NENA RECOMMENDED PSAP MASTER CLOCK STANDARD

Prepared by:
National Emergency Number Association (NENA) PSAP/CPE Technical Committee

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TECHNICAL REFERENCE

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1. INTRODUCTION

1.1 General

This NENA Technical Reference NENA-04-002 defines the Public Safety Answering Point (PSAP) MASTER CLOCK STANDARD requirements intended for use by users, manufactures and providers of E9-1-1 CPE.

The (PSAP) is a designated agency that receives and responds to emergencies such as Police, Fire, Ambulance, etc.

1.2 Purpose and Scope of Document

This Technical Reference is a guide for designers and manufacturers of PSAP equipment. It identifies engineering and technical requirements to be met before the NENA membership shall consider purchase of such equipment; it may also be of value to purchasers, maintainers and users of such equipment.

This document is not intended to provide complete design specifications for a PSAP Master Clock. It will neither ensure the quality of the performance of the equipment nor should it serve as an exclusive procurement specification.

1.3 Organization of Document

Following the introduction, which provides its purpose and scope, this document is organized into 3 major sections:

Section 2 - Master Clock Feature Description and Feature Definition
Section 3 - RS-232 and ASCII Code
Section 4 - IRIG Specifications

1.4 Document Terminology

The terms "shall", "must be" and "required" are used throughout this document to indicate required parameters and to differentiate from those parameters that are recommendations. Recommendations are identified by the words "it is desirable" or "preferable".

1.5 Reason for Issue

This document is issued to serve as an industry standard and guide for E911 PSAP equipment.

1.6 Reason for Reissue

NENA reserves the right to modify this technical reference. When ever it is reissued, the reason(s) will be provided in this paragraph. Issue 2, April 28, 1998, issued to add Glossary of Terms, Acknowledgments, Paragraph 4-Section 2 and update Section 4, Output Signal, Paragraph A and B. Issue 3, May 17, 2000, issued to change Paragraph 3 - Section 2 to include an Ethernet interface and add new terms to the Glossary.

1.7 Year 2000 Compliance

All systems that are associated with the 9-1-1 process shall be designed and engineered to ensure that no detrimental, or other noticeable impact of any kind, will occur as a result of the date change to the year 2000, or any date subsequent thereto. This shall include embedded application, computer based or any other type application.

To ensure true compliance the manufacturer shall provide verifiable test results to an industry acceptable test plan such as Bellcore GR-2945 or equivalent.

2. MASTER CLOCK Description and Feature Definitions

To insure consistency of time stamps added to event records, reports and voice recordings, it will be required that equipment such as CAD, ANI/ALI Controllers, Voice Recorders, Radio Consoles, etc., will have the ability to synchronize internal clocks to a PSAP master clock.

The PSAP master clock shall be traceable to Coordinated Universal Time (UTC) and have a continuous accuracy of .1 seconds relative to UTC when locked to the UTC time source. In the event the PSAP master clock becomes unlocked from the external UTC source and must "free run", it will not exceed an error accumulation of more than 1 second per day.

The PSAP master clock system shall have a front panel Display to indicate time and shall have the optional capability to provide time codes via an RS-232 serial, IRIG (**I**nter **R**ange **I**nstrumentation **G**roup), and Ethernet 10 / 100 Base T interfaces. These interfaces will provide a time code that will be used by the PSAP equipment to synchronize their internal clocks. The master clock must have the capability to automatically adjustthe Master Clock Display, RS-232 and IRIG time codes for Daylight Saving Time. It must have a selectable 12 or 24 hour display of Hours, Minutes and Seconds. It must have a means to indicate its status; locked / unlocked and time synchronized or unsynchronized to the external UTC time source. The master clock shall have alarm dry contact closures that are activated upon loss of power or when the clock has lost time synchronization. Optionally, equipment synchronizing to the ASCII time code data may derive alarm status by monitoring the Time Sync Status character within the data stream.

When developing site requirements for a PSAP it is important to consider that the type and number of time code interfaces required for each site will vary according to CPE equipment type, quantity, and manufacturer. The PSAP Master Clock system therefore must be configured accordingly to meet the quantity and types of time code interfaces required.

