5.2 Phase Equalizer. Correct phase equalization is very important to the reconstruction of the serial high-density digital data. Adjustable phase equalizers are desirable but not mandatory.

6.11.4.6 Magnetic Tape. High-density digital (HDD) magnetic tapes are recommended; however, wide-band instrumentation tapes can be used on recorder and reproducer systems with 1.27 mm (0.050 in.) track widths (see chapter 7).

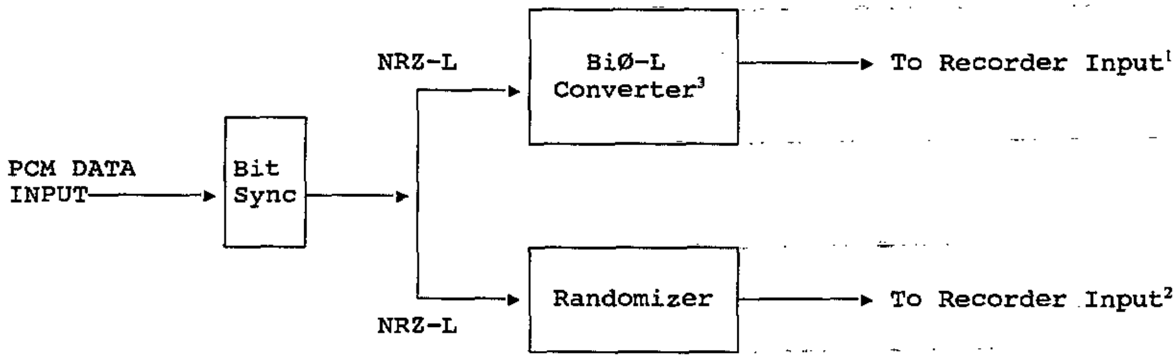
6.11.4.7 Tape Copying. The following practices are recommended when making copies of original data tapes.

6.11.4.7.1 Convert data reproduced from the original tape to a bi-level signal prior to recording a copy.

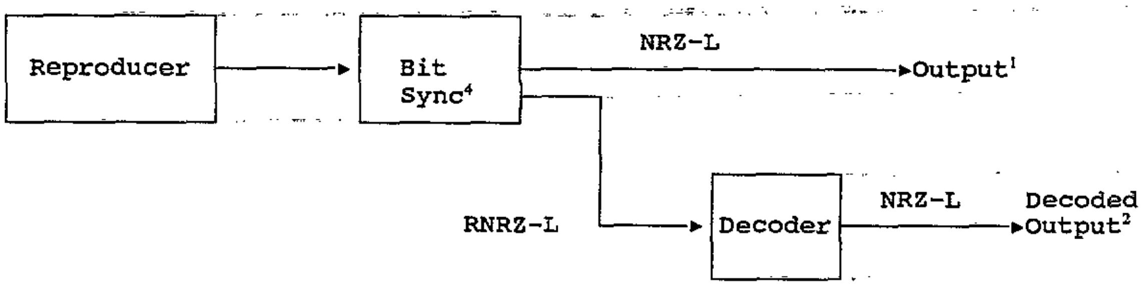
6.11.4.7.2 Align reproduce head azimuth to original tape.

6.11.4.7.3 Adjust reproducer equalizers correctly.

6.11.4.7.4 Prior to recording the copy, use the recorded PCM signature to optimize the quality of the reproduced data.



(See figure D-2, appendix D.)



(See figure D-3, appendix D.)

[1]When BiØ-L is recorded.

[2]When RNRZ-L is recorded.

[3]The BiØ-L converter may be an integral part of the Bit Sync.

[4]Bit Sync input code selector set to NRZ-L if RNRZ-L is recorded or to BiØ-L if BiØ-L is recorded.

Figure 6-5. Serial high density digital record and reproduce.

6.11.4.8 PCM Bit Synchronizer. The PCM bit synchronizer should contain circuitry to reestablish the baseline reference PCM signal (a dc restorer circuit). This circuit is essential when reproducing RNRZ-L at reproduced bit rates less than 1 Mb/s. The PCM bit synchronizer loop bandwidth should be selected for optimum performance between 0.1 and 3 percent of the bit rate.

NOTE
If an appropriate PCM bit synchronizer is not available, the tape can be copied directly; however, the SNR will be decreased.

6.12 Preamble Recording for Automatic or Manual Recorder Alignment

A preamble (or postamble) may be recorded on the same tape as the data signal with known frequency and amplitude elements which will allow automatic or manual alignment of the signal electronics to optimize the performance of the playback system. Reproduce azimuth, equalization, and FM demodulator sensitivity may be adjusted at all available tape speeds. The preamble may be used for manual adjustment of any instrumentation magnetic tape recorder/reproducer (wide-band and double-density). Automatic adjustment requires a recorder/reproducer specifically designed with the capability to automatically adjust one or more of the following: reproduce-head azimuth, amplitude equalization, phase equalization, and FM demodulator sensitivity. The signal source may be internal to the recorder or may be externally generated.

6.12.1 Alignment, Direct Electronics. Direct electronics shall use a 1/11 band edge square wave for both manual and automatic alignment as given in appendix D.

6.12.2 Alignment, FM Electronics. The FM electronics shall use a 1/11 band edge square wave and ±1.414 Vdc or 0.05 Hz square wave for both manual and automatic alignment as given in appendix D.

6.13 19 mm Digital Cassette Helical Scan Recording Standards

These standards are for single-channel high-bit rate helical-scan digital recorders using 19 mm tape cassettes. Bit rates of less than 10 megabits per second to 256 megabits per second or greater may be recorded and reproduced by equipment conforming to these standards. Interchange parties must, however, determine the availability at a particular site of the equipment required to meet particular data recording requirements. Compatibility between the recording device and the expected playback equipment must also be considered.

6.13.1 Track Format. The format recorded and reproduced by these systems shall be as specified in American National Standard For Information Systems 19 mm Type ID-1 Recorded Instrumentation-Digital Tape Format, ANSI X3.175-1990[1]. Helical tracks employ azimuth recording wherein the head gap angle with respect to the recorded track center line is $90° + 15°$ for one scan and $90° - 15°$ for the adjacent scan. (See subparagraph 4.9.2 of standard X3.175-1990). Figure 6-6 and table 6-10 show details of the helical tracks and auxiliary longitudinal tracks for control, timing, and annotation in the ID-1 format.

6.13.2 Tape and Cassettes. The following subparagraphs describe magnetic tape and 19 mm cassettes.

6.13.2.1 Magnetic Tape. The magnetic tape shall meet the requirements for 850 Oersted class (68,000 A/M) magnetic tape in accordance with document SMPTE 225M[2]. Tape base thickness of 16 μm is normally employed.

6.13.2.2 19 mm Cassettes. Recorder/reproducers shall be capable of using 19 mm cassettes that conform to the physical dimensions of medium or large cassettes as defined in SMPTE 226M[2]. [Medium cassette 254 (10 in.) x 150 (5.9 in.) x 33 (1.299 in.); large cassette 366 (14.4 in.) x 206 (8.11 in.) x 33 (1.299 in.)]. Table 6-11 shows tape capacities of the two cassette sizes and indicates the amount of time available for recording, assuming a data input rate of 240 megabits per second.

6.13.3 Recorder/Reproducer Input and Output. Data input and clock are required. The data input shall be in an 8-bit parallel, byte serial format, and the clock signal will be at the required byte rate. Data output will also be in 8-bit parallel format.

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[1]ANSI X3.175-1990. Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

[2]SMPTE 225M and SMPTE 226M. Available from the Society of Motion Picture and Television Engineers, 595 West Hartsdale Avenue, White Plains, NY 10607.

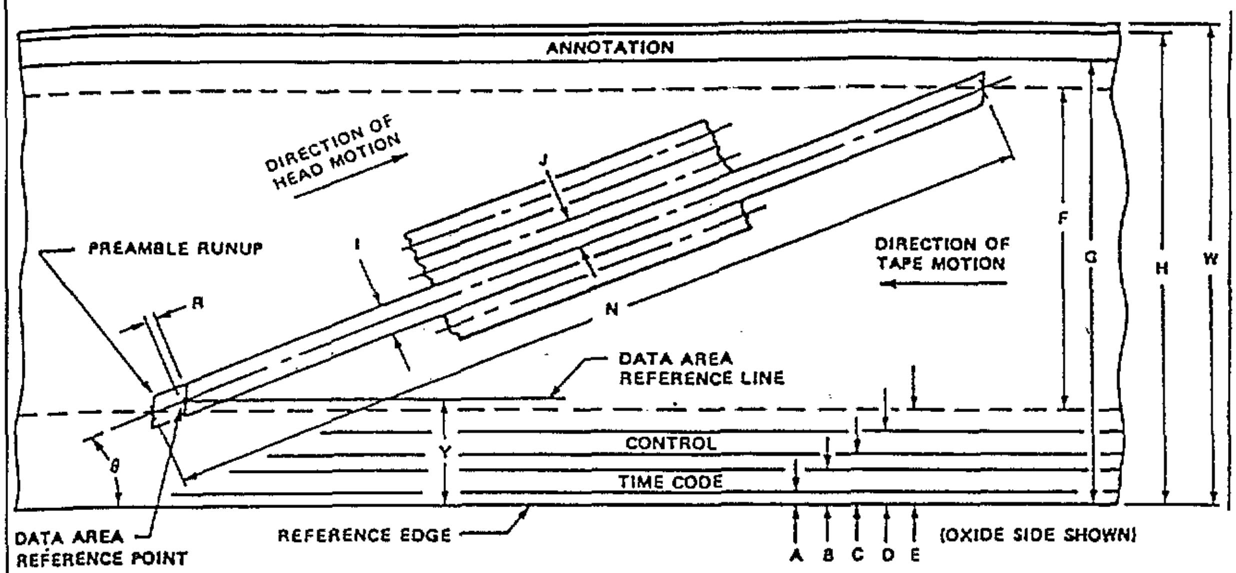

Figure 6-6. Location and dimensions of recorded tracks.

TABLE 6-10. RECORD LOCATION AND DIMENSIONS			
	DIMENSIONS	NOMINALS	
A	TIME-CODE TRACK LOWER EDGE	0.2	mm
B	TIME-CODE TRACK UPPER EDGE	0.7	mm
C	CONTROL TRACK LOWER EDGE	1.0	mm
D	CONTROL TRACK UPPER EDGE	1.5	mm
E	DATA-AREA LOWER EDGE	1.8	mm
F	DATA-AREA WIDTH	16	mm
G	ANNOTATION TRACK LOWER EDGE	18.1	mm
H	ANNOTATION TRACK UPPER EDGE	18.8	mm
I	HELICAL TRACK WIDTH	0.045	mm
J	TRACK PITCH, BASIC	0.045	mm
N	HELICAL TRACK TOTAL LENGTH	170	mm
P	ANNOTATION/TIME-CODE HEAD LOCATION	118.7	mm
R	SECTOR RECORDING TOLERANCE	±0.1	mm
T	CONTROL TRACK SYNC TOLERANCE	±0.1	mm
θ	TRACK ANGLE, ARC-SINE (16/170)	5.4005°	
W	TAPE WIDTH	19.01	mm
Y	DATA-AREA REFERENCE LINE, BASIC	1.8075	mm

TABLE 6-11. TAPE LENGTH AND NOMINAL PLAY RECORD/REPRODUCE TIME AT 240 MEGABITS/SECOND USER DATA RATE			
CASSETTE	TAPE THICKNESS (MICROMETERS)	TAPE LENGTH (METERS)	PLAY TIME (MINUTES)
MEDIUM	16	587	24
LARGE	16	1311	55
CASSETTE DIMENSIONS, NOMINAL			
CASSETTE	LENGTH	WIDTH	THICKNESS
MEDIUM	254 mm	150 mm	33 mm
LARGE	366 mm	206 mm	33 mm

6.14 Multiplex/Demultiplex (MUX/DEMUX) Standards for Multiple Data Channel Recording on Single-Channel, High-Bit Rate Digital Recording/Reproducer Systems

For recording and reproducing multiple channels having bit rates lower than that available in a single-channel high-bit rate recorder, the ADARIO multiplex/demultiplex format is recommended. The ADARIO (Analog/Digital/Adaptable/Recorder Input/Output) format was developed for the Department of Defense, Fort Meade, Maryland. The format is government-owned and may, therefore, be used in equipment provided for government activities. Some of the features of ADARIO are

- requires less than 3 percent overhead to be added to user data;
- accommodates multiple channel record/playback with each channel completely autonomous in sample rate and sample width;
- stores all the necessary parameters for channel data reconstruction for either real-time playback, time-scaled playback, or computer processing;
- preserves phase coherence between data channels;
- provides channel source and timing information; and
- accommodates 2^{24} (over 16 million) blocks of data, each block having 2048 24-bit words (see figure 6-7).

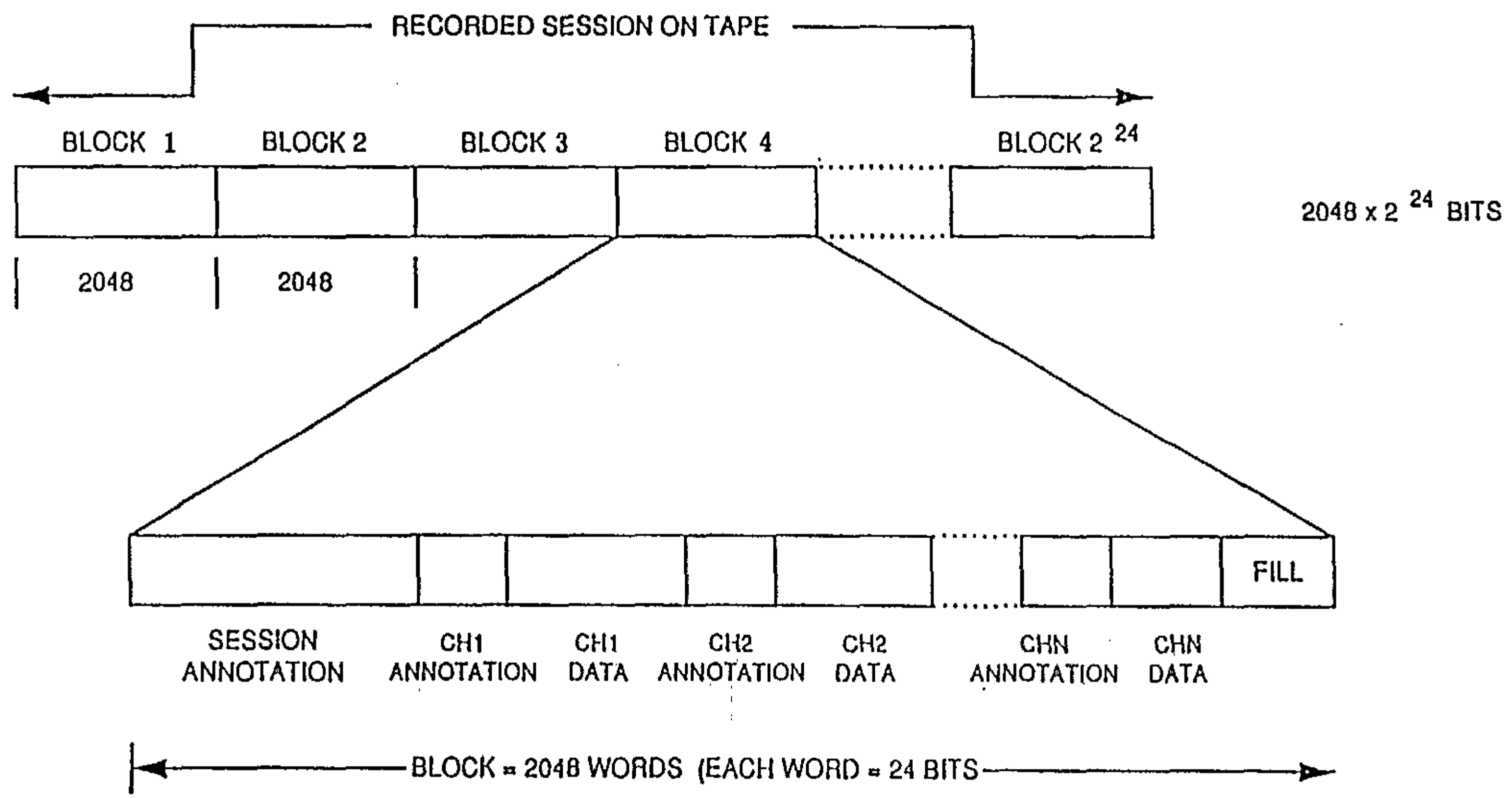

Figure 6-7. ADARIO block format.

6.14.1 Input/Output. The ADARIO format will accept up to 16 channels of asynchronous data with individual clocks. For systems using those standards, data input bit rates from 10 000 bits per second to 35 megabits per second per channel will be accommodated. Data shall be in NRZ-L format at transistor-transistor logic levels. The multiplexed output bit rate cannot exceed the maximum bit rate of the recorder being used. Output of the multiplexer will be 8-bit byte serial. Clock output shall be at the byte rate phased at 0° with respect to the data output.

6.14.2 Block Format on Tape. Figure 6-7 shows the ADARIO block format, while figure 6-8 shows the ADARIO data format. Data format field definitions appear in appendix G. Figure G-3 is a diagram of ADARIO timing parameters.

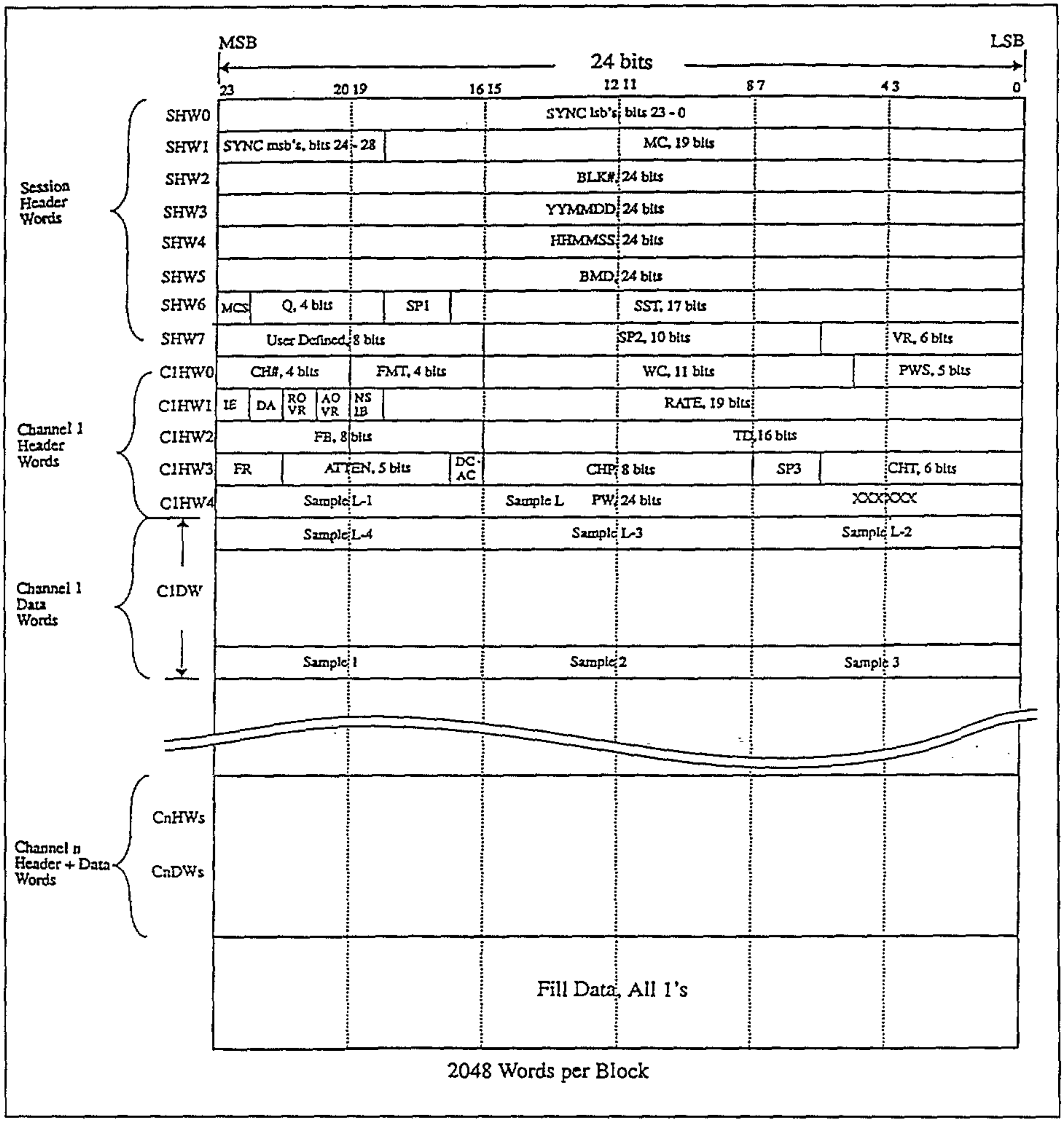

Figure 6-8. ADARIO data format.

CHAPTER 7

MAGNETIC TAPE STANDARDS

7.1 General

These standards define terminology, establish key performance criteria, and reference test procedures for longitudinally-oriented oxide, unrecorded magnetic tape designed for instrumentation recording[1]. Classes of tapes include High Resolution (HR) tapes used for wide-band recording, High Density Digital (HDD) tapes used for high-density digital PCM recording, and High Energy (HE) tapes used for double-density recording. Coercivities of HR and HDD tapes are in the range of 275 to 350 oersteds. High energy tapes have coercivities of 600 to 800 oersteds. Nominal base thickness is 25.4 μm (1.0 mil) and nominal coating thickness is 5 μm (200 microinches) for all tapes. Where required, limits are specified to standardize configurations and to establish the basic handling characteristics of the tape. Limits placed on the remaining requirements must be determined by the tape user in light of the intended application and interchangeability requirements imposed on the tape (see table 7-4 for examples of suggested requirement limits).

7.2 Definitions

Underlined terms appearing within definitions indicate that these terms are defined elsewhere in paragraph 7.2. For the purpose of this standard, the following definitions apply.

7.2.1 Back Coating. A thin coating of conductive material (for example, carbon) bonded to the surface of a magnetic tape opposite the magnetic-coated surface for reducing electrostatic charge accumulation and for enhancing high-speed winding uniformity. Resistivity of the back coating should be 1 megohm per square or less, whereas the oxide-coated magnetic surface resistivity is much higher (also see magnetic oxide coating).

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[1]Federal Specifications W-T-001553[SH] and W-R-175 may be used to replace paragraphs contained in this chapter where applicable. High output and HDD tapes are not included in the Federal Specifications. Other standards are referenced in paragraph 1.0, appendix D.

7.2.2 Base. The material on which the magnetic oxide coating (and back coating, if employed) is applied in the manufacture of magnetic tapes. For most applications, polyester-base materials are currently employed.

TABLE 7-1. TAPE DIMENSIONS

Tape Width	millimeters	inches
	25.4 +0 -0.10	1.000 +0 -0.004

Tape Thickness	millimeters	inches	
Base Material	0.025	0.0010	Nominal[1]
Oxide Thickness	0.005	0.0002	Nominal

Tape Length by Reel Diameters (reels with 76 mm (3 in.) center hole)

Reel Diameter	Nominal Tape Length[2]	Minimum True Length[3]
266 mm (10.5 in.)	1100 m (3600 ft)	1105 m (3625 ft)
" " " "	1400 m (4600 ft)	1410 m (4625 ft)
356 mm (14.0 in.)	2200 m (7200 ft)	2204 m (7230 ft)
" " " "	2800 m (9200 ft)	2815 m (9235 ft)
381 mm (15.0 in.)	3290 m (10 800 ft)	3303 m (10 835 ft)
408 mm (16.0 in.)	3800 m (12 500 ft)	3822 m (12 540 ft)

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[1]Actual tape base material thickness slightly less because of manufacturing conventions.

[2]Original dimensions are in feet. Metric conversions are rounded for convenience.

[3]Tape-to-flange radial clearance (E-value) is 3.18 mm (0.125 in.).

7.2.3 Bias Level. The level of high frequency ac bias current or voltage in a direct-record system needed to produce a specified level of an upper band edge (UBE) frequency sine-wave signal at a particular tape speed. Usually adjusted to produce maximum output or increased beyond maximum to depress the output 2 dB.

7.2.4 Bi-Directional. Ability of a magnetic tape to record and to reproduce a specified range of signals within specified tolerances of various characteristics when either end of the tape on the reel is used as the leading end.

7.2.5 Binder. Material in which the magnetic oxide particles or back-coating particles are mixed to bond them to the base material.

7.2.6 Blocking. Failure of the magnetic coating to adhere to the base material because of layer-to-layer adhesion in a wound tape pack.

7.2.7 Center Tracks. On a recorded tape, center tracks are those which are more than one track distance from either edge of the tape, for example, tracks 2 through 13 of a 14-track tape or tracks 2 through 27 of a 28-track tape.

7.2.8 Dropout. A reproduced signal of abnormally low amplitude caused by tape imperfections severe enough to produce a data error. In digital systems, dropouts produce bit errors.

7.2.9 Edge Tracks. The data tracks nearest the two edges of a recorded magnetic tape, for example, tracks 1 and 14 of a 14-track tape.

7.2.10 Erasure. Removal of signals recorded on a magnetic tape to allow reuse of the tape or to prevent access to sensitive or classified data. Instrumentation recorders and reproducers do not usually have erase heads, so bulk erasers or degaussers must be employed.

7.2.11 E-Value. The radial distance by which the reel flanges extend beyond the outermost layer of tape wound on a reel under a tape tension of 3.33 to 5.56 newtons (12 to 20 ounces of force) per inch of tape width. Inadequate E-value may prohibit the use of protective reel bands.

7.2.12 High-Density Digital Magnetic Tape. Instrumentation magnetic tape with nominal base thickness of 25.40 μm (1 mil) and coercivity of 275 to 350 oersteds used to record and reproduce high-density digital (PCM) signals with per-track bit densities of 590 b/mm (15 kb/in.) or greater.

7.2.13 High-Energy Magnetic Tape. Magnetic tapes having coercivity of 600 to 800 oersteds and nominal base thickness of 25.40 μm (1 mil) used for double-density analog recording and high-density digital recording above 980 b/mm (25 kb/in.).

7.2.14 High-Resolution Magnetic Tape. Instrumentation magnetic tape used for recording on wide-band recorder and reproducer systems. The HR and HDD tapes may have identical coatings and coercivities (275 to 350 oersteds) but differ in the extent and type of testing conducted by the manufacturer.

7.2.15 Layer-to-Layer Signal Transfer (Print Through). Transfer of a signal to a layer of a wound magnetic tape originating from a signal recorded on an adjacent layer of tape on the same reel. Saturation-level recorded signals and tape storage at elevated temperatures are likely contributors to this effect.

7.2.16 Magnetic Oxide Coating. Material applied to a base material to form a magnetic tape. The magnetic oxide coating contains the oxide particles, the binder and other plasticizing and lubricating materials necessary for satisfactory operation of the magnetic tape system (also see back coating).

7.2.17 Manufacturer's Centerline Tape. A tape selected by the manufacturer from his production, where the electrical and physical characteristics are employed as reference standards for all production tapes to be delivered during a particular contractual period. Electrical characteristics include, but are not limited to, bias level, record level, output at 0.1 UBE, and wavelength response. The MCTs are not usually available for procuring agency use.

7.2.18 Manufacturer's Secondary Centerline Tape. A tape selected by a manufacturer from his production and provided in lieu of an MCT. On the MSCT, the electrical characteristics may depart from the MCT characteristics, but calibration data referenced in the MCT are provided. All other characteristics of the MSCT are representative of the manufacturer's product.

7.2.19 Modulation Noise. Noise riding on a reproduced signal that is proportional to the amplitude of the recorded signal (below saturation) and results from tape-coating irregularities in particle size, orientation, coercivity, and dispersion.

7.2.20 Record Level. The level of record current or voltage required to achieve a specified reproduce output level with bias level previously set to the correct value. In direct record systems, standard record level is the level of a 0.1 UBE frequency signal required to produce 1 percent third harmonic distortion in the reproduced output signal because of tape saturation.

7.2.21 Scatterwind. Lateral displacements of tape wound on a reel which gives an irregular appearance to the side surfaces of a tape pack. Scatterwind can result from such things as poorly controlled tape tension, guiding, static electrical charge, and poor tape slitting.

7.2.22 Shedding. Loss of magnetic coating from tape during operation on a tape transport. Excessive shedding causes excessive dropout.

7.2.23 Short Wavelength Output Uniformity. A measure of high-frequency reproduce signal amplitude uniformity caused by oxide coating variations.

7.2.24 Upper Band Edge. The highest frequency that can be recorded and reproduced at a particular tape speed in the direct record mode. The UBE signals are used in setting bias level; 0.1 UBE signals are used to set record level.

7.2.25 Wavelength Response. The record and reproduce characteristic of a magnetic tape which depends on tape formulation, coating thickness, and other tape physical parameters and is a function of the wavelength recorded on the tape (tape speed divided by signal frequency) rather than the actual frequency recorded.

7.2.26 Working Length. Length of tape usable for reliable recording and reproduction of data. Actual tape length on a reel exceeds the working length to provide for tape start and stop at each end of the reel without loss of data.

7.2.27 Working Reference Tape. A tape or tapes of the same type as an MCT or MSCT selected by the user and calibrated to the MCT or MSCT. The working reference tapes (WRT) are employed in conducting tests on tape types during a procurement activity and for aligning and testing recorder and reproducer systems to minimize running the MCT or MSCT.

7.3 General Requirements for Standard Tapes and Reels

The following subparagraphs describe the requirements for tapes and reels.

7.3.1 Reference Tape System. To establish a set of test procedures which can be performed independently and repeatably on different manufacturers' tape transports, a centerline reference tape system employing Manufacturer's Centerline Tapes (MCT), Manufacturer's Secondary Centerline Tapes (MSCT) or Working Reference Tapes (WRT) as required, should be used. The reference tape system provides a centerline tape against which tape or tape recorder specifications may be tested or standard tapes for aligning operational recorders.

7.3.1.1 Manufacturer's Centerline Tape. The electrical characteristics provided for a manufacturer's centerline tape include, but are not limited to, bias level, record level, wavelength response, and output at 0.1 UBE wavelength. The physical characteristics of the MCT shall also represent the manufacturer's production and shall be representative of all production tape delivered during any resultant contractual period (see subparagraph 7.2.17).

7.3.1.2 Manufacturer's Secondary Centerline Tape. On the MSCT, the electrical characteristics are calibrated to the manufacturer's reference tape, and calibration data are supplied with the MSCT. The physical characteristics of the MSCT shall represent the manufacturer's production (see subparagraph 7.2.18).

7.3.1.3 Working Reference Tape. Working reference tapes shall be of the same type as those under procurement or test and shall be used in place of a MCT or MSCT for all applicable test procedures (see subparagraph 7.2.28).

NOTE

The MCT or MSCT shall be a full-length tape of 25.4 mm (1 in.) width, wound on a 266.7 mm (10 1/2 in.) or 355.6 mm (14 in.) reel or as designated by the tape user. The center one-third of the working tape length shall be used as the calibrated working area.

7.3.1.4 Test Recorder and Reproducer. A laboratory-quality test recorder shall be designated for use with the reference tape system during any magnetic tape procurement and test program. The recorder selected shall meet the requirements in chapter 6.

7.3.1.5 MCT/MSCT/WRT Use. Using the MCT or MSCT as a reference, the tape user performs all tests necessary to determine if the manufacturer's centerline performance values meet operational and recorder requirements. All acceptable centerline tapes are retained by the tape user as references in subsequent acceptance test procedures performed in support of resultant contracts or contractual periods. A working reference tape, which has been calibrated to an MCT or MSCT, is used as the actual working reference in the applicable testing procedures outlined in volume III, RCC document 118-XX. Dropout tests should use a tape other than the MSCT or WRT.

7.3.2 Marking and Identifying. See Federal Specification W-T-01553[SH].

7.3.3 Packaging. Specified by user.

7.3.4 Winding. The tape shall be wound on the reel or hub with the oxide surface facing toward the hub ("A" wind). The front of the wound reel is defined as that flange visible when viewing the tape reel with the loose end of the tape hanging from the viewer's right.

7.3.5 Reels and Hubs. Reels and hubs shall conform to the tape user specified requirements of Federal Specification W-R-175 (also see appendix D).

7.3.6 Radial Clearance (E-Value). For all tape lengths use 3.175 mm (0.125 in.) (see subparagraph 7.2.11).

7.3.7 Flammable Materials. Flammable materials shall not be a part of the magnetic tape. Flammable materials will ignite from a match flame and will continue to burn in a still carbon dioxide atmosphere.

7.3.8 Toxic Compounds. Compounds which produce toxic effects in the environmental conditions normally encountered under operating and storing conditions as defined in subparagraph 7.4.2 shall not be part of the magnetic tape. Toxicity is defined as the property of the material which has the ability to do chemical damage to the human body. Highly toxic or corrosive compounds produced under conditions of extreme heat shall be identified and described by the manufacturer.

7.4 General Characteristics of Tapes and Reels

The following subparagraphs describe the general characteristics for tapes and reels.

7.4.1 Dimensional Specifications. Magnetic tape shall be supplied on flanged reels in the standard lengths, widths, and base thicknesses outlined in table 7-1. Reel and hub diameters are taken from Federal Specification W-R-175.

7.4.2 Environmental Conditions. The tape shall be able to withstand, with no physical damage or performance degradation, any natural combination of operating or nonoperating conditions as defined next in subparagraphs 7.4.2.1 and 7.4.2.2.

7.4.2.1 Tape Storing Conditions. Magnetic tape is subject to deterioration at temperature and humidity extremes. In some cases the damage is reversible, but irreversible damage may occur, especially with long-term storage in unfavorable conditions.

7.4.2.2 Operating Environment. Recommended limits:

Condition	**Range**
Temperature:	4 to 30 °C (40 to 85 °F)
Humidity:	20 to 60 percent relative humidity (RH) noncondensing
Pressure:	Normal ground or aircraft operating altitude pressures. For very high altitudes, tape users should consult with manufacturers to determine if tape and recorder compatibility is affected by low atmospheric pressure.

NOTE

(1) Binder/oxide system tends to become sticky and unusable above 50 °C (125 °F).

(2) At low humidities, tape binder and oxide system tend to dry out, and oxide and binder adhesion can be unsatisfactory. Brown stains on heads may appear below 40 percent RH.

(3) At high humidities, abrasivity is increased and other performance problems may arise.

7.4.2.3 Nonoperating Environment. Temperature and Relative Humidity.

Short Term - 0 to 45 °C (32 to 115 °F) and 10 to 70 percent RH noncondensing

Long Term - 1 to 30 °C (33 to 85 °F) and 30 to 60 percent RH noncondensing

NOTE

Experience has shown that with long exposure to temperatures below freezing, lubricants, and plasticizers tend to migrate out of the oxide coating resulting in poor lubrication and gummy surface deposits.

7.4.3 Other Characteristics. Storage life, bi-directional performance, frictional vibration, and scatterwind characteristics shall conform to Federal Specification W-T-001553[SH] unless otherwise specified by the tape user at the time of purchase.

7.5 Physical Characteristics of Tapes and Reels

As specified in Federal Specification W-T-001553[SH] and W-R-175.

7.6 Magnetic and Electrical Characteristics

The following subparagraphs describe required magnetic and electrical tape characteristics.

7.6.1 Bias Level. The bias level (see subparagraph 7.2.3) required by the magnetic tape shall not differ from the bias level requirements of the reference tape by more than the amount specified by the tape user. The test procedure outlined in subparagraph 7.3.1, Bias Level, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.2 Record Level. The record level (see subparagraph 7.2.20) required by the magnetic tape shall not differ from the record level requirements of the reference tape by more than the amount specified by the tape user. The test procedure outlined in subparagraph 7.3.2, Record Level, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.3 Wavelength Response. The output of the magnetic tape, measured at the wavelength values listed in table 7-2, Measurement Wavelengths, shall not differ from the output of the reference tape by more than the amounts specified by the tape user. Wavelength response requirements shall be specified in terms of output after having normalized the output to zero decibels at the 0.1 UBE wavelength. The test procedure outlined in subparagraph 7.3.3, Wavelength Response and Output at 0.1 Upper Band Edge Wavelength, volume III of RCC document 118-XX shall be used to determine compliance with this requirement (see table 7-4A, Suggested Wavelength Response Requirements).

TABLE 7-2. MEASUREMENT WAVELENGTHS

High-Resolution and HDD Tape		High-Energy Tape	
μm	(mils)	μm	(mils)
3810.00	(150.000)	254.00	(10.000)
254.00	(10.000)	25.40	(1.000)
25.40	(1.000)	12.70	(0.500)
6.35	(0.250)	6.35	(0.250)
3.18	(0.125)	3.18	(0.125)
2.54	(0.100)	2.54	(0.100)
2.03	(0.080)	1.52	(0.060)
1.52	(0.060)	1.02	(0.040)
		0.76	(0.030)

7.6.4 Output at 0.1 UBE Wavelength. The wavelength output of the magnetic tape shall not differ from the 0.1 UBE wavelength of the reference tape by more than the amount specified by the tape user. The test procedure outlined in subparagraph 7.3.3, Wavelength Response and Output at 0.1 Upper Band Edge Wavelength, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.5 Short Wavelength Output Uniformity. The short wavelength output of the magnetic tape shall be sufficiently uniform that a signal recorded and reproduced throughout the working tape length in either direction of longitudinal tape motion shall remain free from long-term amplitude variation to the extent specified by the tape user. The test procedure outlined in subparagraph 7.3.4, Short Wavelength Output Uniformity, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.6 Dropouts. The instantaneous nonuniformity (dropout) output of a recorded signal, caused by the magnetic tape, shall not exceed the center-track and edge-track limits specified by the tape user on the basis of dropouts per 30.48 m (100 ft.) of nominal working tape length. The nominal dropout count shall be determined by totaling all the dropouts per track over the working tape length and dividing by the total number of 30.48 m (100 ft.) intervals tested.

A second method of specifying the allowable dropout count is to specify the maximum number per track for each 30.48 m (100 ft.) interval tested. This method may be preferred if critical data is recorded in specific areas of the working tape length, but a specified number of dropouts per hundred feet greater than the average values may be expected.

NOTE

Dropout test results are very dependent on the tape transport used for the test and will vary from run to run on a given transport. Edge tracks tend to contain more dropouts than the center tracks, and more dropouts are allowed on the edge tracks. Refer to table 7-4.

7.6.6.1 For High Resolution (HR) tapes, a dropout is defined as a 6 dB reduction in amplitude for a period of 5 microseconds or more of a 1 MHz sine-wave signal recorded and reproduced at a tape speed of 3048 mm/s (120 ips). Signal losses of 6 dB or more which exceed the 5 microsecond time period shall constitute a dropout count for each 5 microsecond time period occurring in the given signal loss. Track definitions are given in subparagraphs 7.2.7 and 7.2.9. The test procedure outlined in subparagraph 7.1.3.3, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.6.2 For High Density Digital (HDD) tapes, a dropout is defined as a 12 dB or greater reduction in amplitude for a period of 1 microsecond or more of a square-wave test signal of maximum density recorded and reproduced at 3048 mm/s or 1524 mm/s (120 ips or 60 ips). On at least every other track (7 tracks) of the odd head of a 28-track head assembly (alternatively, every other track of the even head) record and reproduce a square-wave test signal of 2 MHz at 3048 mm/s (120 ips) or 1 MHz at 1524 mm/s (60 ips). The record level shall be set slightly above saturation by adjusting the record current to produce maximum reproduce output and increasing the record current until the output signal is reduced to 90 percent of maximum. For playback, a reproduce amplifier and a threshold detector shall be used. The signal-to-noise ratio of the test signal at the input to the threshold detector shall be at least 25 dB, and the detector shall detect any signal loss of 12 dB or more below reference level. The reference level shall be established by averaging the test signal output level over a 10 m (30.8 ft.) nominal tape length in the vicinity of a dropout.

7.6.6.3 For each of the seven tracks tested, the accumulated duration in microseconds of detected dropout events shall be displayed and used to directly display the dropout rate for each track scaled appropriately for the tape working length. Signal losses of 12 dB or more which exceed the 1 microsecond time period shall constitute a dropout count for each microsecond time period occurring in the given signal loss.

7.6.6.4 For high-energy tapes, a dropout is defined as for high-resolution tapes except that a 1 MHz signal is recorded and reproduced at 1524 mm/s (60 ips).

7.6.7 Durability. The magnetic tape shall resist deterioration in magnetic and electrical performance because of wear to the coating surface. Signal losses, as defined below, caused by surface wear shall not occur in excess of the per-pass limits specified in table 7-3 for the first 35 passes.

Signal losses in excess of those limits specified above shall not occur during either a record, record and reproduce or uninterrupted reproduce pass of the working tape length. Signal loss is a reduction in signal amplitude of 3 dB or greater for a time period of 3 through 10 seconds of a recorded and reproduced short wavelength signal. Where a continuous loss of signal of 3 dB or greater exceeds the 10 second time period, a signal loss count shall be required for every sequential 10 second time period occurring in the given signal loss. The test procedure outlined in subparagraph 7.3.6, Durability, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

TABLE 7-3. DURABILITY SIGNAL LOSSES

Designated Tape Length		Number of Allowable Signal Losses (per pass)
meters	feet	
762	(2500)	2
1097	(3600)	2
1402	(4600)	2
1524	(5000)	2
2195	(7200)	3
2804	(9200)	3
3292	(10 800)	4

7.6.8 Modulation Noise. The amplitude modulation superimposed upon a recorded and reproduced signal by the magnetic tape shall not exceed the limits specified by the tape user. The test procedure outlined in subparagraph 7.3.7, Modulation Noise, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.9 Layer-to-Layer Signal Transfer. A signal resulting from layer-to-layer signal transfer shall be reduced in amplitude from the original signal a minimum of 40 dB for 25.4 μm (1.0 mil) tape and 46 dB for 38.1 μm (1.5 mils) tape. The test procedure outlined in subparagraph 7.3.8, Layer-to-Layer Signal Transfer, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.10 Erasure Ease. For HR and HDDR tapes, an erase field of 79.58 kA/M (1000 oersteds) shall effect at least a 60 dB reduction in output amplitude of a previously recorded 25.4 μm (1.0 mil) wavelength signal. For HE tapes, an erase field of 160 kA/m (2000 oersteds) shall effect at least a 60 dB reduction of a previously recorded 25.4 μm (1.0 mil) wavelength signal. The test procedure outlined in subparagraph 7.3.9, Ease of Erasure, volume III of RCC document 118-XX shall be used to determine compliance with this requirement.

7.6.11 Suggested Tape Requirement Limits. Table 7-4 lists some suggested limits to be used for instrumentation tape.

TABLE 7-4. SUGGESTED TAPE REQUIREMENT LIMITS

Par. No.	Tape Requirement	Suggested Limits		
7.6.1	Bias Level	±2.0 dB from MCT		
7.6.2	Record Level	±2.0 dB from MCT		
7.6.3	Wavelength Response (See table 7-4A.)			
7.6.4	Output at 0.1 UBE Wavelength	1.5 dB from MCT		
7.6.5	Short Wavelength Output Uniformity	HR Tape		HE Tape
		2.5 dB		2.5 dB
7.6.6	Dropouts per 30 m (100 ft) (average)	Center Tracks		Edge Tracks
		5	HR Tape	10
		1	HDD Tape	1
		20	HE Tape	30
7.6.7	Durability (See table 7-3.)			
7.6.8	Modulation Noise	1 dB maximum		

TABLE 7-4A. SUGGESTED WAVELENGTH RESPONSE REQUIREMENTS

HR AND HDD TAPE

Measurement Wavelength µm	Measurement Wavelength mils	HR Response (dB)	HDD Response (dB)
3810.00	(150.000)	1.00	2.00
254.00	(10.000)	1.00	1.00
15.14	(0.600)	0.00	0.00
6.35	(0.250)	1.50	1.50
3.18	(0.125)	2.00	2.00
2.54	(0.100)	2.50	2.50
2.03	(0.080)	2.50	2.50
1.52	(0.060)	3.00	3.00

HIGH-ENERGY TAPE

Measurement Wavelength µm	Measurement Wavelength mils	HE Wavelength Response (dB)
25.40	(1.000)	2.00
12.70	(0.500)	2.00
7.62	(0.300)	0.00
3.18	(0.125)	2.50
1.52	(0.060)	2.50
1.02	(0.040)	3.00
0.76	(0.030)	3.50

CHAPTER 8

MIL-STD-1553 100 PERCENT ACQUISITION STANDARD

8.1 General

This standard addresses the acquisition of all the traffic flowing on MIL-STD-1553 A or B data buses. The formats described allow for up to eight data buses to be handled by a single system. Other constraints such as RF bandwidth and tape recording time will dictate the actual number of buses processed by a single system. Standards for both telemetry and tape recorder formats are presented. User outputs of Pulse Code Modulation (PCM) and reconstructed MIL-STD-1553 are described.

