Range Commanders Council

TELECOMMUNICATIONS GROUP

IRIG STANDARD 209-90

EVENT COUNT STATUS CODE FORMATS

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
PACIFIC MISSILE RANGE FACILITY

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 209-90

EVENT COUNT STATUS CODE FORMATS

SEPTEMBER 1990

Prepared by

TIMING COMMITTEE
TELECOMMUNICATIONS GROUP
RANGE COMMANDERS COUNCIL

Published by

Secretariat
Range Commanders Council
U.S. Army White Sands Missile Range
New Mexico 88002

PREFACE

This standard defines four formats to be used for visual display and transfer of event count status information for interrange and intrarange dissemination. This standard should be adhered to by all U.S. Government ranges and facilities where visual count status information is displayed or used for correlation of events with time. For those ranges and facilities where considerable investment has already been made in visual displays, the changeover to the new standard codes can be made over a period of years as equipment is replaced or as new equipment is installed to meet timing requirements. With the publication of this new standard, document 203-64 becomes obsolete.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF FIGURES

ABBREVIATIONS AND TERMS

ABBREVIATION	TERM
BCD	binary coded decimal
BIT	binary/BCD digit
SB	straight binary
SBS	straight binary seconds
CF	control function
CS	count status
dc	direct current
FM	first motion
fps	frames per second
Hz	Hertz (cycles per second)
kHz	kilohertz (1000 Hz)
ns	nanosecond (10^{-9} s)
µs	microsecond (10^{-6} s)
ms	millisecond (10^{-3} s)
s	second
pps	pulses per second
ID	identification
LSB	least significant bit
TOY	time-of-year
ECS	event count status

ABBREVIATIONS AND TERMS (CONT'D)

ABBREVATION	TERM
ECSS	event count status seconds
TOYLT	time-of-year launch time
Time T_0	the initial time 0^h, 0^m, 0^s January 1
Time t_0	the beginning of an epoch or event, for example, first motion

DEFINITIONS

The following terms are used in this document:

ACCURACY -- Systematic uncertainty (deviation) of a measured value with respect to a standard reference.

BINARY CODED DECIMAL (BCD) -- A numbering system which uses decimal digits encoded in a binary representation (1n 2n 4n 8n) where n=1, 10, 100, 1k, 10k...N (see appendix A).

BINARY NUMBERING SYSTEM (STRAIGHT BINARY) -- A numbering system which has two as its base and uses two symbols, usually denoted by 0 and 1 (see appendix A).

BIT -- An abbreviation of binary or binary coded decimal digits which form each word/subword and which determines the resolution of the time code word or event count status word.

COUNT STATUS CODE -- A system of symbols used for identifying specific instants of count status.

COUNT STATUS CODE WORD -- A specific set of count status code symbols which identifies one instant of count status. A count status word may be subdivided into subwords.

FIRST MOTION -- An indication of the launch or test event. Also called liftoff or broach.

FRAME RATE -- The repetition rate of a time code or event count status code.

HOLD COUNT -- The minus count at which an event or operation is temporarily held until the count is resumed or recycled to a predetermined value.

IDENTIFICATION (ID) Bits -- All code formats reserve two bits for encoding the identification of the particular code.

INDEX COUNT -- The number which identifies a specific bit position with respect to a reference marker.

INDEX MARKER -- Uncoded, periodic interpolating bits in the count status code frame.

DEFINITIONS (CONT'D)

MINUS COUNT -- Predicted count status in days, hours, minutes, and seconds to a scheduled event such as liftoff or first motion of a vehicle.

ON-TIME -- The leading edge of the reference bit P_r of each count status frame.

PLUS COUNT -- Count status in increments of days, hours, minutes, and seconds after an event.

REFERENCE MARKER -- A periodic combination of bits which establishes that instant of time defined by the time code word or event count status word.

RESOLUTION -- The smallest increment or least significant bit of time or count status which can be defined by a code word or subword.

SECOND -- Basic unit of time or time interval in the International System of Units (SI) which is equal to 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of cesium 133.

SUBWORD -- A subdivision of the time code or count status word containing only one type of time unit, for example, days, hours, minutes, seconds, or tenths of seconds.

TIME -- Signifies epoch, for example, the designation of an instant of time in a selected time scale such as International Atomic Time (TAI) or Coordinated Universal Time (UTC).

TIME CODE -- A system of symbols used for identifying specific instants of time.

TIME CODE WORD -- A specific set of time code symbols which identifies one instant of time. A time code word may be subdivided into subwords.

TIME FRAME -- The time interval between consecutive reference markers containing all the bits that determine the time code or count status format.

TIME INTERVAL -- The duration between two instants read on the same time scale, usually expressed in seconds or in multiples or submultiples of a second.

TIME REFERENCE -- The basic repetition rate chosen as the common time reference for all instrumentation (system) timing (usually 1 pps).

GLOSSARY OF SELECTED TERMS

COORDINATED UNIVERSAL TIME (UTC) -- A time maintained by the Bureau International de l'Heure (BIH) which forms the basis of a coordinated dissemination of standard frequencies and time signals.

EPOCH -- Signifies the beginning of an event.

INTERNATIONAL ATOMIC TIME (TAI) -- Represents a binary count of elapsed time in seconds since the 1 January 1958 epoch. The Bureau International de l'Heure (BIH), the U.S. Naval Observatory (USNO), and other national observatories and laboratories maintain this count which accumulates at 86 400 seconds per day.

INTRODUCTION

Interrange and intrarange participation in launch, tracking, and recovery missions makes it mandatory to transmit count status information for visual display as well as for controlling event timers or sequencers. This standard defines the characteristics of four visual count status code formats. Each permissible code format is assigned a numerical designator, so users can define the particular code format being used.

This standard reflects the state of the art and is not intended to constrain research and development in the area. This standard will be revised as required.

1.0 GENERAL DESCRIPTION OF STANDARD

This standard describes a family of four serial Event Count Status (ECS) codes with formats containing coded expressions or words (and subwords) within a 1 second time frame. The codes are designated Count Status One (CS-1), Count Status Two (CS-2), Count Status Three (CS-3), and Count Status Four (CS-4).

The basic intended use of these codes is to provide visual count status information; however, the codes can be used for computer input to correlate data with time or with count status. Also, if desired, the codes can be used to not only drive visual displays but to turn on equipment such as cameras and recorders. The application of these codes is at the discretion of the user range or facility. These codes can be software and hardware generated and controlled depending on the user requirement and application.