It is desirable that the PSAP master clock be connected to an uninteruptable power supply (UPS) or be equipped with internal batteries which are continually charged from main power. If equipped with internal batteries, the batteries must be capable of powering the equipment for a minimum of 15 minutes.

Equipment connected to the master clock must maintain a continuous accuracy of ± .25 seconds relative to the PSAP master clock.

3. RS-232 ASCII Time Code

The RS-232 ASCII time code shall be in the following format and the baud rate shall be 1200 to 9600. The ASCII time code must be available on both a bi-directional serial communications port and a broadcast port. The bi-directional serial port must send time code when requested by the client. The broadcast port shall automatically send time code once per second at the beginning of the second.

A character consists of 1 start, 8 data, and 1 stop bit, no parity. The data stream contains a time sync status character, day of year, time zone setting, DST/Standard Time Indicator, and the time zone switch setting. Data structure is shown below:

(CR)(LF)I(^)(^)DDD(^)HH:MM:SS(^)DTZ=XX(CR)(LF)

where:

CR =	Carriage Return
LF =	Line Feed
I =	Time Sync Status (space, ?, *)
^ =	space separator
DDD =	Day of Year (001 - 366)
HH =	Hours (00-23)
: =	Colon separator
MM =	Minutes (00-59)
SS =	Seconds (00 - 60)
D =	Daylight Savings Time indicator (S,I,D,0)
TZ =	Time Zone
XX =	Time Zone Switch Setting (00-23)

The leading edge of the first character (CR) marks the on-time point of the data stream.

Time sync status character I is described below:

I =	(space) when the master clock is synchronized to UTC source.
=	* when the master clock time is set manually.
=	? when the master clock has not achieved or has lost synchronization to UTC source.

The Daylight Saving Time indicator provides notice whether Standard Time or DST is in effect and warns of upcoming transitional periods. The Daylight Saving Time indicator D is described below:

D = S during periods of Standard Time.
= I on the day of the change INTO Daylight Saving Time.
= D during periods of Daylight Saving Time.
= O on the day of the change OUT of Daylight Saving Time..

The data is output in a 24-hour time format. The time may be offset to a local time by setting the time zone switches to the appropriate value.

4. IRIG Specifications

Signal Type:

A. IRIG B: B000, B120
B. IRIG E: E001, E111

Accuracy: Within 0.3 milliseconds of the on-time pulse.

Output Connector: BNC

Output Signal: Amplitude modulated or pulse width coded, switch selectable.

A. Amplitude Modulated Output:
Signal level shall have a mark to space ratio of 3.3 to 1.
Mark amplitude levels shall be adjustable over a range of 2.0 to 7.0 volts peak to peak into a 600 ohm load.

B. Pulse Width Coded TTL Output:
Open circuit levels: High ≥ 4.0 volts
Low ≤ 0.6 volts.
Loading: Output TTL-compatible into loads ≥ 600 ohms.

The IRIG B or E time code will be in the following format and may be configured as amplitude modulated or pulse width coded.

The IRIG B output contains the Binary Coded Decimal (BCD) and Straight Binary Seconds (SBS) time data per IRIG B specification. The IRIG E output provides BCD data per specification and additionally SBS data in the Control Function Field. A time sync status character and year information shall be encoded in the Control Function Field for both formats.

4.1 IRIG Formats

Selectable IRIG formats from the PSAP master clock will be:

IRIG B
IRIG B with Signature Control
IRIG E
IRIG E with Signature Control

The IRIG output will be selectable in either amplitude modulated or pulse width coded.

4.2 Signature Control

Signature control removes the time code modulation from the IRIG output whenever the master clock has lost time sync to UTC. Under signature control only the full or mark amplitude carrier will be output for amplitude modulated signals. A TTL logical high will be output for pulse width coded signals. Once the master clock reacquires time sync to the UTC source, the full IRIG output is restored.

4.3 IRIG B Output

The IRIG B output contains BCD and SBS time data per IRIG specifications. The PSAP master clock may output local time by using the time zone offsets.