A selected measurement method resulting in a standard Class I PCM format (defined in chapter 4) is the preferred method for MIL-STD-1553 data acquisition. In those cases where 100 percent acquisition is required, the methods in this chapter should be employed.

8.2 Definitions

8.2.1 Bus Monitor. The terminal assigned the task of receiving bus traffic and extracting all information to be used at a later time.

8.2.2 Data Bus. All hardware including twisted shielded pair cables, isolation resistors, and transformers required to provide a single data path between the bus controller and all the associated remote terminals.

8.2.3 Dual Redundant Data Bus. The use of two data buses to provide multiple paths between the subsystems.

8.2.4 Bus Loading. The percentage of time the data bus is active.

8.2.5 Maximum Burst Length. The maximum length of a continuous burst of messages with minimum length message gaps.

8.3 Source Signal

The source of data is a signal conforming to MIL-STD-1553A or MIL-STD-1553B. The input configuration is for a dual redundant data bus system per bus. The interface device performing the data acquisition shall be configured as a bus monitor. Figure 8-1 depicts in block diagram form the concept of 100 percent MIL-STD-1553 bus data acquisition.

> **NOTE**
>
> In the design of the interface to the MIL-STD-1553 bus, it may be necessary to include an input buffer to prevent loss of data and to conserve bandwidth. The buffer size is influenced by bus loading, maximum burst length, output bit rate, tape recording speed, time tagging, and auxiliary inputs.

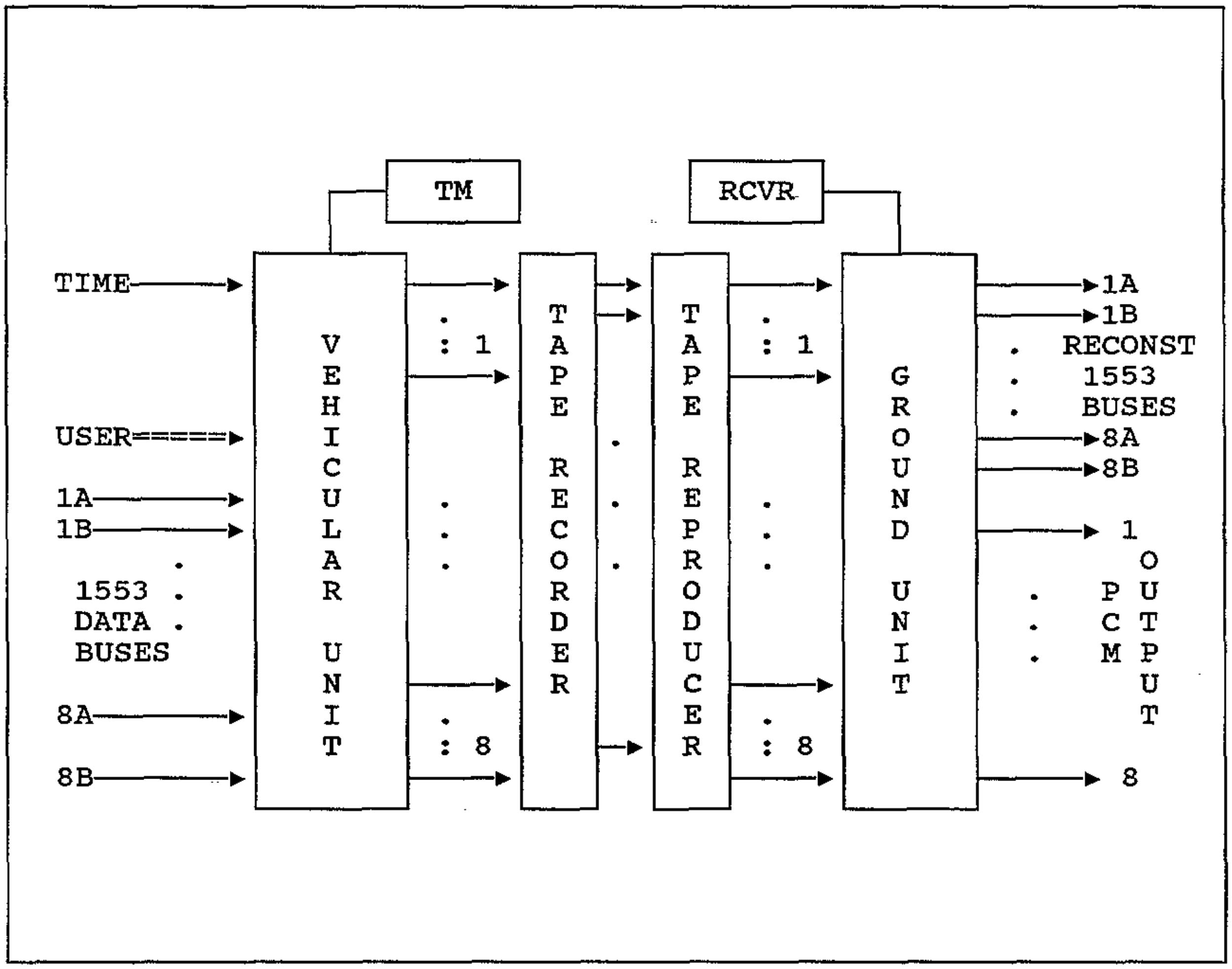

Figure 8-1. System block diagram.

8.4 Word Structure

The following subparagraphs describe the general word structure to be used for the formatted output.

8.4.1 The formatted data shall be a 24-bit word constructed as shown in figure 8-2a.

8.4.2 The information extracted from the data bus shall have the synchronization pattern and parity bit removed.

8.4.3 Each incoming MIL-STD-1553 word (Command, Status or Data), auxiliary input or time word shall be appropriately labeled with a four-bit identifier as described in figure 8-2c.

8.4.4 Data extracted from the MIL-STD-1553 bus shall maintain bit order integrity in the information field for a command, status, data, and error word. Bit position four in the MIL-STD-1553 bus word shall be placed in bit position nine in the formatted data word. The remaining bits of the MIL-STD-1553 bus word shall be placed in successive bit positions in the formatted data word. Transposing or reordering of the bits is not permitted.

8.4.5 Each word shall also carry a three-bit bus identifier field as shown in figure 8-2b.

8.4.6 An odd-parity bit generated for the resulting formatted data shall be the most significant bit as shown in figure 8-2a.

8.4.7 Fill words, as required to maintain continuous data output, shall have 1010101010101010 as the information bit pattern.

8.4.8 For bus errors (Error A - 1100 or Error B - 1000) the synchronization pattern and the parity bit are removed as stated in subparagraph 8.4.2. The information bits, 9 through 24, of the formatted word shall contain the resulting 16-bit pattern extracted from the bus.

8.5 Time Words

The following subparagraphs describe the structure and use of time words within the formatted output.

8.5.1 There shall be four words dedicated to providing timing information. These words are designated high order time, low order time, microsecond time, and if used, response time. The high and low order time words may be binary or BCD weighted, and the microsecond and response time words shall be binary weighted. Time word construction is shown in figure 8-2d.

8.5.2 The microsecond time word shall have a resolution of one microsecond; that is, the least significant bit, bit 24, has a value of 0.000001 second. This word shall increment until it attains a value of 10 milliseconds at which time it will reset to zero.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PARITY	BUS IDENT			IDENT LABEL				INFORMATION															

a. BIT DEFINITION

BIT 2 3 4		BIT 2 3 4	
0 0 0	BUS 1	1 0 0	BUS 5
0 0 1	BUS 2	1 0 1	BUS 6
0 1 0	BUS 3	1 1 0	BUS 7
0 1 1	BUS 4	1 1 1	BUS 8

b. BUS IDENTIFIER DEFINITION
BITS 2,3 & 4

BIT 5 6 7 8		BIT 5 6 7 8	
1 1 1 1	COMMAND A	0 1 1 1	TIME - HIGH ORDER
1 1 1 0	STATUS A	0 1 1 0	TIME - LOW ORDER
1 1 0 1	DATA A	0 1 0 1	TIME - MICROSECOND
1 1 0 0	ERROR A	0 1 0 0	TIME - RESPONSE (optional)
1 0 1 1	COMMAND B	0 0 1 1	USER DEFINED
1 0 1 0	STATUS B	0 0 1 0	USER DEFINED
1 0 0 1	DATA B	0 0 0 1	FILL WORD
1 0 0 0	ERROR B	0 0 0 0	BUFFER OVERFLOW

NOTE

A = primary channel of the dual redundant bus
B = secondary channel of the dual redundant bus

c. IDENTIFIER LABEL DEFINITION
BITS 5,6,7 & 8

Figure 8-2. Word construction.

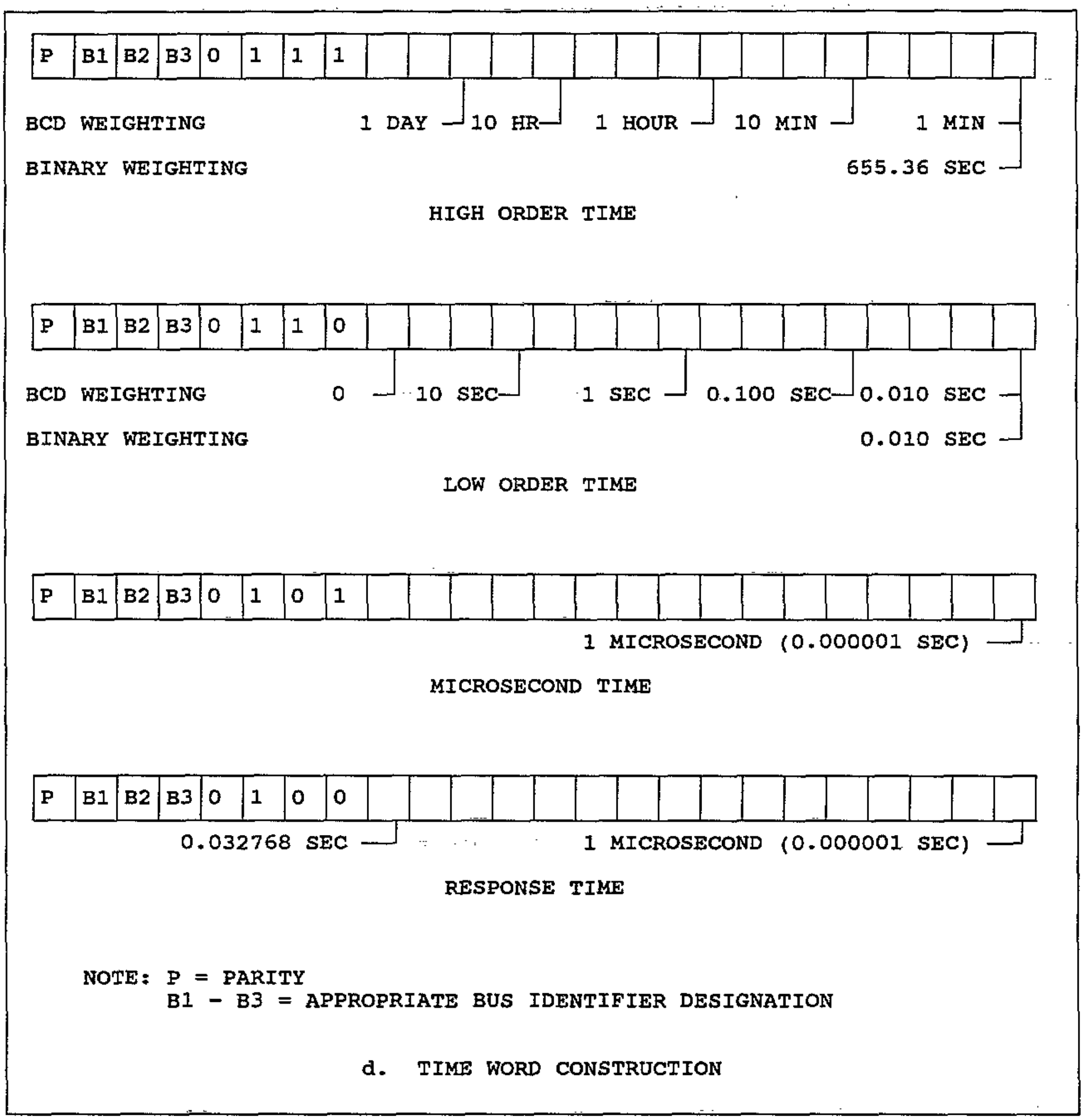

Figure 8-2 (Cont'd). Word construction.

8.5.3 The low order time word shall have a resolution of 10 milliseconds; that is, the least significant bit, bit 24, has a value of 0.010 second. This word shall increment as a function of the microsecond time word.

8.5.4 The high order time word shall have a resolution of 655.36 seconds when binary weighted; that is, the least significant bit, bit 24, has a value of 655.36 seconds. When BCD weighted, the least significant bit; that is, bit 24, of the high order time word shall have a value of 1 minute. The word shall increment as a function of the low order time word.

8.5.5 The occurrence of each MIL-STD-1553 command word shall be capable of being time tagged to the nearest 1 microsecond.

8.5.6 Time tagging of the command word shall be with the microsecond time word, and the time word shall follow the command word in the output sequence.

8.5.7 There shall be a response time word with 1 microsecond resolution which shall indicate the response time of the data bus. The response time word shall immediately precede the status word associated with it.

NOTE

If the response time function is not used, the identifier label 0100 may be assigned to user defined inputs.

8.6 Telemetry Output

The following subparagraphs describe the characteristics for a singular composite output signal.

8.6.1 The output generated for telemetry purposes shall conform to the particulars for pulse-code modulation as stated in chapter 4.

8.6.2 The data shall be transmitted most significant bit first.

8.6.3 The NRZ-L code as defined in figure 4-1 shall be used.

8.6.4 The bit rate is dependent on several factors including bus loading and auxiliary inputs and shall be programmable but should be sufficient to preclude any loss of data.

8.6.5 The order of bus words must remain unaltered except in the case of a buffer overflow.

8.6.6 The frame length shall be fixed using fill words as required and shall be ≥ 128 words and ≤ 256 words including the frame synchronization word.

8.6.7 The frame synchronization word shall be fixed and 24 consecutive bits in length. The pattern, also shown in appendix C, is 111 110 101 111 001 100 100 000.

8.6.8 The frame structure shall consist of the frame synchronization word, followed by the high order time word, followed by the low order time word, followed by the microsecond time word, followed by the data words from all sources making up a composite signal up to the frame length specified in subparagraph 8.6.6 (see figure 8-3).

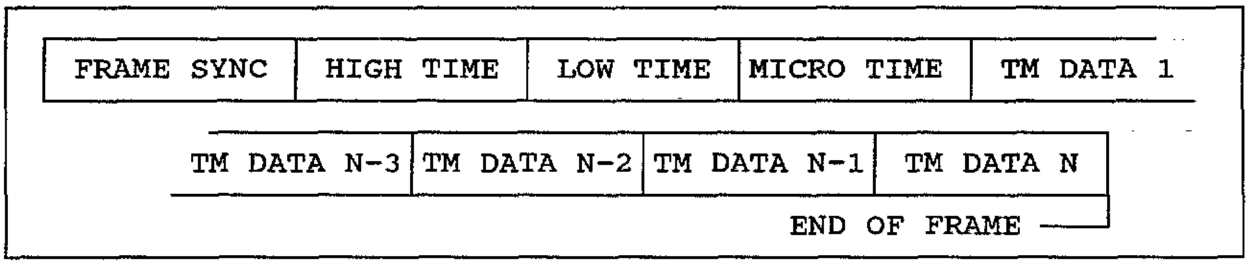

Figure 8-3. Telemetry frame structure.

8.7 Tape Recording Format

The following subparagraphs describe the characteristics of a multiple track spread output on a MIL-STD-1553 bus by bus basis.

8.7.1 The code generated for tape recording shall be RNRZ-L or Bi-phase-L as described in chapters 4 and 6.

NOTE
Bit rates less than 200 000 bits per second are not recommended when using RNRZ-L.

8.7.2 The tape recorder/reproducer is a longitudinal fixed-head machine described in chapter 6 and not one employing parallel high density digital recording (HDDR) or rotary head recording characteristics. If using other than a longitudinal fixed-head machine, the telemetry signal should be used as the input and conform to the appropriate sections of this standard.

8.7.3 To extend recording time while still acquiring 100 percent of the MIL-STD-1553 bus data, a multiple track recording technique is presented.

8.7.3.1 When necessary to use more than one tape recording track (to extend record time), separate PCM streams shall be created and delayed by 24/TK bits with respect to each other, where TK represents the number of tape tracks used for a given bus.

8.7.3.2 When multiple track recording is required, the track spread shall be on a bus basis such as bus number 1 spread over four tracks, and bus number 2 spread over two tracks rather than spreading the composite signal across several tracks. The maximum number of tracks per bus shall be limited to four.

NOTE

Consideration should be given to spread track assignments; that is, all tracks associated with a given bus should be recorded on the same head stack.

8.7.3.3 Each stream shall have a frame synchronization pattern 24 bits in length, while conforming to subparagraph 8.6.7. The synchronization pattern shall be the same for all tracks used for a given bus.

8.7.3.4 The word structure shall be identical to that described in paragraph 8.4.

8.7.3.5 The frame length shall be fixed and shall be the same for each track used for a given bus, while conforming to the guidelines of subparagraph 8.6.6.

8.7.3.6 The data shall be formatted such that it is transmitted most significant bit first.

8.7.3.7 The PCM stream designated TK1 for each bus shall be constructed as the frame synchronization word, followed by the high order time word, followed by data words (see figure 8-4). The PCM stream designated TK2 for each bus shall be constructed as the frame synchronization word, followed by the low order time word, followed by data words. The PCM stream designated TK3 for each bus shall be constructed as the frame synchronization word, followed by the microsecond time word, followed by data words. The PCM stream designated TK4 for each bus shall be constructed as the frame synchronization word, followed by the first data word, followed by other data words. Schemes using one, two, or three tracks for a given bus shall follow like construction, that is, sequencing through the data track by track.

8.7.3.8 The length or structure of the frame shall be adjusted such that the time between low order time words does not result in a time ambiguity. If necessary, to reduce the bit rate to an acceptable level, additional time words (high time, low time) may be inserted into the PCM frame.

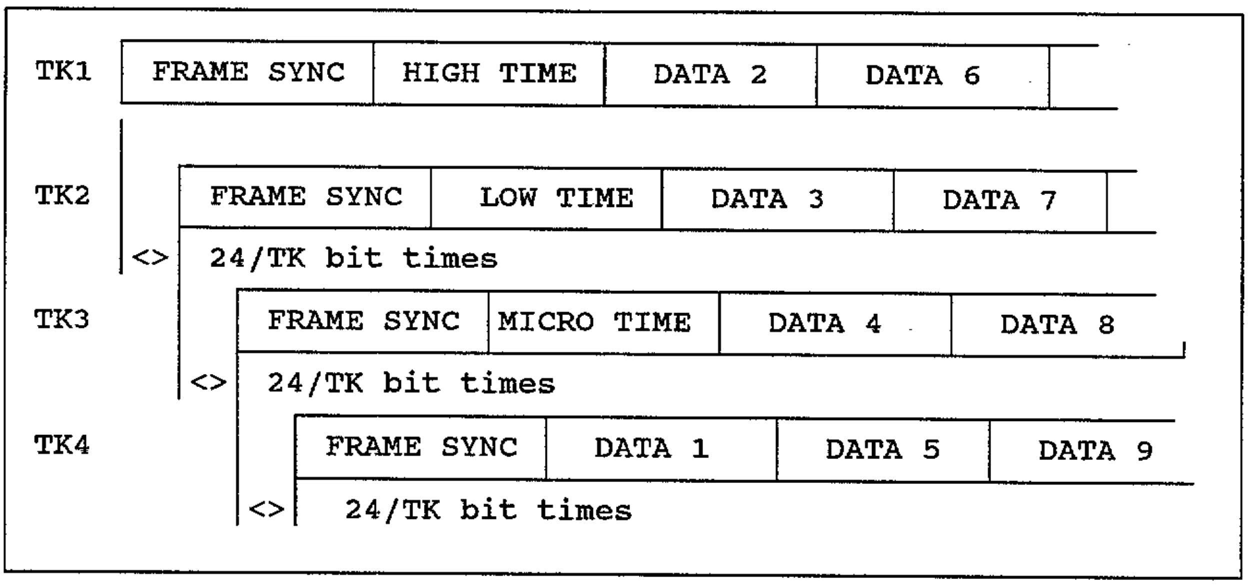

Figure 8-4. Multiple tape track format (4-track spread example).

8.8 User Output Signals

Those signals available from the ground unit depicted in figure 8-1.

8.8.1 Reconstructed MIL-STD-1553. The reconstructed data bus shall conform to the word structure of MIL-STD-1553.

8.8.1.1 The reconstructed MIL-STD-1553 data bus signal shall preserve unaltered the order of occurrence of each data bus word, and shall preserve timing to within 48 microseconds uncertainty with respect to the original input signal unless the response time word is used for better accuracy.

8.8.1.2 The parity bit removed prior to recording or transmission must be reconstructed and reinserted.

8.8.1.3 The output characteristics such as levels and impedance shall be compatible with MIL-STD-1553 requirements.

8.8.2 Pulse Code Modulation. There shall be a PCM signal output from the ground unit for each bus. It shall contain all the information which is associated with that particular bus identifier. The PCM signal shall conform to the characteristics described in paragraph 8.6 and subparagraphs 8.6.1 through 8.6.8.

CHAPTER 9

TELEMETRY ATTRIBUTES TRANSFER STANDARD

9.1 General

Telemetry attributes are those parameters required by the receiving/processing system to acquire, process and display the telemetry data received from the test item/source. The Telemetry Attributes Transfer Standard (TMATS) provides a common definition and format to facilitate the transfer of information between the user and the test range and between ranges. The telemetry attributes are defined such that the information required to set up the telemetry receiving and processing equipment is provided. The format, while not necessarily compatible with any receiving/processing system, will allow test ranges or other receiving systems to develop a computer conversion program to extract the information and to set up data required for their unique equipment configuration. Nonstandard parameter variations are not included in the attribute listings of choices but may be included by exception in the remarks section of each group.

9.2 Scope

The TMATS provides the definition of the telemetry attributes and specifies the media and data format necessary to permit the ready transfer of the information required to set up the telemetry receiving/processing functions at a test range. The standard does not conform to nor does it define existing or planned capabilities of any given test range. Only those parameters which are defined in this document are included by specific reference. Other nonstandard parameter values/definitions may be included in the comments segment of each group.

9.3 Purpose

The purpose of TMATS is to provide a common format for the transfer of information between the user and a test range or between ranges (see appendix H). This format will minimize the "station unique" activities that are necessary to support any test item. In addition, it is intended to relieve the labor-intensive process currently required to reformat the information by providing the information on computer compatible media, thus reducing errors and requiring less preparation time for test support.

9.4 Media and Data Structure

The following media are acceptable for transfer:

MS-DOS* 3.3 or later 5.25" diameter disk
MS-DOS* 3.3 or later 3.5" diameter disk
9 track 1600 BPI unlabelled magnetic tape
9 track 6250 BPI unlabelled magnetic tape.

The parties involved must agree to the specific media for the exchange of attribute information. A cover sheet describing the system which produced the attribute medium should accompany the disk or tape. A recommended format for the cover sheet is given in appendix I.

9.4.1 Physical Format

Attributes for each mission configuration are to be supplied in a single physical file with contents as 7-bit ASCII coded characters. Line feed (LF) and carriage return (CR) may be used to improve readability of the information. Nonprintable characters will be discarded by the destination agency prior to translating the attributes into telemetry system configuration information. On magnetic tape, physical records may be any size up to 2048 bytes. A single end-of-file (EOF) mark indicates the end of a mission configuration. Additional mission configurations can be included in sequential files on a single 9-track tape. A double EOF is used to indicate the end of the last mission configuration on the tape. A "stick on" label and an accompanying cover sheet identifying the missions for each configuration are required.

MS-DOS* formatting defines the physical record size for disks. Multiple mission configurations may be provided on a single disk; however, each configuration must be in a separate file identified in the MS-DOS* disk directory. A stick-on label and the accompanying cover sheet identifies the filenames corresponding to the mission configuration used for each mission.

*MS-DOS is a trademark of Microsoft, Inc.

9.4.2 Logical Format

Each attribute appears in the file as a unique code name and as a data item. The code name appears first, delimited by a colon. The data item follows, delimited by a semicolon. Thus an attribute is formatted as A:B;, where A is the code name and B is the data item, in accordance with the tables in paragraph 9.5. Numeric values for data items may be either integer or decimal (scientific notation is not allowed). Semicolons are not allowed in any data item (including comment items). Any number of attributes may be supplied within a physical record subject to the maximum mentioned in subparagraph 9.4.1. Attributes may appear in any order.

There are two basic types of attribute code names: single and multiple entry. Single-entry attributes are those for which there is only one data item. Multiple-entry attributes appear once in the definition tables in paragraph 9.5 but have multiple items; these items are assigned a number. The number appears in the code name preceded by a hyphen. For example, data source identifiers might have the following entries:

```
G\DSI-1:Aircraft;
G\DSI-2:Missile;
G\DSI-3:Target;
```

Refer to paragraph 9.5 for detailed definition of code names and attributes and appendix J for an example application of this standard.

9.5 Telemetry Attributes

The description of the mission configuration includes all potential sources of data, RF links, pre- or post-detected analog tapes, or onboard recorded magnetic tapes. Each of these have unique characteristics which must be defined. Each source is given a unique identity and its characteristics are specifically defined in associated attributes fields. In multiplexed systems, each data stream is uniquely identified by a data link name, which, in turn, is related to the data source name.

> NOTE
>
> Only the information which is essential to define the attributes of a system is required. Nonapplicable information does not need to be included in the file. However, all attribute information given is to be provided in the specified format.

The attributes defined in this section proceed from the general level to the detailed level. The groups defined, in terms of data to be entered, are described next.

- General Information - establishes the top-level program definition and identifies the data sources.

- Transmission Attributes - define an RF link. There will be one group for each RF link identified in the General Information Group.

- Tape Source Attributes - identify a tape data source.

- Multiplex/Modulation Attributes - describe the FM/FM, FM/PM, or PM/PM multiplex characteristics. Each multiplexed waveform must have a unique set of attributes. For the analog measurement, the tie to the engineering units conversion is made in this group.

- Digital Data Attributes - are divided into three groups: the PCM Format Attributes, the PCM Measurement Description and the 1553 Bus Data Attributes.

- PCM Format Attributes - define the PCM data format characteristics, including subframes and embedded formats. Each PCM format will have a separate format attributes group.

- PCM Measurement Descriptions - define each PCM measurand which ties the PCM measurement, format, and data conversion (calibration) together.

- 1553 Bus Data Attributes - specify the PCM encoded 1553 bus format characteristics.

- PAM Attributes - contain the definition of the PAM system. It includes the PAM format characteristics and measurement attributes. The tie to the engineering unit conversion is made for the measurands contained in the PAM format.

- Data Conversion Attributes - contain the data conversion information for all measurements in this telemetry system. The calibration data and conversion definition of raw telemetry data to engineering units is included. The tie to the measurands of the telemetry systems defined in the previous groups is via the measurement name.

9.5.1 Contents

The following subparagraphs discuss the organization of the attributes and their relationships with the various groups.

9.5.1.1 Organization. Attribute information is organized according to a hierarchical structure in which related items are grouped and given a common heading. The number of levels varies within the overall structure and is a function of the logical association of the attributes. At the highest level, the telemetry attributes are defined for the following groups

Identifier	Title
G	General Information
T	Transmission Attributes
R	Tape Source Attributes
M	Multiplexing/Modulation Attributes
P	PCM Format Attributes
D	PCM Measurement Description
B	1553 Bus Data Attributes
A	PAM Attributes
C	Data Conversion Attributes

Within the structure, a lower case letter, for example, n, p, or r, indicates a multiple entry item with the index being the lower case letter. The range of these counters is from one to the number indicated in another data entry, usually with the appendage "\N".

9.5.1.2 Group Relationships. The interrelationships between the various groups are shown pictorially in figure 9-1.

NOTES

1. Data Source ID is unique within a General Information Group (G). It ties the Transmission Group (T) or the Tape Group (R) or both to the G group and to the Multiplex/Modulation Group (M).

2. The tie from the M group to a PCM Group (P), a PAM Group (A) or a 1553 Bus Group (B) is the Data Link Name.

3. The tie from the P group to an embedded P group is another Data Link Name.

4. The tie from the M group to the Data Conversion Group (C) for an analog measurement is the Measurement Name.

5. The tie from the P group to the PCM Measurement Description Group (D) is the Data Link Name.

6. The tie from either the A, D, or B groups to the Data Conversion group is the Measurement Name.

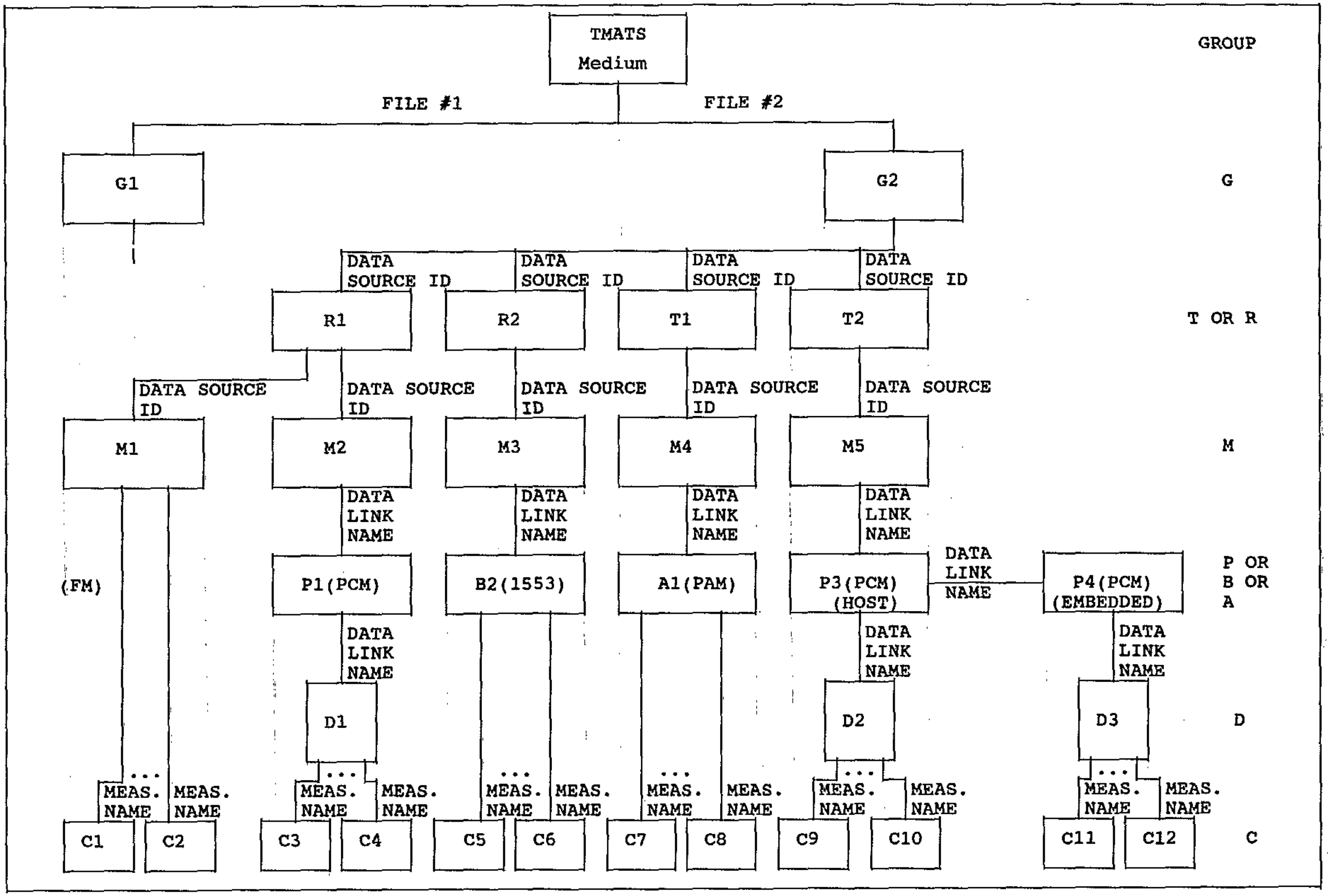

Figure 9-1. Group relationships.

9.5.2 General Information (G)

The general information group provides overall program information. Figure 9-2 gives the overall information that is included in this group and that can be used in conjunction with the table to follow the flow of the data requirements. Table 9-1 identifies and defines the data required including the dates associated with the detailed information. Since the identification of the data sources is an integral part of the remaining groups, each source must be identified uniquely.

GENERAL INFORMATION GROUP (G)

	CODE NAME	REFERENCE PAGE
PROGRAM NAME	(G\PN)	(9-8)
— TEST ITEM	(G\TA)	(9-8)
— *INFORMATION		
—— ORIGINATION DATE	(G\OD)	
—— REVISION NUMBER	(G\RN)	
—— REVISION DATE	(G\RD)	
—— UPDATE NUMBER	(G\UN)	
—— UPDATE DATE	(G\UD)	
—— TEST NUMBER	(G\TN)	
—— NUMBER OF POINTS OF CONTACT	(G\POC\N)	
—— *POINT OF CONTACT		
——— NAME	(G\POC1-n)	
——— AGENCY	(G\POC2-n)	
——— ADDRESS	(G\POC3-n)	
——— TELEPHONE	(G\POC4-n)	
— *DATA SOURCE IDENTIFICATION		(9-9)
—— NUMBER OF DATA SOURCES	(G\DSI\N)	
——— DATA SOURCE ID	(G\DSI-n)	
——— DATA SOURCE TYPE	(G\DST-n)	
— *TEST INFORMATION		(9-9)
—— TEST DURATION	(G\TI1)	
—— PRE-TEST REQUIREMENT	(G\TI2)	
—— POST-TEST REQUIREMENT	(G\TI3)	
— SECURITY CLASSIFICATION	(G\SC)	
— COMMENTS	(G\COM)	(9-10)

*HEADING ONLY - NO DATA ENTRY

Figure 9-2. General Information Group (G).

TABLE 9-1. GENERAL INFORMATION GROUP (G)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
PROGRAM NAME	16	G\PN	NAME OF PROGRAM
TEST ITEM	64	G\TA	TEST ITEM DESCRIPTION IN TERMS OF NAME, MODEL, PLATFORM OR IDENTIFICATION CODE, AS APPROPRIATE.
INFORMATION			
ORIGINATION DATE	8	G\OD	DATE OF ORIGINATION OF THIS MISSION CONFIGURATION. DD - DAY MM - MONTH YY - YEAR (MM-DD-YY)
REVISION NUMBER	4	G\RN	REVISION NUMBER ASSOCIATED WITH THIS MISSION CONFIGURATION.
REVISION DATE	8	G\RD	DATE OF REVISION. DD - DAY MM - MONTH YY - YEAR (MM-DD-YY)
UPDATE NUMBER	2	G\UN	UPDATE NUMBER OF CURRENT CHANGE WHICH HAS NOT BEEN INCORPORATED AS A REVISION
UPDATE DATE	8	G\UD	DATE OF UPDATE. DD - DAY MM - MONTH YY - YEAR (MM-DD-YY)
TEST NUMBER	16	G\TN	TEST IDENTIFICATION
NUMBER OF POINTS OF CONTACT	1	G\POC\N	NUMBER OF POINTS OF CONTACT TO BE GIVEN

TABLE 9-1 (Cont'd). GENERAL INFORMATION GROUP (G)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
POINT OF CONTACT: NAME AGENCY ADDRESS TELEPHONE	 24 48 48 20	 G\POC1-n G\POC2-n G\POC3-n G\POC4-n	LIST EACH OF THE RESPONSIBLE AGENCIES AND THEIR POINT OF CONTACT.
DATA SOURCE IDENTIFICATION			
NUMBER OF DATA SOURCES	2	G\DSI\N	SPECIFY THE NUMBER OF DATA SOURCES: FOR RF TELEMETRY SYSTEMS, GIVE THE NUMBER OF CARRIERS; FOR TAPE RECORDED DATA, IDENTIFY THE NUMBER OF TAPE SOURCES.
DATA SOURCE ID	32	G\DSI-n	PROVIDE A DESCRIPTIVE NAME FOR THIS SOURCE. EACH SOURCE IDENTIFIER MUST BE UNIQUE.
DATA SOURCE TYPE	3	G\DST-n	SPECIFY THE TYPE OF SOURCE: RF - RF TAPE - TAP OTHER - OTH
PROVIDE THE ABOVE TWO ITEMS FOR EACH DATA SOURCE.			
TEST INFORMATION			
TEST DURATION	4	G\TI1	APPROXIMATE DURATION OF TEST IN HOURS.
PRE-TEST REQUIREMENT	1	G\TI2	INDICATE WHETHER A PRE-TEST REQUIREMENT(S) IS APPLICABLE. PROVIDE DETAILS IN COMMENT RECORD (Y/N).
POST-TEST REQUIREMENT	1	G\TI3	SPECIFY WHETHER A POST-TEST REQUIREMENT(S) IS APPLICABLE. PROVIDE DETAILS IN COMMENT RECORD (Y/N).

TABLE 9-1 (Cont'd). GENERAL INFORMATION GROUP (G)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
SECURITY CLASSIFICATION	1	G\SC	PROVIDE THE CLASSIFICATION OF THE PROJECT DATA. PROVIDE CLASSIFICATION GUIDE DESCRIPTION IN COMMENT RECORD. UNCLASSIFIED - U CONFIDENTIAL - C SECRET - S TOP SECRET - T OTHER - O.
COMMENTS	1600	G\COM	INFORMATION WHICH IS NEEDED TO COMPLETE DATA REQUESTED AND ANY OTHER INFORMATION DESIRED.

9.5.3 Transmission Attributes (T)

The Transmission Attributes are presented graphically in figure 9-3 and specified in table 9-2. The information contained within this group is used to set up the RF receiver through the detection and recovery of the baseband composite waveform. The format contains the information needed to configure the antenna and receiver subsystems.

Additional equipment inserted in a specific range configuration such as microwave or other relay is intended to be transparent to the user and is not described under Transmission Attributes.

Because the information is mutually exclusive, only the appropriate frequency modulation (FM) or phase modulation (PM) system data set is required for a link.

DATA SOURCE ID — CODE NAME (T-x\ID) — REFERENCE PAGE (9-12)

- *SOURCE RF ATTRIBUTES — (9-12)
  - TRANSMITTER ID — (T-x\TID)
  - FREQUENCY — (T-x\RF1)
  - RF BANDWIDTH — (T-x\RF2)
  - DATA BANDWIDTH — (T-x\RF3)
  - MODULATION TYPE — (T-x\RF4)
  - TOTAL CARRIER MODULATION — (T-x\RF5)
  - POWER (RADIATED) — (T-x\RF6)
  - NUMBER OF SUBCARRIERS — (T-x\SCO\N)
    - SUBCARRIER NUMBER — (T-x\SCO1-n) — (9-13)
    - MODULATION INDEX — (T-x\SCO2-n)
  - MODULATOR NON-LINEARITY — (T-x\RF7)
  - *PREMODULATION FILTER — (9-13)
    - BANDWIDTH — (T-x\PMF1)
    - SLOPE — (T-x\PMF2)
    - TYPE — (T-x\PMF3)
  - *TRANSMIT ANTENNA — (9-13)
    - TRANSMIT ANTENNA TYPE — (T-x\AN1)
    - TRANSMIT POLARIZATION — (T-x\AN2)
    - ANTENNA LOCATION — (T-x\AN3)
    - *ANTENNA PATTERNS — (9-14)
      - DOCUMENT — (T-x\AP)
      - *POINT OF CONTACT
        - NAME — (T-x\AP\POC1)
        - AGENCY — (T-x\AP\POC2)
        - ADDRESS — (T-x\AP\POC3)
        - TELEPHONE — (T-x\AP\POC4)
- *GROUND STATION ATTRIBUTES — (9-14)
  - IF BANDWIDTH — (T-x\GST1)
  - BASEBAND COMPOSITE BANDWIDTH — (T-x\GST2)
  - *GAIN CONTROL — (9-14)
    - AGC TIME CONSTANT — (T-x\GST3)
    - OR
    - MGC GAIN SET POINT — (T-x\GST4)
  - AFC/APC — (T-x\GST5)
    - TRACKING BANDWIDTH — (T-x\GST6)
  - POLARIZATION RECEPTION — (T-x\GST7) — (9-15)
  - *FM SYSTEMS — (9-15)
    - DISCRIMINATOR BANDWIDTH — (T-x\FM1)
    - DISCRIMINATOR LINEARITY — (T-x\FM2)
  - OR
  - *PM SYSTEMS — (9-15)
    - PHASE LOCK LOOP BANDWIDTH — (T-x\PLL)
- COMMENTS — (T-x\COM) — (9-15)

* HEADING ONLY - NO DATA ENTRY

Figure 9-3. Transmission Attributes Group (T).

TABLE 9-2. TRANSMISSION ATTRIBUTES GROUP (T)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA SOURCE ID	32	T-x\ID	DATA SOURCE ID CONSISTENT WITH GENERAL INFORMATION GROUP.
SOURCE RF ATTRIBUTES			
TRANSMITTER ID	12	T-x\TID	TRANSMITTER IDENTIFICATION.
FREQUENCY	6	T-x\RF1	CARRIER FREQUENCY, IN MEGAHERTZ. IF PROGRAM-MABLE, ENTER P, AND DEFINE IN COMMENT RECORD.
RF BANDWIDTH	6	T-x\RF2	TOTAL RF BANDWIDTH (-60dB) OF MODULATED SIGNAL, IN MEGAHERTZ.
DATA BANDWIDTH	6	T-x\RF3	COMPOSITE BASEBAND DATA BANDWIDTH (3dB), IN KILOHERTZ.
MODULATION TYPE	5	T-x\RF4	DEFINE THE MODULATION TYPE: FM PM BPSK DPSK QPSK OTHER
TOTAL CARRIER MODULATION	6	T-x\RF5	FOR FM SYSTEM DEFINE TOTAL CARRIER DEVIATION, PEAK-TO-PEAK, IN kHz. FOR PM SYSTEM DEFINE TOTAL PHASE MODULATION, PEAK-TO-PEAK, IN RADIANS.
POWER (RADIATED)	4	T-x\RF6	TOTAL TRANSMITTED POWER WHEN MODULATED, IN WATTS.
NUMBER OF SUBCARRIERS	2	T-x\SCO\N	NUMBER OF SUBCARRIERS IN THE COMPOSITE BASEBAND WAVEFORM, n. IF NONE ENTER NO.