2.0 GENERAL DESCRIPTION OF FORMATS

An overview of the formats is described in the following subparagraphs.

2.1 Code CS-1 (see figure 1) contains two coded expressions or words. Word one is the standard IRIG-B Time-of-Year BCD word. Word two is the event count status word used to drive visual displays of status information such as pre-launch, launch, or post-launch events. The frame also contains identification (ID), sign, reset, and hold bits.

2.2 Code CS-2 (see figure 2) contains two coded words. Word one is an event count status, and word two is event count status in BCD seconds. The frame also contains identification (ID), control function, test code, sign, reset, and hold bits.

2.3 Code CS-3 (see figure 3) contains two coded words. Word one is event count status, and word two is UTC Time-of-Year at the event time t_0. The frame also contains first motion (FM), identification (ID), sign, reset, and hold bits.

2.4 Code CS-4 (see figure 4) contains two coded words. Word one is event count status, and word two is event count status in straight binary seconds (SBS). The time frame also contains identification (ID), control function, test code, sign, reset, and hold bits.

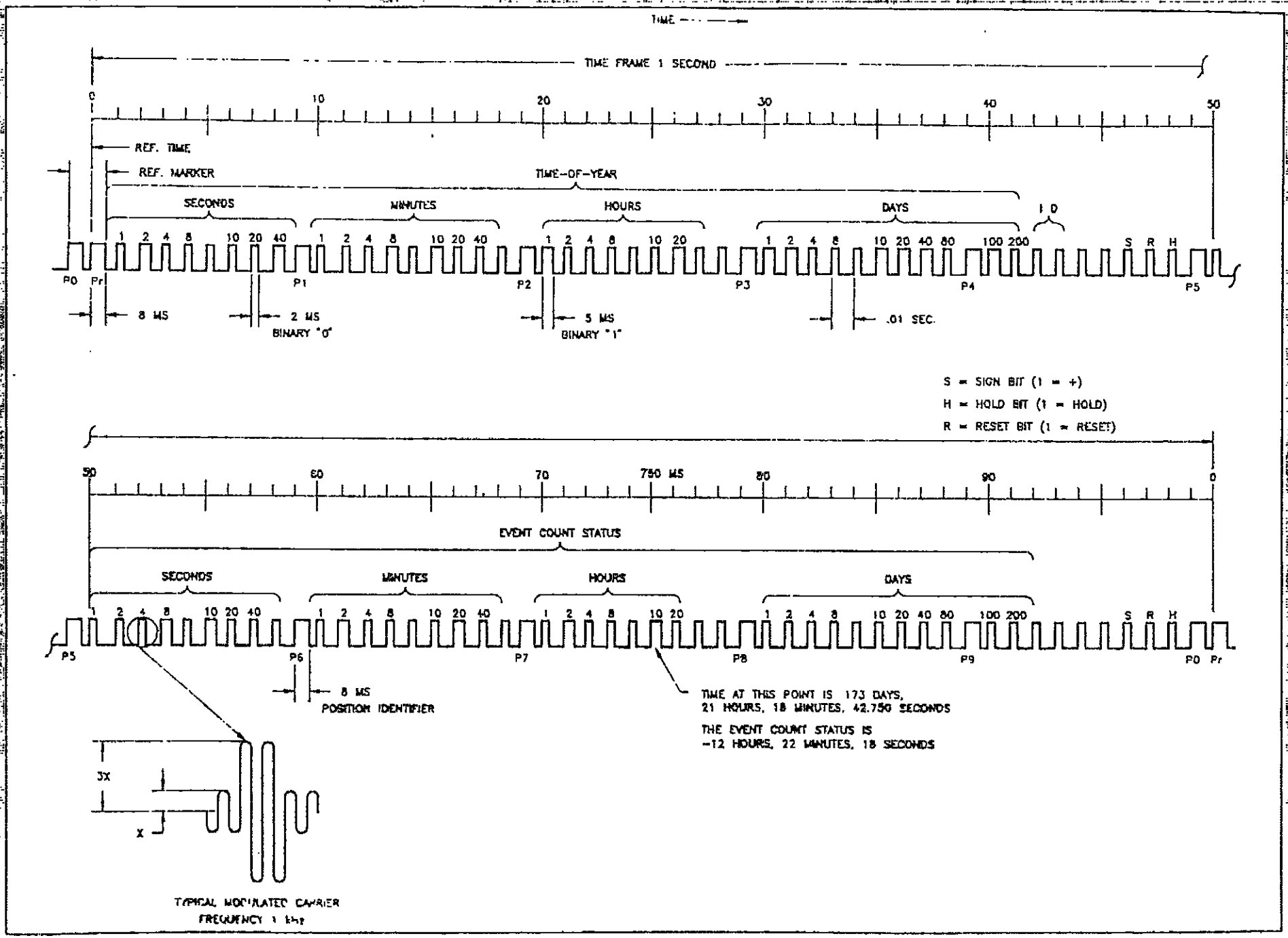


Figure 1. CS-1 Code format.