4.4 IRIG B General Description

1. Time frame: 1.0 seconds.
2. Code digit weighting:
   - A. Binary Coded Decimal time-of-year.
     Code word - 30 binary digits.
     Seconds, minutes hours, and days.
     Recycles yearly.
   - B. Straight Binary Seconds time-of-day.
     Code word - 17 binary digits.
     Seconds only, recycles daily.
3. Code word structure:
   - BCD: Word seconds digits begin at index count 1. Binary coded elements occur between position identifier elements P_0 and P_5 (7 for seconds, 7 for minutes, 6 for hours, and 10 for days) until the code word is complete. An index marker occurs between decimal digits in each group to provide separation for visual resolution. Lease significant digit occurs first.
   - SBS: Word begins at index count 80. Seventeen Straight Binary Coded elements occur with a position identifier between the 9th and 10th binary coded elements. Least significant digit occurs first.

4. Pulse rates:
   A. Element rate: 100 per second.
   B. Position identifier rate: 10 per second.
   C. Reference marker rate: 1 per second.
5. Element identification: The "on time" reference point for all elements will be the pulse leading edge.
   A. Index marker (Binary 0 or uncoded element): 2 millisecond duration.
   B. Code digit (Binary 1): 5 millisecond duration.
   C. Position identifier: 8 millisecond duration.
   D. Reference marker, 1 per second. The reference marker appears as two consecutive position identifiers. The second position identifier marks the on-time point for the succeeding code word.
6. Resolution:
   Pulse width coded signal: 10 milliseconds.
   Amplitude modulated signal: 1 millisecond.
7. Carrier frequency: 1 kHz when modulated.

Control Function Field

ELEMENT #	*C.F. DIGIT #*	*FUNCTION*
50	1	Space
51	2	Space
52	3	Space
53	4	Space
54	5	Space
55	6	Time Sync Status
56	7	Space
57	8	Space
58	9	Space
59	PID P6	Position Identifier
60	10	Years Units Y1
61	11	Years Units Y2
62	12	Years Units Y4
63	13	Years Units Y8
64	14	Space
65	15	Years Tens Y10
66	16	Years Tens Y20
67	17	Years Tens Y40
68	18	Years Tens Y80
69	PID P7	Position Identifier
70	19	Space
71	20	Space
72	21	Space
73	22	Space
74	23	Space
75	24	Space
76	25	Space
77	26	Space
78	27	Space

Figure 4-1 IRIG B CONTROL FUNCTION FIELD

Element 55 is the time sync status bit. Element 55 is a Binary 1 when the master clock is synchronized, and a Binary 0 when unsynchronized.

Year information consists of the last two digits of the current year (94, 95...00 = 2000). Elements 60 through 63 contain the binary equivalent of year units. Elements 65 through 68 contain the binary equivalent of tens of years. All unused control functions are filled with a space (Binary 0).