TABLE 9-2 (Cont'd). TRANSMISSION ATTRIBUTES GROUP (T)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
SUBCARRIER NUMBER	5	T-x\SCO1-n	GIVE THE IRIG CHANNEL NUMBER FOR THE SUBCARRIER. IF NONSTANDARD SUBCARRIER ENTER NO AND ENTER FREQUENCY IN THE COMMENTS SECTION WHERE n IS AN IDENTIFICATION TAG FOR THE SUBCARRIER.
MODULATION INDEX	4	T-x\SCO2-n	SPECIFY THE MODULATION INDEX FOR EACH SUBCARRIER IN THE COMPOSITE WAVEFORM, AS APPROPRIATE.
MODULATOR NONLINEARITY	4	T-x\RF7	MODULATOR NONLINEARITY, IN PERCENT.
PREMODULATION FILTER			
BANDWIDTH	6	T-x\PMF1	PRE-MODULATION COMPOSITE FILTER BANDWIDTH, 3 dB CUT-OFF FREQUENCY, IN kHz.
SLOPE	2	T-x\PMF2	PRE-MODULATION FILTER ASYMPTOTIC ROLL-OFF SLOPE, dB/OCTAVE.
TYPE	2	T-x\PMF3	SPECIFY THE FILTER TYPE: CONSTANT AMPLITUDE - CA CONSTANT DELAY - CD OTHER -OT.
TRANSMIT ANTENNA			
TRANSMIT ANTENNA TYPE	16	T-x\AN1	TRANSMIT ANTENNA TYPE.
TRANSMIT POLARIZATION	4	T-x\AN2	TRANSMIT ANTENNA POLARIZATION. RHCP LHCP LINEAR - LIN

TABLE 9-2 (Cont'd). TRANSMISSION ATTRIBUTES GROUP (T)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
ANTENNA LOCATION	16	T-x\AN3	DESCRIBE THE ANTENNA LOCATION.
ANTENNA PATTERNS			
DOCUMENT	16	T-x\AP	IDENTIFY DOCUMENT WHICH HAS ANTENNA PATTERNS
POINT OF CONTACT: NAME AGENCY ADDRESS TELEPHONE	 24 48 48 20	 T-x\AP\ POC1 T-x\AP\ POC2 T-x\AP\ POC3 T-x\AP\ POC4	IDENTIFY THE POINT OF CONTACT FOR ADDITIONAL INFORMATION.
GROUND STATION ATTRIBUTES			
IF BANDWIDTH	6	T-x\ GST1	DEFINE THE IF BANDWIDTH (3dB), IN MHz.
BASEBAND COMPOSITE	6	T-x\ GST2	DEFINE THE CUT-OFF FREQUENCY (3dB), IN kHz, OF THE OUTPUT FILTER.
GAIN CONTROL			
AGC TIME CONSTANT	4	T-x\ GST3	SPECIFY THE AGC TIME CONSTANT DESIRED IN MILLISECONDS.
MGC GAIN SET POINT	6	T-x\ GST4	PROVIDE THE MANUAL GAIN CONTROL SET POINT IN TERMS OF RECEIVED SIGNAL STRENGTH, dBm.
AFC/APC	3	T-x\ GST5	SPECIFY AUTOMATIC FREQUENCY CONTROL (AFC) OR AUTOMATIC PHASE CONTROL (APC) OR NONE (NON).

TABLE 9-2 (Cont'd). TRANSMISSION ATTRIBUTES GROUP (T)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
TRACKING BANDWIDTH	4	T-x\GST6	SPECIFY TRACKING LOOP BANDWIDTH IN HERTZ.
POLARIZATION RECEPTION	5	T-x\GST7	SPECIFY POLARIZATION TO BE USED: RHCP - RHCP LHCP - LHCP BOTH - BOTH BOTH WITH DIVERSITY COMBINING: PRE-DETECTION-B&DPR POST-DETECTION-B&DPO DIVERSITY COMBINING (ONLY): PRE-DETECTION-PRE-D POST-DETECTION-POS-D OTHER - OTH, SPECIFY IN COMMENTS.
FM SYSTEMS			
DISCRIMINATOR BANDWIDTH	4	T-x\FM1	SPECIFY THE DISCRIMINATOR BANDWIDTH REQUIRED IN MEGAHERTZ.
DISCRIMINATOR LINEARITY	4	T-x\FM2	SPECIFY THE REQUIRED LINEARITY OVER THE BANDWIDTH SPECIFIED.
PM SYSTEMS			
PHASE LOCK LOOP BANDWIDTH	4	T-x\PLL	SPECIFY THE PHASE LOCKED LOOP BANDWIDTH.
COMMENTS	1600	T-x\COM	PROVIDE THE ADDITIONAL INFORMATION REQUIRED TO COMPLETE THE ABOVE INFORMATION REQUESTED OR TO PROVIDE ANY OTHER INFORMATION THAT IS DESIRED.

9.5.4 Tape Source Attributes (R)

This group describes the attributes required when the data source is a magnetic tape as specified in chapter 6. In the case of the tape data link identification, each data source must be identified. In some cases the data source identification may be identical, particularly when the same information has been received from different receiver sites, on different polarizations, or on different carriers for redundancy purposes. Some of the information requested will be available only from the recording site or the dubbing location.

Figure 9-4 indicates the information required. Various categories of information have been included. In the data section of the attributes, it will be necessary to repeat the items until all of the data sources have been defined, including the multiple tracks which contain ground station data of interest. Table 9-3 defines the information required. Any nonstandard tape recordings will require explanation in the comments and may require supplemental definition.

	CODE NAME	REFERENCE PAGE
DATA SOURCE ID	(R-x\ID)	(9-18)
TAPE ID	(R-x\RID)	(9-18)
TAPE DESCRIPTION	(R-x\R1)	
*TAPE CHARACTERISTICS		
— TAPE TYPE	(R-x\TC1)	
— TAPE MANUFACTURER	(R-x\TC2)	
— TAPE CODE	(R-x\TC3)	
— TAPE WIDTH	(R-x\TC4)	
— REEL DIAMETER	(R-x\TC5)	
— NUMBER OF TRACKS	(R-x\N)	
— RECORD SPEED	(R-x\TC6)	
— DATA PACKING DENSITY	(R-x\TC7)	
— TAPE REWOUND	(R-x\TC8)	
*RECORDER INFORMATION		(9-19)
— TAPE DRIVE MANUFACTURER	(R-x\RI1)	
— TAPE DRIVE MODEL	(R-x\RI2)	
— ORIGINAL TAPE	(R-x\RI3)	
— DATE AND TIME CREATED	(R-x\RI4)	
— *CREATING ORGANIZATION POINT OF CONTACT		(9-19)
— — NAME	(R-x\POC1)	
— — AGENCY	(R-x\POC2)	
— — ADDRESS	(R-x\POC3)	
— — TELEPHONE	(R-x\POC4)	
— DATE OF DUB	(R-x\RI5)	
— *DUBBING ORGANIZATION POINT OF CONTACT		
— — NAME	(R-x\DPOC1)	
— — AGENCY	(R-x\DPOC2)	
— — ADDRESS	(R-x\DPOC3)	
— — TELEPHONE	(R-x\DPOC4)	
*DATA		(9-20)
— TRACK NUMBER	(R-x\TK1-n)	
— RECORDING TECHNIQUE	(R-x\TK2-n)	
— DATA SOURCE ID	(R-x\DSI-n)	
— DATA DIRECTION	(R-x\TK3-n)	
*REFERENCE TRACK		(9-21)
— NUMBER OF REFERENCE TRACKS	(R-x\RT\N)	
— TRACK NUMBER	(R-x\RT1-n)	
— REFERENCE FREQUENCY	(R-x\RT2-n)	
COMMENTS	(R-x\COM)	(9-21)

*HEADING ONLY - NO DATA ENTRY

Figure 9-4. Tape Source Attributes Group (R).

TABLE 9-3. TAPE SOURCE ATTRIBUTES GROUP (R)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA SOURCE ID	32	R-x\ID	DATA SOURCE ID CONSISTENT WITH GENERAL INFORMATION GROUP.
TAPE IDENTIFICATION	32	R-x\ RID	TAPE IDENTIFICATION.
TAPE DESCRIPTION	32	R-x\R1	TAPE REEL NUMBER OR OTHER DEFINITION.
TAPE CHARACTERISTICS			
TAPE TYPE	4	R-x\ TC1	SPECIFY THE TAPE TYPE: ANALOG - ANAL HDDR - HDDR PARALLEL - PARA OTHER - OTH, DEFINE IN COMMENTS RECORD.
TAPE MANUFACTURER	8	R-x\ TC2	NAME OF MANUFACTURER OF THE TAPE.
TAPE CODE	8	R-x\ TC3	SPECIFY MANUFACTURER'S TAPE DESIGNATION CODE.
TAPE WIDTH	4	R-x\ TC4	PHYSICAL DIMENSION OF TAPE WIDTH, IN.
REEL DIAMETER	5	R-x\ TC5	STATE THE REEL SIZE, INCHES: 10.5 16.0 14.0 OTHER 15.0
NUMBER OF TRACKS	2	R-x\N	STATE THE NUMBER OF TRACKS ON THE TAPE.
RECORD SPEED	4	R-x\ TC6	STATE RECORD SPEED IN INCHES PER SECOND.

TABLE 9-3 (Cont'd). TAPE SOURCE ATTRIBUTES GROUP (R)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA PACKING DENSITY	3	R-x\ TC7	STATE RECORDING SYSTEM BANDWIDTH: INTERMEDIATE BAND - IM WIDEBAND - WB DOUBLE DENSITY - DD OTHER - OTH
TAPE REWOUND	1	R-x\ TC8	YES - Y NO - N.
RECORDER INFORMATION			
TAPE DRIVE MANUFACTURER	8	R-x\ RI1	NAME OF TAPE DRIVE MANUFACTURER.
TAPE DRIVE MODEL	8	R-x\ RI2	MANUFACTURER'S MODEL NUMBER OF TAPE DRIVE USED TO CREATE THE TAPE.
ORIGINAL TAPE	1	R-x\ RI3	YES - Y NO - N.
DATE AND TIME CREATED	17	R-x\ RI4	DATE AND TIME TAPE WAS CREATED: DD - DAY MM -MONTH YY - YEAR HH -HOUR MI - MINUTE SS - SECOND (MM-DD-YY-HH-MI-SS).
CREATING ORGANIZATION POINT OF CONTACT NAME AGENCY ADDRESS TELEPHONE	 24 48 48 20	 R-x\ POC1 R-x\ POC2 R-x\ POC3 R-x\ POC4	POINT OF CONTACT AT THE FACILITY CREATING THE TAPE, NAME, ADDRESS, AND TELEPHONE.

TABLE 9-3 (Cont'd). TAPE SOURCE ATTRIBUTES GROUP (R)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATE OF DUB	8	R-x\RI5	DATE THE DUB WAS MADE: DD - DAY MM - MONTH YY - YEAR (MM-DD-YY)
DUBBING ORGANIZATION POINT OF CONTACT			POINT OF CONTACT AT THE DUBBING AGENCY, NAME, ADDRESS, AND TELEPHONE.
NAME	24	R-x\DPOC1	
AGENCY	48	R-x\DPOC2	
ADDRESS	48	R-x\DPOC3	
TELEPHONE	20	R-x\DPOC4	
DATA, DEFINE INFORMATION CONTAINED ON EACH TRACK OF THE TAPE.			
TRACK NUMBER	2	R-x\TK1-n	SPECIFY THE TRACK NUMBER(S) THAT CONTAIN THE DATA TO BE SPECIFIED.
RECORDING TECHNIQUE	6	R-x\TK2-n	SPECIFY THE RECORDING TECHNIQUE USED FOR THIS TRACK: FM/FM - FM/FM HDDR - HDDR PRE-DETECTION - PRE-D DIRECT - DIRECT FM-WIDEBAND GRP I - FMWBI FM-WIDEBAND GRP II - FMWBII FM-INTERMEDIATE BAND FM-IM FM-NARROW BAND - FM-NB DOUBLE DENSITY - DOUDEN OTHER -OTHER.

TABLE 9-3 (Cont'd). TAPE SOURCE ATTRIBUTES GROUP (R)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA SOURCE ID	32	R-x\ DSI-n	SPECIFY THE DATA SOURCE IDENTIFICATION. FOR A SITE RECORDED MULTI-PLEXED TRACK, PROVIDE A DATA SOURCE IDENTIFICATION.
DATA DIRECTION	3	R-x\ TK3-n	FORWARD - FWD, REVERSE - REV.
REFERENCE TRACK			
NUMBER OF REFERENCE TRACKS	1	R-x\ RT\N	SPECIFY THE NUMBER OF REFERENCE TRACKS.
TRACK NUMBER	2	R-x\ RT1-n	STATE THE TRACK LOCATION OF THE REFERENCE SIGNAL.
REFERENCE FREQUENCY	6	R-x\ RT2-n	FREQUENCY OF REFERENCE SIGNAL, kHz.
THERE WILL BE ONE TAPE SOURCE ATTRIBUTES GROUP FOR EACH TAPE SOURCE.			
COMMENTS	3200	R-x\ COM	THIS RECORD IS TO BE USED TO PROVIDE THE ADDITIONAL INFORMATION REQUESTED AND TO PROVIDE ANY OTHER INFORMATION DESIRED.

9.5.5 Multiplex/Modulation Attributes (M)

The composite baseband waveform is received from the receiver or tape reproducer electronics and is passed to the demultiplexer/demodulator for further processing. Figure 9-5 summarizes the information that is required to continue processing the data. The composite baseband waveform may consist of any number of signals which are modulated directly onto the RF carrier including a baseband data signal and one or more subcarriers.

The baseband data signal may be PCM, pulse amplitude modulation (PAM), or analog data. The PCM and PAM data streams must be defined in terms of a data link name. This data link name is unique for each system that contains different data, has a different format, or has a different data rate. The analog measurand is typically converted into engineering units appropriate for the measurand. The measurement name provides the connection to the Data Conversion Attributes Group (C).

Subcarriers, both standard and nonstandard, may be part of the baseband composite waveform. These, in turn, may be modulated with PCM, PAM, or analog data. As with the baseband data signal, these data channels must be defined. Table 9-4 specifies the required information for the data signal attributes.

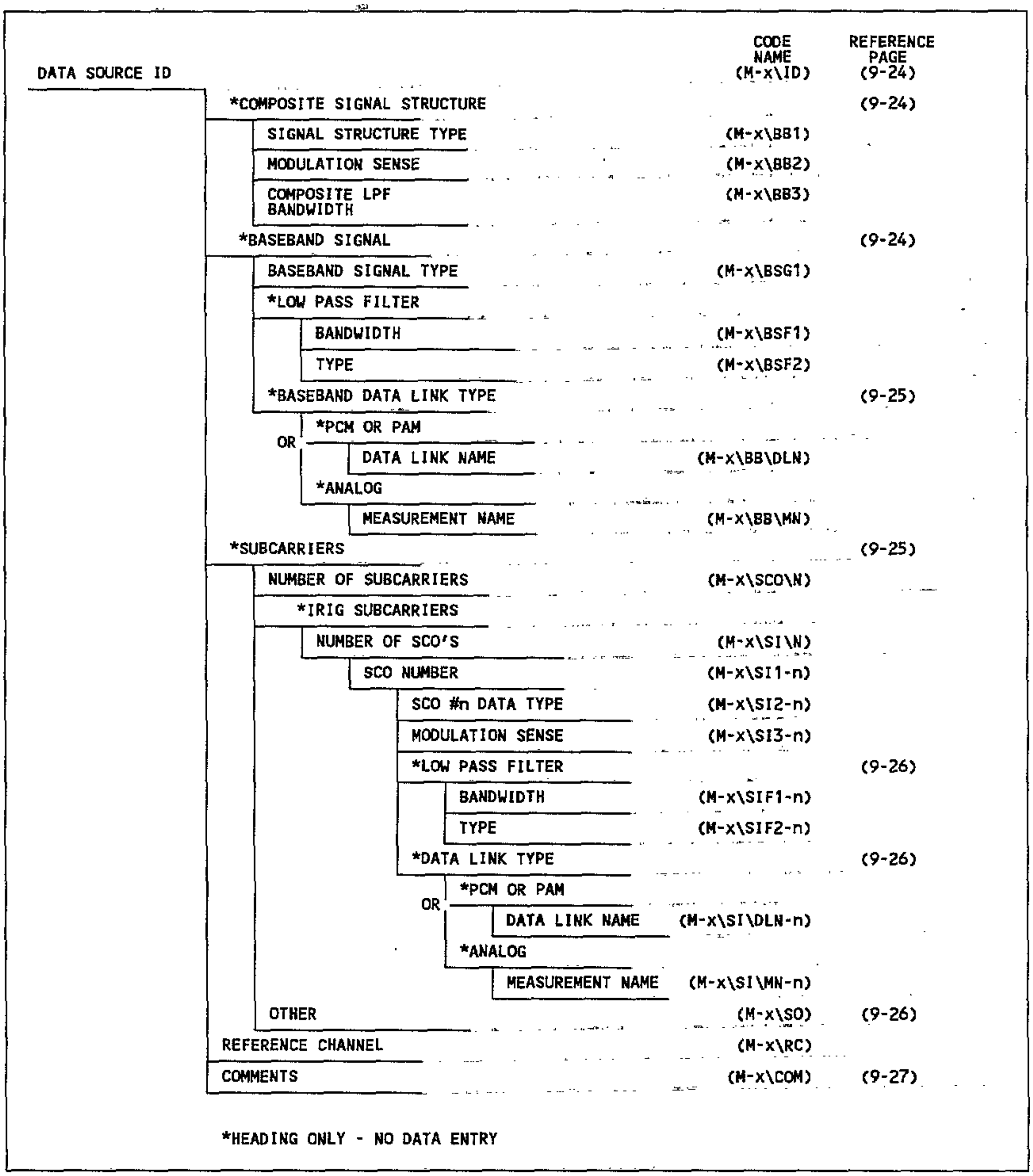

Figure 9-5. Multiplex/Modulation Attributes Group (M).

TABLE 9-4. MULTIPLEX/MODULATION GROUP (M)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA SOURCE ID	32	M-x\ID	DATA SOURCE IDENTIFICATION.
COMPOSITE SIGNAL STRUCTURE			
SIGNAL STRUCTURE TYPE	7	M-x\BB1	SPECIFY THE COMPOSITE BASEBAND SIGNAL STRUCTURE: PCM HYBRID: PAM ANA/SCO ANALOG PAM/SCO SCO's PCM/SCO OTHER.
MODULATION SENSE	3	M-x\BB2	SPECIFY THE MODULATION SENSE: POS - INDICATES THAT AN INCREASING VOLTAGE RESULTS IN AN INCREASE IN FREQUENCY. NEG - INDICATES THAT A DECREASING VOLTAGE RESULTS IN AN INCREASE IN FREQUENCY.
COMPOSITE LPF BANDWIDTH	6	M-x\BB3	GIVE THE LOW PASS BANDWIDTH OF THE COMPOSITE WAVEFORM, IN kHz.(3 dB CUT-OFF FREQUENCY)
BASEBAND SIGNAL			
BASEBAND SIGNAL TYPE	3	M-x\BSG1	TYPE OF BASEBAND DATA: PCM ANA(ANALOG) PAM OTH(OTHER) NON(NONE).
LOW PASS FILTER			
BANDWIDTH	6	M-x\BSF1	SPECIFY LOW PASS FILTER BANDWIDTH, 3dB, CUT OFF FREQUENCY, IN kHz.

TABLE 9-4 (Cont'd). MULTIPLEX/MODULATION GROUP (M)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
TYPE	2	M-x\BSF2	SPECIFY THE FILTER TYPE: CONSTANT AMPLITUDE - CA CONSTANT DELAY - CD OTHER - OT, DEFINE IN THE COMMENT RECORD.
BASEBAND DATA LINK TYPE			
PCM OR PAM			
DATA LINK NAME	32	M-x\ BB\DLN	SPECIFY THE DATA LINK NAME FOR PCM OR PAM DATA FORMAT.
ANALOG			
MEASUREMENT NAME	32	M-x\ BB\MN	GIVE THE MEASURAND NAME.
SUBCARRIERS			
NUMBER OF SUBCARRIERS	2	M-x\ SCO\N	SPECIFY THE NUMBER OF SUBCARRIERS ON THIS DATA LINK.
IRIG SUBCARRIERS			
NUMBER OF SCO'S	2	M-x\SI\N	SPECIFY THE NUMBER OF IRIG SUBCARRIERS.
SCO NUMBER	5	M-x\ SI1-n	GIVE THE IRIG CHANNEL NUMBER FOR THE SUBCARRIER.
SCO #n DATA TYPE	3	M-x\ SI2-n	SPECIFY THE TYPE OF DATA ON THE SUBCARRIER: PCM - PCM ANALOG - ANA PAM - PAM OTHER - OTH.

TABLE 9-4 (Cont'd). MULTIPLEX/MODULATION GROUP (M)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
MODULATION SENSE	3	M-x\SI3-n	SPECIFY THE MODULATION SENSE: POS - INDICATES THAT AN INCREASING VOLTAGE RESULTS IN AN INCREASE IN FREQUENCY. NEG - INDICATES THAT A DECREASING VOLTAGE RESULTS IN AN INCREASE IN FREQUENCY.
LOW PASS FILTER			
BANDWIDTH	6	M-x\SIF1-n	SPECIFY THE LOW PASS FILTER CUT-OFF FREQUENCY (3dB), IN kHz.
TYPE	3	M-x\SIF2-n	SPECIFY THE FILTER TYPE: CONSTANT AMPLITUDE - CA CONSTANT DELAY - CD OTHER - OTH, DEFINE IN THE COMMENT RECORD.
DATA LINK TYPE			
PCM OR PAM			
DATA LINK NAME	32	M-x\SI\DLN-n	SPECIFY THE DATA LINK NAME FOR PCM, AND PAM DATA FORMATS.
ANALOG			
MEASUREMENT NAME	32	M-x\SI\MN-n	GIVE THE MEASURAND NAME.
REPEAT THE ABOVE FOR EACH IRIG SUBCARRIER ON THIS CARRIER.			
OTHER	1	M-x\SO	ARE THERE NONSTANDARD SUBCARRIERS? YES - Y, NO - N. DEFINE IN THE COMMENTS.

TABLE 9-4 (Cont'd). MULTIPLEX/MODULATION GROUP (M)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
REFERENCE CHANNEL	6	M-x\RC	FREQUENCY OF REFERENCE CHANNEL IN kHz, IF APPLICABLE.
COMMENTS	3200	M-x\COM	PROVIDE THE ADDITIONAL INFORMATION REQUIRED AND ANY OTHER INFORMATION DESIRED.

9.5.6 Digital Data Attributes

The digital data attributes are separated into three groups containing PCM-related attribute information. The PCM Format Attributes Group (P) is described in subparagraph 9.5.6.1. The PCM Measurement Description Attributes, contained in (D), are described in subparagraph 9.5.6.2. Subparagraph 9.5.6.3 depicts the MIL-STD-1553 Bus Data attributes (B).

9.5.6.1 PCM Format Attributes (P)

The PCM Format Attributes Group contains the information required to decommutate the PCM data stream. Operations of both class I and class II are included. (Limited information is incorporated for class II operation.) Figure 9-6 presents the flow and summary of the information required. In general, only standard methods of synchronization have been included except for cases where considerable application is already in place. Inclusion should not be taken to mean that the nonstandard approaches are better or desired. Table 9-5 contains the PCM Format Attributes. The group defines and specifies the frame format and the information necessary to set up the PCM decommutation. Refer to chapter 4 for the definition of terms such as major and minor frames, independent and dependent subframes, and word numbering conventions.

DATA LINK NAME	CODE NAME (P-d\DLN)	REFERENCE PAGE (9-30)
*INPUT DATA		(9-30)
PCM CODE	(P-d\D1)	
BIT RATE	(P-d\D2)	
ENCRYPTED	(P-d\D3)	
POLARITY	(P-d\D4)	
AUTO-POLARITY CORRECTION	(P-d\D5)	
DATA DIRECTION	(P-d\D6)	
DATA RANDOMIZED	(P-d\D7)	
RANDOMIZER LENGTH	(P-d\D8)	
*FORMAT		(9-31)
TYPE FORMAT	(P-d\TF)	
COMMON WORD LENGTH	(P-d\F1)	
WORD TRANSFER ORDER	(P-d\F2)	
PARITY	(P-d\F3)	
PARITY TRANSFER ORDER	(P-d\F4)	
*MINOR FRAME		(9-32)
NUMBER OF MINOR FRAMES IN MAJOR FRAME	(P-d\MF\N)	
NUMBER OF WORDS IN A MINOR FRAME	(P-d\MF1)	
NUMBER OF BITS IN A MINOR FRAME	(P-d\MF2)	
SYNC TYPE	(P-d\MF3)	(9-32)
*SYNCHRONIZATION PATTERN		
LENGTH	(P-d\MF4)	
PATTERN	(P-d\MF5)	
*SYNCHRONIZATION CRITERIA		(9-33)
IN SYNC CRITERIA	(P-d\SYNC1)	
SYNC PATTERN CRITERIA	(P-d\SYNC2)	
*OUT OF SYNCHRONIZATION CRITERIA		(9-33)
NUMBER OF DISAGREES	(P-d\SYNC3)	
SYNC PATTERN CRITERIA	(P-d\SYNC4)	
*MINOR FRAME FORMAT DEFINITION		(9-33)
WORD NUMBER	(P-d\MFW1-n)	
NUMBER OF BITS IN WORD	(P-d\MFW2-n)	
*INDEPENDENT SUBFRAME DEFINITION		(9-34)
NUMBER OF INDEPENDENT SUBFRAMES	(P-d\ISF\N)	
INDEPENDENT SUBFRAME NAME	(P-d\ISF1-n)	
SUBFRAME SYNC TYPE	(P-d\ISF2-n)	
*ID COUNTER		(9-34)

Figure 9-6. PCM Format Attributes Group (P).

- SFID COUNTER LOCATION (P-d\IDC1-n)
- ID COUNTER WORD LENGTH (P-d\IDC2-n)
- ID COUNTER MSB STARTING BIT LOCATION (P-d\IDC3-n)
- ID COUNTER LENGTH (P-d\IDC4-n)
- ID COUNTER TRANSFER ORDER (P-d\IDC5-n)
- ID COUNTER INITIAL VALUE (P-d\IDC6-n) (9-35)
- INITIAL COUNT SUBFRAME NUMBER (P-d\IDC7-n)
- ID COUNTER END VALUE (P-d\IDC8-n)
- END COUNT SUBFRAME NUMBER (P-d\IDC9-n)
- COUNT DIRECTION (P-d\IDC10-n)

*DEPENDENT SUBFRAME DEFINITION (9-35)

- NUMBER OF DEPENDENT SUBFRAMES (P-d\SF\N-n)
- *SUBFRAME DEFINITION (9-35)
  - SUBFRAME NAME (P-d\SF1-n-m)
  - SUPERCOM (P-d\SF2-n-m)
  - LOCATION DEFINITION (P-d\SF3-n-m)
  - SUBFRAME LOCATION (P-d\SF4-n-m-w)
  - INTERVAL (P-d\SF5-n-m)
  - SUBFRAME DEPTH (P-d\SF6-n-m)

*ASYNCHRONOUS EMBEDDED FORMAT (9-36)

- NUMBER OF ASYNCHRONOUS EMBEDDED FORMATS (P-d\AEF\N)
  - DATA LINK NAME (P-d\AEF\DLN-n) (9-37)
  - SUPERCOM'ED (P-d\AEF1-n)
  - LOCATION DEFINITION (P-d\AEF2-n)
    - LOCATION (P-d\AEF3-n-w)
    - INTERVAL (P-d\AEF4-n)
    - WORD LENGTH (P-d\AEF5-n-w)
    - MASK (P-d\AEF6-n-w)

*FORMAT CHANGE (9-38)

- *FRAME FORMAT IDENTIFIER
  - LOCATION (P-d\FFI1)
  - MASK (P-d\FFI2)
- OR *MEASUREMENT LIST CHANGE (9-39)
  - NUMBER OF MEASUREMENT LISTS (P-d\MLC\N)
  - FFI PATTERN (P-d\MLC1-n)
  - MEASUREMENT LIST NAME (P-d\MLC2-n)

Figure 9-6 (Cont'd). PCM Format Attributes Group (P).

```
|         | *FORMAT STRUCTURE CHANGE                                  (9-39)
|         |          NUMBER OF FORMATS          (P-d\FSC\N)
|         |          FFI PATTERN                (P-d\FSC1-n)
|         |          DATA LINK ID               (P-d\FSC2-n)
|         *ALTERNATE TAG AND DATA                                     (9-39)
|               NUMBER OF TAGS                  (P-d\ALT\N)
|               NUMBER OF BITS IN TAG           (P-d\ALT1)
|               NUMBER OF BITS IN DATA WORD     (P-d\ALT2)
|               FIRST TAG LOCATION              (P-d\ALT3)
|               SEQUENCE                        (P-d\ALT4)
COMMENTS                                        (P-d\COM)             (9-40)

*HEADING ONLY - NO DATA ENTRY
```

Figure 9-6 (Cont'd). PCM Format Attributes Group (P).

TABLE 9-5. PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA LINK NAME	32	P-d\DLN	IDENTIFY THE DATA LINK NAME CONSISTENT WITH THE MUX/MOD GROUP.
INPUT DATA			
PCM CODE	6	P-d\D1	DEFINE THE DATA FORMAT CODE: NRZ-L BIO-L DBIO-M NRZ-M BIO-M DBIO-S NRZ-S BIO-S RNRZ-L OTHER
BIT RATE	9	P-d\D2	DATA RATE IN BITS PER SECOND.
ENCRYPTED	1	P-d\D3	DATA IS ENCRYPTED - E DATA IS UNENCRYPTED - U IF THE DATA IS ENCRYPTED PROVIDE DETAILS IN COMMENTS RECORD.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
POLARITY	1	P-d\D4	DATA POLARITY: NORMAL - N INVERTED - I.
AUTO-POLARITY CORRECTION	1	P-d\D5	IS AUTOMATIC POLARITY CORRECTION TO BE USED? YES - Y NO - N.
DATA DIRECTION	1	P-d\D6	TIME SEQUENCE OF DATA: NORMAL - N REVERSED - R.
DATA RANDOMIZED	1	P-d\D7	YES - Y OR NO - N.
RANDOMIZER LENGTH	3	P-d\D8	SPECIFY THE RANDOMIZER LENGTH: STANDARD (15 BITS)-STD OTHER - OTH, DEFINE IN COMMENTS RECORD. NOT APPLICABLE - N/A.
FORMAT			
TYPE FORMAT	4	P-d\TF	TYPE OF PCM FORMAT: CLASS I - ONE 1553 BUS - 1553 ALTERNATE TAG AND DATA - ALTD OTHER - OTHR, DESCRIBE IN COMMENTS RECORD.
COMMON WORD LENGTH	2	P-d\F1	NUMBER OF BITS IN COMMON WORD LENGTH.
WORD TRANSFER ORDER	1	P-d\F2	DEFINE THE DEFAULT FOR THE FIRST BIT TRANSFERRED IN NORMAL TIME SEQUENCE: MOST SIGNIFICANT BIT - M LEAST SIGNIFICANT BIT - L.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
PARITY	2	P-d\F3	NORMAL WORD PARITY EVEN - EV ODD - OD NONE - NO
PARITY TRANSFER ORDER	1	P-d\F4	PARITY BIT LOCATION LEADS WORD - L TRAILS WORD - T.
MINOR FRAME			
NUMBER OF MINOR FRAMES IN MAJOR FRAME	3	P-d\MF\N	NUMBER OF MINOR FRAMES IN A MAJOR FRAME.
NUMBER OF WORDS IN A MINOR FRAME	4	P-d\MF1	SPECIFY THE NUMBER OF WORDS IN A MINOR FRAME.
NUMBER OF BITS IN A MINOR FRAME	5	P-d\MF2	NUMBER OF BITS IN A MINOR FRAME INCLUDING MINOR FRAME SYNCHRONIZATION PATTERN.
SYNC TYPE	3	P-d\MF3	DEFINE MINOR FRAME SYNCHRONIZATION TYPE: FIXED PATTERN -FPT OTHER - OTH.
SYNCHRONIZATION PATTERN			
LENGTH	2	P-d\MF4	SPECIFY THE MINOR FRAME SYNCHRONIZATION PATTERN LENGTH IN NUMBER OF BITS.
PATTERN	33	P-d\MF5	DEFINE MINOR FRAME SYNCHRONIZATION PATTERN IN BITS ("1"'S AND "0"'S) WITH THE LEFT MOST BIT AS THE "FIRST BIT TRANSMITTED."

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
SYNCHRONIZATION CRITERIA			
IN SYNC CRITERIA	2	P-d\SYNC1	THIS SPECIFIES THE DESIRED CRITERIA FOR DECLARING THE SYSTEM TO BE IN SYNC: FIRST GOOD SYNC - 00 CHECK - NUMBER OF AGREES (1 OR GREATER) NOT SPECIFIED - NS.
SYNC PATTERN CRITERIA	2	P-d\SYNC2	NUMBER OF BITS WHICH MAY BE IN ERROR IN THE SYNCHRONIZATION PATTERN.
OUT OF SYNCHRONIZATION CRITERIA			
NUMBER OF DISAGREES	2	P-d\SYNC3	THIS SPECIFIES THE DESIRED CRITERIA FOR DECLARING THE SYSTEM OUT OF SYNC: NUMBER OF DISAGREES, NOT SPECIFIED - NS.
SYNC PATTERN CRITERIA	2	P-d\SYNC4	NUMBER OF BITS WHICH MAY BE IN ERROR IN THE SYNCHRONIZATION PATTERN.
MINOR FRAME FORMAT DEFINITION			
WORD NUMBER	4	P-d\ MFW1-n	WORD POSITION (#n) IN A MINOR FRAME OR FOR CLASS II SYSTEMS THE POSITION IN THE DEFINED FRAME. WORD POSITION 1 FOLLOWS THE SYNCHRONIZATION PATTERN.
NUMBER OF BITS IN WORD	2	P-d\ MFW2-n	THE NUMBER OF BITS IN WORD POSITION #n, IF DEFAULT VALUE DO NOT INCLUDE.
THE ABOVE PAIR SET MUST BE DEFINED FOR ALL WORDS WHICH HAVE A LENGTH OTHER THAN THE COMMON WORD LENGTH. THEREFORE, ALL WORD POSITIONS NOT INCLUDED IN THE ABOVE WILL HAVE THE COMMON WORD LENGTH AS A DEFAULT VALUE.			

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
INDEPENDENT SUBFRAME DEFINITION			
NUMBER OF INDEPENDENT SUBFRAMES	2	P-d\ISF\N	SPECIFY THE NUMBER OF INDEPENDENT SUBFRAMES DEFINED WITHIN THE MINOR FRAME.
INDEPENDENT SUBFRAME NAME	8	P-d\ ISF1-n	SPECIFY THE INDEPENDENT SUBFRAME NAME.
SUBFRAME SYNC TYPE	2	P-d\ ISF2-n	DEFINE THE SUBFRAME SYNCHRONIZATION TYPE: ID COUNTER - ID OTHER - OT, DEFINE IN COMMENTS.
ID COUNTER			
SUBFRAME ID COUNTER LOCATION	4	P-d\ IDC1-n	IF ID COUNTER IS DESIGNATED AS THE SUBFRAME SYNC TYPE, GIVE THE MINOR FRAME WORD POSITION OF THE COUNTER.
ID COUNTER WORD LENGTH	2	P-d\ IDC2-n	SPECIFY THE MINOR FRAME WORD LENGTH OF THE WORD CONTAINING THE ID COUNTER, NUMBER OF BITS.
ID COUNTER MSB STARTING BIT LOCATION	2	P-d\ IDC3-n	SPECIFY THE OFFSET OF THE ID COUNTER MSB FROM THE WORD MSB.
ID COUNTER LENGTH	2	P-d\ IDC4-n	SPECIFY THE SUBFRAME ID COUNTER LENGTH. NUMBER OF BITS.
ID COUNTER TRANSFER ORDER	1	P-d\ IDC5-n	SPECIFY WHETHER THE MOST OR LEAST SIGNIFICANT BIT IS TRANSFERED FIRST: MOST SIGNIFICANT - M LEAST SIGNIFICANT - L.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
ID COUNTER INITIAL VALUE	3	P-d\ IDC6-n	SPECIFY THE INITIAL VALUE OF THE ID COUNTER.
INITIAL COUNT SUBFRAME NUMBER	3	P-d\ IDC7-n	SPECIFY THE MINOR FRAME NUMBER ASSOCIATED WITH THE INITIAL COUNT VALUE.
ID COUNTER END VALUE	3	P-d\ IDC8-n	SPECIFY THE END VALUE OF THE ID COUNTER.
END COUNT SUBFRAME NUMBER	3	P-d\ IDC9-n	SPECIFY THE MINOR FRAME NUMBER ASSOCIATED WITH THE END COUNT VALUE.
COUNT DIRECTION	3	P-d\ IDC10-n	SPECIFY THE DIRECTION OF THE COUNT INCREMENT: INCREASING - INC DECREASING - DEC.
DEPENDENT SUBFRAME DEFINITION			
NUMBER OF DEPENDENT SUBFRAMES	4	P-d\SF\N-n	SPECIFY THE NUMBER OF DEPENDENT SUBFRAMES ASSOCIATED WITH INDEPENDENT SUBFRAME NAMED ABOVE.
SUBFRAME DEFINITION			
SUBFRAME NAME	8	P-d\ SF1-n-m	SPECIFY THE SUBFRAME NAME. BEGIN WITH THE INDEPENDENT SUBFRAME AND REPEAT FOR ALL THE DEPENDENT SUBFRAMES.
SUPERCOM	2	P-d\ SF2-n-m	IF NOT SUPERCOMMUTATED ENTER, NO, OTHERWISE ENTER THE NUMBER OF WORD POSITIONS.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
LOCATION DEFINITION	2	P-d\SF3-n-m	IF SUPERCOMMUTATED, SPECIFY HOW THE WORD LOCATIONS ARE DEFINED: FIRST WORD AND INTERVAL - FI EVERY LOCATION - EL NOT APPLICABLE - NA.
SUBFRAME LOCATION	4	P-d\SF4-n-m-w	SPECIFY THE FIRST WORD WITHIN THE MINOR FRAME WHICH CONTAINS THE SUBFRAME IDENTIFIED. FOR THE CASE WHEN EVERY WORD LOCATION IS DEFINED, REPEAT THIS ENTRY FOR EACH WORD POSITION APPLICABLE. FOR THE FIRST WORD AND INTERVAL, INCLUDE THE NEXT ENTRY TO DEFINE THE INTERVAL.
INTERVAL	4	P-d\SF5-n-m	SPECIFY THE INTERVAL TO BE USED TO DEFINE THE SUBFRAME LOCATION.
SUBFRAME DEPTH	3	P-d\SF6-n-m	SPECIFY THE SUBFRAME DEPTH. IF NO ENTRY, THEN THE INDEPENDENT SUBFRAME DEPTH WILL BE USED AS THE DEFAULT VALUE.
REPEAT THE ABOVE FOR EACH INDEPENDENT (n) AND DEPENDENT (m) SUBFRAME IN THE MINOR FRAME FORMAT.			
ASYNCHRONOUS EMBEDDED FORMAT			
NUMBER OF ASYNCHRONOUS EMBEDDED FORMATS	1	P-d\AEF\N	SPECIFY THE NUMBER OF ASYNCHRONOUS EMBEDDED FORMATS: ONE - 1 TWO - 2 NONE - 0.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA LINK NAME	32	P-d\AEF\DLN-n	PROVIDE THE DATA LINK NAME FOR THIS ASYNCHRONOUS EMBEDDED FORMAT. REPEAT THIS AND THE FOLLOWING ENTRIES FOR THE SECOND FORMAT, AS APPROPRIATE. (A SEPARATE DATA LINK DEFINITION MUST BE PROVIDED FOR EACH ASYNCHRONOUS EMBEDDED FORMAT.)
SUPERCOM'ED	2	P-d\AEF1-n	IF THE ASYNCHRONOUS FORMAT IS NOT SUPER-COMMUTATED ENTER - NO, OTHERWISE ENTER THE NUMBER OF HOST MINOR FRAME WORDS THAT ARE USED.
LOCATION DEFINITION	2	P-d\AEF2-n	IF SUPERCOMMUTATED, SPECIFY HOW THE WORD LOCATIONS ARE DEFINED: FIRST WORD AND INTERVAL - FI EVERY LOCATION - EL CONTIGUOUS WORDS - CW NOT APPLICABLE - NA.
LOCATION	4	P-d\AEF3-n-w	SPECIFY THE FIRST WORD WITHIN THE MINOR FRAME WHICH CONTAINS THE ASYNCHRONOUS EMBEDDED FORMAT IDENTIFIED. FOR THE METHOD WHEN EVERY WORD LOCATION IS DEFINED, REPEAT THIS ENTRY FOR EACH WORD POSITION APPLICABLE. FOR THE FIRST WORD AND INTERVAL METHOD, INCLUDE THE NEXT ENTRY TO DEFINE THE INTERVAL.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
INTERVAL	4	P-d\ AEF4-n	SPECIFY THE INTERVAL TO BE USED TO DEFINE THE ASYNCHRONOUS EMBEDDED FORMAT LOCATION.
WORD LENGTH	2	P-d\ AEF5-n-w	SPECIFY THE NUMBER OF EMBEDDED BITS IN THIS HOST WORD LOCATION.
MASK	64	P-d\ AEF6-n-w	IF THE ASYNCHRONOUS PORTION OF THE WORD IS SHORTER THAN THE WORD LENGTH, THEN PROVIDE THE BINARY MASK REQUIRED TO INDICATE WHICH BITS ARE USED. (1'S USED, 0'S NOT USED) LEFTMOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
FORMAT CHANGE			
FRAME FORMAT IDENTIFIER			
LOCATION	4	P-d\ FFI1	SPECIFY THE POSITION IN THE MINOR FRAME WHICH CONTAINS THE FRAME FORMAT IDENTIFICATION (FFI) WORD. IF MORE THAN ONE WORD LOCATION PROVIDE THE DETAILS IN THE COMMENTS RECORD.
MASK	64	P-d\ FFI2	IF THE FFI IS SHORTER THAN THE WORD LENGTH, THEN PROVIDE THE BINARY MASK REQUIRED TO INDICATE WHICH BITS ARE USED. LEFTMOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
MEASUREMENT LIST CHANGE			
NUMBER OF MEASUREMENT LISTS	2	P-d\MLC\N	SPECIFY THE NUMBER OF MEASUREMENT LISTS THAT ARE REQUIRED TO BE SELECTED. IF NONE ENTER - NO, OTHERWISE ENTER THE NUMBER, n.
FFI PATTERN	16	P-d\MLC1-n	SPECIFY THE FFI PATTERN WHICH CORRESPONDS TO THE MEASUREMENT LIST("1"'S AND "0"'S). THIS ENTRY AND THE NEXT ARE AN ORDERED PAIR.
MEASUREMENT LIST NAME	32	P-d\MLC2-n	SPECIFY THE MEASUREMENT LIST NAME.
FORMAT STRUCTURE CHANGE			
NUMBER OF FORMATS	2	P-d\FSC\N	SPECIFY NUMBER OF FORMATS THAT ARE TO BE DEFINED.
FFI PATTERN	16	P-d\FSC1-n	SPECIFY THE FFI PATTERN WHICH CORRESPONDS TO THE FORMAT WHICH IS DEFINED. THIS ENTRY AND THE FOLLOWING ARE AN ORDERED PAIR.
DATA LINK ID	32	P-d\FSC2-n	IDENTIFY THE FORMAT WHICH CORRESPONDS TO THIS FFI CODE.
ALTERNATE TAG AND DATA			
NUMBER OF TAGS	3	P-d\ALT\N	SPECIFY THE NUMBER OF PARAMETERS WHICH ARE INCLUDED WITHIN THIS CATEGORY, THAT IS THE NUMBER OF TAGS.

TABLE 9-5 (Cont'd). PCM FORMAT ATTRIBUTES GROUP (P)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
NUMBER OF BITS IN TAG	2	P-d\ ALT1	SPECIFY THE NUMBER OF BITS WHICH ARE IN THIS TAG.
NUMBER OF BITS IN DATA WORD	2	P-d\ ALT2	SPECIFY THE NUMBER OF BITS WHICH ARE IN THE COMMON DATA WORD.
FIRST TAG LOCATION	2	P-d\ ALT3	IDENTIFY THE LOCATION OF THE START OF THE FIRST TAG LOCATION IN TERMS OF BITS WITH THE FIRST BIT POSITION AFTER THE SYNCHRONIZATION PATTERN BEING NUMBER 1.
SEQUENCE	1	P-d\ ALT4	IF THE TAG/DATA WORD SEQUENCE IS TAG THEN DATA ENTER "N" FOR NORMAL, IF THE DATA PRECEDES THE TAG ENTER "R" FOR REVERSED.
COMMENTS	6400	P-d\COM	PROVIDE ANY ADDITIONAL REQUIRED OR DESIRED INFORMATION.