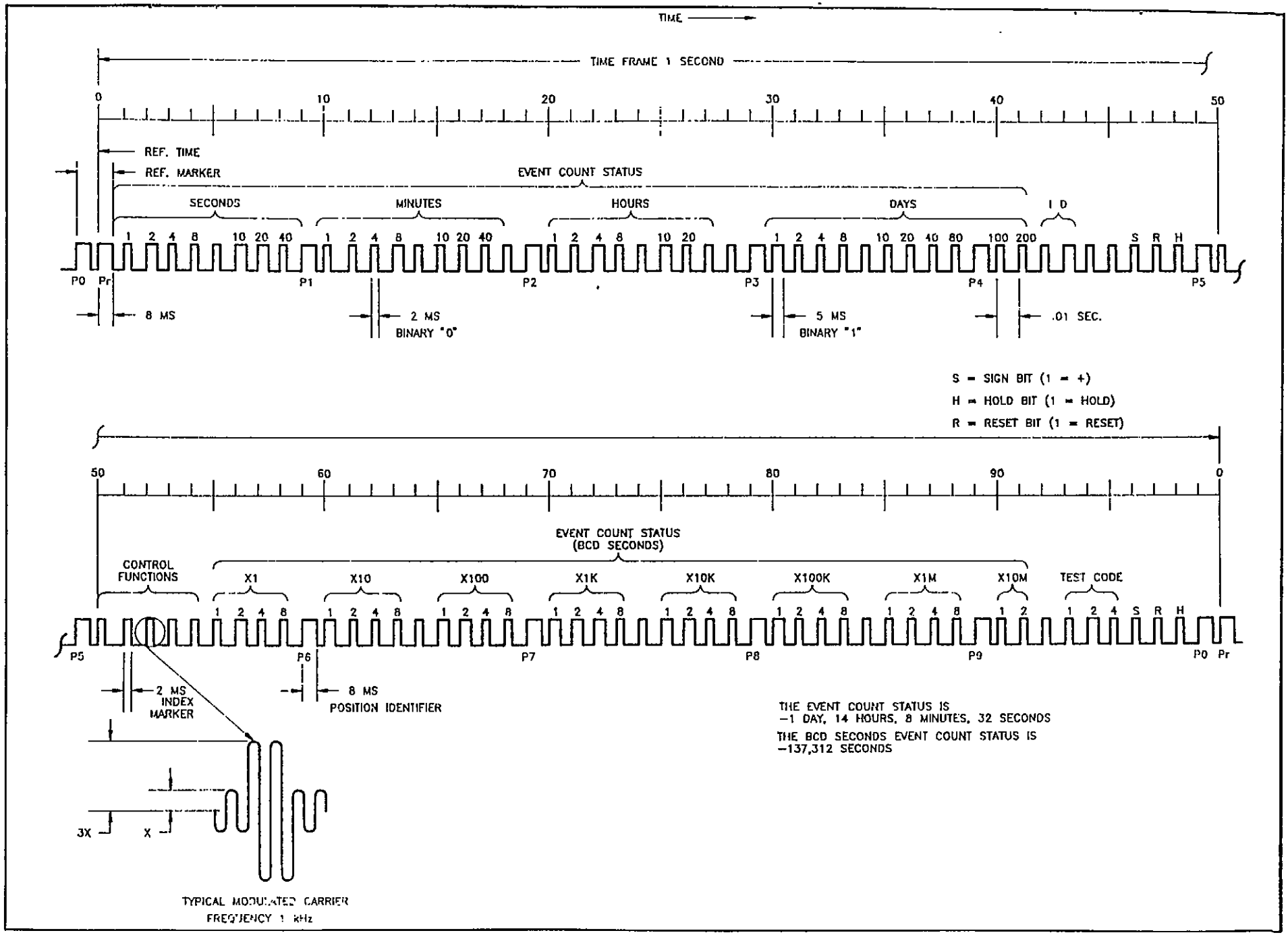


Figure 2. CS-2 Code format.

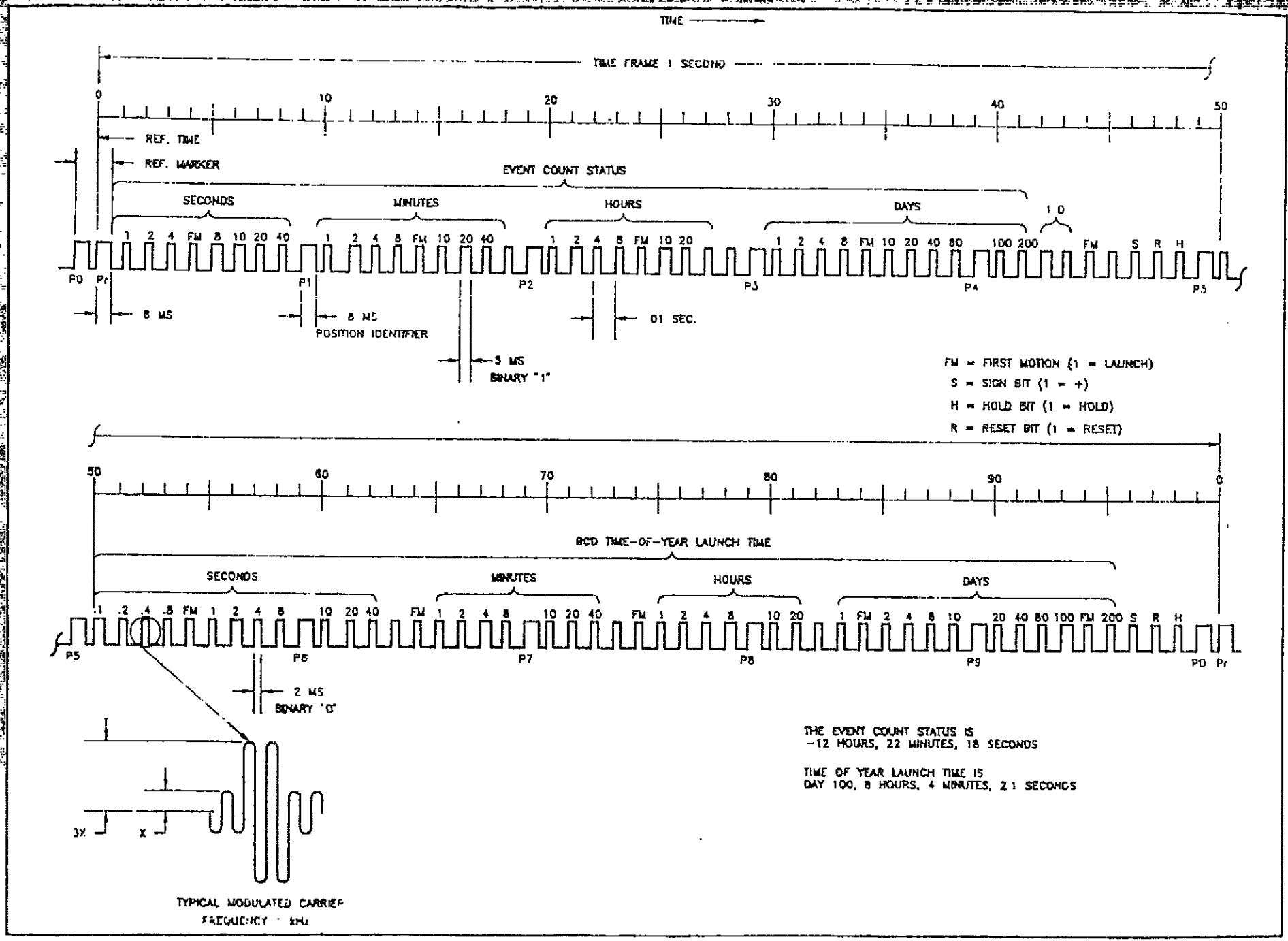


Figure 3. CS-3 Code format.

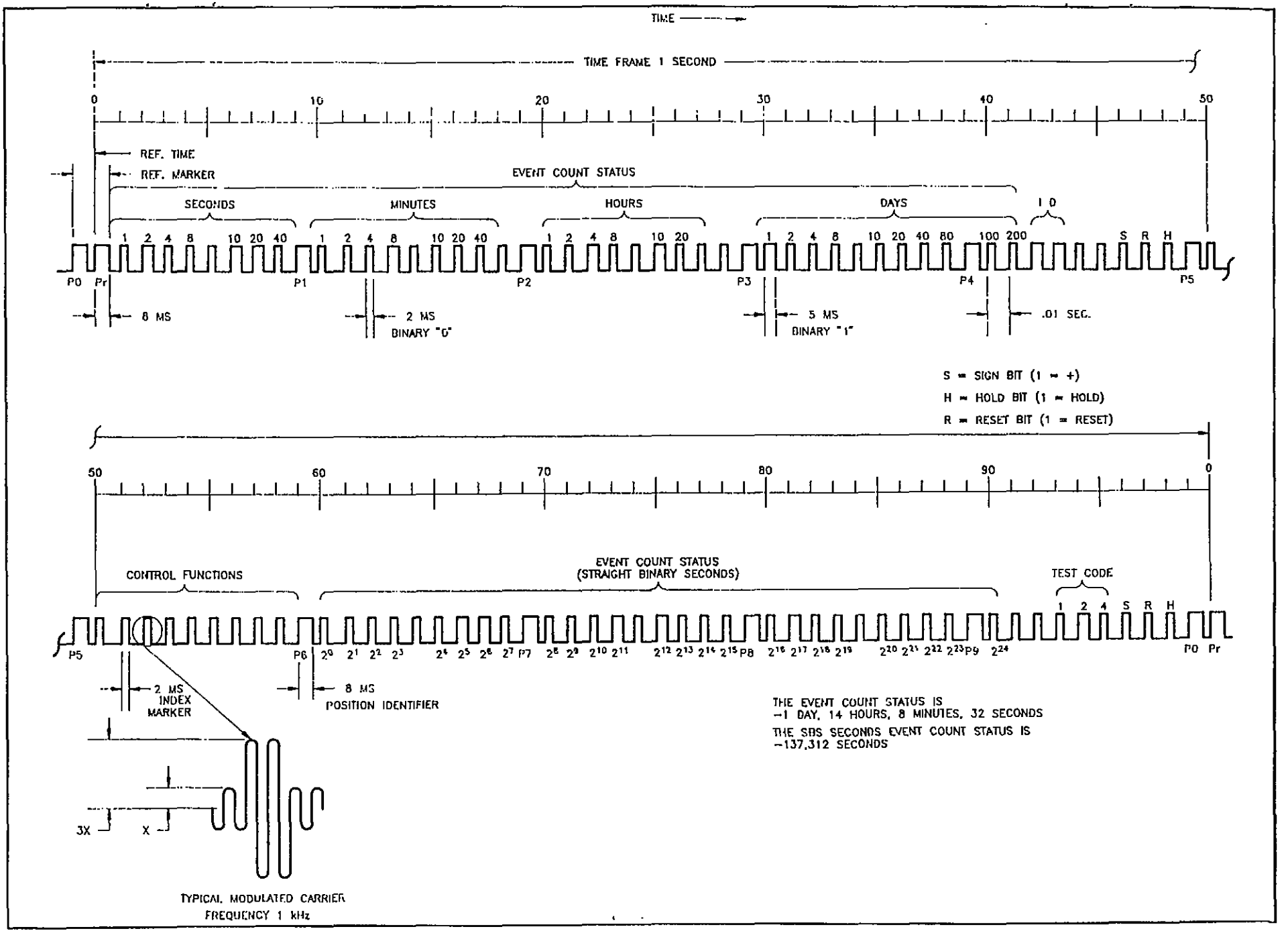


Figure 4. CS-4 Code format.

2.5 EVENT COUNT STATUS CODE WORD STRUCTURE

The basic code word is composed of subwords. Each subword is formed by binary bits with various resolutions which may include days, hours, minutes, seconds, and tenths of seconds. Each subword represents a particular resolution of the time or count status being identified.

The formats of the four codes must conform to the IRIG-B format and contain 100 bits in the 1 second frame length. Fill bits of all zeros are added to achieve the desired frame length and code repetition rate. Spare bits may be used for encoding of various control, identification, and other special purpose functions.

2.6 PULSE RISE TIME

The specified pulse (dc level shift bit) rise time shall be obtained between the 10 and 90 percent amplitude points (see appendix B).

2.7 JITTER

The modulated code jitter is defined as a percent of the carrier frequency. The dc level shift code jitter is defined as the pulse-to-pulse variation at the 50 percent amplitude points on the leading edges of successive pulses or bits (see appendix B).

2.8 BIT RATE AND INDEX COUNT

Each pulse in a count status code word/subword is called a bit. The "on-time" reference point for all bits is the leading edge of the bit. The repetition rate at which the bits occur is called the bit rate. Each bit has an associated numerical index count identification. The time interval between the leading edge of two consecutive bits is the index count interval. The index count begins at the on-time frame reference marker with index count zero and increases one count each index count until the CS frame is complete. The bit rate and index count interval of the event count status code formats are 100 pps and 10 ms.

2.9 COUNT STATUS FRAME, FRAME REFERENCE, AND FRAME RATE

An event count status code frame begins with a frame reference marker P_0 (position identifier) followed by a reference bit P_r with each having a duration equal to 8.0 ms. The on-time reference point of a code frame is the leading edge of the reference bit P_r. The repetition rate at which the CS frames occur is called the frame rate. The frame rate and frame interval of the event count status formats are 1 fps and 1 second.