9.5.6.2 PCM Measurement Description (D)

Table 9-6 and figure 9-7 contain the PCM Measurement Descriptions. The descriptions define each measurand or data item of interest within the frame format specified in the PCM attributes. Table 9-6 includes the measurement name which links the measurement to the Data Conversion Attributes Group.

DATA LINK NAME	CODE NAME	REFERENCE PAGE
DATA LINK NAME	(D-x\DLN)	(9-43)
NUMBER OF MEASUREMENT LISTS	(D-x\ML\N)	
MEASUREMENT LIST NAME	(D-x\MLN-y)	(9-43)
NUMBER OF MEASURANDS	(D-x\MN\N-y)	
MEASUREMENT NAME	(D-x\MN-y-n)	(9-43)
— PARITY	(D-x\MN1-y-n)	
— PARITY TRANSFER ORDER	(D-x\MN2-y-n)	
— MEASUREMENT TRANSFER ORDER	(D-x\MN3-y-n)	
— *MEASUREMENT LOCATION		(9-44)
— — MEASUREMENT LOCATION TYPE	(D-x\LT-y-n)	
— — *MINOR FRAME		(9-44)
— — — MINOR FRAME LOCATION	(D-x\MF-y-n)	
— — — BIT MASK	(D-x\MFM-y-n)	
— — OR *MINOR FRAME SUPERCOMMUTATED		(9-44)
— — — NUMBER OF MINOR FRAME LOCATIONS	(D-x\MFS\N-y-n)	
— — — LOCATION DEFINITION	(D-x\MFS1-y-n)	
— — — *INTERVAL		(9-45)
— — — — LOCATION IN MINOR FRAME	(D-x\MFS2-y-n)	
— — — — BIT MASK	(D-x\MFS3-y-n)	
— — — — INTERVAL	(D-x\MFS4-y-n)	
— — — OR *EVERY LOCATION		
— — — — MINOR FRAME LOCATION	(D-x\MFSW-y-n-e)	
— — — — BIT MASK	(D-x\MFSM-y-n-e)	
— — OR *MINOR FRAME FRAGMENTED		(9-46)
— — — NUMBER OF FRAGMENTS	(D-x\FMF\N-y-n)	
— — — MEASUREMENT WORD LENGTH	(D-x\FMF1-y-n)	
— — — LOCATION DEFINITION	(D-x\FMF2-y-n)	
— — — *INTERVAL		
— — — — LOCATION IN MINOR FRAME	(D-x\FMF3-y-n)	
— — — — BIT MASK	(D-x\FMF4-y-n)	
— — — — INTERVAL	(D-x\FMF5-y-n)	
— — — OR *EVERY LOCATION		(9-47)
— — — — MINOR FRAME LOCATION	(D-x\FMF6-y-n-e)	
— — — — BIT MASK	(D-x\FMF7-y-n-e)	
— — — — FRAGMENT TRANSFER ORDER	(D-x\FMF8-y-n-e)	
— — — — FRAGMENT POSITION	(D-x\FMF9-y-n-e)	

Figure 9-7. PCM Measurement Description Group (D).

OR *SUBFRAME		(9-47)
SUBFRAME NAME	(D-x\SF1-y-n)	
LOCATION IN SUBFRAME	(D-x\SF2-y-n)	
BIT MASK	(D-x\SFM-y-n)	
OR *SUBFRAME SUPERCOMMUTATED		(9-48)
SUBFRAME NAME	(D-x\SFS1-y-n)	
NUMBER OF SUBFRAME LOCATIONS	(D-x\SFS\N-y-n)	
LOCATION DEFINITION	(D-x\SFS2-y-n)	
OR *INTERVAL		(9-48)
LOCATION IN SUBFRAME	(D-x\SFS3-y-n)	
BIT MASK	(D-x\SFS4-y-n)	
INTERVAL	(D-x\SFS5-y-n)	
*EVERY LOCATION		(9-49)
SUBFRAME LOCATION	(D-x\SFS6-y-n-e)	
BIT MASK	(D-x\SFS7-y-n-e)	
*SUBFRAME FRAGMENTED		(9-49)
NUMBER OF FRAGMENTS	(D-x\FSF\N-y-n)	
MEASUREMENT WORD LENGTH	(D-x\FSF1-y-n)	
NUMBER OF SUBFRAMES	(D-x\FSF2\N-y-n)	
SUBFRAME NAME	(D-x\FSF3-y-n-m)	
LOCATION DEFINITION	(D-x\FSF4-y-n-m)	
OR *INTERVAL		(9-50)
LOCATION IN SUBFRAME	(D-x\FSF5-y-n-m)	
BIT MASK	(D-x\FSF6-y-n-m)	
INTERVAL	(D-x\FSF7-y-n-m)	
*EVERY LOCATION		(9-50)
SUBFRAME LOCATION	(D-x\FSF8-y-n-m-e)	
BIT MASK	(D-x\FSF9-y-n-m-e)	
FRAGMENT TRANSFER ORDER	(D-x\FSF10-y-n-m-e)	
FRAGMENT POSITION	(D-x\FSF11-y-n-m-e)	
COMMENTS	(D-x\COM)	(9-51)

*HEADING ONLY - NO DATA ENTRY

Figure 9-7 (Cont'd). PCM Measurement Description Group (D).

TABLE 9-6. PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA LINK NAME	32	D-x\DLN	PROVIDE THE DATA LINK NAME.
NUMBER OF MEASUREMENTS LISTS	2	D-x\ML\N	SPECIFY THE NUMBER OF MEASUREMENTS LISTS TO BE PROVIDED.
MEASUREMENT LIST NAME	32	D-x\MLN-y	PROVIDE THE MEASUREMENT LIST NAME ASSOCIATED WITH THE FOLLOWING ATTRIBUTES. THE FOLLOWING INFORMATION WILL HAVE TO BE REPEATED FOR EACH MEASUREMENT LIST IDENTIFIED IN THE PCM FORMAT ATTRIBUTES GROUP.
NUMBER OF MEASURANDS	4	D-x\ MN\N-y	SPECIFY THE NUMBER OF MEASURANDS INCLUDED WITHIN THIS MEASUREMENT LIST.
MEASUREMENT NAME	32	D-x\MN-y-n	MEASURAND NAME.
PARITY	2	D-x\MN1-y-n	SPECIFY PARITY: EVEN - EV ODD - OD NONE - NO DEFAULT TO MINOR FRAME DEFINITION - DE.
PARITY TRANSFER ORDER	1	D-x\MN2-y-n	PARITY BIT LOCATION LEADS WORD - L TRAILS WORD - T MINOR FRAME DEFAULT - D.
MEASUREMENT TRANSFER ORDER	1	D-x\MN3-y-n	MOST SIGNIFICANT BIT FIRST - M LEAST SIGNIFICANT BIT FIRST -L DEFAULT - D.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
MEASUREMENT LOCATION			
MEASUREMENT LOCATION TYPE	4	D-x\LT-y-n	SPECIFY THE NATURE OF THE LOCATION OF THIS MEASURAND. MINOR FRAME - MF MINOR FRAME SUPERCOMMUTATED - MFSC MINOR FRAME FRAGMENTED - MFFR SUBFRAME - SF SUBFRAME SUPERCOMMUTATED - SFSC SUBFRAME FRAGMENTED - SFFR.
MINOR FRAME			
MINOR FRAME LOCATION	4	D-x\MF-y-n	THE MINOR FRAME WORD POSITION OF THE MEASUREMENT.
BIT MASK	64	D-x\MFM-y-n	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD LOCATION WHICH ARE ASSIGNED TO THIS MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
MINOR FRAME SUPERCOMMUTATED			
NUMBER OF MINOR FRAME LOCATIONS	4	D-x \MFS\N-y-n	NUMBER OF WORD POSITIONS THAT THE SUPERCOMMUTATED CHANNEL OCCUPIES, N.
LOCATION DEFINITION	1	D-x \MFS1-y-n	TO SPECIFY THE INTERVAL ENTER - I. TO SPECIFY EVERY WORD LOCATION ENTER - E.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
INTERVAL			
LOCATION IN MINOR FRAME	4	D-x\MFS2-y-n	SPECIFY THE FIRST WORD LOCATION IN THE MINOR FRAME.
BIT MASK	64	D-x\MFS3-y-n	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD LOCATION WHICH ARE ASSIGNED TO THIS SUPERCOMMUTATED MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
INTERVAL	3	D-x\MFS4-y-n	SPECIFY THE INTERVAL COUNT WHICH IS THE OFFSET FROM THE FIRST WORD LOCATION AND EACH SUBSEQUENT LOCATION.
EVERY LOCATION			
MINOR FRAME LOCATION	4	D-x \MFSW-y-n-e	ENTER THE MINOR FRAME WORD POSITION OF THE MEASUREMENT.
BIT MASK	64	D-x \MFSM-y-n-e	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD LOCATION WHICH ARE ASSIGNED TO THIS SUPERCOMMUTATED MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
ENTER THE MINOR FRAME LOCATION AND BIT MASK FOR EACH OF THE WORD POSITIONS THAT THE SUPERCOMMUTATED CHANNEL OCCUPIES, (N) LOCATIONS.			

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
MINOR FRAME FRAGMENTED			
NUMBER OF FRAGMENTS	1	D-x \FMF\N-y-n	NUMBER OF MINOR FRAME WORD POSITIONS THAT THE FRAGMENTED CHANNEL OCCUPIES, N.
MEASUREMENT WORD LENGTH	3	D-x \FMF1-y-n	TOTAL LENGTH OF THE RECONSTRUCTED BINARY DATA WORD.
LOCATION DEFINITION	1	D-x \FMF2-y-n	TO SPECIFY THE INTERVAL ENTER - I. TO SPECIFY EVERY WORD LOCATION ENTER - E.
INTERVAL			
LOCATION IN MINOR FRAME	4	D-x\FMF3-y-n	SPECIFY THE FIRST WORD POSITION THAT THE FRAGMENTED WORD OCCUPIES IN THE MINOR FRAME.
BIT MASK	64	D-x\FMF4-y-n	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS FRAGMENTED CHANNEL, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
INTERVAL	4	D-x\FMF5-y-n	SPECIFY THE INTERVAL WHICH IS THE OFFSET FROM THE FIRST WORD LOCATION AND EACH SUBSEQUENT LOCATION.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
EVERY LOCATION			
MINOR FRAME LOCATION	4	D-x\FMF6-y-n-e	ENTER THE MINOR FRAME WORD POSITION OF THE MEASUREMENT.
BIT MASK	64	D-x\FMF7-y-n-e	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS FRAGMENTED MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
FRAGMENT TRANSFER ORDER	1	D-x\FMF8-y-n-e	MOST SIGNIFICANT BIT FIRST - M, LEAST SIGNIFICANT BIT FIRST - L, DEFAULT - D.
FRAGMENT POSITION	1	D-x\FMF9-y-n-e	A NUMBER FROM 1 TO N SPECIFYING POSITION OF THE FRAGMENT WITHIN THE RECONSTRUCTED BINARY DATA WORD. (1 CORRESPONDS TO MOST SIGNIFICANT FRAGMENT).
ENTER THE MINOR FRAME LOCATION AND BIT MASK FOR EACH OF THE WORD POSITIONS THAT THE FRAGMENTED CHANNEL OCCUPIES, (N) LOCATIONS.			
SUBFRAME			
SUBFRAME NAME	4	D-x\SF1-y-n	ENTER THE SUBFRAME NAME.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
LOCATION IN SUBFRAME	4	D-x\SF2-y-n	SPECIFY THE WORD NUMBER IN THE SUBFRAME.
BIT MASK	64	D-x\SFM-y-n	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BITS IN A WORD LOCATION WHICH ARE ASSIGNED TO THIS MEASUREMENT, IF THE FULL WORD IS USED FOR THE MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
SUBFRAME SUPERCOMMUTATED			
SUBFRAME NAME	4	D-x\SFS1-y-n	ENTER THE SUBFRAME NAME.
NUMBER OF SUBFRAME LOCATIONS	3	D-x \SFS\N-y-n	NUMBER OF SUBFRAME WORD POSITIONS THAT THE SUPERCOMMUTATED CHANNEL OCCUPIES.
LOCATION DEFINITION	1	D-x\SFS2-y-n	TO SPECIFY: INTERVAL ENTER - I EVERY WORD ENTER - E.
INTERVAL			
LOCATION IN SUBFRAME	4	D-x\SFS3-y-n	SPECIFY THE FIRST WORD POSITION THAT THE SUPERCOMMUTATED WORD OCCUPIES IN THE SUBFRAME.
BIT MASK	64	D-x\SFS4-y-n	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BIT LOCATIONS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS SUPERCOMMUTATED CHANNEL, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
INTERVAL	3	D-x\SFS5-y-n	SPECIFY THE INTERVAL WHICH IS THE OFFSET FROM THE FIRST WORD LOCATION AND EACH SUBSEQUENT LOCATION.
EVERY LOCATION			
SUBFRAME LOCATION	4	D-x \SFS6-y-n-e	ENTER THE SUBFRAME WORD POSITION OF THE MEASUREMENT.
BIT MASK	64	D-x \SFS7-y-n-e	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BIT LOCATIONS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS SUPERCOMMUTATED MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
ENTER THE SUBFRAME LOCATION AND BIT MASK FOR EACH OF THE WORD POSITIONS THAT THE SUPERCOMMUTATED CHANNEL OCCUPIES, (N) LOCATIONS.			
SUBFRAME FRAGMENTED			
NUMBER OF FRAGMENTS	1	D-x \FSF\N-y-n	NUMBER OF SUBFRAME WORD POSITIONS THAT THE FRAGMENTED CHANNEL OCCUPIES, N.
MEASUREMENT WORD LENGTH	3	D-x\FSF1-y-n	TOTAL LENGTH OF THE RECONSTRUCTED BINARY DATA WORD.
NUMBER OF SUBFRAMES	1	D-x \FSF2\N-y-n	NUMBER OF SUBFRAMES CONTAINING THE FRAGMENTS.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
SUBFRAME NAME	4	D-x\FSF3-y-n-m	ENTER THE SUBFRAME NAME.
LOCATION DEFINITION	1	D-x\FSF4-y-n-m	TO SPECIFY: INTERVAL - I EVERY WORD - E.
INTERVAL			
LOCATION IN SUBFRAME	3	D-x\FSF5-y-n-m	SPECIFY THE FIRST WORD POSITION THAT THE FRAGMENTED WORD OCCUPIES IN THE SUBFRAME.
BIT MASK	64	D-x\FSF6-y-n-m	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BIT LOCATIONS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS FRAGMENTED CHANNEL, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
INTERVAL	3	D-x\FSF7-y-n-m	SPECIFY THE INTERVAL WHICH IS THE OFFSET FROM THE FIRST WORD LOCATION AND EACH SUBSEQUENT LOCATION.
EVERY LOCATION			
SUBFRAME LOCATION	3	D-x\FSF8-y-n-m-e	ENTER THE SUBFRAME WORD POSITION OF THE MEASUREMENT.

TABLE 9-6 (Cont'd). PCM MEASUREMENT DESCRIPTION GROUP (D)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
BIT MASK	64	D-x\FSF9-y-n-m-e	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BIT LOCATIONS IN A WORD POSITION WHICH ARE ASSIGNED TO THIS FRAGMENTED MEASUREMENT, IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFT MOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
FRAGMENT TRANSFER ORDER	1	D-x\FSF10-y-n-m-e	MOST SIGNIFICANT BIT FIRST - M, LEAST SIGNIFICANT BIT FIRST - L, DEFAULT - D.
FRAGMENT POSITION	1	D-x\FSF11-y-n-m-e	A NUMBER FROM 1 TO N SPECIFYING POSITION OF THIS FRAGMENT WITHIN THE RECONSTRUCTED BINARY DATA WORD. (1 CORRESPONDS TO MOST SIGNIFICANT FRAGMENT).
ENTER THE SUBFRAME LOCATION AND BIT MASK FOR EACH OF THE WORD POSITIONS THAT THE FRAGMENTED CHANNEL OCCUPIES, (N) LOCATIONS.			
REPEAT THE ABOVE ENTRIES, AS APPROPRIATE FOR EACH SUBFRAME THAT CONTAINS THE COMPONENTS OF THE FRAGMENTED WORD.			
COMMENTS	3200	D-x\COM	PROVIDE ANY ADDITIONAL INFORMATION REQUIRED OR DESIRED.
THIS GROUP WILL CONTAIN A REPETITION OF THE ABOVE INFORMATION UNTIL EACH MEASUREMENT HAS BEEN DEFINED. ANY WORD POSITION NOT INCLUDED WILL BE TREATED AS A SPARE CHANNEL OR A "DON'T CARE" CHANNEL. INFORMATION WILL NOT BE PROCESSED FOR THESE "SPARE" CHANNELS. NOTE THAT MEASUREMENT LIST CHANGES AND FORMAT CHANGES WHICH ARE A PART OF CLASS II SYSTEMS ARE INCLUDED IN THE ABOVE SINCE THE KEY TO THE MEASUREMENT DEFINITION IS THE DATA LINK NAME (FORMAT) AND THE MEASUREMENT LIST.			

9.5.6.3 <u>1553 Bus Data Attributes (B)</u>

Figure 9-8 and table 9-7 describe the 1553 bus-originated data formats. The 1553 Bus Data Attributes Group defines the attributes of a data acquisition system that is compliant with chapter 8. The primary components of this group are the recording description and message content definition. The former defines the method by which the data were recorded on the tape such as track spread versus composite. The latter consists of the message identification information and the measurement description set. The message identification information defines the contents of the control word that identifies each 1553 message. The measurement description set describes the measurement attributes and contains the measurement name which links the measurand to the Data Conversion Attributes Group (C).

Mode codes are described in the message identification information. If the Subterminal Address (STA) field contains 00000 or 11111, the information in the Data Word Count/Mode Code field is a mode code and identifies the function of the mode code. If the mode code has associated data words, they are described in this section of the attributes. If the 1553 message is a remote terminal to remote terminal transfer, both the transmit command and the receive command are used to identify the message. Multiple receive commands may be listed to indicate different remote terminals which may receive a given message.

DATA LINK NAME	CODE NAME	REFERENCE PAGE
DATA LINK NAME	(B-x\DLN)	(9-54)
TEST ITEM	(B-x\TA)	(9-54)
NUMBER OF BUSES	(B-x\NBS\N)	
BUS NUMBER	(B-x\BID-i)	
BUS NAME	(B-x\BNA-i)	
*RECORDING DESCRIPTION		(9-55)
NUMBER OF TRACKS	(B-x\TK\N-i)	
TRACK SEQUENCE	(B-x\TS-i-k)	
*MESSAGE CONTENT DEFINITION		(9-55)
NUMBER OF MESSAGES	(B-x\NMS\N-i)	
MESSAGE NUMBER	(B-x\MID-i-n)	
MESSAGE NAME	(B-x\MNA-i-n)	
REMOTE TERMINAL NAME	(B-x\TRN-i-n)	
REMOTE TERMINAL ADDRESS	(B-x\TRA-i-n)	
SUBTERMINAL NAME	(B-x\STN-i-n)	
SUBTERMINAL ADDRESS	(B-x\STA-i-n)	
TRANSMIT/RECEIVE MODE	(B-x\TRM-i-n)	
DATA WORD COUNT/ MODE CODE	(B-x\DWC-i-n)	
SPECIAL PROCESSING	(B-x\SPR-i-n)	
*RT/RT RECEIVE COMMAND LIST		(9-56)
NUMBER OF REMOTE TERMINALS	(B-x\RNRT\N-i-n)	
REMOTE TERMINAL NAME	(B-x\RTRN-i-n-m)	
REMOTE TERMINAL ADDRESS	B-x\RTRA-i-n-m)	
SUBTERMINAL NAME	(B-x\RSTN-i-n-m)	
SUBTERMINAL ADDRESS	(B-x\RSTA-i-n-m)	
DATA WORD COUNT	(B-x\RDWC-i-n-m)	
*MODE CODE		(9-57)
MODE CODE DESCRIPTION	(B-x\MCD-i-n)	
MODE CODE DATA WORD DESCRIPTION	(B-x\MCW-i-n)	
*MEASUREMENT DESCRIPTION SET		(9-57)
NUMBER OF MEASURANDS	(B-x\MN\N-i-n)	
MEASUREMENT NAME	(B-x\MN-i-n-p)	
PARITY	(B-x\MN1-i-n-p)	
PARITY TRANSFER ORDER	(B-x\MN2-i-n-p)	

Figure 9-8. 1553 Bus Data Attributes Group (B).

*MEASUREMENT LOCATION (9-58)

- NUMBER OF MEASUREMENT LOCATIONS (B-x\NML\N-i-n-p)
- MESSAGE WORD NUMBER (B-x\MWN-i-n-p-e)
- BIT MASK (B-x\MBM-i-n-p-e)
- TRANSFER ORDER (B-x\MTO-i-n-p-e)
- FRAGMENT POSITION (B-x\MFP-i-n-p-e)

COMMENTS (B-x\COM) (9-59)

*HEADING ONLY - NO DATA ENTRY

Figure 9-8 (Cont'd). 1553 Bus Data Attributes Group (B).

TABLE 9-7. 1553 BUS DATA ATTRIBUTES GROUP (B)

PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA LINK NAME	32	B-x\DLN	IDENTIFY THE DATA LINK CONSISTENT WITH THE MULTIPLEX/MODULATION GROUP. THE PCM FORMAT OF THE DATA STREAM SHALL BE DEFINED IN THE PCM FORMAT ATTRIBUTES GROUP.
TEST ITEM	16	B-x\TA	TEST ITEM DESCRIPTION IN TERMS OF NAME, MODEL, PLATFORM, OR IDENTIFICATION CODE THAT CONTAINS THE DATA ACQUISITION SYSTEM.
NUMBER OF BUSES	1	B-x\NBS\N	SPECIFY THE NUMBER OF BUSES INCLUDED WITHIN THIS DATA LINK.
BUS NUMBER	3	B-x\BID-i	ENTER THE BUS NUMBER AS A BINARY STRING.
BUS NAME	32	B-x\BNA-i	SPECIFY THE BUS NAME.

TABLE 9-7 (Cont'd). 1553 BUS DATA ATTRIBUTES GROUP (B)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
RECORDING DESCRIPTION			
NUMBER OF TRACKS	2	B-x\TK\N-i	ENTER THE NUMBER OF TAPE TRACKS USED TO RECORD DATA. ANY ENTRY GREATER THAN ONE INDICATES THAT THE DATA HAS BEEN SPREAD ACROSS MULTIPLE TRACKS.
TRACK SEQUENCE	3	B-x\TS-i-k	IN THE FOLLOWING ENTRIES GIVE THE SEQUENCE ORDER OF TAPE TRACKS THAT SHOULD BE USED TO RECOVER THE DATA STREAM IN THE CORRECT ORDER. (THE ORDER GIVEN SHOULD CORRESPOND TO THE ACTUAL SKEW OF THE DATA ON THE TAPE.)
MESSAGE CONTENT DEFINITION			
NUMBER OF MESSAGES	5	B-x\NMS\N-i	THE NUMBER OF MESSAGES TO BE DEFINED.
MESSAGE NUMBER	8	B-x\ MID-i-n	THE MESSAGE NUMBER WHICH CONTAINS THE FOLLOWING DATA.
MESSAGE NAME	32	B-x\MNA-i-n	SPECIFY THE MESSAGE NAME.
REMOTE TERMINAL NAME	32	B-x\TRN-i-n	ENTER THE NAME OF THE REMOTE TERMINAL THAT IS SENDING OR RECEIVING THIS MESSAGE.
REMOTE TERMINAL ADDRESS	5	B-x\TRA-i-n	SPECIFY THE FIVE BIT REMOTE TERMINAL ADDRESS FOR THIS MESSAGE.

TABLE 9-7 (Cont'd). 1553 BUS DATA ATTRIBUTES GROUP (B)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
SUBTERMINAL NAME	32	B-x\STN-i-n	ENTER THE NAME OF THE SUBTERMINAL THAT IS SENDING OR RECEIVING THIS MESSAGE.
SUBTERMINAL ADDRESS	5	B-x\STA-i-n	SPECIFY THE FIVE BIT SUBTERMINAL ADDRESS FOR THIS MESSAGE.
TRANSMIT/ RECEIVE MODE	1	B-x\TRM-i-n	INDICATE IF THIS COMMAND WORD IS A TRANSMIT OR RECEIVE COMMAND: TRANSMIT - 1 RECEIVE - 0.
DATA WORD COUNT/MODE CODE	5	B-x\DWC-i-n	ENTER THE NUMBER OF DATA WORDS AS A BINARY STRING, USING "X" TO INDICATE A "DON'T CARE" BIT. IF THE SUB-TERMINAL ADDRESS INDICATES A MODE CODE ENTER THE MODE CODE VALUE AS A BINARY STRING.
SPECIAL PROCESSING	200	B-x\SPR-i-n	PROVIDE ANY SPECIAL PROCESSING REQUIREMENTS PERTAINING TO THIS MESSAGE.
RT/RT RECEIVE COMMAND LIST			
NUMBER OF REMOTE TERMINALS	2	B-x\ RNRT\N-i-n	SPECIFY THE NUMBER OF REMOTE TERMINALS WHICH MAY RECEIVE THIS RT/RT MESSAGE.
REMOTE TERMINAL NAME	32	B-x\ RTRN-i-n-m	ENTER THE NAME OF THE REMOTE TERMINAL THAT IS RECEIVING THIS RT/RT MESSAGE.

TABLE 9-7 (Cont'd). 1553 BUS DATA ATTRIBUTES GROUP (B)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
REMOTE TERMINAL ADDRESS	5	B-x\RTRA-i-n-m	SPECIFY THE FIVE BIT REMOTE TERMINAL ADDRESS FOR THIS RT/RT MESSAGE.
SUBTERMINAL NAME	32	B-x\RSTN-i-n-m	ENTER THE NAME OF THE SUBTERMINAL THAT IS RECEIVING THIS RT/RT MESSAGE.
SUBTERMINAL ADDRESS	5	B-x\RSTA-i-n-m	SPECIFY THE FIVE BIT SUBTERMINAL ADDRESS FOR THIS RT/RT MESSAGE.
DATA WORD COUNT	5	B-x\RDWC-i-n-m	ENTER THE NUMBER OF DATA WORDS AS A BINARY STRING, USING "X" TO INDICATE A "DON'T CARE" BIT. EXCLUDE STATUS AND TIME WORDS. (AN RT/RT MESSAGE CANNOT CONTAIN A MODE CODE).
MODE CODE			
MODE CODE DESCRIPTION	200	B-x\MCD-i-n	DESCRIBE THE FUNCTION OR ACTION ASSOCIATED WITH THIS MODE CODE.
MODE CODE DATA WORD DESCRIPTION	200	B-x\MCW-i-n	IF THE MODE CODE HAS AN ASSOCIATED DATA WORD FOLLOWING THE MODE CODE COMMAND, PROVIDE A COMPLETE DESCRIPTION OF THE DATA WORD.
MEASUREMENT DESCRIPTION SET			
NUMBER OF MEASURANDS	4	B-x\MN\N-i-n	SPECIFY THE NUMBER OF MEASURANDS.
MEASUREMENT NAME	32	B-x\MN-i-n-p	MEASURAND NAME.

TABLE 9-7 (Cont'd). 1553 BUS DATA ATTRIBUTES GROUP (B)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
PARITY	2	B-x\ MN1-i-n-p	NORMAL WORD PARITY. EVEN - EV ODD - OD NONE - NO.
PARITY TRANSFER ORDER	1	B-x\ MN2-i-n-p	PARITY BIT LOCATION LEADS WORD - L TRAILS WORD - T.
MEASUREMENT LOCATION			
NUMBER OF MEASUREMENT LOCATIONS	2	B-x\ NML\N-i-n-p	IF THIS MEASUREMENT IS CONTAINED IN ONE WORD, ENTER 1. IF THIS MEASUREMENT IS FRAGMENTED, ENTER THE NUMBER OF FRAGMENTS.
MESSAGE WORD NUMBER	3	B-x\ MWN-i-n-p-e	ENTER THE NUMBER CORRESPONDING TO THE DATA WORD COUNT WITHIN A MESSAGE WHICH CONTAINS THE MEASUREMENT OR THE FRAGMENTED MEASURAND.
BIT MASK	64	B-x\ MBM-i-n-p-e	BINARY STRING OF 1'S AND 0'S TO IDENTIFY THE BIT LOCATIONS WHICH ARE ASSIGNED TO THIS MEASUREMENT IN THE WORD IDENTIFIED ABOVE. IF THE FULL WORD IS USED FOR THIS MEASUREMENT ENTER - FW. LEFTMOST BIT CORRESPONDS TO FIRST BIT TRANSMITTED.
TRANSFER ORDER	3	B-x\ MTO-i-n-p-e	SPECIFY IF THE START BIT IS: MOST SIGNIFICANT-MSB LEAST SIGNIFICANT-LSB

TABLE 9-7 (Cont'd). 1553 BUS DATA ATTRIBUTES GROUP (B)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
FRAGMENT POSITION	1	B-x\MFP-i-n-p-e	A NUMBER FROM 1 TO N WHICH SPECIFIES THE POSITION OF THE FRAGMENT WITHIN THE RECONSTRUCTED BINARY DATA WORD, (1 CORRESPONDS TO THE MOST SIGNIFICANT FRAGMENT).
REPEAT THE ABOVE TO DESCRIBE EACH FRAGMENT OF A FRAGMENTED WORD. THE TRANSFER ORDER INDICATES WHETHER TO TRANSPOSE THE ORDER OF THE BIT SEQUENCE OR NOT (LSB INDICATES TO TRANSPOSE THE BIT SEQUENCE).			
COMMENTS	3200	B-x\COM	PROVIDE ANY ADDITIONAL INFORMATION REQUIRED OR DESIRED.

9.5.7 PAM Attributes (A)

This group provides the information necessary to define the channelization and measurand definition for a PAM waveform. As with the PCM signal, the tie to the calibration data is with the measurement name. Figure 9-9 summarizes the types of inputs required. Table 9-8 specifies the details required. The information which defines the measurand for each channel is required for the channels of interest.

	CODE NAME	REFERENCE PAGE
DATA LINK NAME	(A-x\DLN)	(9-61)
INPUT CODE	(A-x\A1)	(9-61)
POLARITY	(A-x\A2)	
SYNC PATTERN TYPE	(A-x\A3)	
SYNC PATTERN (OTHER)	(A-x\A4)	
CHANNEL RATE	(A-x\A5)	
CHANNELS PER FRAME	(A-x\A\N)	
NUMBER OF MEASURANDS	(A-x\A\MN\N)	
*REFERENCE CHANNELS		(9-62)
0% SCALE CHANNEL NUMBER	(A-x\RC1)	
50% SCALE CHANNEL NUMBER	(A-x\RC2)	
FULL SCALE CHANNEL NUMBER	(A-x\RC3)	
*SUBFRAME DEFINITION		(9-62)
NUMBER OF SUBFRAMES	(A-x\SF\N)	
SUBFRAME n LOCATION	(A-x\SF1-n)	
SUBFRAME n SYNCHRONIZATION	(A-x\SF2-n)	
SUBFRAME n SYNCHRONIZATION PATTERN	(A-x\SF3-n)	
*CHANNEL ASSIGNMENT		(9-63)
MEASUREMENT NAME	(A-x\MN1-n)	
SUBCOM	(A-x\MN2-n)	
SUPERCOM	(A-x\MN3-n)	
*LOCATION		(9-63)
CHANNEL NUMBER	(A-x\LCW-n-s)	
SUBFRAME CHANNEL NUMBER	(A-x\LCN-n-s-r)	
COMMENTS	(A-x\COM)	(9-63)

*HEADING ONLY - NO DATA ENTRY

Figure 9-9. PAM Attributes Group (A).

TABLE 9-8. PAM ATTRIBUTES GROUP (A)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DATA LINK NAME	32	A-x\DLN	IDENTIFY THE DATA LINK NAME.
INPUT CODE	2	A-x\A1	DEFINE THE INPUT CODE: 50% DUTY CYCLE - RZ 100% DUTY CYCLE(NRZ) - NR.
POLARITY	1	A-x\A2	NORMAL - N INVERTED - I.
SYNC PATTERN TYPE	3	A-x\A3	SPECIFY THE SYNCHRONIZATION PATTERN IRIG 106 - STD OTHER - OTH.
SYNC PATTERN (OTHER)	5	A-x\A4	DEFINE THE OTHER (NON-STANDARD) SYNCHRONIZATION PATTERN IN TERMS OF 0 - ZERO SCALE H - HALF SCALE F - FULL SCALE X - DON'T CARE.
CHANNEL RATE	6	A-x\A5	SPECIFY THE CHANNEL RATE IN CHANNELS PER SECOND.
CHANNELS PER FRAME	3	A-x\A\N	SPECIFY THE NUMBER OF CHANNELS PER FRAME INCLUDING THE SYNC PATTERN AND CALIBRATION CHANNELS. MAXIMUM ALLOWED IS 128.
NUMBER OF MEASURANDS	4	A-x\A\MN\N	INDICATE THE NUMBER OF MEASURANDS ASSOCIATED WITH THIS DATA LINK (SOURCE).

TABLE 9-8 (Cont'd). PAM ATTRIBUTES GROUP (A)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
REFERENCE CHANNELS			
0% SCALE CHANNEL NUMBER	3	A-x\RC1	CHANNEL NUMBER OF ZERO PERCENT SCALE REFERENCE, IF NOT USED ENTER NONE (NON).
50% SCALE CHANNEL NUMBER	3	A-x\RC2	CHANNEL NUMBER OF 50% SCALE REFERENCE, IF NOT USED ENTER NONE (NON).
FULL SCALE CHANNEL NUMBER	3	A-x\RC3	CHANNEL NUMBER OF FULL SCALE REFERENCE, IF NOT USED ENTER NONE (NON).
SUBFRAME DEFINITION			
NUMBER OF SUBFRAMES	1	A-x\SF\N	SPECIFY THE NUMBER OF SUBMULTIPLEXED CHANNELS IN THE FRAME.
SUBFRAME n LOCATION	3	A-x\SF1-n	CHANNEL NUMBER OF THE SUBFRAME (REPEAT THIS ENTRY AND THE FOLLOWING TWO ENTRIES FOR EACH SUBFRAME AS A SET).
SUBFRAME n SYNCHRONIZATION	3	A-x\SF2-n	SPECIFY THE SYNCHRONIZATION PATTERN FOR THE SUBFRAME: IRIG 106 - STD OTHER - OTH.
SUBFRAME n SYNCHRONIZATION PATTERN	5	A-x\SF3-n	DEFINE THE OTHER (NON-STANDARD) SYNCHRONIZATION PATTERN IN TERMS OF 0 - ZERO SCALE H - HALF SCALE F - FULL SCALE X - DON'T CARE OTR - OTHER.

TABLE 9-8 (Cont'd). PAM ATTRIBUTES GROUP (A)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
CHANNEL ASSIGNMENT			
MEASUREMENT NAME	32	A-x\MN1-n	GIVE THE MEASUREMENT NAME.
SUBCOM	1	A-x\MN2-n	IS THIS A SUBCOMMUTATED CHANNEL? Y/N.
SUPERCOM	1	A-x\MN3-n	IS THIS A SUPER COMMUTATED CHANNEL? IF YES, ENTER THE NUMBER OF POSITIONS IT OCCUPIES - n IF NO ENTER - N. A SUPERCOMMUTATED SUBCOMMUTATED PARAMETER IS ALLOWABLE AND WILL HAVE ENTRIES IN THIS AND THE PREVIOUS RECORD.
LOCATION			
CHANNEL NUMBER	3	A-x\LCW-n-s	NUMBER OF THE CHANNEL WHICH CONTAINS THIS MEASURAND, IF THIS IS A SUBCOMMUTATED CHANNEL, ENTER THE CHANNEL THAT CONTAINS THE SUBCOMMUTATED CHANNEL.
SUBFRAME CHANNEL NUMBER	3	A-x\ LCN-n-s-r	CHANNEL NUMBER IN THE SUBFRAME IF APPROPRIATE.
COMMENTS	3200	A-x\COM	PROVIDE ANY ADDITIONAL INFORMATION REQUIRED OR DESIRED.

9.5.8 Data Conversion Attributes (C)

The Data Conversion Attributes Group includes a definition of the method by which the raw telemetry data is to be converted to meaningful information. The sensor calibration is contained in the group for each type of sensor which uses a standard calibration curve or for each sensor or parameter which has a unique calibration requirement. The calibration information can be entered in several different formats. Provision is made to permit a test organization to convert data set entries to coefficients of an appropriate curve fit and record the derived coefficients. Figure 9-10 shows the structure of the data conversion attributes. Table 9-9 contains the detailed information required.

> **NOTE**
>
> For reference purposes, the following telemetry unit definitions apply:
>
> PCM - Natural binary range as indicated by binary format entry
>
> PAM - Zero to full scale (100)
>
> FM (Analog) - Lower band edge (-100) to upper band edge (+100).

MEASUREMENT NAME	CODE NAME (C-d\DCN)	REFERENCE PAGE (9-67)
*TRANSDUCER INFORMATION		(9-67)
TYPE	(C-d\TRD1)	
MODEL NUMBER	(C-d\TRD2)	
SERIAL NUMBER	(C-d\TRD3)	
SECURITY CLASSIFICATION	(C-d\TRD4)	
ORIGINATION DATE	(C-d\TRD5)	
REVISION NUMBER	(C-d\TRD6)	
ORIENTATION	(C-d\TRD7)	
*POINT OF CONTACT		
NAME	(C-d\POC1)	
AGENCY	(C-d\POC2)	
ADDRESS	(C-d\POC3)	
TELEPHONE	(C-d\POC4)	
*MEASURAND		(9-68)
DESCRIPTION	(C-d\MN1)	
EXCITATION VOLTAGE	(C-d\MN2)	
ENGINEERING UNITS	(C-d\MN3)	
LINK TYPE	(C-d\MN4)	
*TELEMETRY VALUE DEFINITION		(9-68)
BINARY FORMAT	(C-d\BFM)	
*INFLIGHT CALIBRATION		(9-69)
NUMBER OF POINTS	(C-d\MC\N)	
STIMULUS	(C-d\MC1-n)	
TELEMETRY VALUE	(C-d\MC2-n)	
DATA VALUE	(C-d\MC3-n)	
*AMBIENT VALUE		(9-69)
STIMULUS	(C-d\MA1)	
TELEMETRY VALUE	(C-d\MA2)	
DATA VALUE	(C-d\MA3)	
*OTHER INFORMATION		(9-70)
HIGH MEASUREMENT VALUE	(C-d\MOT1)	
LOW MEASUREMENT VALUE	(C-d\MOT2)	
HIGH LIMIT VALUE	(C-d\MOT3)	
LOW LIMIT VALUE	(C-d\MOT4)	
SAMPLE RATE	(C-d\SR)	

Figure 9-10. Data Conversion Attributes Group (C).

- *DATA CONVERSION (9-70)
  - CONVERSION TYPE (C-d\DCT)
  - *ENGINEERING UNITS CONVERSION (9-71)
    - *PAIR SETS (9-71)
      - NUMBER OF SETS (C-d\PS\N)
      - APPLICATION (C-d\PS1)
      - ORDER OF FIT (C-d\PS2)
      - TELEMETRY VALUE (C-d\PS3-n)
      - ENGINEERING UNITS VALUE (C-d\PS4-n)
    - OR *COEFFICIENTS (9-71)
      - ORDER OF CURVE FIT (C-d\CO\N)
      - DERIVED FROM PAIR SET (C-d\CO1)
      - COEFFICIENT(0) (C-d\CO)
      - N-TH COEFFICIENT (C-d\CO-n)
    - OR *OTHER (9-72)
      - DEFINITION OF OTHER DATA CONVERSION (C-d\OTH)
    - OR *DERIVED PARAMETER (9-72)
      - NUMBER OF INDEPENDENT VARIABLES (C-d\DP\N)
      - MEASURAND #N (C-d\DP-n)
      - ALGORITHM (C-d\DPA)
    - OR *DISCRETE (9-73)
      - NUMBER OF EVENTS (C-d\DIC\N)
      - NUMBER OF INDICATORS (C-d\DICI\N)
      - CONVERSION DATA (C-d\DICC-n)
      - PARAMETER EVENT DEFINITION (C-d\DICP-n)
- OR *DIGITAL VOICE (9-73)
  - ENCODING METHOD (C-d\VOI\E)
  - DESCRIPTION (C-d\VOI\D)
- OR *DIGITAL VIDEO (9-74)
  - ENCODING METHOD (C-d\VID\E)
  - DESCRIPTION (C-d\VID\D)
- COMMENTS (C-d\COM) (9-74)

*HEADING ONLY - NO DATA ENTRY

Figure 9-10 (Cont'd). Data Conversion Attributes Group (C).

TABLE 9-9. DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
MEASUREMENT NAME	32	C-d\DCN	GIVE THE MEASUREMENT NAME.
TRANSDUCER INFORMATION			
TYPE	32	C-d\TRD1	TYPE OF SENSOR, IF APPROPRIATE.
MODEL NUMBER	32	C-d\TRD2	IF APPROPRIATE.
SERIAL NUMBER	32	C-d\TRD3	IF APPLICABLE.
SECURITY CLASSIFICATION	4	C-d\TRD4	ENTER THE SECURITY CLASSIFICATION OF THIS MEASURAND. UNCLASSIFIED - U CONFIDENTIAL - C SECRET - S TOP SECRET - T OTHER - OTH. APPEND THE FOLLOWING: IF RECEIVED TELEMETRY SIGNAL (COUNTS) IS CLASSIFIED ADD - R IF EXPRESSED IN ENGINEERING UNITS THE MEASURAND VALUE IS CLASSIFIED ADD - E, IF BOTH ARE CLASSIFIED ADD - B.
ORIGINATION DATE	8	C-d\TRD5	DATE OF ORIGINATION OF THIS DATA FILE. (MM-DD-YY) DD - DAY. MM - MONTH. YY - YEAR.
REVISION NUMBER	4	C-d\TRD6	SPECIFY THE REVISION NUMBER OF THE DATA PROVIDED.
ORIENTATION	32	C-d\TRD7	DESCRIBE THE PHYSICAL ORIENTATION OF THE SENSOR.

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
POINT OF CONTACT: NAME AGENCY ADDRESS TELEPHONE	 24 48 48 20	 C-d\POC1 C-d\POC2 C-d\POC3 C-d\POC4	POINT OF CONTACT WITH THE ORGANIZATION THAT PROVIDED THE CALIBRATION DATA.
MEASURAND			
DESCRIPTION	64	C-d\MN1	DESCRIBE THE PARAMETER BEING MEASURED.
EXCITATION VOLTAGE	10	C-d\MN2	SENSOR REFERENCE VOLTAGE IN VOLTS.
ENGINEERING UNITS	16	C-d\MN3	DEFINE THE ENGINEERING UNITS APPLICABLE TO THE OUTPUT DATA.
LINK TYPE	3	C-d\MN4	DEFINE THE SOURCE DATA LINK TYPE: FM(ANALOG) - ANA PCM - PCM PAM - PAM OTHER - OTH.
TELEMETRY VALUE DEFINITION			
BINARY FORMAT	3	C-d\BFM	FORMAT OF THE BINARY INFORMATION: INTEGER - INT UNSIGNED INTEGER BINARY - UNS SIGN AND MAGNITUDE BINARY - SIG ONE'S COMPLEMENT - ONE TWO'S COMPLEMENT - TWO OFFSET BINARY - OFF OTHER - OTH, DEFINE IN COMMENTS (FOR EXAMPLE, FLOATING POINT DATA).

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
INFLIGHT CALIBRATION			
NUMBER OF POINTS	1	C-d\MC\N	IS INFLIGHT CALIBRATION REQUIRED? N FOR NO OR A NUMBER BETWEEN 1 AND 5, IF IT IS REQUIRED. A MAXIMUM OF FIVE CALIBRATION POINTS MAY BE INCLUDED.
STIMULUS	32	C-d\MC1-n	PROVIDE THE STIMULUS FOR THIS CALIBRATION POINT.
TELEMETRY VALUE	16	C-d\MC2-n	TELEMETRY UNITS VALUE.
DATA VALUE	16	C-d\MC3-n	ENGINEERING UNITS VALUE.
THE ABOVE SET OF THREE ENTRIES MUST BE REPEATED FOR EACH INFLIGHT CALIBRATION POINT.			
AMBIENT VALUE			
STIMULUS	32	C-d\MA1	DESCRIPTION OF THE STATIC ENVIRONMENT IN WHICH A NON-TEST STIMULUS OR SIMULATOR IS THE DATA SOURCE.
TELEMETRY VALUE	16	C-d\MA2	TELEMETRY UNITS VALUE FOR THE STATIC STIMULUS.
DATA VALUE	32	C-d\MA3	ENGINEERING UNITS FOR THE STATIC OR SIMULATED CONDITION.

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
OTHER INFORMATION			
HIGH MEASUREMENT VALUE	32	C-d\MOT1	HIGHEST ENGINEERING UNIT VALUE DEFINED BY THE CALIBRATION DATA.
LOW MEASUREMENT VALUE	32	C-d\MOT2	LOWEST ENGINEERING UNIT VALUE DEFINED IN THE CALIBRATION DATA.
HIGH LIMIT VALUE	32	C-d\MOT3	HIGHEST ENGINEERING UNIT VALUE EXPECTED OR SAFE OPERATING VALUE OF THE PARAMETER.
LOW LIMIT VALUE	32	C-d\MOT4	LOWEST ENGINEERING UNIT VALUE EXPECTED OR THE SAFE OPERATING VALUE OF THE PARAMETER.
SAMPLE RATE	6	C-d\SR	ENTER THE SAMPLE RATE IN TERMS OF SAMPLES/ SECOND.
DATA CONVERSION			
CONVERSION TYPE	3	C-d\DCT	DEFINE THE CHARACTERISTICS OF THE DATA CONVERSION: NONE - NON ENGINEERING UNITS: PAIR SET - PRS COEFFICIENTS - COE OTHER - OTH DERIVED - DER DISCRETE - DIS SPECIAL PROCESSING - SP (ENTER IN COMMENTS).

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
ENGINEERING UNITS CONVERSION			
PAIR SETS			
NUMBER OF SETS	2	C-d\PS\N	SPECIFY THE NUMBER OF PAIR SETS PROVIDED, n.
APPLICATION	1	C-d\PS1	IS THE DATA TO BE USED TO DEFINE A POLYNOMINAL CURVE FIT? Y(ES) OR N(O). IF THE ANSWER IS N, THEN THE DATA IS TO BE USED AS A "TABLE LOOK-UP" WITH LINEAR INTERPOLATION BETWEEN THE DEFINED POINTS.
ORDER OF FIT	2	C-d\PS2	SPECIFY THE ORDER OF THE CURVE FIT TO BE PERFORMED, m. AT LEAST 2 PAIR SETS MUST BE PROVIDED AND A MAXIMUM OF 32 PAIR SETS MAY BE INCLUDED. 12 OR MORE PAIR SETS ARE RECOMMENDED FOR A FIFTH ORDER FIT.
TELEMETRY VALUE	16	C-d\PS3-n	TELEMETRY UNITS VALUE.
ENGINEERING UNITS VALUE	32	C-d\PS4-n	ENGINEERING UNITS VALUE.
REPEAT THE ABOVE FOR THE n DATA SETS.			
COEFFICIENTS			
ORDER OF CURVE FIT	2	C-d\CO\N	SPECIFY THE ORDER OF THE POLYNOMINAL CURVE FIT, n.

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DERIVED FROM PAIR SET	1	C-d\CO1	WERE THE COEFFICIENTS DERIVED FROM THE PAIR SET CALIBRATION DATA PROVIDED, Y/N? IF YES, PROVIDE A POINT OF CONTACT IN THE COMMENTS RECORD.
COEFFICIENT (0)	32	C-d\CO	VALUE OF THE ZERO ORDER TERM. (OFFSET)
N-TH COEFFICIENT	32	C-d\CO-n	VALUE OF THE COEFFICIENT OF THE N-TH POWER OF X (FIRST ORDER COEFFICIENT IS THE EQUIVALENT OF BIT WEIGHT).
REPEAT UNTIL ALL N+1 COEFFICIENTS ARE DEFINED.			
OTHER			
DEFINITION OF OTHER DATA CONVERSION	1000	C-d\OTH	DEFINE OTHER DATA CONVERSION TECHNIQUE OR SPECIAL PROCESSING REQUIREMENT.
DERIVED PARAMETER			
NUMBER OF INDEPENDENT VARIABLES	1	C-d\DP\N	THIS PARAMETER IS DERIVED FROM OTHER MEASURANDS FOR PRESENTATION PURPOSES. SPECIFY THE NUMBER OF INDEPENDENT MEASURANDS TO BE USED, n.
MEASURAND #N	32	C-d\DP-n	SPECIFY THE MEASURAND NAME FOR THE N-TH MEASUREMENT.
CONTINUE UNTIL ALL n MEASURANDS ARE DEFINED.			

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
ALGORITHM	240	C-d\DPA	DEFINE THE ALGORITHM TO BE USED IN DERIVING THE PARAMETER.
DISCRETE			
NUMBER OF EVENTS	2	C-d\DIC\N	HOW MANY EVENTS ARE ASSOCIATED WITH THIS DISCRETE FIELD, n?
NUMBER OF INDICATORS	2	C-d\DICI\N	NUMBER OF INDICATORS: FOR A PCM SYSTEM PROVIDE THE NUMBER OF BITS USED FOR THIS DISCRETE SET. FOR A PAM OR ANALOG CHANNEL PROVIDE THE NUMBER OF LEVELS USED TO DEFINE THIS DISCRETE SET.
CONVERSION DATA	16	C-d\DICC-n	TELEMETRY VALUE, COUNTS FOR PCM, PERCENT OF FULL SCALE FOR PAM OR ANALOG.
PARAMETER EVENT DEFINITION	240	C-d\DICP-n	DEFINE THE EVENT FOR THE BIT OR BIT FIELD IN A WORD THAT CORRESPONDS TO A DISCRETE EVENT OR THE PERCENT FULL SCALE VALUE SUCH AS SWITCH ON OR OFF.
CONTINUE TO DEFINE THE EVENTS FOR EACH BIT PATTERN OR VALUE OF THE DISCRETE MEASURAND.			
DIGITAL VOICE			
ENCODING METHOD	64	C-d\VOI\E	SPECIFY THE VOICE ENCODING METHOD USED.
DESCRIPTION	640	C-d\VOI\D	SPECIFY THE DECODING ALGORITHM TO BE USED.

TABLE 9-9 (Cont'd). DATA CONVERSION ATTRIBUTES GROUP (C)			
PARAMETER	MAXIMUM FIELD SIZE	CODE NAME	DEFINITION
DIGITAL VIDEO			
ENCODING METHOD	64	C-d\VID\E	SPECIFY THE VIDEO ENCODING METHOD USED.
DESCRIPTION	640	C-d\VID\D	SPECIFY THE DECODING ALGORITHM TO BE USED.
COMMENTS	3200	C-d\COM	PROVIDE ANY OTHER INFORMATION REQUIRED OR DESIRED.

APPENDIX A

FREQUENCY CONSIDERATIONS FOR TELEMETRY

APPENDIX A

FREQUENCY CONSIDERATIONS FOR TELEMETRY

1.0 Purpose

This plan was prepared with the cooperation and assistance of the RCC Frequency Management Group (FMG) to provide guidance to telemetry users for the most effective use of allocated UHF telemetry bands 1435 to 1535 MHz, 2200 to 2290 MHz, and 2310 to 2390 MHz.

2.0 Scope

This plan is to be used as a guide by users of telemetry frequencies at DOD-related test ranges and contractor facilities. The goal of frequency management is to encourage maximal use and minimal interference among telemetry users and between telemetry users and other users of the electromagnetic spectrum.

3.0 VHF Band

After 1 January 1970, telemetry operations in the VHF band from 216 to 265 MHz were to cease entirely except in certain instances. The P-band in use prior to 1970 included 44 channels of 500 kHz maximum bandwidth. New assignments in the VHF band are made only in instances where standard UHF assignments are unacceptable.

4.0 UHF Telemetry Frequency Assignments

Air- and space-to-ground telemetering is allocated from the UHF bands 1435 to 1530, 2200 to 2290, and 2310 to 2390 MHz; commonly known as the L-band, the S-band, and the Upper S-band. Telemetry assignments in any other frequency range are permitted only in the application process where the standard bands are unsatisfactory for some specific purpose.

4.1 Application Process. Frequency allocation and specific operating frequency assignments are obtained for a program through a two-step process beginning with the government agency requesting frequency band allocation on a standard form DD 1494, *Application for Equipment Frequency Allocation*. After granting of the allocation (called a "J/F-12"), specific frequencies may be requested in the second step.

> **NOTE**
>
> This complete process may take a year or more. Actual radiation on the assigned frequencies is handled by a scheduling process at the test ranges or facilities involved.

4.2 Other Users. The bands 1435 to 1530 and 2310 to 2390 MHz are nationally allocated for government and nongovernment telemetry use for testing of manned and unmanned aircraft, missiles, space vehicles, and their major components on a shared basis. The 2200 to 2290 MHz band is allocated to government fixed and mobile communications and telemetry on a coequal basis. Frequencies from 2290 to 2300 MHz are for exclusive use in space-to-ground and ground-to-space communications and telemetry.

4.3 Channelization. Channel spacings for all types of telemetry uses are described in the following subparagraphs.

4.3.1 Narrow-Band Channels. Narrow-band telemetry channel spacing is in increments of 100 kHz beginning 100 kHz from the lower band edge such as 1435.1, 1435.2, and 1435.3 MHz, assigned in such a way that transmitting bandwidths greater than 200 kHz do not fall outside the allocated band.

> **NOTE**
>
> Not all test ranges can accommodate narrow-band channels, which require high frequency accuracy and stability for oscillators in transmitters and receivers.

4.3.2 Standard Bandwidth Channels. Standard bandwidth channel spacing is in increments of 1 MHz, beginning 500 kHz from the lower band edge such as 1435.5, 1436.5, and 1437.5 MHz. By definition, the band edges of a standard bandwidth channel cannot fall outside the allocated band.

4.3.3 Wide Bandwidth Channels. Channels with bandwidths greater than 1 MHz are assigned channels on spacings as standard bandwidth channels. In the case of channels whose bandwidths are greater than 2N+1 and less than 2N+2 MHz in bandwidth, N an integer, may be assigned channels on integral frequencies, for example, 1436, 1437, and 1438 MHz, assigned in such a way that transmitting bandwidths do not fall outside the allocated band.

NOTE

Synthesized receivers may not have the capability to tune integral frequencies.

5.0 RF Bandwidth Definitions

The NTIA manual defines the "occupied bandwidth" as being the bandwidth over which 0.5 percent of the total spectral energy falls below and 0.5 percent falls above. Thus 99 percent of the total power radiated is contained within the occupied bandwidth. Spectral energy within any narrower band of frequencies, called "bins" in digital systems, is the integral of the power at all frequencies within that bin. Modern spectrum analyzers can calculate total power in a large number of bins easily, and the readings obtained are less likely to depend on IF and video bandwidth settings or peak versus average readings.

5.1 Asymmetrical Spectra. If a signal is such that its spectrum is asymmetrical with respect to its center (or carrier) frequency, bandwidth is taken to be twice the distance between the unmodulated carrier frequency and the sideband skirt which is farther, unless the carrier frequency is intentionally offset to compensate for the asymmetry.

5.2 Narrow-Band Signal. A narrow-band signal occupies a bandwidth of 500 kHz or less.

5.3 Standard Bandwidth Signal. A standard bandwidth signal is a signal that occupies a bandwidth of 500 kHz to less than 1 MHz.

5.4 Wide Bandwidth Signal. A wide bandwidth signal is a signal that occupies a bandwidth greater than 1 MHz.[1]

5.5 Frequency Assignments. Frequency scheduling for simultaneous use at the same location shall not be made for systems whose closest 99 percent power band edges are separated by less than the 99 percent bandwidth of the wider of the two. Scheduling as stated here should ensure a desired signal to interfering signal ratio of at least 40 dB for two signals of equal bandwidth and effective radiated power at the same distance to the receiving antenna when the receiver bandwidth includes less than 99 percent of the desired signal's energy. In instances when this ratio is insufficient to ensure desired data quality, the frequency separation must be increased.

---

[1]Bandwidths for telemetry systems greater than 10 MHz, operating on the standard telemetry bands, are highly discouraged.

6.0 Frequency Usage Guidance

Frequency uses are controlled by scheduling in the areas in which the tests will be conducted. The following recommendations are based on good engineering practice for such usages.

6.1 Geographical Separation. Two or more telemetry systems operating in a given geographical area[2] should be separated in frequency such that overlap between spectra for each pair of signals is less than 0.5 percent of the power of either in the -20 dB receiver passband of the other. Overlap separation can be provided by a combination of frequency selection, power levels, antenna positioning and aiming, and geographical separation.

6.2 Simultaneous Operation. Standard practice for multiple emitters at the same location, power level, bandwidth, and transmitting antenna direction (if applicable) should have spectra which are separated from one another by a "guard band" greater or equal to the bandwidths of either transmitter. When more than one transmitter is used on the same host vehicle, frequency selection should be made to minimize spectrum overlap and RF interactions including intermodulation between the transmitters. Multichannel operations should avoid channels separated by the IF frequencies of the receivers used if possible.[3]

6.3 Multicarrier Operation. If two transmitters are operated simultaneously and sent or received through the same antenna system, interference because of intermodulation is likely at $(2f_1 - f_2)$ and $(2f_2 - f_1)$. Between three transmitters, the two-frequency possibilities exist, but intermodulation products may exist as well at $(f_1 + f_2 - f_3)$, $(f_1 + f_3 - f_2)$, and $(f_2 + f_3 - f_1)$, where f_1, f_2, and f_3 represent the output frequencies of the transmitters. Intermodulation products arise from slight nonlinearities in the antenna systems and harmonics present in the transmitted signals themselves. The generation of intermodulation products is inevitable, but the effects are generally of concern only when such products exceed the -25 dBm or -60 dB_{uc} levels. The general rule for avoiding third-order intermodulation interference is that in any group of transmitter

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[2]The extent of a geographical area over which the frequency use must be protected varies with the nature of the usage. For airborne systems, such an area is specified by the actual aircraft flight path and its maximum altitude.

[3]In theory, at least, J/F-12 data exists on all receivers as well as transmitters.

frequencies, the separation between any pair of frequencies is not equal to the separation between any other pair of frequencies. Because individual signals have sidebands, it should be noted that intermodulation products have sidebands spectrally wider than the sidebands of the individual signals that caused them.

7.0 Bandwidth

The definitions of bandwidth in this section are universally applicable. The limits shown here are applicable for telemetry operations in the telemetry bands 1435 to 1530, 2200 to 2290, and 2310 to 2390 MHz. How bandwidth is actually measured and what the limits are expressed in terms of that measuring system are detailed in the following paragraphs.

7.1 Concept. The term "bandwidth" has an exact meaning in situations where an AM, DSB, or SSB signal is produced with a band-limited modulating signal. In systems employing frequency modulation (FM) or phase modulation (PM), or any modulation system where the modulating signal is not band limited, bandwidth is infinite with energy extending toward zero and infinite frequency falling off from the peak value in some exponential fashion. In this more general case, bandwidth is defined as the band of frequencies in which most of the signal's energy is contained. The definition of "most" is imprecise. One measure is the bandwidth necessary in a receiver to receive the signal with negligible distortion. This bandwidth is lower than a measure of the interaction between two adjacent frequencies to determine if overlap between them will interfere with reception of either signal. The overlap problem is increased if the desired signal is lower in power than the interfering signal or if the two signals differ in bandwidth or modulation type such as AM and FM. The following terms are applied to bandwidth:

- Authorized Bandwidth - the bandwidth authorized for a particular use. This number is fixed, no matter what actual modulation bandwidth is used; the actual number authorized should resemble what is actually used.
- Occupied Bandwidth - the bandwidth a transmission actually uses. Occupied bandwidth may vary with the characteristics of the modulating signal[4] but should never exceed the authorized bandwidth.

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[4]In systems involving a baseband signal, for example, the bandwidth will increase as the amplitude of the baseband signal increases.

- Emission Bandwidth - (same as occupied bandwidth), indicates the bandwidth emitted by the transmitter or antenna system.

- Necessary Bandwidth - defined as: (1) the minimum bandwidth required to transmit a given modulating signal (generally 1 to about 2.5 times the modulating signal bandwidth); (2) the minimum bandwidth required to *receive* a specific baseband signal; or (3) the minimum bandwidth required to receive a specific modulated signal.

NOTE
Necessary bandwidth should be avoided altogether.

- Received (or Receiver) Bandwidth - the bandwidth of the RF/IF section of the receiver, however defined, often the -1 or -3 dB points with respect to center frequency, required to reproduce the original modulating signal at the output of the receiver with negligible distortion. Because the received and occupied bandwidth are measured in different ways, they are not the same number even for the same signal. In general, the received bandwidth is lower than the emission bandwidth.

7.2 Bandwidth Estimation and Measurement. The methods used to measure bandwidth of a signal that is not band limited vary. The most common methods are[5]

- Estimation Methods. Carson's Rule is an empirical way to determine the bandwidth occupied by at least 99 percent of the energy (power) in an FM subcarrier system. Carson's rule states

$$\beta = 2 \times (\Delta f + f_{max}) \quad (1)$$

[5] I. Korn, Digital Communications, New York: Van Nostrand, 1985.

where β is the bandwidth, Δf is the one-way peak deviation of the carrier frequency, and f_{max} is the highest frequency in the modulating signal.[6] Carson's Rule will result in a number greater than the bandwidth if little of the carrier deviation is due to high-frequency energy in the modulating signal (if pre-emphasis is *not* used).

- PCM/FM with premodulation filter with low-pass 3 dB point at 0.7 times the bit rate is

$$\beta_{99\%} = 1.16f_b \qquad (2)$$

  Where f_b is the bit rate for NRZ data.

- PCM/FM without premodulation filter is

$$\beta_{99\%} = 1.78f_b \text{ for } \Delta f = 0.35f_b \qquad (3)$$
$$\beta_{99\%} = 1.18f_b \text{ for } \Delta f = 0.25f_b \qquad (4)$$
$$\beta_{99\%} = 1.93f_b \text{ for } \Delta f = 0.40f_b \qquad (5)$$

  where Δf is the peak carrier deviation.

- Minimum-shift keying [MSK] is

$$\beta_{99\%} = 1.18f_b \qquad (6)$$

- Antipodal phase-shift keying [PSK] with premodulation filter with low-pass point at 0.7 times the bit rate is

$$\beta_{99\%} = 1.5f_b \qquad (7)$$

- PCM/PM or PSK without premodulation filter is

$$\beta_{99\%} = 19.3f_b \qquad (8)$$

- Quadrature phase-shift keying [QPSK] or offset QPSK [OQPSK] without premodulation filter is

$$\beta_{99\%} = 9.65f_b \qquad (9)$$

- OQPSK with half-sine weighting is

$$\beta_{99\%} = 1.18f_b \qquad (10)$$

---

[6]Many types of modulating signals are not band limited such as PAM and PCM signals, which are composed of square-wave components. In these cases, a premodulation filter reduces energy in those frequencies beyond those which are necessary to allow a reconstruction of the signal at the receiving end.

- The -60 dB_{uc} bandwidth, using a spectrum analyzer resolution bandwidth of 10 kHz, video bandwidth of 1 kHz, and max hold) of a random NRZ PCM/FM waveform with a peak deviation of $0.35f_b$ and a four-pole premodulation filter with 3 dB corner at $0.7f_b$ for bit rates f_b greater than or equal to 1 Mb/s is given by

$$\beta_{-60dB} = \{2.78 - 0.3 \times \log_{10}(f_b)\} \times f_b \qquad (11)$$

  where β is in MHz and f_b is in Mb/s. Thus the bandwidth of a 1 Mb/s RNRZ system under these conditions would be 2.78 MHz. The -60 dB bandwidth will be greater if peak deviation is increased or the number of filter poles is decreased.

- Below Unmodulated Carrier. To measure actual spectrum on a spectrum analyzer, a calibration is required which places the unmodulated carrier at the 0 dB reference (the top of the display). In AM systems, the carrier power never changes; in FM systems, an unmodulated transmission must be used for calibration. Since frequency modulation by its nature spreads the spectrum of a constant amount of power, this calibration is required. With the spectrum analyzer set for a specific bandwidth (say 10 kHz)[7], the bandwidth is taken as the distance between the two points outside of which the spectrum is thereafter some number (say, 60 dB) below the original unmodulated carrier power. The total carrier power at the spectrum analyzer input for most practical angle modulated (FM or PM) systems can be found by setting the spectrum analyzer's resolution and bandwidths to their widest settings, setting the analyzer output to peak (or max) hold and allowing the analyzer to sweep for several seconds (see figure A-3).

- 99 Percent Power. A measure of the bandwidth containing 99 percent of the total modulated power. If the two points which define the edges of the band are not symmetrical about f_o, their actual frequencies should be noted as well as their difference.

[7]For digital spectrum analyzers, *bandwidth* is replaced by *resolution*, which represents "bin size."

- Receiver Bandwidth. Receiver RF/IF bandwidth is measured at the points where the response to the carrier before demodulation is -1 dB or -3 dB from the center frequency response. The carrier bandwidth response of the receiver is, or is intended to be, symmetrical about the carrier in most instances. Outside the stated bandwidth, the response usually falls sharply, with the response often 20 dB or more below the passband response at 1.5 to 2 times the passband response or so. The rapid falloff outside the passband is to reduce interference from nearby channels and has no other effect on data. The receiver bandwidth for most signals is equal to or slightly larger than the emission bandwidth predicted by Carson's Rule.

- Receiver Noise Bandwidth. For the purpose of calculating noise in the receiver, the bandwidth of the RF/IF path must be considered, integrated over the actual shape of the IF, which in general is not a square-sided function. Typically, the figure used for noise power calculations is the 3 dB bandwidth of the receiver.

- Below Peak. The modulated peak is the least accurate measurement method, measuring between points where the spectrum is thereafter XX dB below the level of the highest point on the modulated spectrum. Since the most efficient modulation methods spread energy evenly over a large portion of the spectrum, a below peak reading overstates the bandwidth of the most optimum signals. In the absence of an unmodulated carrier to use for calibration, the below peak measurement is often (erroneously) used and described as a below unmodulated carrier measurement. Using peak (or max) hold intended for measurement of pulsed systems exacerbates this effect still further. In all instances the bandwidth is overstated, but the amount varies. A 20 dB below-peak bandwidth can correspond fairly closely to the Carson's Rule prediction, but it would be difficult to measure in systems with deviation close to optimal. Spread spectrum systems, which employ spectral widths far in excess of optimal, may have no meaningful 20 or even 50 dB bandwidth.

7.3 Phase-Modulated Systems. Telemetry systems using phase modulation (PM) rather than frequency modulation (FM) produce spectra which are considerably wider than FM. This sideband energy is reduced in most systems by filtering at the modulation input and/or the transmitter output, and sideband energy is reconstructed in the receiving apparatus as part of the demodulation process. Phase-modulation systems, even with more than one data bit per symbol, are not necessarily more spectrally efficient than FM transmissions.

7.4 Other Notations. The following notations are used here and in frequency management literature. Other references may define these terms slightly differently.

P_t	transmitter power output, in watts or dBm
P_r	received power in dBm
f_0	assigned center frequency
f_U	upper carrier deviation limit
f_L	lower carrier deviation limit
$\beta_{99\%}$	bandwidth (NTIA/IRAC definition)
β_{-60dB}	bandwidth (FMG definition)
β	modulation index
AA′	99 percent bandwidth (see figures)
BB′	-25 dBm/10 kHz limit
EIRP	effective isotropic radiated power, in watts or dBm
TPO	transmitter power output at the antenna connector, in watts or dBm
dB_{uc}	decibels above or below the power level of an unmodulated carrier
NTIA	the National Telecommunications and Information Administration
ECAC	the Electronic Compatibility Analysis Center (Annapolis)
IRAC	the Interdepartmental Radio Advisory Committee

The BB′ limit measures the bandwidth over which output is greater than -25 dBm in a 10 kHz bandwidth, which is wider than the AA′ limits for most telemetry systems.

7.5 Symmetry. Most modulating schemes produce a spectrum which is asymmetrical with respect to the carrier frequency when FM transmission is used. Exceptions include FM subcarrier systems and PCM NRZ systems using randomization or BIΦ formats, placing f_o halfway between A and A′ (and halfway between B and B′). The most extreme case of asymmetry is due to single-sideband transmission, which places f_o at the end of the spectrum defined by AA′ or slightly outside it. If the spectrum is *not* symmetrical about the band center, the bandwidth and the extent of asymmetry must be noted for frequency management purposes.

7.6 RCC/TG Bandwidth Definitions. For the purposes of expressing bandwidths, unless stated otherwise, bandwidths are defined as the 99 percent power bandwidth and the -60 dB_{uc} bandwidth using 10 kHz resolution, 1 kHz video bandwidth, and peak (or max) hold, and spectra are assumed symmetrical about f_0 unless specified otherwise.

7.7 RNRZ Spectrum Examples. Figures A-1 through A-3 show randomized NRZ signals as observed on a spectrum analyzer using 10 kHz resolution bandwidth, 1 kHz video bandwidth, and max hold. Modulation signals for all examples were filtered with a linear-phase filter with -3 dB corner frequency at 0.7 times the respective bit rate. Displays were calibrated such that the unmodulated carrier registered 0 dB (shown superimposed on figure A-3), hence the display can be read directly in dB_{uc} and the 99 percent power points are indicated.

Figure A-1 shows a single PCM/FM signal with f_o=1455.5 MHz with an 800 kB/s randomized NRZ input and ±280 kHz deviation. Note that the peak level for the spectrum analyzer settings is about 15 dB below the calibrated unmodulated carrier level.

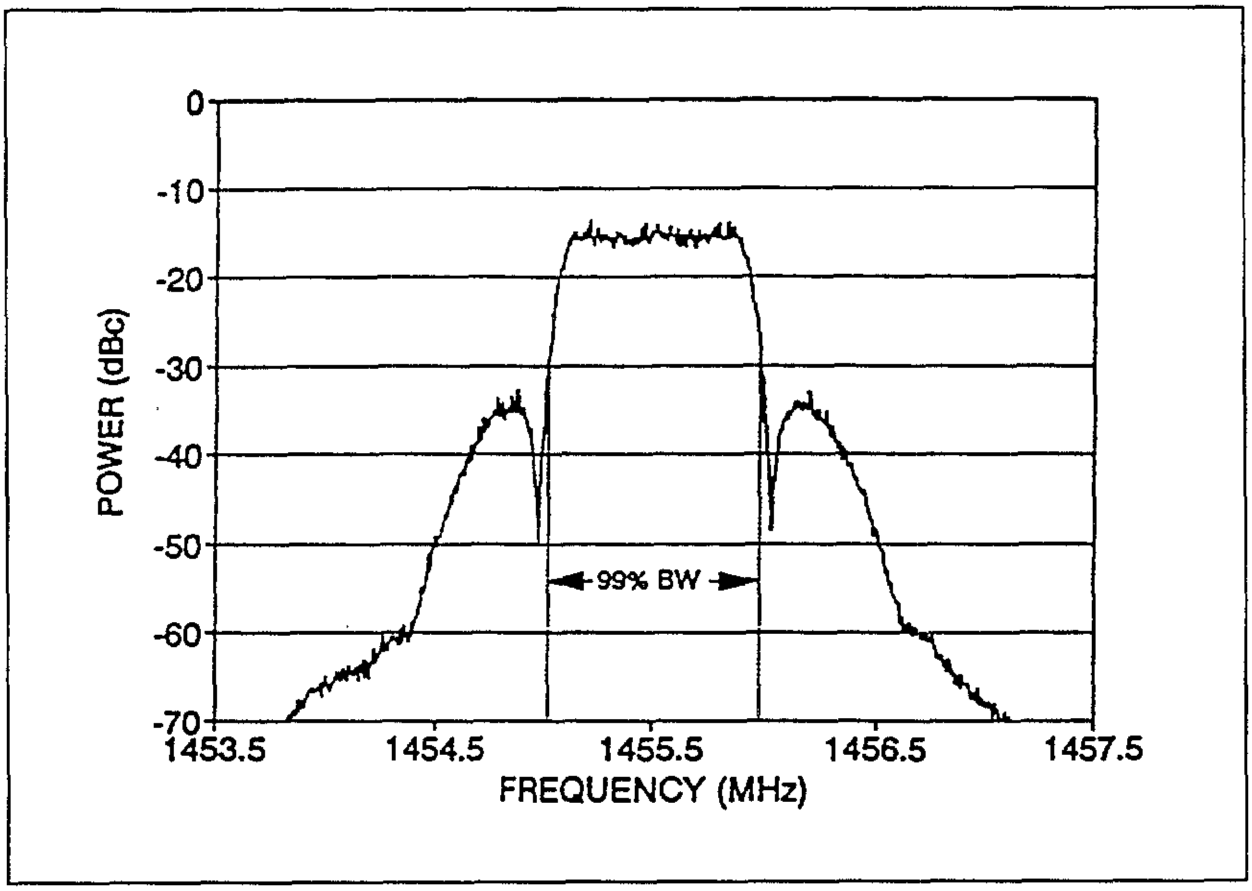


Figure A-1. 800 kB/s RNRZ PCM signal.

Figure A-2 shows the PCM/FM signal from figure A-1 with a second signal with the same transmitter output power level as the first but with a 5 Mb/s RNRZ signal using ±1.75 MHz deviation with f_o=1465.5 MHz. Sweep width for the figure has been increased to display both signals. Note that since the wide-band signal is spread over a greater spectrum, its peak is lower than that of the narrower bandwidth signal.

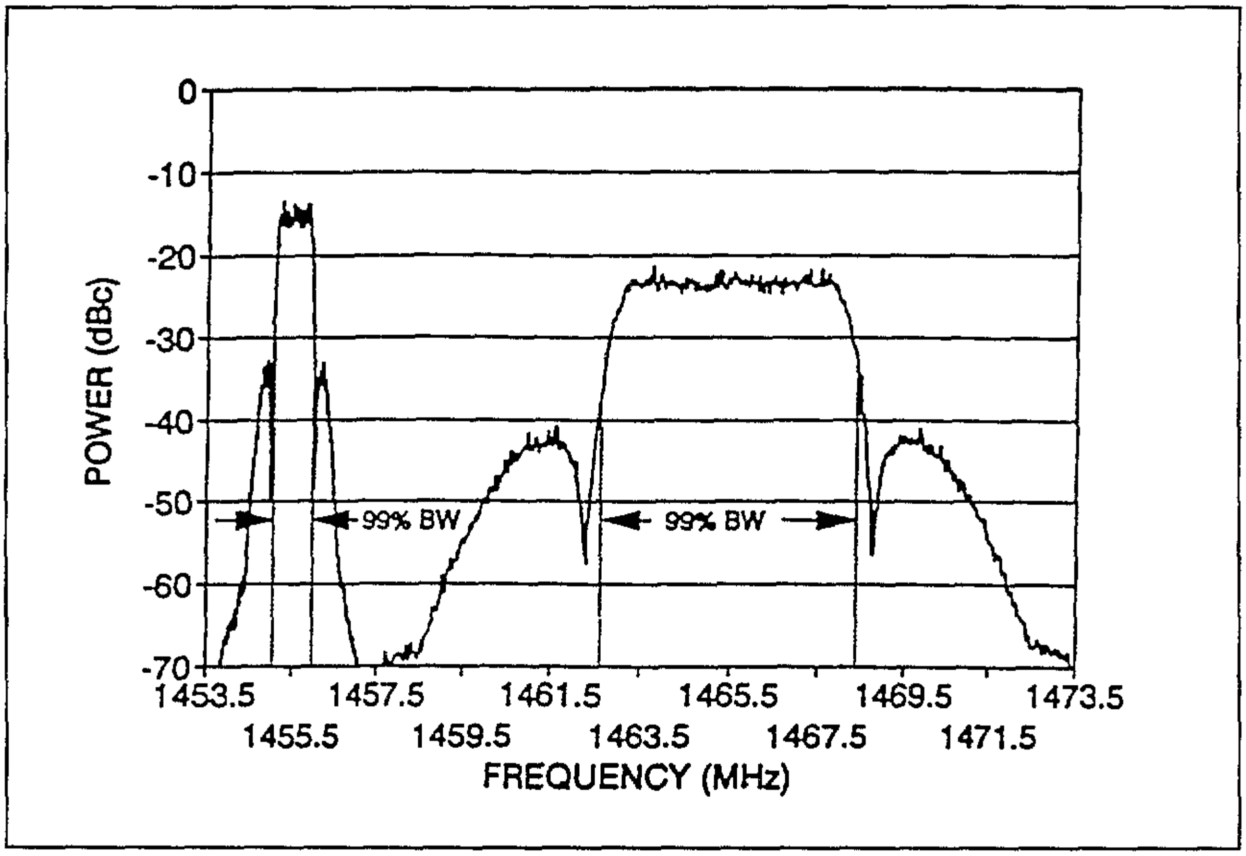


Figure A-2. 800 kB/s RNRZ PCM signal and 5 Mb/s RNRZ signal.

Figure A-3 shows the calibration signals, made by use of the widest spectral bin size, used to provide the unmodulated carrier calibration even in the presence of frequency or phase modulation. In practice, the calibration would be performed first, and the scale adjusted to put the peak of the curve obtained at the top (0 dB point) of the display.

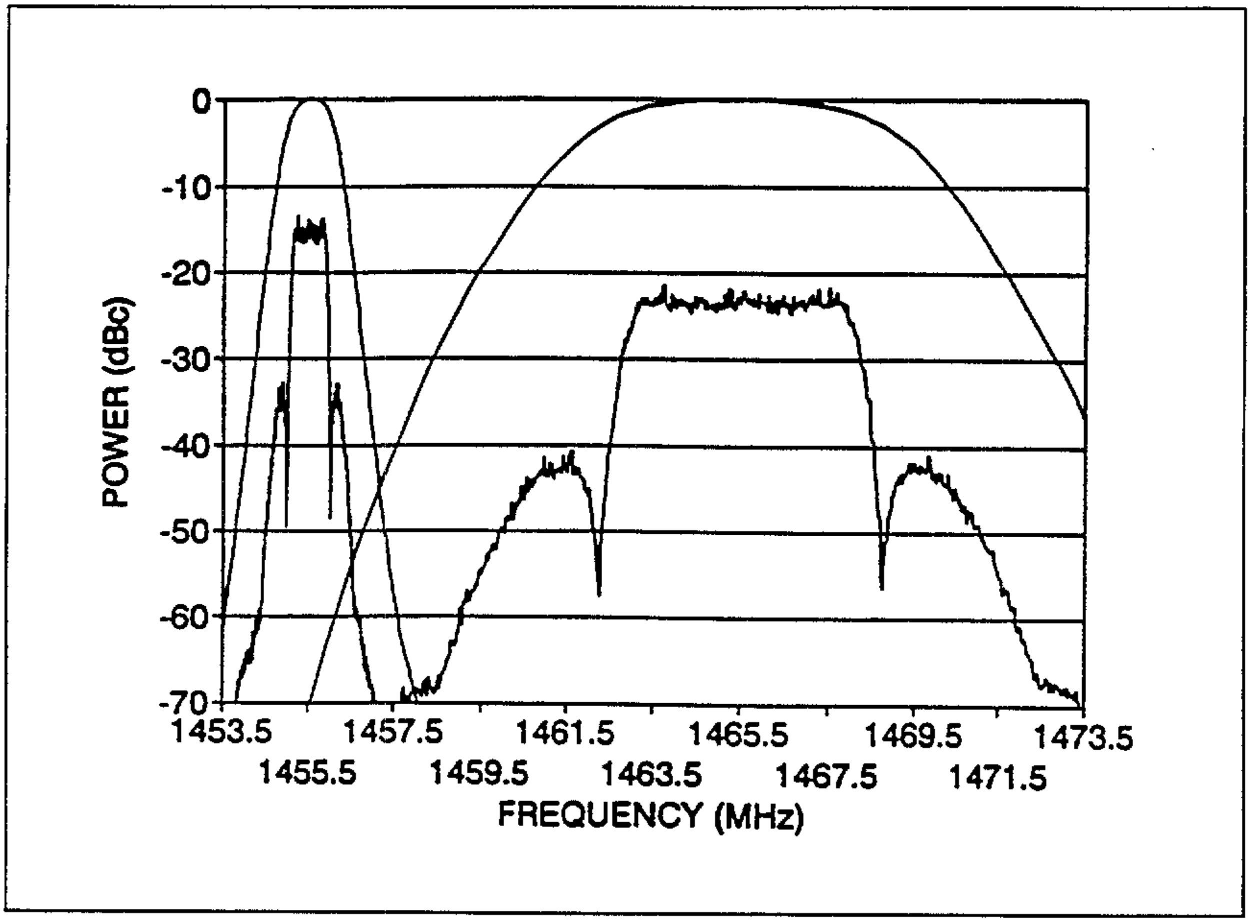


Figure A-3. Spectrum analyzer calibration.

APPENDIX B

USE CRITERIA FOR FREQUENCY DIVISION MULTIPLEXING

APPENDIX B

USE CRITERIA FOR FREQUENCY DIVISION MULTIPLEXING

1.0 General

Successful application of Frequency Division Multiplexing Telemetry Standards depends on recognition of performance limits and performance tradeoffs which may be required in implementation of a system. The use criteria included in this appendix are offered in this context as a guide for orderly application of the standards which are presented in chapter 3. It is the responsibility of the telemetry system designer to select the range of performance that will meet data measurement requirements and at the same time permit operation within the limits of the standards. A designer or user must also recognize the fact that even though the standards for FM/FM multiplexing encompass a broad range of performance limits, tradeoffs such as data accuracy for data bandwidth may be necessary. Nominal values for such parameters as frequency response and rise time are listed to indicate the majority of expected use and should not be interpreted as inflexible operational limits. It must be remembered that system performance is influenced by other considerations such as hardware performance capabilities. In summary, the scope of the standards together with the use criteria are intended to offer flexibility of operation and yet provide realistic limits.

2.0 FM Subcarrier Performance

The nominal and maximum frequency response of the subcarrier channels listed in tables 3-1 and 3-2 is 10 and 50 percent of the maximum allowable deviation bandwidth. The nominal frequency response of the channels employs a deviation ratio of five. The deviation ratio of a channel is one-half the defined deviation bandwidth divided by the cutoff frequency of the discriminator output filter.

2.1 The use of other deviation ratios for any of the subcarrier channels listed may be selected by the range users to conform with the specific data response requirements for the channel. As a rule, the rms signal-to-noise ratio (SNR) of a specific channel varies as the three-halves power of that subcarrier deviation ratio.

2.2 The nominal and minimum channel rise times indicated in tables 3-1 and 3-2 have been determined from the equation which states that rise time is equal to 0.35 divided by the frequency response for the nominal and maximum frequency response. The equation is normally employed to define 10 to 90 percent rise time for a step function of the channel input signal. However, deviations from these values may be encountered because of variations in subcarrier components in the system.

3.0 <u>FM Subcarrier Performance Tradeoffs</u>

The number of subcarrier channels which may be used simultaneously to modulate an RF carrier is limited by the RF channel bandwidth and by the output SNR that is acceptable for the application at hand. As channels are added, it is necessary to reduce the transmitter deviation allowed for each individual channel to keep the overall multiplex with the RF channel assignment. This reduction lowers the subcarrier-to-noise performance at the discriminator inputs. Thus, the system designer's problem is to determine acceptable tradeoffs between the number of subcarrier channels and acceptable subcarrier-to-noise ratios.

3.1 Background information relating to the level of performance and the tradeoffs that may be made is included in <u>Telemetry FM/FM Baseband Structure Study</u>, volumes I and II; which were completed under a contract administered by the Telemetry Working Group of IRIG. The Defense Technical Information Center (DTIC) access numbers for these documents dated 14 June 1965 are AD-621139 and AD-621140. The results of the study show that proportional bandwidth channels with center frequencies up to 165 kHz and constant bandwidth channels with center frequencies up to 176 kHz may be used within the constraints of these standards. The test criteria included the adjustment of the system components for approximately equal SNRs at all of the discriminator outputs with the receiver input near RF threshold. Intermodulation, caused by the radio-link components carrying the composite multiplex signal, limits the channel's performance under large signal conditions.

3.2 With subcarrier deviation ratios of four, channel data errors on the order of 2 percent rms were observed. Data channel errors on the order of 5 percent rms of full-scale bandwidth were observed when subcarrier deviation ratios of two were employed. When deviation ratios of one were used, it was observed that channel-data errors exceeded 5 percent. Some channels showed peak-to-peak errors as high as 30 percent. It must be emphasized, however, that the results of the tests performed in this study are based on specific methods of measurement on one system sample and that this system sample represents a unique configuration of components. Systems having different performance characteristics may not yield the same system performance.

3.3 System performance may be improved, in terms of better data accuracy, by sacrificing system data bandwidth; that is, if the user is willing to limit the number of subcarrier channels in the multiplex, particularly the higher frequency channels, the input level to the transmitter can be increased. The SNR of each subcarrier is then improved through the increased per-channel transmitter deviation. For example, the baseband structure study indicated that when the 165 kHz channel and the 93 kHz channel were not included in the proportional-bandwidth multiplex, performance improvement can be expected in the remaining channels equivalent to approximately 12 dB increased transmitter power.

3.4 Likewise, elimination of the five highest frequency channels in the constant-bandwidth multiplex allowed a 6 dB increase in performance.

3.5 A general formula which can be used to estimate the thermal noise performance of an FM/FM channel above threshold[1] is as follows.

$$\left(\frac{S}{N}\right)_d = \left(\frac{S}{N}\right)_c \left(\frac{3}{4}\right)^{1/2} \left[\frac{B_c}{F_{ud}}\right]^{1/2} \left(\frac{f_{dc}}{f_s}\right) \left(\frac{f_{ds}}{F_{ud}}\right),$$

where

$\left(\frac{S}{N}\right)_d$ = discriminator output signal-to-noise ratio (rms voltage ratio),

$\left(\frac{S}{N}\right)_c$ = receiver carrier-to-noise ratio (rms voltage ratio),

B_c = carrier bandwidth (receiver IF bandwidth),

F_{ud} = subcarrier discriminator output filter: 3 dB frequency,

f_s = subcarrier center frequency,

f_{dc} = carrier peak deviation of the particular subcarrier of interest, and

f_{ds} = subcarrier peak deviation.

[1]K. M. Uglow, _Noise and Bandwidth in FM/FM Radio Telemetry,_ IRE Transaction on Telemetry and Remote Control, pp. 19-22 (May 1957).

If the RF carrier power is such that the thermal noise is greater than the intermodulation noise, the above relation provides estimates accurate to within a few decibels. Additional information is contained in RCC document 119-88, ***Telemetry Applications Handbook***.

3.6 The FM/FM composite-multiplex signal used to modulate the RF carrier may be a proportional-bandwidth format, a constant-bandwidth format, or a combination of the two types provided only that guard bands allowed for channels used in a mixed format be equal to or greater than the guard band allowed for the same channel in an unmixed format.

4.0 FM System Component Considerations

System performance is dependent on all components in the system. Neglecting the effects of the RF and recording system, data channel accuracy is primarily a function of the linearity and frequency response of the subcarrier oscillators and discriminators employed. Systems designed to transmit data frequencies up to the nominal frequency responses shown in tables 3-1 and 3-2 have generally well-known response capabilities, and reasonable data accuracy estimates can be easily made. For data-channel requirements approaching the maximum frequency response of tables 3-1 and 3-2, oscillator and discriminator characteristics are less consistent and less well-defined, making data accuracy estimates less dependable.

4.1 The effect of the RF system on data accuracy is primarily in the form of noise because of intermodulation at high RF signal conditions well above threshold. Under low RF signal conditions, noise on the data channels is increased because of the degraded SNR existing in the receiver.