2.10 COUNT STATUS CODE FRAME SPECIFICATIONS

PULSE RATES

Bit Rate: 100 pps
Position Identifiers: 10 pps
Reference Mark: 1 pps

RESOLUTION

10 ms dc Level Shift
1 ms Modulated 1 kHz Carrier
0.5 ms Modulated 2 kHz Carrier

PULSE DURATION

Index Marker: 2 ms
Binary Zero or Uncoded Bit: 2 ms

Binary One or Coded Bit: 5 ms
Position Identifiers: 8 ms
Reference Bit: 8 ms

MARK-TO-SPACE RATIO

Range of 3:1 to 6:1
Nominal Value of 10:3

2.11 POSITION IDENTIFIERS

Position identifiers have a duration of 8.0 ms. The leading edge of the position identifier P_0 occurs one index count interval before the frame reference point P_r, and the succeeding position identifiers (P_1, P_2...P_0) occur every succeeding 10th bit. The repetition rate at which the position identifiers occur is 10 pps.

2.12 COUNT STATUS CODE WORDS

The code words/subwords employed in this standard are coded in binary coded decimal (BCD) with the exception of the straight binary (SB) seconds in Code CS-4. All code formats are pulse-width coded. A binary 1 bit has a duration of 5 ms and a binary 0 bit has a duration of 2 ms. The BCD Time-of-Year Code (CS-1) reads 0 hours, minutes, and seconds at 2400 hours each day and reads day 001 at 2400 of day 365 or day 366 (leap year).

2.13 IDENTIFICATION BITS

All code formats reserve two bits for encoding the identification of the particular code. The ID bits are in index count positions 42 and 43.

CODE	IDENTIFICATION BITS	
	42	43
CODE CS-1	0	0
CODE CS-2	0	1
CODE CS-3	1	0
CODE CS-4	1	1

2.14 SIGN, RESET, AND HOLD BITS

All code formats reserve bits for encoding the sign (±) of the count, reset bits (reset to 0 or other count), and hold bits (for holding the count at a particular count). The sign bits (S) are in index count positions 46 and 96, the reset bits (R) are in positions 47 and 97, and the hold bits (H) are in positions 48 and 98.

The sign, reset, and hold bits are placed at the end of each 50 bit count within the code frame, before position identifiers P_5 and P_0, so a user, who may need only the first half of a code, can truncate the code after 50 bits and retain the sign, reset, and hold capability. After a hold bit is activated, the frame latches and does not increment to the next frame or second.

The following conventional notations apply:

S = Sign Bit: 1 = +, Count up
0 = -, Count down

- 00:00:00 is undefined
+ 00:00:00 is time t_0

R = Reset Bit: 1 = Count reset to some value
0 = Count not reset

H = Hold Bit: 1 = Count held at some value
0 = Count continues

Normally, a count would not be reset unless a hold was on the count or the mission or event rescheduled.

2.15 FIRST MOTION (FM) BITS

Bits indicating the function called liftoff, broach, or first motion (FM) are imbedded in the CS-3 Code format in index marker positions 4, 14, 24, 34, 44, 54, 64, 74, 84, and 94. The FM bits may first be set at any designated position within the code frame after indication of first motion and then in every code frame and designated position thereafter until termination of events. This placement of FM bits permits an indication of first motion to a resolution of 100 ms. The FM bits may also be used to activate instrumentation.

Prior to first motion, all FM bits and Time-of-Year launch time (TOYLT) bits are encoded with binary 0s. After first motion, the FM bits become binary 1s, and the TOYLT word is encoded with UTC (USNO) TOY information. The code does not increment but remains encoded with UTC launch time until events are terminated.

2.16 CONTROL FUNCTIONS

Formats CS-2 and CS-4 reserve a set of bits known as control functions (CF) for the purpose of encoding various control, identification, or other special purpose functions. The control bits may be programmed in any predetermined coding system. A binary 0 bit has a duration of 2 ms and a binary 1 bit has a duration of 5 ms.

2.17 TEST CODE

Formats CS-2 and CS-4 reserve three bits (93, 94, and 95) for a test code which can be used to identify a particular test.

2.18 INDEX MARKERS

Index markers (uncoded bits) occur at all index count positions which are not assigned a function such as a reference marker, position identifier, code word, or control function. Index marker bits have a duration equal to 2 ms.

2.19 AMPLITUDE MODULATED CARRIER

A standard sine wave carrier frequency, to be amplitude modulated by a CS code, is synchronized to have positive-going, zero-axis crossings coincident with the leading edges of the modulating code bits. The standard mark-to-space ratio range is between 3:1 to 6:1 with a nominal value of 10:3 (see figure 5). The standard modulation frequencies are either 1 or 2 kHz depending on user requirements and transmission specifications.