4.2 Intermodulation of the subcarriers in a system is caused by characteristics such as amplitude and phase nonlinearities of the transmitter, receiver, magnetic tape recorder/reproducer, or other system components required to handle the multiplex signal under the modulation conditions employed. In systems employing preemphasis of the upper subcarriers, the lower subcarriers may experience intermodulation interference because of the difference frequencies of the high-frequency and high-amplitude channels.

4.3 The use of magnetic tape recorders for recording a subcarrier multiplex may degrade the data channel accuracy because of the tape speed differences or variations between record and playback. These speed errors can normally be compensated for in present discriminator systems when the nominal response rating of the channels is employed and a reference frequency is recorded with the subcarrier multiplex.

5.0 Range Capability For FM Subcarrier Systems

See the following subparagraphs for additional range capabilities.

5.1 Receivers and Tape Recorders. The use of subcarrier frequencies greater than 2 MHz may require tape recorders of a greater capability than are in current use at some ranges. It is recommended that users, who anticipate employing any of the above channels at a range, check the range's capability at a sufficiently early date to allow procurement of necessary equipment.

5.2 Discriminator Channel Selection Filters. Inclusion of the higher frequency proportional-bandwidth channels and the constant-bandwidth channels may require the ranges to acquire additional band selection filters. In addition to referencing tables 3-1 and 3-2 for acquiring channel-selector filters, consideration should also be given to acquiring discriminators corresponding to the predetection carrier frequencies shown in table 6-5. In applications where minimum time delay variation within the filter is important, such as tape speed compensation or high-rate PAM or PCM, constant-delay filter designs are recommended.

APPENDIX C

PCM STANDARDS - ADDITIONAL INFORMATION AND RECOMMENDATIONS

APPENDIX C

PCM STANDARDS - ADDITIONAL INFORMATION AND RECOMMENDATIONS

1.0 Bit Rate Versus Receiver Intermediate-Frequency Bandwidth

The following subparagraphs contain information to be considered when comparing bit rate versus receiver intermediate-frequency (IF) bandwidth.

1.1 The receiver IF bandwidth should be selected from those values listed in table 2-1. Only those discrete receiver IF bandwidths listed should be used for data channel selection (optional below 12 500 Hz). The selections in table 2-1 have been made on the consideration that automatic tracking of RF carrier drift or shift will be used in the receiver. However, Doppler shift considerations may require wide RF/discriminator bandwidths for the automatic frequency control (AFC) system.

1.2 For reference purposes in a well-designed PCM/FM system (NRZ-L data code) with the peak deviation equal to 0.35 times the bit rate and an IF bandwidth (3 dB) equal to the bit rate, a receiver IF SNR (power) of approximately 13 dB will result in a bit error probability (BEP) of 10^{-6}. A 1 dB change (increase or decrease) in this SNR will result in an order of magnitude change (10^{7} or 10^{5} from 10^{6}) in the BEP. Other data codes and modulation (PM) will have different BEP versus SNR performance characteristics.

1.3 It is recommended that the period between ensured bit transitions be a maximum of 64 bit intervals to ensure adequate bit synchronization.

2.0 Recommended PCM Synchronization Patterns

Table C-1 contains recommended frame synchronization patterns for general use in PCM telemetry. Pattern lengths shorter than 16 bits are primarily for use in submultiple frame synchronization when necessary.

TABLE C-1. OPTIMUM FRAME SYNCHRONIZATION PATTERNS FOR PCM TELEMETRY

Pattern Length	Patterns						
7	101	100	0				
8	101	110	00				
9	101	110	000				
10	110	111	000	0			
11	101	101	110	00			
12	110	101	100	000			
13	111	010	110	000	0		
14	111	001	101	000	00		
15	111	011	001	010	000		
16	111	010	111	001	000	0	
17	111	100	110	101	000	00	
18	111	100	110	101	000	000	
19	111	110	011	001	010	000	0
20	111	011	011	110	001	000	00

TABLE C-1 (Cont'd) OPTIMUM FRAME SYNCHRONIZATION PATTERNS FOR PCM TELEMETRY

Pattern Length	Patterns										
21	111	011	101	001	011	000	000				
22	111	100	110	110	101	000	000	0			
23	111	101	011	100	110	100	000	00			
24	111	110	101	111	001	100	100	000			
25	111	110	010	110	111	000	100	000	0		
26	111	110	100	110	101	100	110	000	00		
27	111	110	101	101	001	100	110	000	000		
28	111	101	011	110	010	110	011	000	000	0	
29	111	101	011	110	011	001	101	000	000	00	
30	111	110	101	111	001	100	110	100	000	000	
31	111	111	100	110	111	110	101	000	010	000	0
32	111	111	100	110	101	100	101	000	010	000	00
33	111	110	111	010	011	101	001	010	010	011	000

The technique used in the determination of the patterns for lengths 7 through 30 was essentially that of the patterns of 2^n binary patterns of a given length, n, for that pattern with the smallest total probability of false synchronization over the entire pattern overlap portion of the ground station frame synchronization.[1] The patterns for lengths 31 through 33 were obtained from a second source.[2]

3.0 Spectral Comparisons for NRZ and BiØ[3]

Figure C-1 shows the power spectral densities of NRZ and BiØ coding with random data (DBiØ spectra are the same as BiØ spectra for random data). These curves were calculated using the equations presented below. Figure C-2 presents the theoretical bit error probabilities versus signal-to-noise ratio for the level, mark, and space versions of NRZ and BiØ codes and also for RNRZ-L.

$$\text{NRZ SPECTRAL DENSITY} \propto \frac{\sin^2(\pi f T)}{(\pi f T)^2}$$

$$\text{BiØ SPECTRAL DENSITY} \propto \frac{\sin^4(\pi f T/2)}{(\pi f T/2)^2}$$

where T is the bit period.

---

[1]A more detailed account of this investigation can be found in a paper by J. L. Maury, Jr. and J. Styles, "Development of Optimum Frame Synchronization Codes for Goddard Space Flight Center PCM Telemetry Standards," in *Proceedings of the National Telemetering Conference,* June 1964.

[2]The recommended synchronization patterns for lengths 31 through 33 are discussed more fully in a paper by E. R. Hill, "Techniques for Synchronizing Pulse-Code Modulated Telemetry," in *Proceedings of the National Telemetering Conference,* May 1963.

[3]Material presented in paragraph 3.0 is taken from a study by W. C. Lindsey (University of Southern California), *Bit Synchronization System Performance Characterization, Modeling and Tradeoff Study*, Naval Missile Center Technical Publication TP-73-18. This material is also contained in a book by W. C. Lindsey and M. K. Simon, *Telecommunications Systems Engineering*, Prentice-Hall, Englewood cliffs, NJ, 1973, pages 18-20.

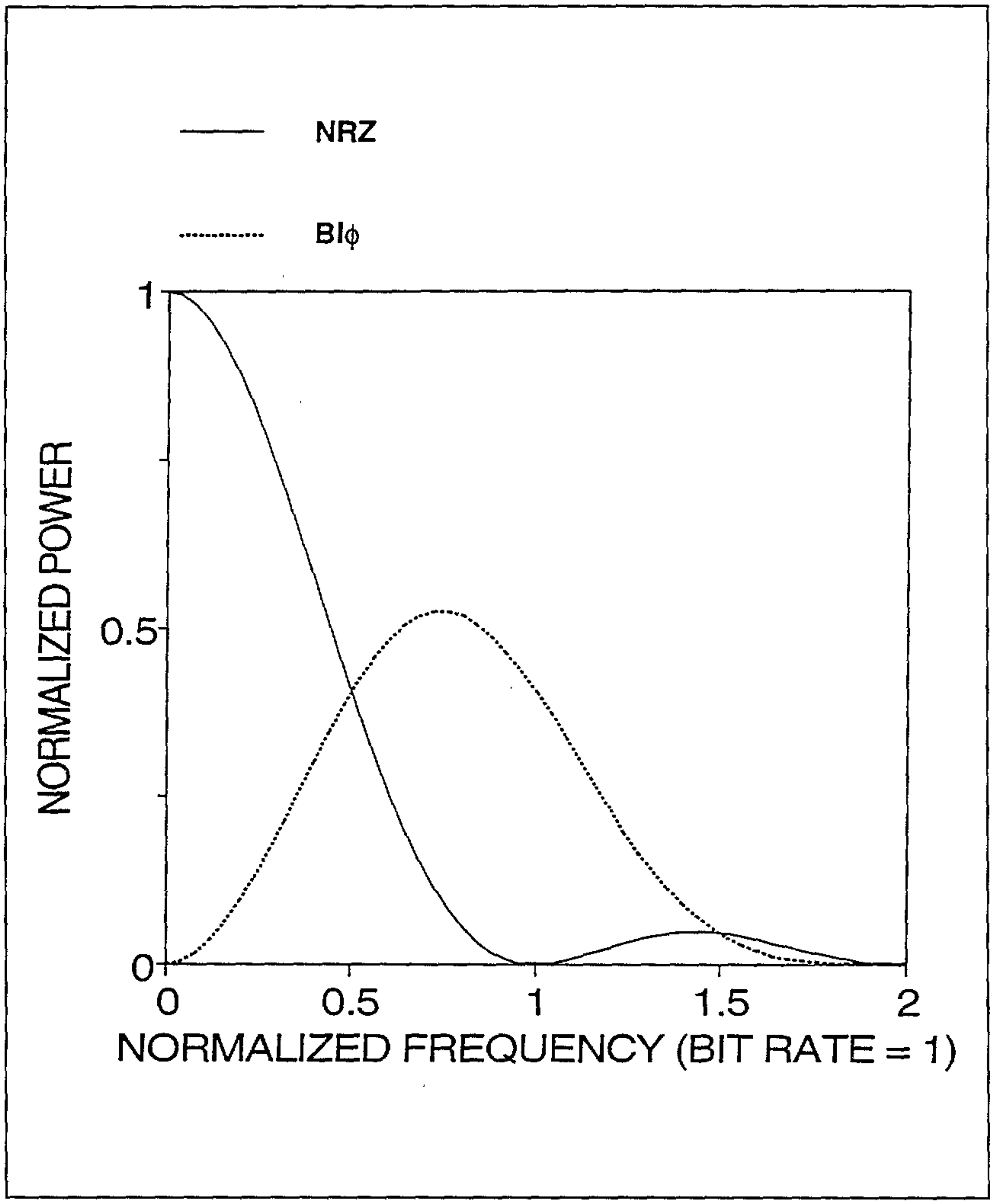


Figure C-1. Spectral densities of random NRZ and BiØ codes.

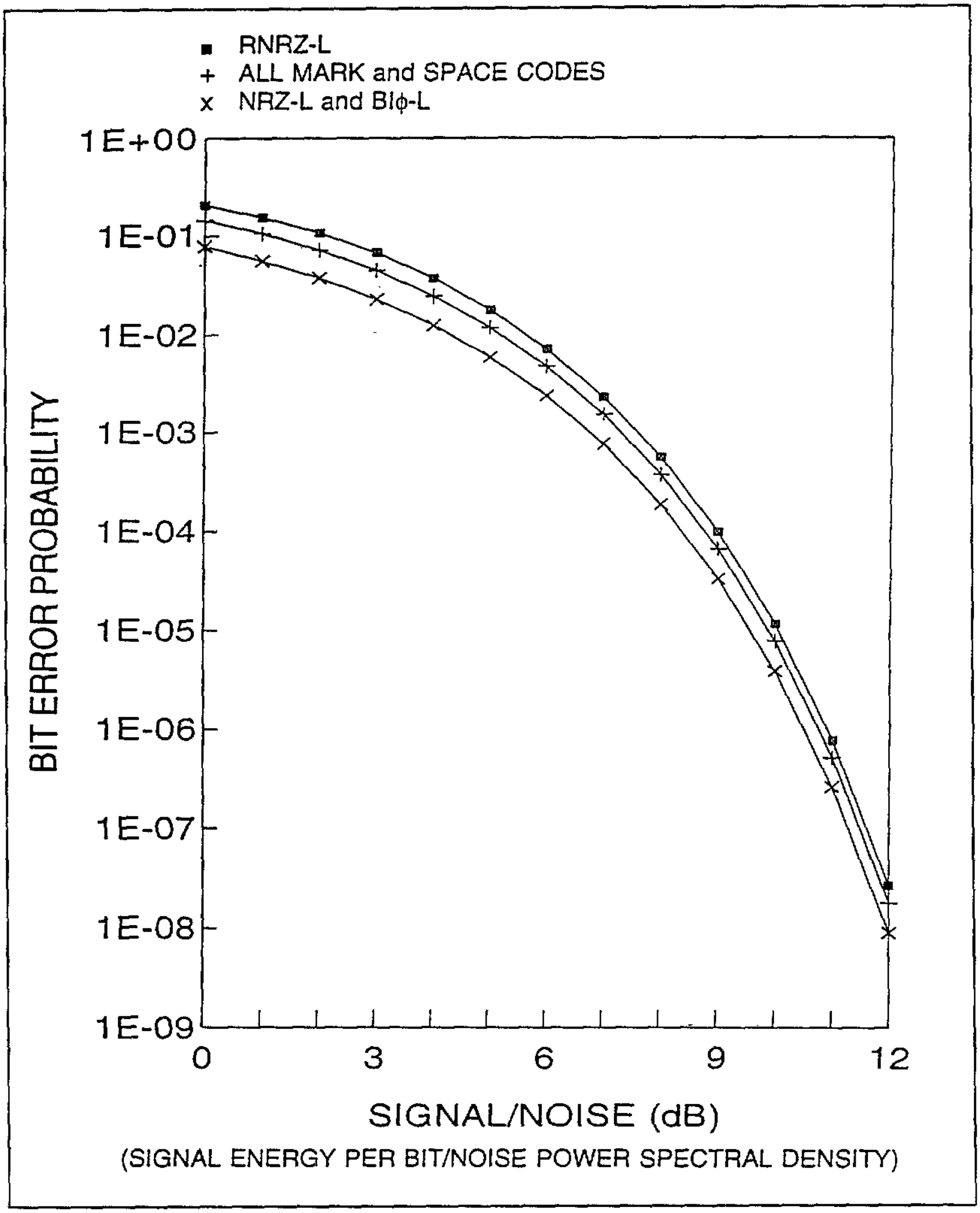


Figure C-2. Theoretical bit error probability performance for various baseband PCM signaling techniques (perfect bit sync assumed).

APPENDIX D

MAGNETIC TAPE RECORDER AND REPRODUCER INFORMATION AND USE CRITERIA

APPENDIX D

MAGNETIC TAPE RECORDER AND REPRODUCER INFORMATION AND USE CRITERIA

1.0 Other Instrumentation Magnetic Tape Recorder Standards

The X3B6 Committee of the American National Standards Institute and the International Standards Organizations have prepared several standards for instrumentation magnetic tape recording. Documents may be obtained by contacting the

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018
Telephone (212) 354-3300

The following documents may be of interest:

ISO 1860	Information Processing - Precision reels for magnetic tape used in interchange instrumentation applications.
ISO 6068	Information Processing - Telemetry systems (including the recording characteristics of instrumentation magnetic tape) - interchange practices and recommended test methods.
ISO 6371	Information Processing - Interchange requirements and test methods for unrecorded instrumentation magnetic tape.
ISO 8441/1	High Density Digital Recording (HDDR) - Part 1: Unrecorded magnetic tape for HDDR applications.
ISO 8441/2	High Density Digital Recording (HDDR) - Part 2: Interchange requirements and test methods for HDDR applications (including the characteristics of recorded magnetic tape).
ANSI X3.175-1990	19 mm Type ID-1 Recorded Instrumentation - Digital Cassette Tape Format

2.0 Double-Density Longitudinal Recording

Wide band double-density analog recording standards allowing recording of up to 4 MHz signals at 3048 mm/s (120 ips) are included in these standards. For interchange purposes, either narrow track widths 0.635 mm (25 mils) must be employed, or other special heads must be used. These requirements are necessary because of the difficulty in maintaining individual head-segment gap-azimuth alignment across a head close enough to keep each track's response within the ±2 dB variation allowed by the standards. Moreover, at the lower tape speeds employed in double-density recording, the 38 mm (1.5 in.) spacing employed in interlaced head assemblies results in interchannel time displacement variations between odd and even tracks that may be unacceptable for some applications. For those reasons, it was decided that a 14-track in-line configuration on 25.4 mm (1-inch) tape should be adopted as a standard. This configuration results in essentially the same format as head number one of the 28-track interlaced configuration in the standards.

2.1 The 14-track interlaced heads are not compatible with tapes produced on an in-line standard configuration, and if tapes must be interchanged, a cross-configuration dubbing may be required, or a change of head assemblies on the reproducing machine is necessary.

2.2 High energy magnetic tape is required for double-density systems. Such tapes are available, but may require special testing for applications requiring a low number of dropouts per track.

2.2.1 Other Track Configurations. The above-referenced standards include configurations resulting in 7, 14, and 21 tracks in addition to the 14- and 28-track configurations listed in chapter 6. The HDDR Standards also reference an 84-track configuration on 50.8 mm (2-inch) tape. Figure D-1 and table D-1 show the 7 track on 12.7 mm (1/2-inch) tape, table D-2 shows the 14 track on 12.7 mm (1/2-inch) tape, and table D-3 shows the 42 track on 25.4 mm (1-inch) tape configurations.

2.2.2 High-Density PCM Recording. High-density digital recording systems are available from most instrumentation recorder manufacturers. Such systems will record at linear packing densities of 33 000-bits-per-inch or more per track. Special systems are available for error detection and correction with overhead penalties depending on the type and the sophistication of the system employed. The HDDR documents listed in paragraph 1.0 of this appendix reference six different systems that have been produced; others are available.

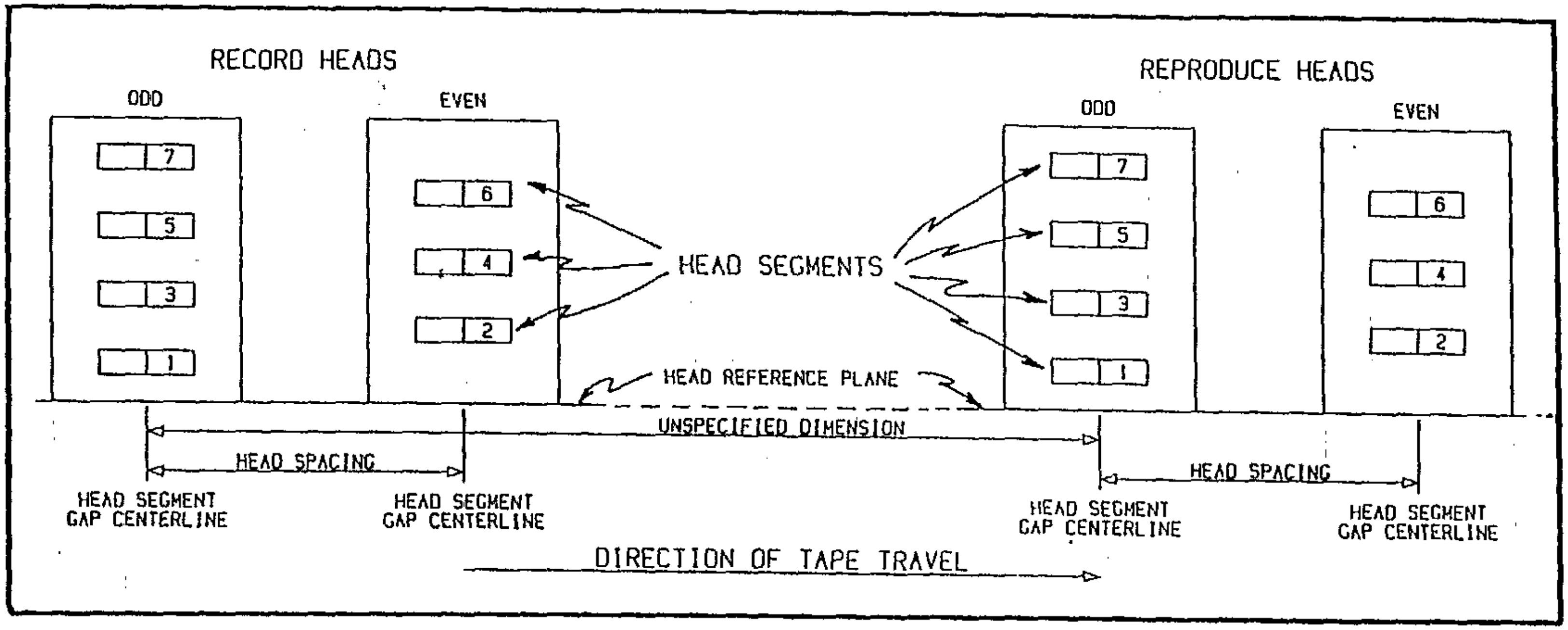


Figure D-1. Record and reproduce head and head segment identification and location (7-track interlaced system).

TABLE D-1. DIMENSIONS - RECORDED TAPE FORMAT, 7 TRACKS INTERLACED ON 12.7 mm (1/2 in.) WIDE TAPE (REFER TO FIGURE 6-1).

Parameters	Millimeters		Inches
	Maximum	Minimum	
Track Width	1.397	1.143	0.050 ±0.005
Track Spacing	1.778		0.070
Head Spacing:			
Fixed Heads	38.125	38.075	1.500 ±0.001
Adjustable Heads	38.151	38.049	1.500 ±0.002
Edge Margin, Minimum	0.127		0.005
Reference Track Location	1.067	0.965	0.040 ±0.002
Track Location Tolerance	0.051	-0.051	±0.002

Track Number	Location of nth track: Millimeters		Inches
	Maximum	Minimum	
1 (Reference)	0.000	0.000	0.000
2	1.829	1.727	0.070
3	3.607	3.505	0.140
4	5.385	5.283	0.210
5	7.163	7.061	0.280
6	8.941	8.839	0.350
7	10.719	10.617	0.420

3.0 Serial HDDR

The following subparagraphs give some of the background for selection of the bi-phase and RNRZ-L systems specified in subparagraph 6.11.3, chapter 6 of this document.

3.1 Serial HDDR is a method of recording digital data on a magnetic tape where the digital data is applied to one track of the recording system as a bi-level signal. The codes recommended for serial HDDR recording of telemetry data are BiØ-L and randomized NRZ-L (RNRZ-L) (refer to paragraph 6.11, chapter 6).

TABLE D-2. DIMENSIONS - RECORDED TAPE FORMAT, 14-TRACKS INTERLACED ON 12.7 mm (1/2 in.) WIDE TAPE (REFER TO FIGURE 6-1.)

Parameters	Millimeters		Inches	
	Maximum	Minimum		
Track Width	0.660	0.610	0.025	±0.001
Track Spacing	0.889		0.035	
Head Spacing:				
Fixed Heads	38.125	38.075	1.500	±0.001
Adjustable Heads	38.151	38.049	1.500	±0.002
Edge Margin, Minimum	0.127		0.005	
Reference Track Location	0.546	0.470	0.0200	±0.001
Track Location Tolerance	0.038	-0.038		±0.0015

Location of nth track

Track Number	Millimeters Maximum	Millimeters Minimum	Inches
1 (Reference)	0.000	0.000	0.000
2	0.927	0.851	0.035
3	1.816	1.740	0.070
4	2.705	2.629	0.105
5	3.594	3.518	0.140
6	4.483	4.407	0.175
7	5.372	5.292	0.210
8	6.261	6.185	0.245
9	7.150	7.074	0.280
10	8.039	7.963	0.315
11	8.928	8.852	0.350
12	9.817	9.741	0.385
13	10.706	10.630	0.420
14	11.595	11.519	0.455

TABLE D-3. DIMENSIONS - RECORDED TAPE FORMAT, 42-TRACKS INTERLACED ON 25.4 mm (1 in.) WIDE TAPE (REFER TO FIGURE 6-1)

Parameters	Millimeters		Inches	
	Maximum	Minimum		
Track Width	0.483	0.432	0.018	±0.001
Track Spacing	0.584		0.023	
Head Spacing:				
Fixed Heads	38.125	38.075	1.500	±0.001
Adjustable Heads	38.151	38.049	1.500	±0.002
Edge Margin, Minimum	0.305		0.012	
Reference Track Location	0.737	0.660	0.0275	±0.015
Track Location Tolerance	0.025	-0.025		±0.000

Track Number	Location of nth track Millimeters		Inches
	Maximum	Minimum	
1 (Reference)	0.000	0.000	0.000
2	0.610	0.559	0.023
3	1.194	1.143	0.046
4	1.778	1.727	0.069
5	2.362	2.311	0.092
6	2.946	2.896	0.115
7	3.531	3.480	0.138
8	4.115	4.064	0.161
9	4.699	4.648	0.184
10	5.283	5.232	0.207
11	5.867	5.817	0.230
12	6.452	6.401	0.253
13	7.036	6.985	0.276
14	7.620	7.569	0.299
15	8.204	8.153	0.322
16	8.788	8.738	0.345

TABLE D-3. (Cont'd) DIMENSIONS - RECORDED TAPE FORMAT, 42-TRACKS INTERLACED ON 25.4 mm (1 in.) WIDE TAPE (REFER TO FIGURE 6-1)

Track Number	Location of nth track Millimeters Maximum	Millimeters Minimum	Inches
17	9.373	9.322	0.368
18	9.957	9.906	0.391
19	10.541	10.490	0.414
20	11.125	11.074	0.437
21	11.709	11.659	0.460
22	12.294	12.243	0.483
23	12.878	12.827	0.506
24	13.462	13.411	0.529
25	14.046	13.995	0.552
26	14.630	14.580	0.575
27	15.215	15.164	0.598
28	15.799	15.748	0.621
29	16.383	16.332	0.664
30	16.967	16.916	0.667
31	17.551	17.501	0.690
32	18.136	18.085	0.713
33	18.720	18.660	0.736
34	19.304	19.253	0.759
35	19.888	19.837	0.782
36	20.472	20.422	0.805
37	21.057	21.006	0.828
38	21.641	21.590	0.851
39	22.225	22.174	0.874
40	22.809	22.758	0.897
41	23.393	23.343	0.920
42	23.978	23.927	0.943

3.2 In preparing paragraph 6.11 of chapter 6, the following codes were considered: Delay Modulation (Miller Code), Miller Squared, Enhanced NRZ, NRZ Level, NRZ Mark, and NRZ Space. These codes are not recommended for interchange applications at the bit rates given in paragraph 6.11.

3.3 The properties of the BiØ-L and RNRZ-L codes relevant to serial HDDR and the methods for generating and decoding RNRZ-L are described next. Recording with bias is required for interchange applications because reproduce amplifier phase and amplitude equalization adjustments for tapes recorded without bias usually differ from those required for tapes recorded with bias.

3.4 The BiØ-L and RNRZ-L codes were selected for this standard because the "level" versions are easier to generate and are usually available as outputs from bit synchronizers. "Mark" and "Space" codes also have about twice as many errors as the level codes for the same SNR. If polarity insensitivity is a major consideration, agreement between interchange parties should be obtained before these codes are used.

3.5 Some characteristics of the BiØ-L code favorable to serial HDDR are listed in the following subparagraphs.

3.5.1 Only a small proportion of the total signal energy occurs near dc.

3.5.2 The maximum time between transitions is 1 bit period.

3.5.3 The symbols for one and zero are antipodal; that is, the symbols are exact opposites of each other. Therefore, the bit error probability versus SNR performance is optimum.

3.5.4 The BiØ-L can be decoded using existing bit synchronizers.

3.5.5 The BiØ-L is less sensitive to misadjustments of bias and reproducer equalizers than most other codes.

3.5.6 The BiØ-L performs well at low tape speeds and low bit rates.

3.6 The most unfavorable characteristic of the BiØ-L code is that it requires approximately twice the bandwidth of NRZ. Consequently, the maximum bit packing density that can be recorded on magnetic tape is relatively low.

3.7 Characteristics of the RNRZ-L code which favor its use for serial HDDR are included in the following subparagraphs.

3.7.1 The RNRZ-L requires approximately one-half the bandwidth of BiØ-L.

3.7.2 The symbols for one and zero are antipodal; therefore, the bit error probability versus SNR performance is optimum.

3.7.3 The RNRZ-L decoder is self-synchronizing.

3.7.4 The RNRZ-L data can be bit-synchronized and signal-conditioned using existing bit synchronizers with the input code selector set to NRZ-L.

3.7.5 The RNRZ-L code is easily generated and decoded.

3.7.6 The RNRZ-L data can be easily decoded in the reverse mode of tape playback.

3.7.7 The RNRZ-L data are bit detected and decoded using a clock at the bit rate. Therefore, the phase margin is much larger than that of codes that require a clock at twice the bit rate for bit detection.

3.7.8 The RNRZ-L code does not require overhead bits.

3.8 Unfavorable characteristics of the RNRZ-L code for serial HDDR are described next.

3.8.1 Long runs of bits without a transition are possible although the probability of occurrence is low, and the maximum run length can be limited by providing transitions in each data word.

3.8.2 Each isolated bit error that occurs after the data has been randomized causes 3-bit errors in the derandomized output-data.

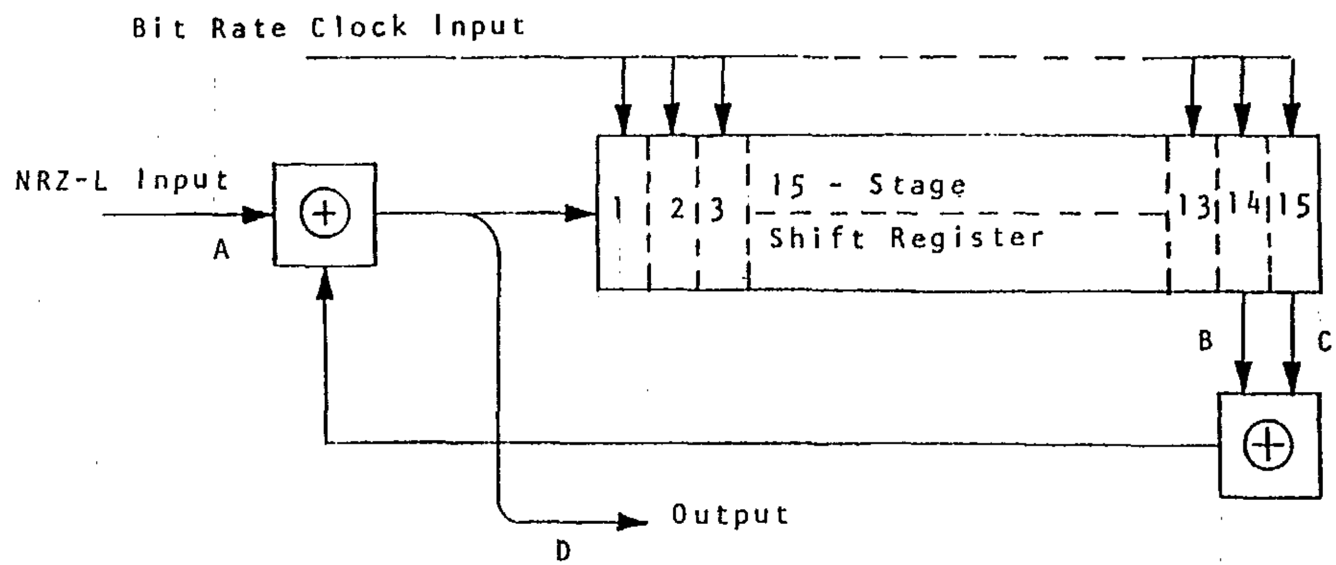
3.8.3 The decoder requires 15 consecutive error-free bits to establish and reestablish error-free operation.

3.8.4 The RNRZ-L bit stream can have a large low frequency content. Consequently, reproducing data at tape speeds which produce PCM bit rates less than 200 kb/s is not recommended unless a bit synchronizer with specially designed dc and low frequency restoration circuitry is available.

3.9 Randomizer for RNRZ-L

The randomizer is implemented with a network of shift registers and modulo-2 adders (exclusive-OR gates). The RNRZ-L bit stream is generated by adding (modulo-2) the reconstructed NRZ-L PCM data to the modulo-2 sum of the outputs of the 14th and 15th stages of a shift register. The output RNRZ-L stream is also the input to the shift register (see figure D-2).

3.9.1 The properties of an RNRZ-L bit stream are similar to the properties of a pseudo-random sequence. A 15-stage RNRZ-L encoder will generate a maximal length pseudo-random sequence of $2^{15}-1$ (32 767) bits if the input data consists only of zeros and there is at least a single one in the shift register. A maximal length pseudo-random sequence is also generated when the input data consists only of ones and the shift register contains at least a single zero. However, if the shift register contains all zeros at the moment that the input bit stream is all zeros, the RNRZ-L output bit stream will also be all zeros. The converse is also true: when the shift register is filled with ones and the input bit stream is all ones, the RNRZ-L output bit stream will contain only ones. In these two cases, the contents of the shift register does not change and the output data is not randomized.



Boolean Expression:

$$D = A \oplus B \oplus C$$

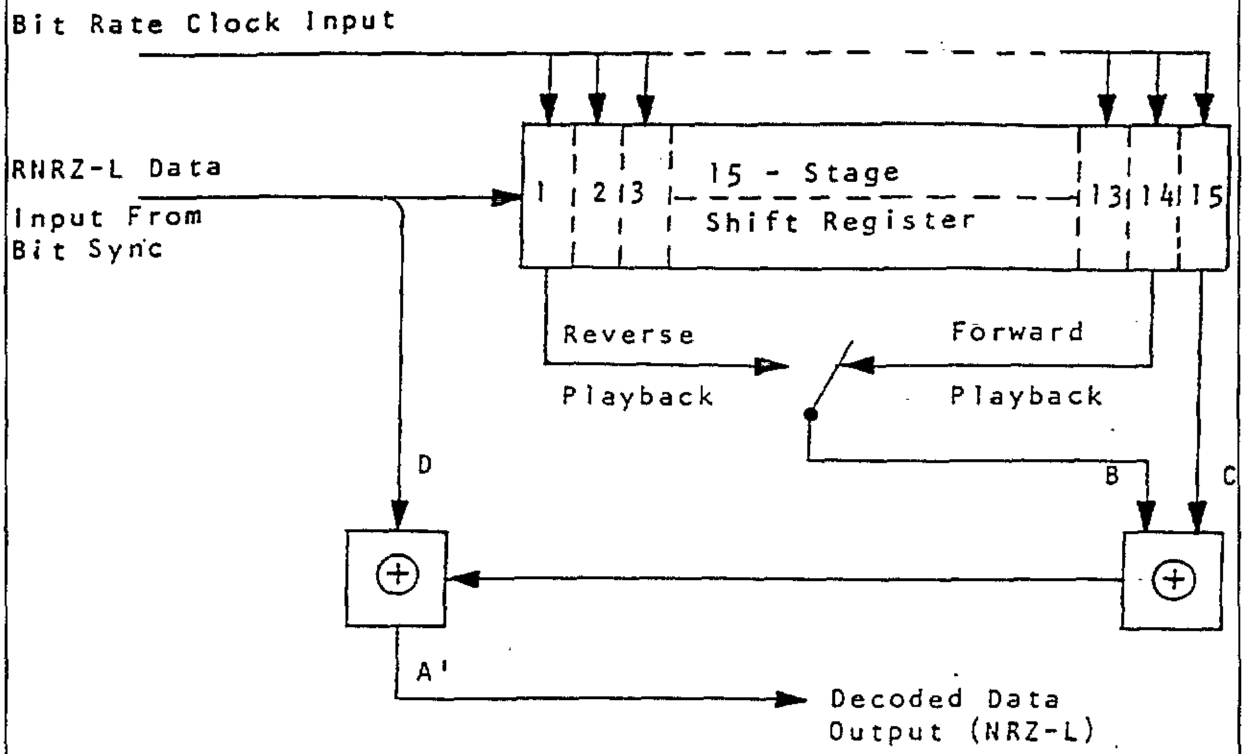
Figure D-2. Randomizer block diagram.

However, the randomizer is not permanently locked-up in this state because a change in the input data will again produce a randomized output. In general, if the input bit stream contains runs of X bits without a transition with a probability of occurrence of p(X), the output will contain runs having a length of up to (X+15) bits with a probability of (2^{-15} x p(X)). Therefore, the output can contain long runs of bits without a transition, but the probability of occurrence is low.

3.9.2 The RNRZ-L bit stream is decoded (derandomized) by adding (modulo-2) the reconstructed RNRZ-L bit stream to the modulo-2 sum of the outputs of the 14th and 15th stages of the shift register. The reconstructed RNRZ-L bit stream is the input to the shift register (see figure D-3). The RNRZ-L data which is reproduced using the reverse playback mode of operation is decoded by adding (modulo-2) the reconstructed RNRZ-L bit stream to the modulo-2 sum of the outputs of the 1st and 15th stages of the shift register (see figure D-3). The net effect is that the decoding shift register runs "backwards" with respect to the randomizing shift register.

3.9.3 Although the RNRZ-L decoder is self-synchronizing, 15 consecutive error-free bits must be loaded into the shift register before the output data will be valid. A bit slip will cause the decoder to lose synchronization, and 15 consecutive error-free data bits must again be loaded into the shift register before the output data is valid. The decoded output data, although correct, will contain the bit slip causing a shift in the data with respect to the frame synchronization pattern. Therefore, frame synchronization must be reacquired before the output provides meaningful data.

3.9.4 The RNRZ-L decoding system has an error multiplication factor of 3 for isolated bit errors (separated from adjacent bit errors by at least 15 bits). An isolated bit error introduced after randomization will produce 3 errors in the output data; the original bit in error, plus 2 additional errors 14 and 15 bits later. In addition, a burst of errors occurring after the data has been randomized will produce a burst of errors in the derandomized output. The number of errors in the output depends on the distribution of errors in the burst and can be greater than, equal to, or less than the number of errors in the input to the derandomizer. However, the derandomization process always increases the number of bits between the first and last error in the burst by 15. Errors introduced prior to randomization are not affected by either the randomizer or the derandomizer. The reverse decoder has the same bit error properties as the forward decoder.



Boolean Expression:

With input data A into randomizer,

Error-Free RNRZ-L Data, $D = A \oplus B \oplus C$

(see Fig. E-1)

$A' = D \oplus B \oplus C = A \oplus B \oplus C \oplus B \oplus C$

$= A \oplus B \oplus B \oplus C \oplus C$. But $B \oplus B = 0$

$C \oplus C = 0$

Therefore:

$A' = A \oplus 0 \oplus 0 = A$

Figure D-3. Randomized NRZ-L decoder block diagram.

3.9.5 Input data containing frequent long runs of bits without transitions creates potential dc and low frequency restoration problems in PCM bit synchronizers because of the low frequency cutoff of direct recorder and reproducer systems. The restoration problem can be minimized by reproducing the data at tape speeds that produce a bit rate for which the maximum time between transitions is less than 100 microseconds. Additional methods of minimizing these effects include selecting bit synchronizers containing special dc and low frequency restoration circuitry or recording data using BiØ-L code.

3.9.6 The power spectra of the RNRZ-L and BiØ-L codes are shown in figure D-4. The power spectral density of RNRZ-L is concentrated at frequencies which are less than one-half the bit rate. The power spectral density of BiØ-L is concentrated at frequencies in a region around 0.75 times the bit rate. The concentration of energy in the low-frequency region (when using the RNRZ-L code) has the effect of reducing the SNR as well as creating baseline wander which the bit synchronizer must follow. Therefore, reproducing data at tape speeds which produce PCM bit rates of less than 200 kb/s is not recommended when using RNRZ-L unless a bit synchronizer with specially designed dc and low frequency restoration circuitry is available.

3.9.7 Alignment of the reproducer system is very important to reproducing high quality PCM data, that is, with the lowest possible bit error probability. A PCM signature using the standard 2047-bit pseudo-random pattern, recorded on the leader or the trailer tape, provides a good method for reproducer alignment. When a pseudo-random bit error detection system is not available or when a PCM signature signal is not recorded, the recommended procedure for reproducer alignment involves the use of the eye pattern technique. The eye pattern is the result of superpositioning the zeros and ones in the PCM bit stream. The eye pattern is displayed on an oscilloscope by inserting the raw reproduced bit stream into the vertical input and the reconstructed bit-rate clock into the external synchronization input of the oscilloscope. The reproducer head azimuth, amplitude equalizers, and phase equalizers are then adjusted to produce the eye pattern with the maximum height and width opening.

3.9.8 Sample eye patterns are shown in figure D-5. Figure D-5a shows a BiØ-L eye pattern at a recorded bit packing density of 15 kb/in (450 kb/s at 30 ips). Figure D-5b shows an RNRZ-L eye pattern at a recorded bit packing density of 25 kb/in (750 kb/s at 30 ips).

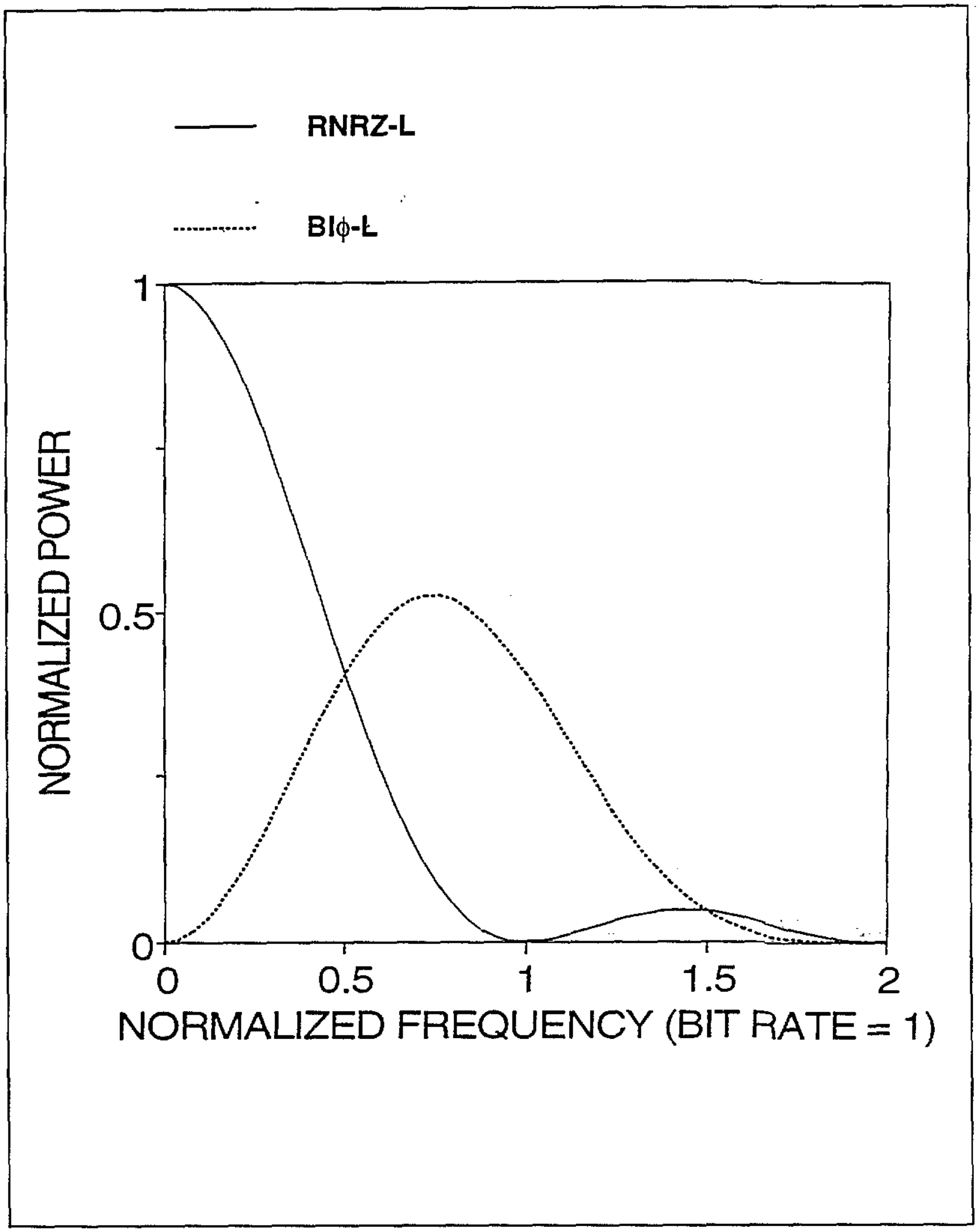
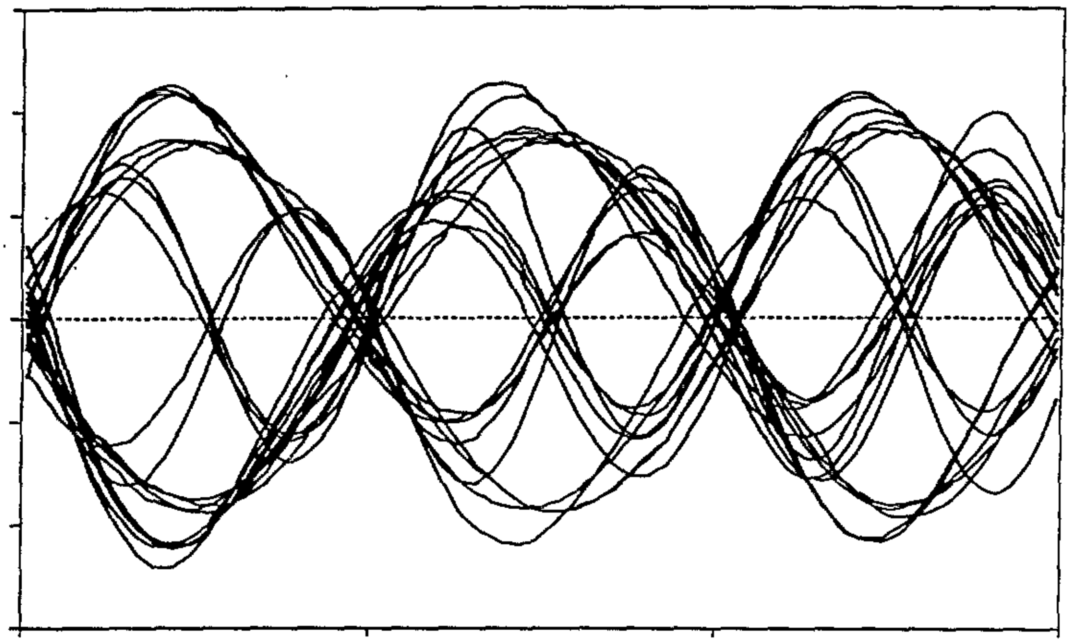
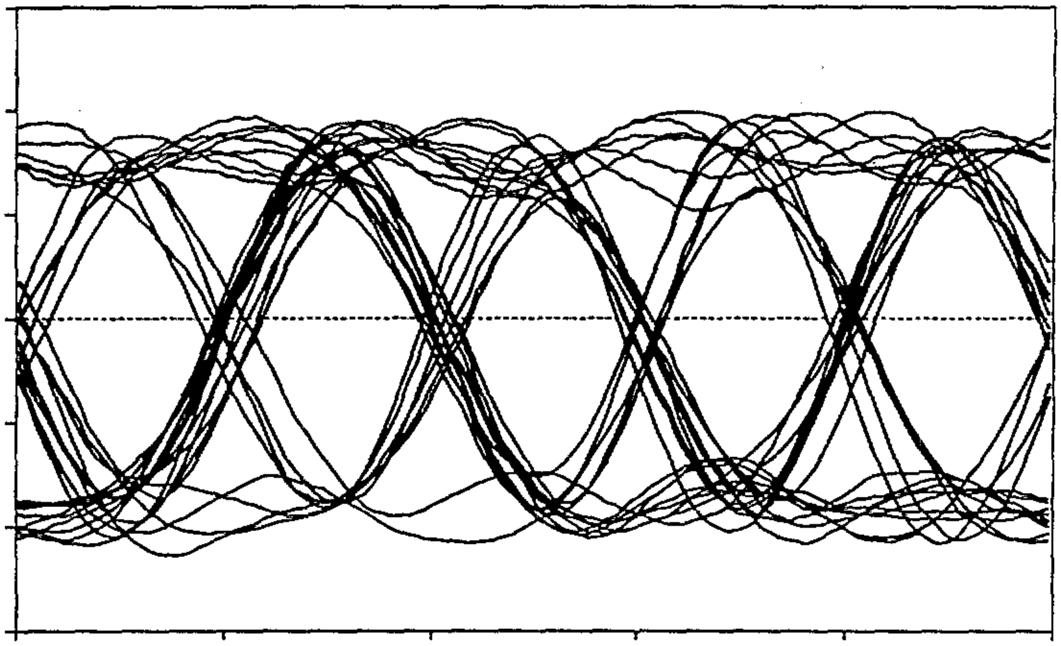


Figure D-4. Random PCM power spectra.



a. BiØ-L at bit packing density of 15 kb/in.



b. RNRZ-L at bit packing density of 25 kb/in.

Figure D-5. Sample eye patterns at output of recorder/reproducer.

4.0 Head Parameters

The following subparagraphs describe the head parameters.

4.1 Gap Scatter. Refer to the definitions in subparagraphs 6.2.22 and 6.2.23 in chapter 6. Gap scatter contains components of azimuth misalignment and deviations from the average line defining the azimuth. Since both components affect data simultaneity from record to reproduce, the measurement is the inclusive distance containing the combined errors. Because azimuth adjustment affects the output of wide-band systems, a 5.08 μm (0.0002 in.) gap scatter is allowed for such recorders and reproducers. A 2.54 μm (0.0001 in.) gap scatter is recommended for fixed-head systems (see upper illustration in figure 6-3).

4.2 Head Polarity. The requirement that a positive pulse at a record amplifier input generate a south-north-north-south magnetic sequence and that a south-north-north-south magnetic sequence on tape produce a positive pulse at the reproduce amplifier output, still leaves two interdependent parameters unspecified. These parameters are (1) polarity inversion or noninversion in record and playback amplifiers and (2) record or playback head winding sense. For the purpose of head replacement, it is necessary that these parameters be determined by the user so that an unsuspected polarity inversion, on tape or off tape, will not occur after heads are replaced.

5.0 Record Level

The standard record level is established as the input level of a sinusoidal signal set at the record level set frequency which, when recorded, produces a signal containing 1 percent third harmonic distortion at the output of a properly terminated reproduce amplifier (see subparagraph 4.1.3.3 of volume III, RCC document 118-XX). A 1 percent harmonic distortion content is achieved when the level of the third harmonic component of the record level set frequency is 40 ±1 dB below the level of a sinusoidal signal of 0.3 UBE which is recorded at the standard record level. Standard test and operating practice is to record and reproduce sinusoidal signals at 0.1 and 0.3 UBE and adjust the equalizers as necessary to establish the reproduced output at 0.3 UBE to within ±1.0 dB of the output at 0.1 UBE. Then a 1 V rms signal at the record level set frequency is applied to the record amplifier input and the record and reproduce level controls are adjusted until the reproduced output contains 1 percent third harmonic distortion at a level of 1 V rms.

The optimum level for recording data will seldom be equal to the standard record level. Signals having noise-like spectral distribution such as baseband multiplexes of FM subcarriers contain high crest factors so that it may be necessary (as determined in paragraph 1.1, Noise Power Ratio (NPR) Test, volume IV, RCC document 118-XX, ***Test Methods for Data Multiplex Equipment***) to record at levels below the standard record level. On the other hand, for predetection and HDDR recording, signals may have to be recorded above the standard record level to give optimum performance in the data system.

6.0 Tape Crossplay Considerations (Wide Band)

Figure D-6 illustrates the typical departure from optimum frequency response that may result when crossplaying wide-band tapes which were recorded with heads employing different record-head gap lengths. Line AA is the idealized output-versus-frequency plot of a machine with record bias and record level, set upper IRIG standards, using a 3.05 μm (120 microinch) record-head gap length and a 1.02 μm (40 microinch) reproduce-head gap length. Lines BB and CC represent the output response curves of the same tapes recorded on machines with 5.08 μm (200 microinch) and 1.27 μm (50 microinch) record-head gap lengths. Each of these recorders was set up individually per IRIG requirements. The tapes were then reproduced on the machine having a 1.02 μm (40 microinch) reproduce-head gap length without readjusting its reproduce equalization.

6.1 The output curves have been normalized to 0 dB at the 0.1 UBE frequency for the purpose of clarity. The normalized curves may be expected to exhibit a ±2.0 dB variance in relative output over the passband. The tape recorded with the shortest head segment gap length will provide the greatest relative output at the UBE.

6.2 While the examples shown are from older equipment with record gap lengths outside the limits recommended in subparagraph 6.5.4, chapter 6, they illustrate the importance of the record gap length in tape interchange applications.

7.0 Standard Tape Signature Procedures

The following subparagraphs describe the PCM signature and the swept-frequency signature.

7.1 PCM Signature Recording Procedures. Configure test equipment as described in paragraph 2.1, volume IV, RCC document 118-XX. The configuration should simulate the operational link as closely as possible, for example, same RF frequency, deviation, bit rate, code type, predetection frequency, receiver bandwidth, and recorder speed.

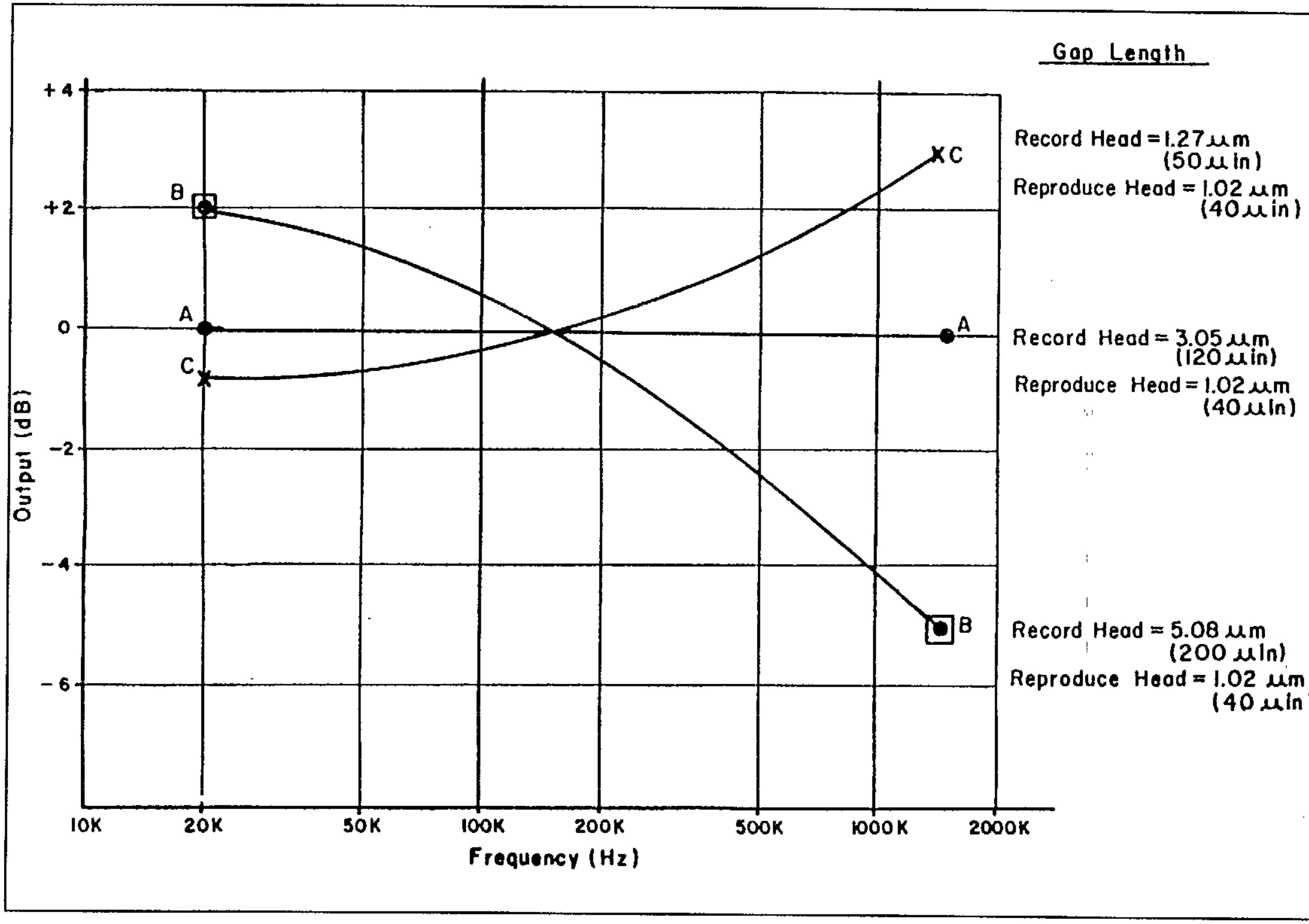


Figure D-6. Tape crossplay.

7.1.1 While recording the pseudo-random data at standard record level, adjust the signal generator output level until approximately one error per 10^5 bits is obtained on the error counter.

7.1.2 Record 30 seconds of the pseudo-random data at the beginning or end of the tape for each data track. A separate 30-second tape signature is recommended for each different data format.

7.1.3 The content, track assignments, and location on the tape leader and trailer of signature signals should be noted on the tape label.

7.2 PCM Signature Playback Procedure. The following subparagraphs explain the playback procedure.

7.2.1 Optimize playback equipment such as receiver tuning and bit synchronizer setup for data being reproduced.

7.2.2 Reproduce the tape signature and observe the error rate on the error counter.

7.2.3 Optimize head azimuth for maximum signal output and minimum errors.

7.2.4 If more than one error per 10^4 bits is obtained, initiate corrective action.

7.2.5 Repeat for each data track.

7.3 Swept Frequency Signature Recording Procedure. The following subparagraphs describe the recording procedure for the swept-frequency signature.

7.3.1 Patch a sweep-frequency oscillator output to all prime data tracks (up to 6 on 7-track recorders or up to 13 on 14-track recorders) (see appendix A, volume III of RCC document 118-XX). As a minimum, patch the sweep oscillator to one odd and one even track.

7.3.2 Connect the sync output of the sweep oscillator to a track not used for sweep signals, preferably an outside track.

7.3.3 Record the signature signals for a minimum of 30 seconds at standard record level.

NOTE

Record levels may be either preadjusted or quickly adjusted in all tracks during the first few seconds of the signature recording.

7.3.4 The content, track assignments, and location on the leader or trailer tape of signature signals should be noted on the tape label.

7.4 Swept-Frequency Signature Playback Procedure. The following subparagraphs define the steps for the playback procedure.

7.4.1 Connect the sync track output of the reproducer to the sync input of the scope.

7.4.2 Select an odd-numbered sweep-signal track and connect the output of the reproducer to the vertical input of the scope. Playback the sweep signal and adjust the scope gain for an amplitude of approximately ±10 minor vertical divisions about the center baseline. Adjust the odd-track azimuth for maximum amplitude of the highest frequency segment (extreme right of the sweep pattern).

7.4.3 Observe amplitude variations through the sweep pattern and adjust the equalization, if necessary, to maintain the amplitude within the required tolerance over the required frequency range.

NOTE

A decrease of sweep signal amplitude to about 0.7 represents a 3 dB loss.

7.4.4 Repeat the playback procedure in subparagraphs 7.4.2 and 7.4.3 for azimuth and equalization adjustments of an even-numbered tape track.

7.4.5 Repeat the procedure in subparagraph 7.4.3 for equalization only of other selected prime data tracks, as required.

8.0 Equipment Required for Swept-Frequency Procedures

Equipment required at the recording site consists of a sweep-frequency oscillator having a constant amplitude sweep range of approximately 400 Hz through 4.4 MHz with frequency markers at 62.5, 125, 250, and 500 kHz and 1.0, 2.0, and 4.0 MHz. The sweep range to 4.4 MHz may be used for all tape speeds because the bandwidth of the recorder and reproducer will attenuate those signal frequencies beyond its range. The sweep rate should be approximately 25 Hz. Care should be exercised in the installation of the sweep generator to ensure a flat response of the sweep signal at the input terminals of the recorder. Appropriate line-driver amplifiers may be required for long cable runs or the low impedance of paralleled inputs.

8.1 A stepped-frequency oscillator could be substituted for the sweep-frequency generator at the recording location. Recommended oscillator wavelengths at the mission tape speed are 7.62 mm (300 mils), 3.81 mm (150 mils), 0.254 mm (10 mils), 0.0254 mm (1 mil), 0.0127 mm (0.5 mil), 0.0064 mm (0.25 mil), 0.0032 mm (0.125 mil), 0.0025 mm (0.1 mil), 0.0020 mm (0.08 mil), and 0.0015 mm (0.06 mil).

8.2 Equipment required at the playback site consists of an ordinary oscilloscope having a flat frequency response from 400 Hz through 4.4 MHz.

9.0 Fixed-Frequency Plus White Noise Procedure

The signature used in this method is the same for all applications. For direct recording of subcarrier multiplexes, only static nonlinearity (nonlinearity which is independent of frequency) is important for crosstalk control. Subparagraph 6.8.2 in chapter 6 provides a reference level for static nonlinearity. All formats of data recording are sensitive to SNR. Predetection recording and HDDR are sensitive to equalization. The following signature procedure satisfies all the above requirements.

9.1 Record a sine-wave frequency of 0.1 UBE (see table 6-3) with the following amplitudes.

9.1.1 Equal to the standard record level for direct recording of subcarrier multiplexes and HDDR (see subparagraph 6.8.2, chapter 6).

9.1.2 Equal to the carrier amplitude to be recorded for pre-detection recording of PCM/FM, PCM/PM, FM/FM, and PAM/FM.

9.2 Record flat band-limited white noise of amplitude 0.7 of the true rms value of the 0 dB standard record level as described in subparagraph 6.8.2, chapter 6. Noise must be limited by a low-pass filter just above the UBE.

9.3 Record with zero input (input terminated in 75 ohms). The three record steps previously described can consist of 10 seconds each. The spectra can be obtained with three manually initiated sweeps of less than a second each, because no great frequency resolution is required. All of the spectrum analyzer parameters can be standardized and set in prior to running the mission tape.

10.0 Signature Playback and Analysis

Before analyzing the signature, the reproducer azimuth should be adjusted. With the short signature, it is probably more convenient to use the data part of the recording for this purpose. If predetection recording is used, the azimuth can be adjusted to maximize the output as observed on the spectrum analyzer or on a voltmeter connected to the output. If baseband recording is used, the azimuth can be adjusted to maximize the spectrum at the upper end of the band. Using a spectrum analyzer, reproduce, store, and photograph the spectra obtained from paragraphs 9.1, 9.2, and 9.3 in this appendix. Store and photograph the spectrum analyzer input level of zero.

10.1 It is evident that any maladjustment of the recorder and reproducer or magnetization of the heads will result in the decrease of SNR across the band and will be seen from the stored spectra or photograph.

10.2 By having a photograph of the spectra, amplitude equalization can be accomplished without shuttling the mission tape as follows.

10.2.1 Use an auxiliary tape (not the mission tape, but preferably the same type tape). With a white-noise input signal band limited, adjust the amplitude equalization of the recorder and reproducer at the tape dubbing or data reduction site and photograph the output spectrum (see paragraph 9.0 of this appendix).

10.2.2 Compare this photo with the photo made from the signature. Note the difference at several points across the band.

10.2.3 Using the auxiliary tape, adjust the amplitude equalization to compensate for the differences noted.

10.2.4 Recheck with the mission tape to verify that the desired amplitude equalization has been achieved.

10.3 If the phase equalization is to be checked, a square-wave signal can be added to the signature in accordance with the manufacturer's specification (see subparagraph 4.9.2.3.3 of volume III, RCC document 118-XX). The same procedure as that recommended for amplitude equalization can be used, except based on oscillograms.

11.0 Recording and Playback Alignment Procedures

When using standard preamble (or postamble), see paragraph 6.12, chapter 6.

11.1 Recording of Preamble for Direct Electronics Alignment

11.1.1 Patch a square-wave generator output set to 1/11 band edge to all tracks having direct electronics or initiate procedure for recording internally generated 1/11 band edge square wave according to manufacturer's instructions.

11.1.2 If the preamble will be used for a manual adjustment, record for a minimum of 30 seconds at the standard record level and tape speed to be used for data recording.

11.1.3 If the preamble will be used only for automatic alignment, record at the standard record level and tape speed to be used for data recording for a sufficient time as specified by the manufacture of the playback recorder/reproducer or as agreed by the interchange parties.

11.2 Playback of Preamble for Direct Electronics Alignment

For systems so equipped, initiate automatic alignment procedure per manufacturer's instructions. The procedure for manual adjustment is described in the next subparagraphs.

11.2.1 Display fundamental and odd harmonics of the square wave (third through eleventh) of selected odd numbered direct track near center of head stack on the spectrum analyzer. Adjust azimuth by peaking output amplitude of the third through eleventh harmonic. Final adjustment should peak the eleventh harmonic.

11.2.2 Repeat the above subparagraph for even numbered direct track. (Only one track is necessary for double density, 14-track, in-line system).

11.2.3 Observe frequency response across the band pass on selected track and correct if necessary. For a flat response, the third harmonic will be 1/3 of the amplitude of the fundamental, fifth harmonic 1/5 the amplitude, and so on. A convenient method is to compare the recorder/reproducer output with that of a square wave generator patched directly to the spectrum analyzer.

NOTE

An alternate but less accurate method is to optimize the square wave as displayed on an oscilloscope rather than a spectrum analyzer.

11.2.4 Repeat the previous subparagraph for each direct track.

11.2.5 Display square wave on oscilloscope. Adjust phase for best square wave response as shown in figure D-7.

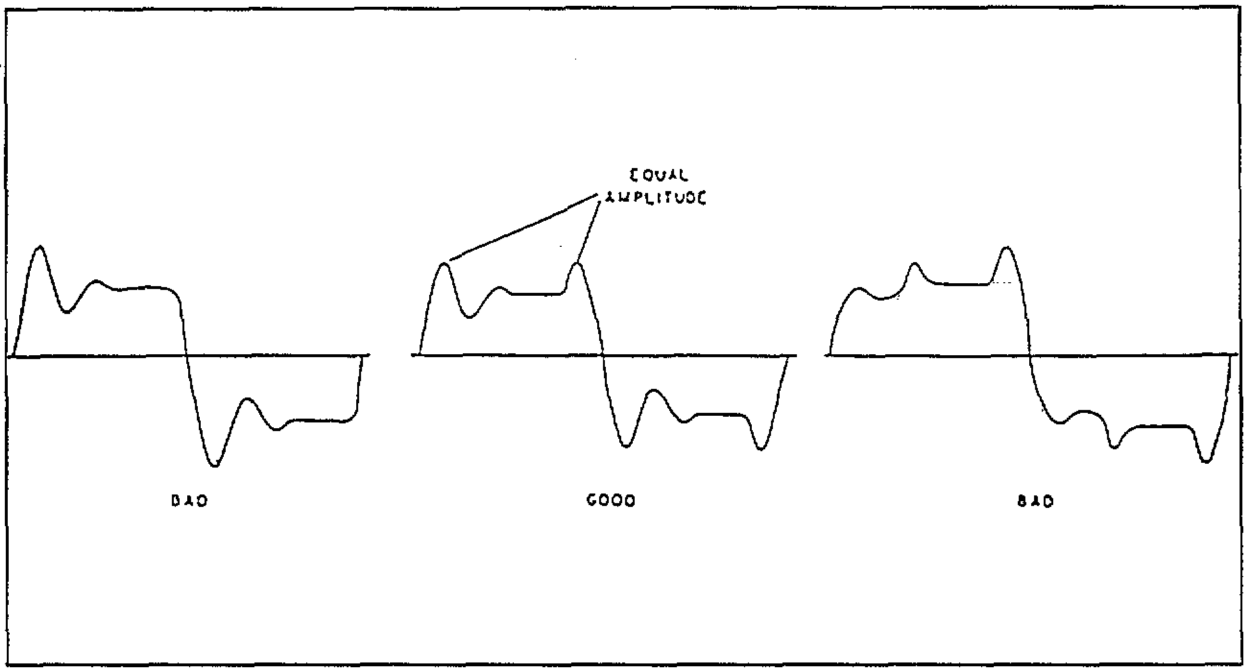


Figure D-7. Square-wave responses.

11.2.6. Repeat the previous subparagraph for each direct track.

11.3 <u>Recording of Preamble for FM Electronics Alignment</u>

If available, initiate procedure for recording internally generated 1/11 band edge square wave and ±1.414 Vdc per manufacturer's instructions. Otherwise, patch a square-wave generator output to all tracks having FM electronics. A near dc signal may be obtained by setting the square-wave generator to 0.05 Hz and ±1.414 V or by using a separate dc source.

11.3.1 If the preamble will be used for manual alignment, record at least one cycle of the 0.05 Hz square wave at ±1.414 V or a positive and negative 1.414 Vdc for a minimum of 10 seconds each at the tape speed to be used for data recording. Next, record a 1/11 band edge square wave for a minimum of 20 seconds.

11.3.2 If the preamble will be used only for automatic alignment, record the above sequence for a sufficient time as specified by the manufacturer of the playback recorder/reproducer or as agreed by the interchange parties.

11.4 Playback of Preamble for FM Electronics Alignment

For systems so equipped, initiate automatic alignment procedure per manufacturer's instructions. The procedure for manual adjustment is described in the next subparagraphs.

11.4.1 Check and adjust for 0 V output at center frequency per RCC document 118-XX, ***Test Methods for Telemetry Systems and Subsystems,*** volume III, Test Methods for Recorder/Reproducer Systems and Magnetic Tape.

11.4.2 Use dc voltmeter to verify a full positive and negative output voltage on the selected track and correct if necessary.

11.4.3 Display fundamental and odd harmonics of the square wave (third through eleventh) on the spectrum analyzer.

11.4.4 Observe frequency response per subparagraph 11.2.3.

11.4.5 Repeat subparagraphs 11.4.1 through 11.4.3 for each FM track.

APPENDIX E

AVAILABLE TRANSDUCER DOCUMENTATION

APPENDIX E

AVAILABLE TRANSDUCER DOCUMENTATION

Documentation pertaining to general and specific transducer types has been published by many sources. Additional documentation is constantly being prepared or updated. Since the content of these documents is subject to continuing review, users are urged to contact the responsible organization for the most up-to-date editions. The following list of documents pertaining to transducers with electrical output is provided as a guide to the type of available material. This listing is not intended to be all inclusive.

Accelerometers and Vibration

ANSI S2.2 - 1959, USA Standard Methods for the Calibration of Shock and Vibration Pickups.

ANSI S2.11 - 1969, American National Standard for the Selection of Calibrations and Tests for Electrical Transducers Used for Measuring Shock and Vibration.

ANSI Z24.21 - 1957, American Standard Method for Specifying the Characteristics of Pickups for Shock and Vibration Measurement.

IEEE Std 337 - 1978, IEEE Standard Specification Format Guide and Test Procedure for Linear, Single-Axis, Pendulous, Analog Torque Balance Accelerometers.

ISA - RP 37.2 - 1982, Guide for Specifications and Tests for Piezoelectric Acceleration Transducers for Aerospace Testing.

ANSI/ISA - S37.5 - 1975, Specifications and Tests for Strain Gage Linear Acceleration Transducers (R.1982).

Fluid Velocity

ASME PTC 19.5.3 - 1965, Fluid Velocity Measurement.

Microphones and Sound Power

ANSI S1.1 - 1960, USA Standard Acoustical Terminology (Including Mechanical Shock and Vibration).

ANSI S1.4 - 1983, American National Standard Specification for Sound Level Meters.

ANSI S1.8 - 1969, American National Standard Preferred Reference Quantities for Acoustical Levels.

ANSI S1.10 - 1966, USA Standard Method for the Calibration of Microphones.

ANSI S1.12 - 1967, USA Standard Specifications for Laboratory Standard Microphones.

ANSI S1.13 - 1971, Methods for Measurement of Sound Pressure Levels (R.1976).

ANSI S1.30 - 1979, Guidelines for Use of Sound Power Standards and for the Preparation of Noise Test Codes (see ASA 10-79).

ANSI S1.31 - 1980, Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms (see ASA 11-80).

ANSI S1.32 - 1980, Precision Methods for Determination of Sound Power Levels of Discrete-Frequency and Narrow Band Noise Sources in Reverberation Rooms (see ASA 12-80).

ANSI S1.33 - 1982, Engineering Methods for Determination of Sound Power Levels of Noise Sources in a Special Reverberation Test Room (see ASA 13-82).

ANSI S1.34 - 1980, Engineering Methods for Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane (see ASA 14-80).

ANSI S1.35 - 1979, Precision Methods for Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi-Anechoic Rooms (see ASA 15-79).

ANSI S1.36 - 1979, Survey Methods for Determination of Sound Power Levels of Noise Sources (R.1985) (see ASA 16-79).

Pressure Transducers

ASME PTC 19.2 - 1964, Pressure Measurements.

ANSI MC88.1 - 1972, A Guide for the Dynamic Calibration of Pressure Transducers.

ANSI/ISA - S37.3 - 1975, Specifications and Tests for Strain Gage Pressure Transducers (R.1982).

ANSI/ISA - S37.6 - 1976, Specifications and Tests of Potentiometric Pressure Transducers (R.1982).

ANSI/ISA - S37.10 - 1975, Specifications and Tests for Piezoelectric Pressure and Sound-Pressure Transducers (R.1982).

Rate Gyros

IEEE No. 292 - July 1986, IEEE Specification Format for Single-Degree-of-Freedom Spring-Restrained Rate Gyros.

IEEE No. 293 - July 1986, IEEE Test Procedure for Single-Degree-Of-Freedom Spring-Restrained Gyros.

Thermocouples

ASTM E 220-86, Standard Method for Calibration of Thermocouples by Comparison Techniques.

ASTM E 230-87, Standard Temperature-Electromotive Force (EMF) Tables for Thermocouples.

ASTM E 344-84, Terminology Relating to Thermometry and Hydrometry.

ASTM E 635-88, Standard Specification for Thermocouples, Sheathed, Type K, for Nuclear or for Other High-Reliability Applications.

SAMA Standard RC21-4 - 1966, Temperature-Resistance Values for Resistance Thermometer Elements of Platinum, Nickel and Copper.

Miscellaneous

ISA - 1991, Standards and Recommended Practices for Instrumentation and Control, 11th Edition.

ISA - 1991, Comprehensive Dictionary of Measurement and Control, Second Edition.

SAMA Standard PMC 20.1 - 1973, Process Measurement and Control Terminology.

APPENDIX F

CONSTANT BANDWIDTH FM SUBCARRIER CHANNEL NOMENCLATURE

APPENDIX F

CONSTANT BANDWIDTH FM SUBCARRIER CHANNEL NOMENCLATURE

1.0 The constant bandwidth FM subcarrier channels have been renamed in conjunction with the expansion of the number of available channels and wider bandwidths. The relationship between the previous designations and the new designations are given.

2.0 The "A" channels are related as follows:

Old Designation	New Designation
1A	16A
2A	24A
3A	32A
4A	40A
5A	48A
6A	56A
7A	64A
8A	72A
9A	80A
10A	88A
11A	96A
12A	104A
13A	112A
14A	120A
15A	128A
16A	136A
17A	144A
18A	152A
19A	160A
20A	168A
21A	176A

3.0 The "B" channels are related as follows:

Old Designation	New Designation
3B	32B
5B	48B
7B	64B
9B	80B
11B	96B
13B	112B

Old Designation	New Designation
15B	128B
17B	144B
19B	160B
21B	176B

4.0 The "C" channels are related as follows:

Old Designation	New Designation
3C	32C
7C	64C
11C	96C
15C	128C
19C	160C

APPENDIX G

ADARIO DATA BLOCK FIELD DEFINITIONS

APPENDIX G

ADARIO DATA BLOCK FIELD DEFINITIONS

The details of the ADARIO data block format are provided in figure G-1 and in the ADARIO data format field summary. As shown in figure G-1, the eight session header words are the first eight words of the block. The channel packet for the highest priority (priority 1) channel is next, followed by the next lower priority channel packet (priority 2). Following the lowest priority channel, fill data consisting of all ones are inserted as required to complete the 2048-word data block.

Within the channel packet, the first five words are the channel header words including the partial word (PW). Following the channel header is the variable size channel data field. The channel data are organized in a last-in-first-out (LIFO) fashion. The first samples acquired in the block time interval appear in the last data word of the channel packet. The sample data are formatted into the 24-bit data word such that the first sample occupies the MSBs of the word. The next sample is formatted into the next available MSBs and so on until the word is full. As an example, data formatted into 8-bit samples is shown in figure G-2.

In cases where the 24-bit data word is not a multiple of the sample size, the sample boundaries do not align with the data words. In these cases, the samples at the word boundaries are divided into two words. The MSBs of the sample appear in LSBs of the first buffered word and the LSBs of the sample appear in the MSBs of the next buffered word. Since the channel data appears in a LIFO fashion in the ADARIO data block, the MSBs of the divided sample will occur in the data word following the word containing LSBs of the sample. Figure G-3 depicts ADARIO timings.

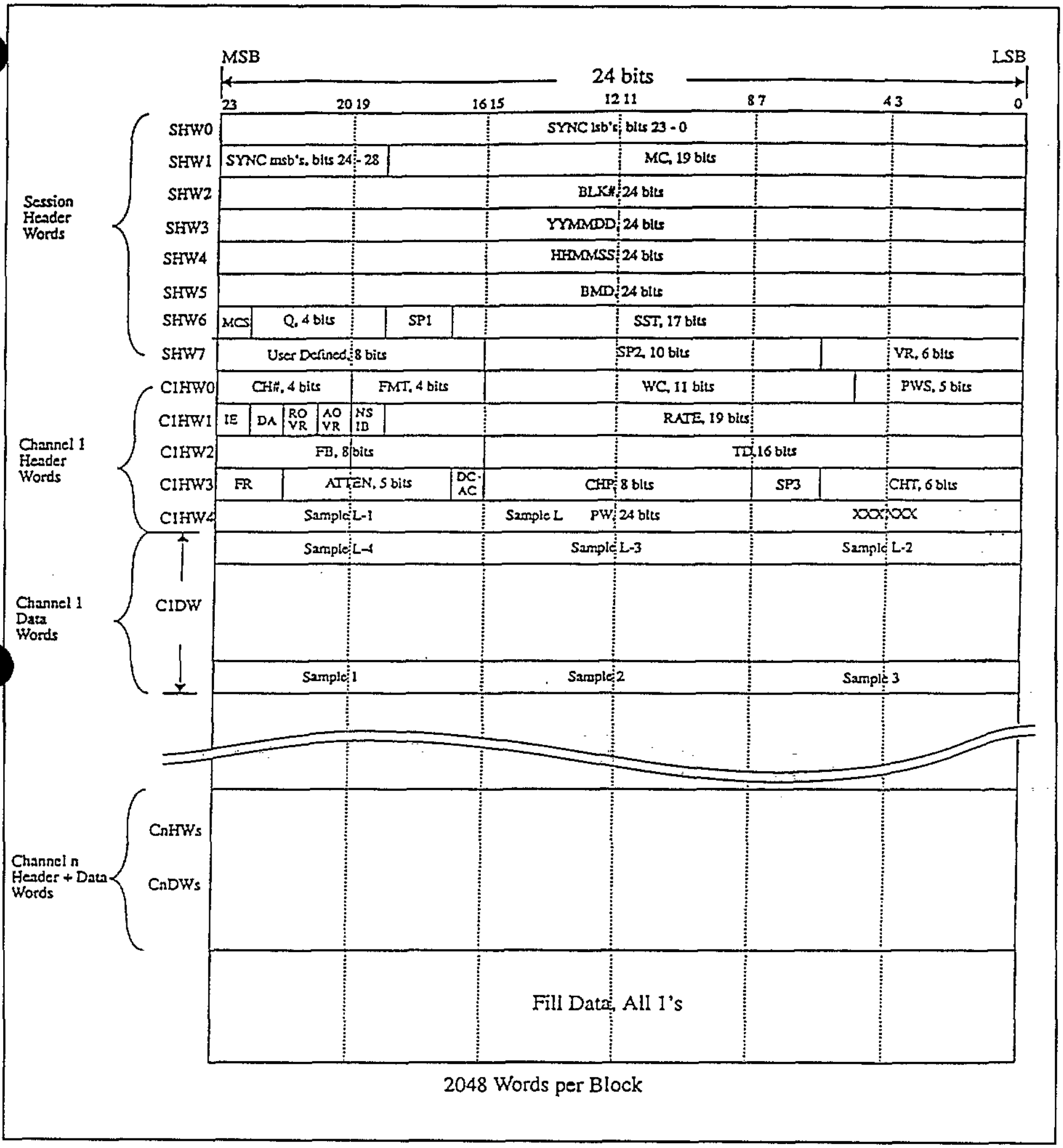


Figure G-1. ADARIO data format.

ADARIO Data Format Field Definitions Summary

1. Block Length - (2048 words, 24-bit words, fixed length)

2. Session Header - (8 words, fixed format)

SHWO	(bits 23 to 0)	SYNC Field, bits 0-23 of the 29-bit block sync. The LSBs of the block sync are 36E19C and are contained here.
SHW1	(bits 23 to 19)	SYNC Field bits 24-28 of the 29-bit block sync. The MSBs of the block sync are 01001 and are contained here. The 29-bit block sync is fixed for all ADARIO configurations and chosen for minimal data cross correlation.
	(bits 18 to 0)	MC, Master Clock, a 19-bit binary value in units of 250 Hz. MC is the clock frequency used to derive session and per channel parameters.
SHW2	(bits 23 to 0)	BLK#, ADARIO Data Block Number, a 24-bit binary value. BLK# is reset to zero at the start of each session and counts up consecutively. Roll-over is allowed.
SHW3	(bits 23 to 0)	YYMMDD, Time Code Field, a BCD representation of the year (YY), month (MM), and day (DD). The YYMMDD Time Code Field is updated during the record process once per second.
SHW4	(bits 23 to 0)	HHMMSS, Time Code Field, a BCD representation of the hour (HH), minute (MM), and second (SS). The HHMMSS Time Code Field is updated during the record process once per second.
SHW5	(bits 23 to 0)	BMD, Block Marker Divisor, a 24-bit binary value. BMD is established so that the block marker frequency, BM, may derived from MC by BM = MC/BMD

SHW6	(bit 23)	MCS, Master Clock Source, a 1-bit flag. 1 = MC was generated internally. 0 = MC was provided from an external source.
	(bits 22-19)	Q, Number of active channels minus one, a 4-bit binary value. For example, 0 indicates that one channel is active.
	(bit 17 to 18)	SP1, Spare field 1, a 2-bit field. It is set to zero.
	(bits 16 to 0)	SST, Session Start Time, a 17-bit binary value in units of seconds. The integer number of seconds represents the session start time of day in seconds, where midnight starts with zero.
SHW7	(bits 23 to 16)	User Defined, an 8-bit field. May be input by the user at any time during a recording session. The interpretation of this bit field is left to the user.
	(bits 15 to 6)	SP2, Spare field 2, a 10-bit field. It is set to zero.
	(bits 5 to 0)	VR, Version number, a 6-bit binary value. Each update of the ADARIO format will be identified by a unique version number.

3. Channel 'n' Header

All channel headers contain five 24-bit ADARIO words with the following fixed format. The first logical channel, n=1, has the highest priority and its channel packet starts in the ninth word of the data block. Each active channel is represented by a channel packet that is present in the data block. The logical channel number, n, represents the relative priority of the channel and the order in which it appears in the data block.

CnHW0	(bits 23 to 20)	CH#, Physical Channel Number, a 4-bit binary value. 0 to 15 represents the physical location of the channel electronics in the ADARIO hardware. The user would see those locations labeled from 1 to 16.
	(bits 19 to 16)	FMT, Format code for the channel data word, a 4-bit binary value. The format code is used to define the size of the user data word by means of the following table:

15=24 bits	7=8 bits
14=22 bits	6=7 bits
13=20 bits	5=6 bits
12=18 bits	4=5 bits
11=16 bits	3=4 bits
10=14 bits	2=3 bits
9=12 bits	1=2 bits
8=10 bits	0=1 bit

	(bits 15 to 5)	WC, Word Count, an 11-bit binary value. WC is the number of full channel data words that should be in the nth channel packet. WC may range from 0 to 2040. A WC greater than the number of actual words in channel packet indicates a data rate overflow, which would occur when a low-priority channel is not provided sufficient space in the fixed length data block as a result of an uncontrolled data rate in a higher priority channel.
	(bits 4 to 0)	PWS, Partial Word Status, a 5-bit binary value. PWS is related to the number of samples in the partial word and may range from 0 to 23. PWS shall be computed as follows: If the number of full samples in the partial word equals zero, then PWS = 0. If the number of full samples in the partial word does not equal zero, then PWS = Round Up [Unused bits In PW/Channel Sample Size]

CnHW1 (bit 23)

IE, Channel Clock Source, a 1-bit flag.
1 = The channel clock was generated internally.
0 = The channel clock was provided from an external source.

(bit 22)

DA, Data type, a 1-bit flag.
1 = The channel is operated as a digital channel.
0 = The channel is operated as an analog channel.

(bit 21)

ROVR, Rate overrun in previous block, a 1-bit flag.
1 = The nth channel packet in the previous data block experienced an overrun.
0 = The nth channel packet in the previous data block did not experience an overrun.

(bit 20)

AOVR, Analog A/D Overrange in current block a 1-bit flag.
1 = The nth channel in the current data block experienced an analog-to-digital conversion overrange condition.
0 = The nth channel in the current data block did not experience an analog-to-digital conversion overrange condition.

(bit 19)

NSIB, No samples in current block, a 1-bit flag.
1 = TRUE, there are no samples for the nth channel in the current block.
0 = False, there are samples for the nth channel in the current block.

NOTE

The definitions that are marked with an asterisk apply to analog channels and to particular hardware implementations of ADARIO. For the purposes of this standard these fields are not used.

		(bits 18 to 0)	RATE, Channel sample rate indicator, 19-bit binary value. The interpretation of the rate value depends on the condition of IE, the channel clock source flag. If IE = 1, then the value of rate is carried by the 16 LSBs of the rate field. Using rate, the frequency of the internal channel clock can be found by internal sample clock = MC/RATE. IF IE = 0, then rate is a 19-bit binary value in units of 250 Hz which equals the frequency of the external channel clock as provided by the user at the time of the setup.
*	CnWD2	(bits 23 to 16)	FB, Filter Bandwidth, an 8-bit binary value. The formula for the bandwidth, BW, of the anti-aliasing filter used in an analog channel incorporates FB as $BW = (FB/2) \times 10^{3+FR}$
		(bits 15 to 0)	TD, Time Display to first sample, a 16-bit binary value. TD is a measure of the time delay from the block marker, BM, to the first sample arriving at the nth channel during the current data block interval. TD is expressed as the number of master clock, MC, periods minus one.
*	CnWD3	(bits 23 to 22)	FR, Filter Range, a 2-bit binary value. The formula for the bandwidth, BW, of the anti-aliasing filter used in an analog channel incorporates FR as $BW = (FB/2) \times 10^{3+FR}$

(bits 21 to 17) ATTEN, Attenuation, a 5-bit binary value. ATTEN represents the setting of the input attenuator (or gain) on the nth channel at the time that the record was formed 0=-15dB and 31=+16dB with intermediate settings expressed in one dB steps.

(bit 16) DCAC, Analog signal coupling, a 1-bit flag.
1 = The channel is operated with dc coupling at the input.
0 = The channel is operated with ac coupling at the input.

(bits 15 to 8) CHP, Channel Parameter field, an 8-bit field. The interpretation of the CHP field depends upon the card type with which it is associated, as defined by the CHT field. Each card type established by the CHT field, as part of its definition, shall specify the form and interpretation of the CHP field. To date, four input card types have been established. The following CHP fields are defined as

* For CHT=0
(bits 15 to 8) remain undefined for the present analog single channel implementation except that the present hardware implementation expects an all zero field. Would be subject to future definition as long as all the zero fill is set aside.

* For CHT=1
(bits 15 to 8) remain unused for the present digital single channel implementations except that the present hardware implementation expects an all zero field. Would be subject to future definition as long as the all zero fill is set aside.

* For CHT=2
  (bits 15 to 8) remain unused for the present dual-purpose channel implementations except that the present hardware implementation expects an all zero field. Would be subject to future definition as long as the all zero fill is set aside.