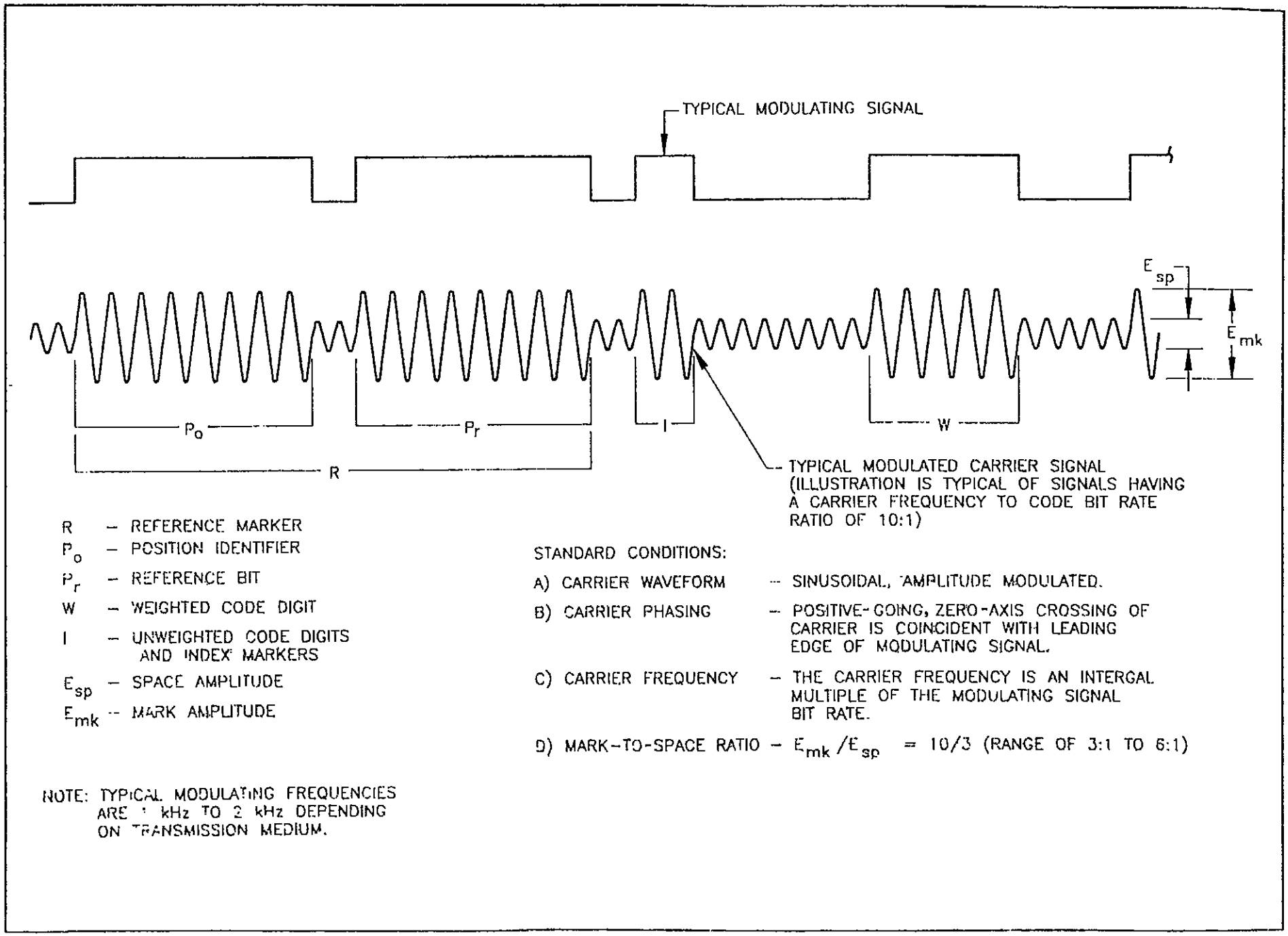
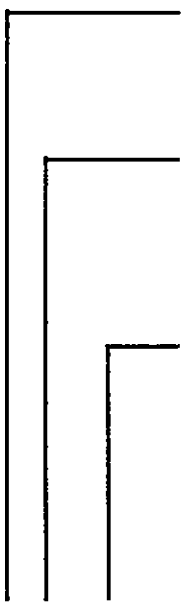


Figure 5. Typical modulated carrier signal.

3.0 DETAILED DESCRIPTION OF FORMATS

Various combinations of subwords and signal forms make up a CS code word. All formats do not contain each standard coded expres-sion; various forms are possible. To differentiate between these forms, signal identification numbers are assigned to each permissible combi-nation according to time of year, event count status, event count status seconds, time of year launch time, and straight binary seconds.



Format Designation:	0	Pulse Width Coded
	1	Sine Wave, Amplitude Modulated
Carrier/Resolution:	0	No Carrier/Index Count Interval
	1	1 kHz/1 ms
	2	2 kHz/0.5 ms
Coded Expressions: (Code Options)	0	TOY, ECS
	1	ECS, ECSS
	2	ECS
	3	ECSS
	4	ECS, TOYLT
	5	TOYLT
	6	ECS, SBS
	7	SBS

1 1 0

Examples of combinations:

Signal CS-1	1 1 0:	Amplitude Modulated, 1 kHz Carrier/1 ms, Containing TOY and ECS.
Signal CS-2	0 0 1:	Pulse Width Coded, Index Count Interval, Containing ECS, and ECSS.
Signal CS-3	1 2 4:	Amplitude Modulated, 2 kHz/0.5 ms, Containing ESC and TOYLT.
Signal CS-4	0 0 2:	Pulse Width Coded, Index Count Interval, Containing ECS.

The following combinations of signals are standard; no other combinations are standard.

CS-1	CS-2	CS-3	CS-4
000	001 111 121	002 112 122	002 112 122
110	002 112 122	004 114 124	006 116 126
120	003 113 123	005 115 125	007 117 127

3.1 CS-1 TIME-OF-YEAR WITH EVENT COUNT STATUS CODE

The BCD Time-of-Year and the event count status code words consist of subwords in days, hours, minutes, and seconds. The position identifiers preceding the decimal digits and the index count locations of the decimal digits are

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Seconds	P_0	1-4
Index Marker		5
Tens of Seconds		6-8
Units of Minutes	P_1	10-13
Index Marker		14
Tens of Minutes		15-17
Index Marker		18
Units of Hours	P_2	20-23
Index Marker		24
Tens of Hours		25-26
Index Marker		27-28
Units of Days	P_3	30-33
Index Marker		34
Tens of Days		35-38
Hundreds of Days	P_4	40-41
Identification		42-43
Index Marker		44-45
Sign, Reset, Hold		46-48
Units of Seconds	P_5	50-53
Index Marker		54
Tens of Seconds		55-57
Index Marker		58

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Seconds	P_5	50-53
Index Marker		54
Tens of Seconds		55-57
Index Marker		58
Units of Minutes	P_6	60-63
Index Marker		64
Tens of Minutes		65-67
Index Marker		68
Units of Hours	P_7	70-73
Index Marker		74
Tens of Hours		75-76
Index Marker		77-78
Units of Days	P_8	80-83
Index Marker		84
Tens of Days		85-88
Hundreds of Days	P_9	90-91
Index Marker		92-95
Sign, Reset, Hold		96-98

3.2 CS-2 EVENT COUNT STATUS CODE WITH BCD SECONDS

The BCD event count status code (word one) consists of subwords in days, hours, minutes, and seconds. The event count status (word two) is in BCD seconds. The position identifiers preceding the decimal digits and the index count locations of the decimal digits are

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Seconds	P_0	1-4
Index Marker		5
Tens of Seconds		6-8

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Minutes	P_1	10-13
Index Marker		14
Tens of Minutes		15-17
Index Marker		18
Units of Hours	P_2	20-23
Index Marker		24
Tens of Hours		25-26
Index Marker		27-28
Units of Days	P_3	30-33
Index Marker		34
Tens of Days		35-38
Hundreds of Days	P_4	40-41
Identification		42-43
Index Marker		44-45
Sign, Reset, Hold		46-48
Control Functions	P_5	50-54
Units of Seconds		55-58
Tens of Seconds	P_6	60-63
Index Marker		64
Hundreds of Seconds		65-68
Thousands of Seconds	P_7	70-73
Index Marker		74
Tens of Thousands of Seconds		75-78
Hundreds of Thousands of Seconds	P_8	80-83
Index Marker		84
Millions of Seconds		85-88

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Tens of Millions of Seconds	P_9	90-91
Index Marker		92
Test Code		93-95
Sign, Reset, Hold		96-98

3.3 CS-3 EVENT COUNT STATUS CODE WITH TIME OF YEAR LAUNCH TIME

The BCD event count status word consists of subwords in days, hours, minutes, and seconds. The UTC Time-of-Year launch time (t_0) word consists of subwords in days, hours, minutes, seconds, and tenths of seconds. The position identifiers preceding the decimal digits and the index count locations of the decimal digits are

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Seconds	P_0	1-3
First Motion		4
Units of Seconds		5
Tens of Seconds		6-8
Units of Minutes	P_1	10-13
First Motion		14
Tens of Minutes		15-17
Index Marker		18
Units of Hours	P_2	20-23
First Motion		24
Tens of Hours		25-26
Index Marker		27-28
Units of Days	P_3	30-33
First Motion		34
Tens of Days		35-38

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Hundreds of Days	P_4	40-41
Identification		42-43
First Motion		44
Index Marker		45
Sign, Reset, Hold		46-48
Tenths of Seconds	P_5	50-53
First Motion		54
Units of Seconds		55-58
Tens of Seconds	P_6	60-62
Index Marker		63
First Motion		64
Units of Seconds		65-68
Tens of Minutes	P_7	70-72
Index Marker		73
First Motion		74
Units of Hours		75-78
Tens of Hours	P_8	80-81
Index Marker		82
Units of Days		83
First Motion		84
Units of Days		85-87
Tens of Days		88
Tens of Days	P_9	90-92
Hundreds of Days		93
First Motion		94
Hundreds of Days		95
Sign, Reset, Hold		96-98

3.4 CS-4 EVENT COUNT STATUS CODE WITH SB SECONDS

The BCD event count status code (word one) consists of subwords in days, hours, minutes, and seconds. The event count status (word two) is straight binary seconds (SBS) and consists of 25 bits from 2^0 through 2^{24}. The position identifiers preceding the decimal/binary digits and index count locations of the decimal/binary digits are

BCD CODE DECIMAL DIGITS	DECIMAL DIGITS FOLLOW POSITION IDENTIFIERS	DIGITS OCCUPY INDEX COUNT POSITIONS
Units of Seconds	P_0	1-4
Index Marker		5
Tens of Seconds		6-8
Units of Minutes	P_1	10-13
Index Marker		14
Tens of Minutes		15-17
Index Marker		18
Units of Hours	P_2	20-23
Index Marker		24
Tens of Hours		25-26
Index Marker		27-28
Units of Days	P_3	30-33
Index Marker		34
Tens of Days		35-38
Hundreds of Days	P_4	40-41
Identification		42-43
Index Marker		44-45
Sign, Reset, Hold		46-68
Control Functions	P_5	50-58
2^0 Through 2^3	P_6	60-63
Index Marker		64
2^4 Through 2^7		65-68
2^8 Through 2^{11}	P_7	70-73
Index Marker		74
2^{12} Through 2^{15}		75-78
2^{16} Through 2^{19}	P_8	80-83
Index Marker		84
2^{20} Through 2^{23}		85-88
2^{24}	P_9	90
Index Marker		91-92
Test Code		93-95
Sign, Reset, Hold		96-98

4.0 DETAILED DESCRIPTION OF EVENT COUNT STATUS CODES

A detailed description of individual time code formats is described in the following paragraphs.

4.0.1 The BCD code word/subwords are expressed in a binary representation (1n 2n 4n 8n) where n=1, 10, 100, 1k, 10k...N (see appendix A).

4.0.2 The SBS code word/subwords are expressed in straight binary notation ($2^n...2^N$) where n = 0, 1, 2...N (see appendix A).

4.0.3 The beginning of each 1.0 second CS frame is identified by two consecutive 8.0 ms bits P_0 and P_r. The leading edge of P_r is the on- time reference point for the succeeding CS code words. Position identifiers, P_0 and P_1 through P_9, (8 ms duration) occur every 10th bit and 10 ms before the leading edge of each succeeding 10 pps on-time bit.

4.0.4 The CS code words and the control functions presented during the code frame are pulse width coded. The binary 0 and the index markers have a duration of 2.0 ms, and a binary 1 has a duration of 5.0 ms. The 100 pps leading edge is the on-time reference point for all bits. The LSB occurs first in all codes.

4.0.5 Depending on the application, the beginning of each code frame (P_r) may or may not be synchronized to UTC system time.

4.1 CS-1 CODE FORMAT

4.1.1 The CS-1 format (see figure 1) contains 30 bits of BCD Time-of- Year information in days, hours, minutes, and seconds and 30 bits of BCD event count status information also in days, hours, minutes, and seconds. Two bits are used for code identification, and 6 bits are used for sign, reset, and hold indications. The leading edge of P_r is the on-time reference point for the succeeding code words.

4.1.2 The 30 bit Time-of-Year code word begins at index count 1. The subword bits occur between position identifiers P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete word one. An index marker occurs between the decimal digits of each subword to provide separation for visual resolution if the code is recorded. The code recycles yearly.

4.1.3 The 30 bit event count status word begins at index count 50. The subword bits occur between position identifiers P_5 and P_0: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete word two. An index marker occurs between the decimal digits in each subword.

4.1.4 Index counts 42 and 43 are reserved for ID bits. For Code CS-1, bits 42 and 43 are binary zeros.

4.1.5 Index counts 46 and 96 are reserved for sign (minus = countdown, plus = count up). Index counts 47 and 97 are reserved for reset (count reset to some value), and counts 48 and 98 are reserved for hold (count on hold) information.