  For CHT=3
  (bits 15 to 12) establish the number of subchannels that are multiplexed into the multichannel data carried by the nth channel. (bits 11 to 8) identify the subchannel number of the first sample contained in the nth channel packet of the data block.

	(bits 7 to 6)	SP3, Spare field 3, a 2-bit field. It is set to zero.
	(bits 5 to 0)	CHT, Channel Type, a 6-bit field. Defines the type of channel through which input data was acquired. Additional channel types to be defined by future users and developers.

* CHT=0 Single channel analog input
* CHT=1 Single channel digital input
* CHT=2 Single channel, dual-purpose, analog or digital input
* CHT=3 Multichannel analog input capable of multiplexing up to 16 analog inputs

CnWD4	(bits 23 to 0)	PW, Partial Word, A 24-bit field. PW contains the last samples of the data block. The most significant bits of word contain the first sample, followed by the next sample in the next most significant bits. The number of samples in the PW is defined in the PWS field. The unused bits are not intentionally set and so contain random data.

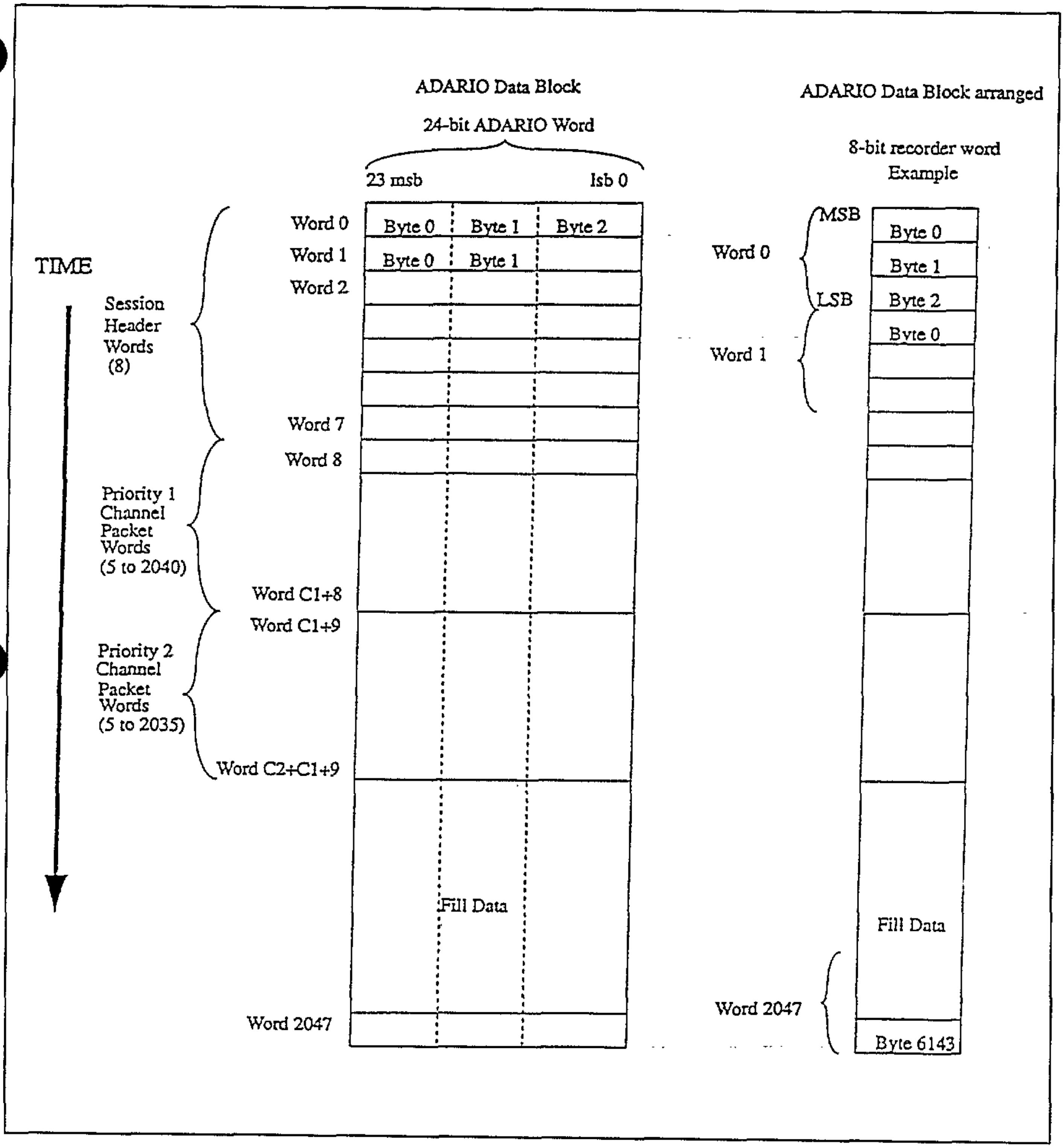


Figure G-2. ADARIO data blocks.

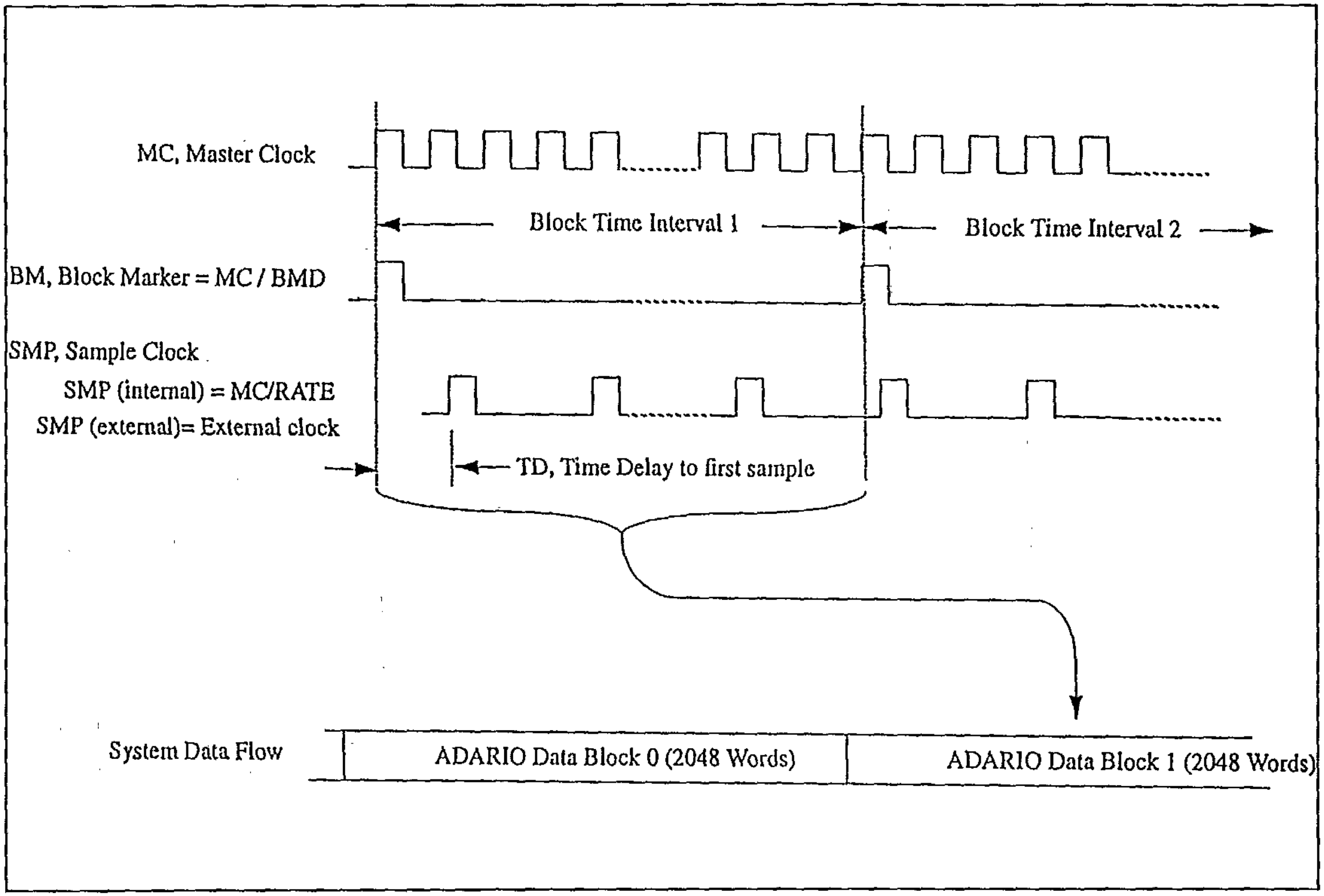


Figure G-3. ADARIO timing.

APPENDIX H

APPLICATION OF THE TELEMETRY ATTRIBUTES TRANSFER STANDARD

APPENDIX H

APPLICATION OF THE TELEMETRY ATTRIBUTES TRANSFER STANDARD

Interchange of telemetry attributes occurs between vehicle instrumentation organizations (the source) and the telemetry ground stations (the destination). Interchange may also take place between ranges. The typical elements of this process are

- data entry system
- source data base
- export program
- interchange medium [this standard]
- import program
- destination data base
- telemetry setup system
- telemetry processing equipment

These elements are depicted in figure H-1 and are defined next.

1. The data entry system is the source organization's human interface where telemetry attributes are entered into a computer-based system. (Not affected by this standard.)

2. The source data base is where telemetry attributes are maintained in a form appropriate to the local organization's needs. (Not affected by this standard.)

3. The export program converts the telemetry attributes from the source data base format to the format defined by this standard and stores them on the interchange medium.

4. The interchange medium contains the telemetry attributes being transferred from the source organization to the destination organization. Format and contents are defined by this standard.

5. The import program reads the standardized interchange medium and converts the attributes to the destination data base format in accordance with local needs, system characteristics, and limitations.

6. The destination data base is where telemetry attributes are maintained in a form suitable to the local ground station's needs. (Not affected by this standard.)

7. The <u>telemetry setup system</u> accesses the destination data base to load the telemetry processing equipment. (Not affected by this standard.)

8. The <u>telemetry processing equipment</u> is where the attributes will ultimately be used to properly handle the data being transmitted. (Not affected by this standard.)

The interchange medium is intended as a standard means of information exchange. The source and destination organizations are not constrained by this standard as to how the attributes are stored, viewed, used, or maintained.

To use the attribute transfer standard, import and export software must be developed. Once in place, these programs should eliminate the need for test item or project specific software at either the supplying (source) organizations or the processing (destination) organizations.

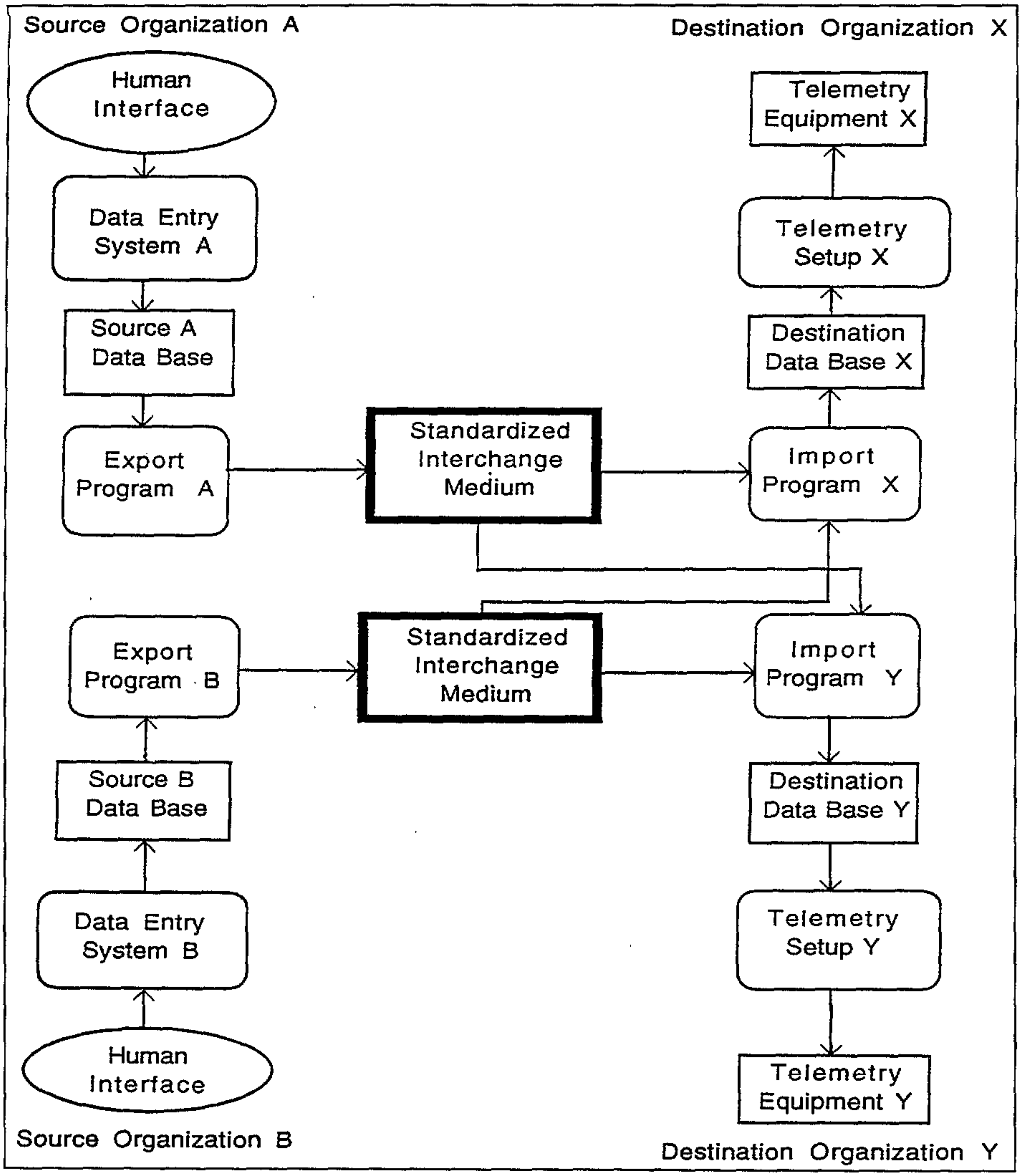


Figure H-1. Typical elements of the telemetry attributes transfer process.

APPENDIX I

TELEMETRY ATTRIBUTES TRANSFER STANDARD COVER SHEET

APPENDIX I

TELEMETRY ATTRIBUTES TRANSFER STANDARD COVER SHEET

Each attribute transfer file (disk or tape) should be accompanied by a cover sheet describing the originating agency's computer system used to construct the attribute file. The recommended format for this cover sheet is given here.

Telemetry Measurement Attributes Transfer Standard

Date: MM\DD\YY

From: Name

Address

Telephone

To: Name

Address

Telephone

Originating computer system:

Computer make and model:

Medium characteristics:

Description:

Comments:

APPENDIX J

TELEMETRY ATTRIBUTES TRANSFER STANDARD FORMAT EXAMPLE

APPENDIX J

TELEMETRY ATTRIBUTES TRANSFER STANDARD FORMAT EXAMPLE

The following example is for illustrative purposes and is by no means a complete attributes file; it is representative of the types of information likely to be transferred. Many attributes are purposely omitted to simplify the example. In some of the groups, only those entries necessary to link to other groups are provided. Attributes which link the various groups together are indicated in **boldface.**

Selected attributes are described in text form as an aid to following the example. *All text which describes the example is printed in smaller italics.* All text which is part of the example file is printed in larger, plain text.

The example file being transferred consists of the attributes of a single RF data source and an analog tape containing two data sources. The RF data source is a PCM signal which contains an embedded asynchronous wave train. The two recorded data sources are PCM signals: one is an aircraft telemetry stream, and the other is a radar data telemetry stream. Figure J-1 shows the example file in terms of the attribute groups and their interrelationships. Refer to the attribute tables while reviewing the example.

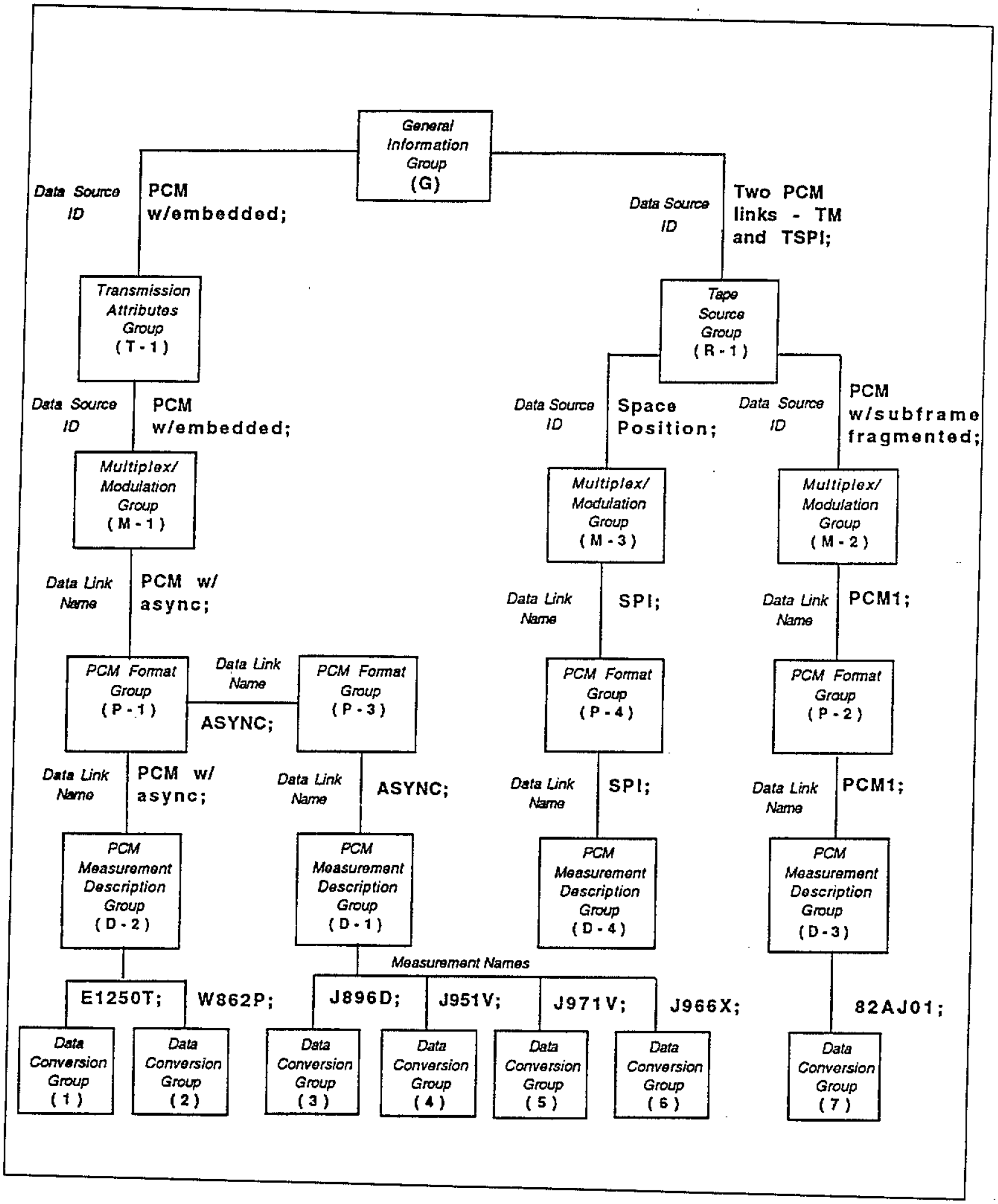


Figure J-1. Group linkages.

General Information Group (G)

Program name, test name, origination date, revision number: 0, test number: 13.

G\PN: TMATS example; G\TA: Wright Flyer; G\OD: 07-12-41; G\RN:0; G\TN:13; G\POC1-1: Wilbur; G\POC1-2: Bikes,LTD; G\POC3-1: Dayton; G\POC4-1: 555-1212;

Live data source.

G\DSI-1:PCM w/embedded; G\DST-1:RF;

Tape source.

G\DSI-2:Two PCM links - TM & TSPI; G\DST-2:TAP; G\COM: I hope this flies.; G\POC1-2: Orville; G\POC2-2:Bikes,LTD; G\POC3-2: Dayton; G\POC4-2: 555-1212;

Transmission Attributes Group (T-1)

Frequency: 1489.5, RF bandwidth: 100, data bandwidth: 100; not encrypted, modulation type: FM, total carrier modulation: 500, no subcarriers, transmit polarization: linear.

T-1\ID:PCM w/embedded; T-1\RF1:1489.5; T-1\RF2:100; T-1\RF3:100; T-1\RF4:FM; T-1\RF5:500; T-1\SCO\N:NO; T-1\AN2:LIN; T-1\AP\POC1: Pat Tern; T-1\AP\POC2:Transmissions,Inc.; T-1\AP\POC3:Amityville,NY; T-1\AP\POC4:800-555-1212;

R-1\ID:Two PCM links - TM & TSPI;
R-1\R1:Reel #1; R-1\TC1:ANAL; R-1\TC2:ACME; R-1\TC3:795;

Tape width: 1 inch, reel diameter: 14 inches, 14 tracks, record speed: 7.5 inches/second.

R-1\TC4:1.0; R-1\TC5:14.0; R-1\N:14; R-1\TC6:7.5;

Rewound: Yes, manufacturer: ZZ; model: 13, original: yes.

R-1\TC8:Y; R-1\RI1:ZZ; R-1\RI2:13; R-1\RI3:Y;
R-1\RI4:07-12-91-07-55-59; R-1\POC1:Mr. Reel; R-1\POC2:Tape Creations; R-1\POC3:Anywhere,Ttown; R-1\POC4:555-1212;

Track Number 2 contains aircraft telemetry PCM (w/subframe fragmented)

R-1\TK1-1:2; R-1\TK2-1:FM/FM;
R-1\DSI-1:PCM w/subframe fragmented; R-1\TK3-1:FWD;

Track Number 4 contains Space Position Information via PCM link

R-1\TK1-2:4; **R-1\DSI-2:Space Position Information;**

Multiplex/Modulation Groups (M-1, M-2, M-3)

Baseband type: PCM, modulation sense: POS, baseband data: PCM, low pass filter type: constant amplitude

M-1\ID:PCM w/embedded; M-1\BB1:PCM; M-1\BB2:POS; M-1\BSG1:PCM; M-1\BSF2:CA;
M-1\BB\DLN:PCM w/async;

M-2\ID:PCM w/subframe fragmented; M-2\BB\DLN:PCM1;

M-3\ID:Space Position; M-3\BB\DLN:SPI;

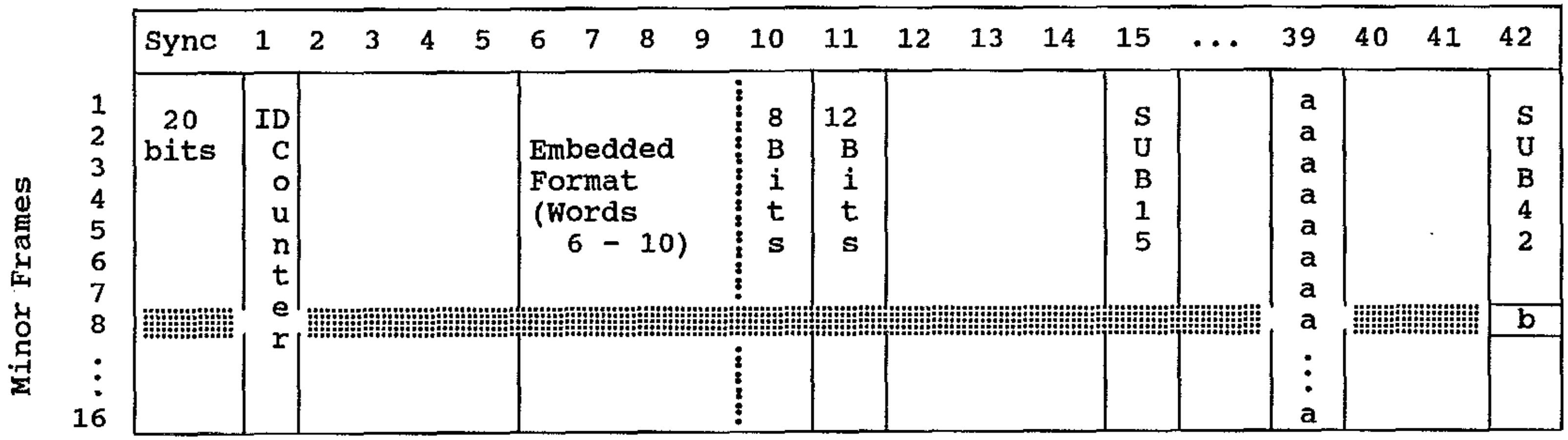
PCM Format Attributes Groups (P)

P-1 is a live PCM signal and contains the asynchronous wave train (see figure J-2).

P-2 is a recorded signal (see figure J-3).

P-3 is the asynchronous wave train (see figure J-4).

P-4 is a recorded signal.

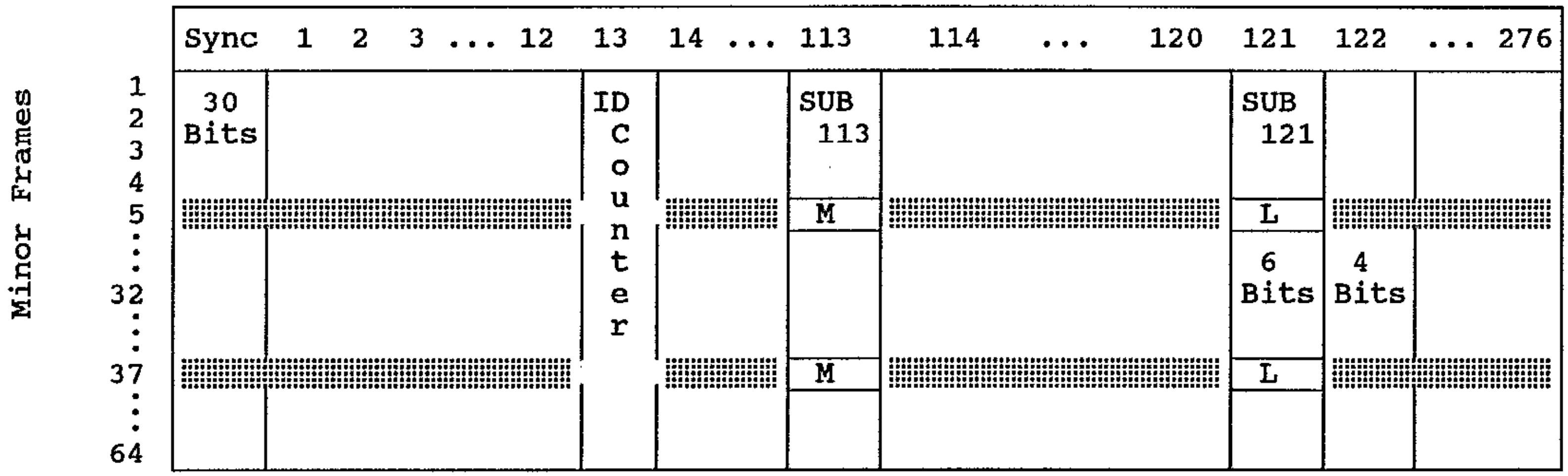


Major frame characteristics
one major frame = 16 minor frames
Word lengths = 10 bits (default value) except
Word 10 has 8 bits
and Word 11 has 12 bits.

a = measurement E1250T at minor frame position 39
b = measurement W862P in subframe SUB42, position 8.

PCM Format Group = P-1
PCM Measurement Description Group = D-2
Data Link Name = PCM w/async

Figure J-2. PCM format for PCM w/async.



Major frame characteristics:

One major frame = 64 minor frames
Subframes SUB113 and SUB121 are 32 deep
ID counter counts 0 - 63
Word lengths = 10 (default value) except
Word 121 has 6 bits
and Word 122 has 4 bits.

Measurement 82AJ01 is 16 bits, which is fragmented with the 10 most significant bits indicated as M and the 6 least significant bits as L. The measurement is located in position 5 of subframes SUB113 and SUB121 (minor frames 5 and 37 of the major frame).

PCM Format Group = P-2
PCM Measurement Description Group = D-3
Data Link Name = PCM1

Figure J-3. PCM format for PCM1.

Minor Frames	Sync	1	2	3	...	11	...	14	...	20	...	29	...	33	...	39	...	45	46	47	48	49
1	16 Bits	ID Counter	a	b	..	a	...	c	...	a	...	a	...	a	...		...	ASUB2		a		
2			a	ASUB1	..	a	...	ASUB3	...	a	...	a	...	a	...	c ASUB3	...			a		
3			a		..	a	...		...	a	...	a	...	a	...		...	d		a		

Major Frame characteristics
One major frame = 3 minor frames
Word lengths = 16 bits (default value)

a = measurement J971U, supercommutated at positions 2, 11, 20, 29, 33, and 47
b = measurement J951V in subframe ASUB1, position 1
c = measurement J896D in supercommutated subframe ASUB3, positions 1 and 4
d = measurement J966X in subframe ASUB2, position 3.

PCM Format Group = P-3
PCM Measurement Description Group = D-1
Data Link Name = ASYNC

Figure J-4. PCM format for async.

(Start of P-1)

Live PCM signal (host wave train) : Class I

P-1\DLN:PCM w/async; P-1\D1:NRZ-L; P-1\D2:44000; P-1\D3:U;
P-1\D4:N; P-1\D6:N; P-1\D7:N; P-1\TF:ONE;

10 bits default word length, 16 minor frames/major frame, 43 words/frame

P-1\F1:10; P-1\F2:M; P-1\F3:NO; P-1\MF\N:16; P-1\MF1:43;
P-1\MF2:440; P-1\MF3:FPT; P-1\MF4:20;
P-1\MF5: 01111010011010110001; P-1\SYNC1:1; P-1\SYNC2:0;
P-1\SYNC3:1;P-1\SYNC4:0;

Word position #10, 8 bits,
Word position #11, 12 bits

P-1\MFW1-1:10; P-1\MFW2-1:8; P-1\MFW1-2:11; P-1\MFW2-2:12;

One independent subframe

P-1\ISF\N:1; P-1\ISF1-1:1; P-1\ISF2-1:ID; P-1\IDC1-1:1;

ID counter word length : 10 bits,
MSB starting bit location : 7,
ID counter length : 4

P-1\IDC2-1:10; P-1\IDC3-1:7; P-1\IDC4-1:4; P-1\IDC5-1:M;
P-1\IDC6-1:0; P-1\IDC7-1:1; P-1\IDC8-1:15; P-1\IDC9-1:16;
P-1\IDC10-1:INC;

Dependent subframe definition
SUB42 is located at 42, SUB15 at 15.
All have depth 16.

P-1\SF\N-1:2;

P-1\SF1-1-1:SUB42; P-1\SF2-1-1:NO;
P-1\SF4-1-1-1:42; P-1\SF6-1-1:16;

P-1\SF1-1-2:SUB15; P-1\SF2-1-2:NO;
P-1\SF4-1-2-1:15; P-1\SF6-1-2:16;

Asynchronous embedded wave train information

Data Link Name (to be referenced in the format definition of the asynchronous wave train) is ASYNC.

Five contiguous minor frame word positions starting at location 6.

P-1\AEF\N:1; **P-1\AEF\DLN-1:ASYNC;** P-1\AEF1-1:5; P-1\AEF2-1:CW;
P-1\AEF3-1-1:6;

(End of P-1)

(Start of P-2)

Recorded PCM signal format attributes.

Data Link Name is PCM1, Data Format is NRZ-L, Bit rate is 2 Mbit/sec, Unencrypted, Normal polarity, class I, Common word length is 10, MSB first, No parity, 64 minor frames per major frame, 277 words per minor frame, Sync pattern length is 30. Word position 121 is 6 bits. Word position 122 is 4 bits.

P-2\DLN:PCM1;P-2\D1:NRZ-L; P-2\D2:2000000; P-2\D3:U; P-2\D4:N; P-2\TF:ONE; P-2\F1:10; P-2\F2:M; P-2\F3:NO; P-2\MF\N:64; P-2\MF1:277; P-2\MF4:30; P-2\MF5:101110000001100111110101101011; P-2\SYNC1:1; P-2\MFW1-1:121; P-2\MFW2-1:6; P-2\MFW1-2:122; P-2\MFW2-2:4;

Subframe characteristics:

One independent subframe named 1. Sync type is ID counter. ID counter location is 13. ID counter word length is 10. ID counter MSB location is 5. ID counter length is 6. ID counter transfer order is MSB first. ID counter initial value is 0. ID counter initial subframe is 1. ID counter end value is 63. ID counter end subframe is 64. ID counter is increasing.

Two dependent subframes. First subframe name is SUB121. Not supercommutated, subframe location = word position 121, depth = 32. Second subframe name is SUB113. Not supercommutated, location = 113, depth = 32.

P-2\ISF\N:1; P-2\ISF1-1:1; P-2\ISF2-1:ID; P-2\IDC1-1:13; P-2\IDC2-1:10; P-2\IDC3-1:5; P-2\IDC4-1:6; P-2\IDC5-1:M; P-2\IDC6-1:0; P-2\IDC7-1:1; P-2\IDC8-1:63; P-2\IDC9-1:64; P-2\IDC10-1:INC; P-2\SF\N-1:2; P-2\SF1-1-1:SUB121; P-2\SF2-1-1:NO; P-2\SF4-1-1-1:121; P-2\SF6-1-1:32; P-2\SF1-1-2:SUB113; P-2\SF2-1-2:NO; P-2\SF4-1-2-1:113; P-2\SF6-1-2:32;

(End of P-2)

(Start of P-3)

Asynchronous wave train PCM format attributes.

Data Link Name: ASYNC
Class I, Common word length : 16, LSB transfer order, no parity
3 minor frames per major frame, 50 words/minor frame,
800 bits per minor frame, fixed pattern synchronization, 16 bit sync. pattern.

P-3\DLN:ASYNC; P-3\TF:ONE; P-3\F1:16; P-3\F2:L; P-3\F3:NO;
P-3\MF\N:3; P-3\MF1:50; P-3\MF2:800; P-3\MF3:FPT; P-3\MF4:16;
P-3\MF5: 1111100110110001; P-3\SYNC1:1;

Subframe definition.

Three subframes with ID counter word length 16 at word position 1.

P-3\ISF\N:1; P-3\ISF1-1:2; P-3\ISF2-1:ID; P-3\IDC1-1:1;
P-3\IDC2-1:16; P-3\IDC3-1:15; P-3\IDC4-1:2; P-3\IDC5-1:L;
P-3\IDC6-1:0; P-3\IDC7-1:1; P-3\IDC8-1:2; P-3\IDC9-1:3;
P-3\IDC10-1:INC;

ASUB1 is at word position 3.
ASUB2 is at word position 45.
ASUB3 is supercommutated at word positions 14 and 39.

P-3\SF\N-1:3; P-3\SF1-1-1:ASUB1; P-3\SF2-1-1:NO; P-3\SF3-1-1:NA;
P-3\SF4-1-1-1:3; P-3\SF6-1-1:3; P-3\SF1-1-2:ASUB2;
P-3\SF2-1-2:NO; P-3\SF3-1-2:NA; P-3\SF4-1-2-1:45; P-3\SF6-1-2:3;
P-3\SF1-1-3:ASUB3; P-3\SF2-1-3:2; P-3\SF3-1-3:EL;
P-3\SF4-1-3-1:14; P-3\SF4-1-3-2:39; P-3\SF6-1-3:3;

(End of P-3)

(Start of P-4)

P-4\DLN:SPI;

(End of P-4)

PCM Measurement Description (D)

D-1 contains the measurements which make up the asynchronous wave train,

D-2 contains the measurements which make up the live PCM signal (which hosts the asynchronous wave train),

D-3 contains the measurements which make up one of the recorded PCM signals, and

D-4 contains the measurements which make up the other recorded PCM signal.

(Start of D-1)

Asynchronous Wave Train: One measurement list, 4 measurements

D-1\DLN:ASYNC; D-1\ML\N:1; D-1\MLN-1:JUST ONE; D-1\MN\N-1:4;

Measurement Name : J896D, LSB first,
Subframe supercommutated, 2 locations: 1 and 4 of ASUB3.

D-1\MN-1-1:J896D; D-1\MN3-1-1:L; D-1\LT-1-1:SFSC;
D-1\SFS1-1-1:ASUB3; D-1\SFS\N-1-1:2; D-1\SFS2-1-1:E;
D-1\SFS6-1-1-1:1; D-1\SFS6-1-1-2:4; D-1\SFS7-1-1-1:FW;
D-1\SFS7-1-1-2:FW;

Measurement Name: J951V, LSB first, default parity, subframe ASUB1, location 1.

D-1\MN-1-2:J951V; D-1\MN1-1-2:DE; D-1\MN2-1-2:D; D-1\MN3-1-2:L;
D-1\LT-1-2:SF; D-1\SF2-1-2:1; D-1\SFM-1-2:1111111100000000;
D-1\SF1-1-2:ASUB1;

Measurement Name : J971U, LSB first,
supercommutated at positions 2, 11, 20, 29, 33, and 47.

D-1\MN-1-3:J971U; D-1\MN1-1-3:DE; D-1\MN2-1-3:D; D-1\MN3-1-3:L;
D-1\LT-1-3:MFSC; D-1\MFS\N-1-3:6; D-1\MFS1-1-3:E;
D-1\MFSW-1-3-1:2; D-1\MFSW-1-3-2:11; D-1\MFSW-1-3-3:20;
D-1\MFSW-1-3-4:29; D-1\MFSW-1-3-5:33; D-1\MFSW-1-3-6:47;

Measurement Name : J966X, LSB first, subframe ASUB2, location 3.

D-1\MN-1-4:J966X; D-1\MN1-1-4:DE; D-1\MN2-1-4:D;
D-1\MN3-1-4:L; D-1\LT-1-4:SF; D-1\SF1-1-4:ASUB2;
D-1\SF2-1-4:3; D-1\SFM-1-4:FW;

(End of D-1)

(Start of D-2)

Live PCM signal: single measurement list, 2 measurements.

D-2\DLN:PCM w/async; D-2\MLN-1:JUST ONE; D-2\MN\N-1:2;

Measurement name: E1250T, unclassified, unsigned, MSB first.

D-2\MN-1-1:E1250T; D-2\MN1-1-1:DE; D-2\MN2-1-1:D;
D-2\MN3-1-1:M; D-2\LT-1-1:MF; D-2\MF-1-1:39; D-2\MFM-1-1:FW;

Measurement name: W862P, unclassified, MSB first,
subframe name: SUB42, location 8 in subframe, full word.

D-2\MN-1-2:W862P; D-2\MN1-1-2:DE; D-2\MN2-1-2:D; D-2\MN3-1-2:M;
D-2\LT-1-2:SF; D-2\SF1-1-2:SUB42; D-2\SF2-1-2:8; D-2\SFM-1-2:FW;

(End of D-2)

(Start of D-3)

Recorded PCM signal: single measurement list: 1 measurement.

D-3\DLN:PCM1; D-3\MLN-1:ONLY ONE; D-3\MN\N-1:1;

Measurement name: 82AJ01, subframe fragmented, 2 fragments,
subframes: SUB113 and SUB121, subframe location: 5.

D-3\MN-1-1:82AJ01; D-3\LT-1-1:SFFR; D-3\FSF\N-1-1:2;
D-3\FSF1-1-1:16; D-3\FSF2\N-1-1:2; D-3\FSF3-1-1-1:SUB113;
D-3\FSF3-1-1-2:SUB121; D-3\FSF4-1-1-1:E; D-3\FSF8-1-1-1-1:5;

(End of D-3)

(Start of D-4)

Recorded PCM signal

D-4\DLN:SPI;

(End of D-4)

Data Conversion Groups (C)

C-1 and C-2 are measurements which are part of the live PCM signal (see also D-2).

C-3, C-4, C-5, and C-6 are from the asynchronous wave train (see also D-1).

C-7 is from the recorded PCM signal (see also D-3).

Measurement: E1250T, description: Inlet Temp Bellmouth, units: Deg C, binary format: unsigned; high value: 128, low value: -0.4,
conversion type: pair set, number of pair sets: 2,
application (polynomial) : Yes; order of fit: 1,
telemetry value #1: 0, engineering unit value #1: -0.4,
telemetry value #2: 1023, engineering unit value #2: 128.

C-1\DCN:E1250T; C-1\MN1:Inlet Temp Bellmouth; C-1\MN3:DEGC; C-1\BFM:UNS; C-1\MOT1:128; C-1\MOT2:-0.4; C-1\DCT:PRS; C-1\PS\N:2; C-1\PS1:Y; C-1\PS2:1; C-1\PS3-1:0; C-1\PS4-1:-0.4; C-1\PS3-2:1023; C-1\PS4-2:128;

Measurement: W862P, description: Fuel Pump Inlet, binary format: unsigned;
conversion type: pair set, number of pair sets: 2,
application (polynomial): Yes; order of fit: 1,
telemetry value #1: 0, engineering unit value #1: -0.1
telemetry value #2: 1023, engineering unit value #2: 76.7

C-2\DCN:W862P; C-2\MN1:Fuel Pump Inlet; C-2\BFM:UNS; C-2\DCT:PRS; C-2\PS\N:2; C-2\PS1:Y; C-2\PS2:1; C-2\PS3-1:0; C-2\PS4-1:-0.1; C-2\PS3-2:1023; C-2\PS4-2:76.7;

Measurement: J896D, description: Terrian Altitude, units: Feet, binary format: two's complement; high value: 32768, low value: -32768, conversion type: pair sets; number of pair sets: 2, application(polynomial): Yes, order of fit: 1
telemetry value #1: -32768, engineering unit value #1: -32768,
telemetry value #2: 32767, engineering unit value #2: 32767

C-3\DCN:J896D; C-3\MN1:Terrian Altitude; C-3\MN3:FEET; C-3\BFM:TWO; C-3\MOT1:32768; C-3\MOT2:-32768; C-3\DCT:PRS; C-3\PS\N:2; C-3\PS1:Y; C-3\PS2:1; C-3\PS3-1:-32768; C-3\PS4-1:-32768; C-3\PS3-2:32767; C-3\PS4-2:32767;

Measurement: J951V, description: Throttle Command, units: VDC, high value: 10.164, low value: -10.164, conversion type: pair set, number of pair sets: 2, application(polynomial): Yes, order of fit: 1
telemetry value #1: -128, engineering unit value #1: -10.164,
telemetry value #2: 127, engineering unit value #2: 10.164
binary format: two's complement;

C-4\DCN:J951V; C-4\MN1:Throttle Command; C-4\MN3:VDC; C-4\MOT1:10.164; C-4\MOT2:-10.164; C-4\DCT:PRS; C-4\PS\N:2; C-4\PS1:Y; C-4\PS2:1; C-4\PS3-1:-128; C-4\PS4-1:-10.164; C-4\PS3-2:127; C-4\PS4-2:10.164; C-4\BFM:TWO;

Measurement: J971U; description: DISC, conversion type: discrete, binary format: unsigned.

C-5\DCN:J971U; C-5\MN1:DISC; C-5\DCT:DIS; C-5\BFM:UNS;

Measurement: J966X; description: Discrete, conversion type: discrete, binary format: unsigned.

C-6\DCN:J966X; C-6\MN1:Discrete; C-6\DCT:DIS; C-6\BFM: UNS;

Measurement: 82AJ01, description: LANTZ Norm acceleration, units: MTR/S/S, High value: 1023.97, Low value: -1023.97, conversion type: Coefficients
Order of curve fit: 1, derived from pair sets: No, Coefficient (0): 0, Coefficient(1): 0.03125, binary format: two's complement

C-7\DCN:82AJ01; C-7\MN1:LANTZ Norm acceleration; C-7\MN3:MTR/S/S; C-7\MOT1:1023.97; C-7\MOT2:-1023.97; C-7\DCT:COE; C-7\CO\N:1; C-7\CO1:N; C-7\CO:0; C-7\CO-1:.03125; C-7\BFM:TWO;

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