4.2 CS-2 CODE FORMAT

4.2.1 The CS-2 format (see figure 2) contains 30 bits of BCD event count status in days, hours, minutes, and seconds, and 30 bits of event count status in BCD seconds. Two bits are used for code identification, 5 bits are reserved for control functions, 3 for a test code, and 6 for sign, reset, and hold indications. The leading edge of P_r is the on-time reference point for the succeeding code words.

4.2.2 The 30 bit event count status word begins at index count 1. The subword bits occur between position identifiers P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete the word. Index markers occur between the decimal digits of each subword.

4.2.3 The 30 bit event count status word (BCD seconds) begins at index count 55. The subword bits occur between position identifiers P_5 and P_0: 4 for units of seconds, 4 for tens of seconds, 4 for hundreds of seconds, 4 for thousands of seconds, 4 for tens of thousands of seconds, 4 for hundreds of thousands of seconds, 4 for millions of seconds, and 2 for tens of millions of seconds. Index markers occur between the binary digits of each subword. The code has a maximum count of ±365/366 days, or ±31 536 000/31 622 400 seconds.

4.2.4 Five control functions occur between position identifiers P_5 and P_6.

4.2.5 Two ID bits occur at index counts 42 and 43. For Code CS-2, bit 42 is a binary zero and bit 43 is a binary one.

4.2.6 Three test code bits occur at index counts 93, 94, and 95.

4.2.7 Index counts 46 and 96 are reserved for sign, index counts 47 and 97 are reserved for reset, and index counts 48 and 98 are reserved for hold information.

4.3 CS-3 CODE FORMAT

4.3.1 The CS-3 format (see figure 3) contains 30 bits of BCD event count status in days, hours, minutes, and seconds and 34 bits of BCD TOYLT in days, hours, minutes, seconds, and tenths of seconds. Ten bits are used for indication of first

motion, 2 bits are used for code identification, and 6 bits are for sign, reset, and hold indications. The leading edge of P_r is the on-time reference point for the succeeding code words.

4.3.2 The 30 bit event count status word begins at index count 1. The subword bits occur between position identifiers P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete the word.

4.3.3 The 34 bit time-of-year launch time word begins at index count 50. The subwords occur between position identifiers P_5 and P_0: 4 for tenths of seconds, 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete the word.

4.3.4 The 10 first motion bits are in index count positions 4, 14, 24, 34, 44, 54, 64, 74, 84, and 94.

4.3.5 Two ID bits occur at index counts 42 and 43. For code CS-3, bit 42 is a binary one, and bit 43 is a binary zero.

4.3.6 Index counts 46 and 96 are reserved for sign, index counts 47 and 97 are reserved for reset, and index counts 48 and 98 are reserved for hold information.

4.4 CS-4 CODE FORMAT

4.4.1 The CS-4 format (see figure 4) contains 30 bits of BCD count status in days, hours, minutes, and seconds and 25 bits of event count status in straight binary seconds (SBS). Two bits are used for code identification, 9 bits are reserved for control functions, 3 for a test code, and 6 for sign, reset, and hold indications. The leading edge of P_r is the on-time reference point for the succeeding code words.

4.4.2 The 30 bit BCD event count status word begins at index count 1. The subword bits occur between position identifiers P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete the word. Index markers occur between the decimal digits of each subword.

4.4.3 The 25 bit SBS event count status word begins at index count 60. The subword bits occur between position identifiers P_6 and P_0 with values of 2^0 through 2^{24} for a maximum count of ±365/366 days or ±31 536 000/31 622 400 straight binary seconds.

4.4.4 Nine control function bits occur between position identifiers P_5 and P_6.

4.4.5 Two ID bits occur at index counts 42 and 43. For Code CS-4, bits 42 and 43 are binary ones.

4.4.6 Three test bits occur at index counts 93, 94, and 95.

4.4.7 Index counts 46 and 96 are reserved for sign, index counts 47 and 97 are reserved for reset, and index counts 48 and 98 are reserved for hold information.

APPENDIX A

BINARY CODED DECIMAL COUNT

AND

BINARY COUNT

BINARY CODED DECIMAL (BCD) COUNT
(1n 2n 4n 8n)

DECIMAL NUMBER	n	BCD BITS
1	1	1
5	1	3
10	10	5
15	10	5
150	100	9
1 500	$1x10^3$	13
15 000	$10x10^3$	17
150 000	$100x10^3$	21
1 500 000	$1x10^6$	25
15 000 000	$10x10^6$	29
150 000 000	$100x10^6$	33
1 500 000 000	$1x10^9$	37
15 000 000 000	$10x10^9$	41
150 000 000 000	$100x10^9$	45
1 500 000 000 000	$1x10^{12}$	49
15 000 000 000 000	$10x10^{12}$	53
150 000 000 000 000	$100x10^{12}$	57

BINARY COUNT (2^n)

DECIMAL NUMBER	BINARY NUMBER	DECIMAL NUMBER	BINARY NUMBER
n	2n	2n	2n
0	1		
1	2	26	671 08864
2	4	27	1342 17728
3	8	28	2684 35456
4	16	29	5368 70912
5	32	30	10737 41825
6	64	31	21474 83648
7	128	32	42949 67296
8	256	33	85899 34592
9	512	34	1 71798 69184
10	1024	35	3 43597 38368
11	2048	36	6 87194 76736
12	4096	37	13 74389 53472
13	8192	38	27 48779 06944
14	16384	39	54 97558 13888
15	32768	40	109 95116 27776
16	65536	41	219 90232 55552
17	1 31072	42	439 80465 11104
18	2 62144	43	879 60930 22208
19	5 24288	44	1759 21860 44416
20	10 48576	45	3518 43720 88832
21	20 97152	46	7036 87441 77664
22	41 94304	47	14073 74883 55328
23	83 88608	48	28147 49767 10656
24	167 77216	49	56294 99534 21312
25	335 54432	50	112589 99068 42624

APPENDIX B

EVENT COUNT STATUS HARDWARE DESIGN GOALS

EVENT COUNT STATUS HARDWARE DESIGN GOALS

Pulse Rise Time

The pulse rise time (dc level shift bit) shall be obtained between the 10 and 90 percent amplitude points. A hardware design goal is ≤1 us.

Jitter

The modulated code jitter design goal is defined as ≤1 percent at the carrier frequency.

The dc level shift code jitter is defined as the pulse-to-pulse variation at the 50 percent amplitude points on the leading edge of successive pulses or bits. A 6 hardware design goal is ≤200 ns.