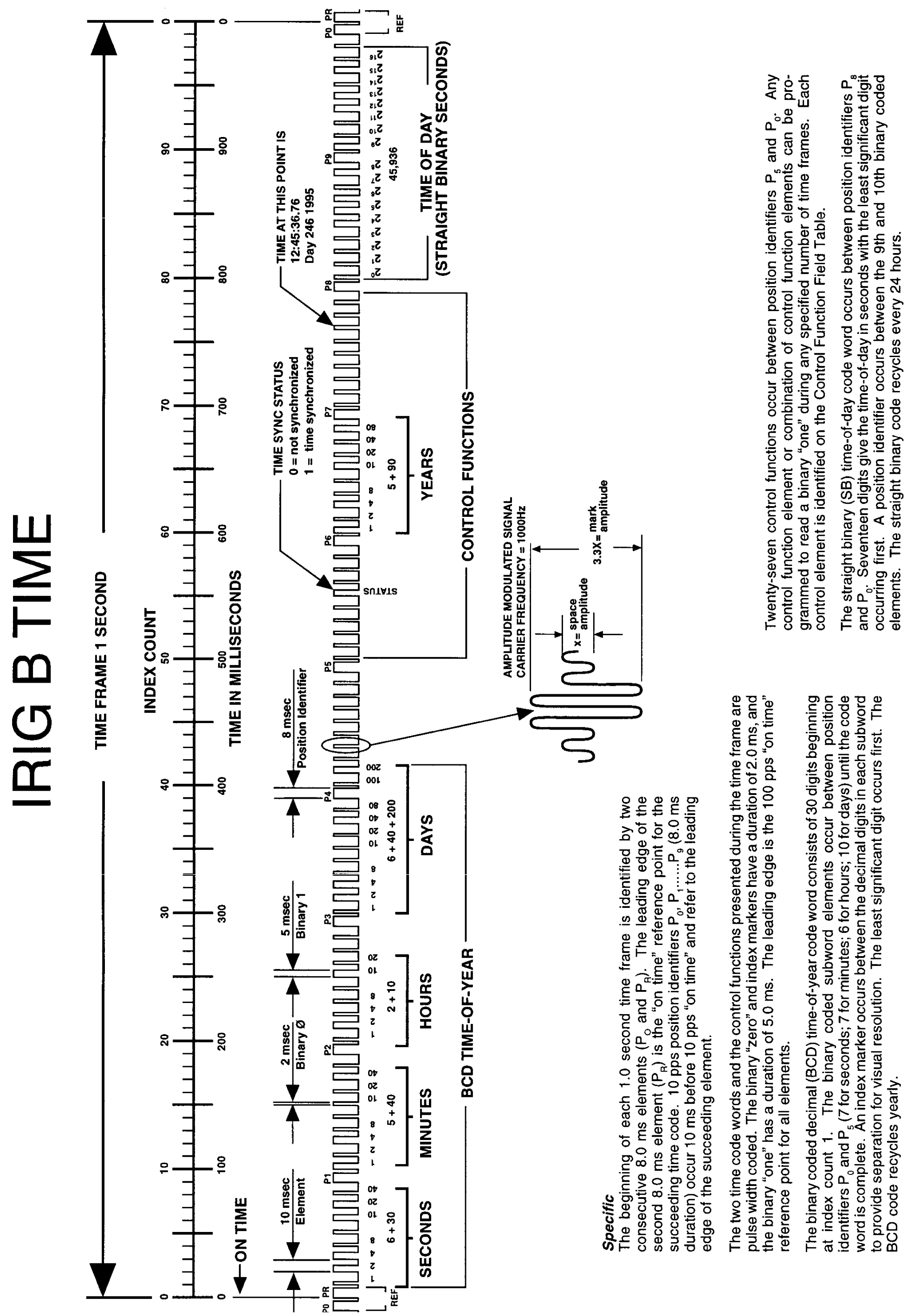


Figure 4-2 IRIG B TIME CODE

4.5 IRIG E Output

The IRIG E Output contains BCD time data per IRIG specifications. The PSAP master clock may output local time by using the time zone offsets.

4.6 IRIG E General Description

1. Time frame: 10 seconds.
2. Code Digit Weighting:
   Binary Coded Decimal time of year.
   Code world - 26 binary digits.
   Tens of seconds, minutes, hours, and days.
   Recycles yearly.
3. Code Word Structure: BCD word tens of seconds digits begin at index count 6. Binary coded elements occur between position identifier elements

   P_0 and P_5 (3 for seconds, 7 for minutes, 6 for hours, and 10 for days) until the code word is complete. An index marker occurs between decimal digits in each group to provide separation for visual resolution. Least significant digit occurs first.
4. Pulse rates:
   A. Element rate: 10 per second.
   B. Position identifier rate: 1 per second.
   C. Reference marker rate: 1 per 10 seconds.
5. Element identification: The "on-time" reference point for all elements is the pulse leading edge.
   A. Index marker (Binary 0 or uncoded element): 20 milliseconds duration.
   B. Code digit (Binary 1): 50 millisecond duration.
   C. Position identifier: 80 millisecond duration.
   D. Reference marker: 80 millisecond duration, 1 per 10 seconds. The reference marker appears as two consecutive position identifiers. The second position identifier or reference marker is the on time point for the succeeding code word.
6. Resolution:
   Pulse width coded signal: 0.1 second.
   Amplitude modulated signal: 0.01 second.
7. Carrier frequency: 100 Hz when modulated.

4.7 Control Function Field

IRIG formats reserve a set of elements known as Control Functions (CF) for the encoding of various control, identification, or other special purpose functions. IRIG E has 45 Control Functions located between elements 50 and 98. The master clock uses the control function field to encode year data, time sync status, and SBS time data. Table 4-4 lists the Control Function Field and each element's function.

Element 55 is the time sync status bit. Element 55 is a Binary 1 when the master clock is synchronized, and a Binary 0 when unsynchronized.

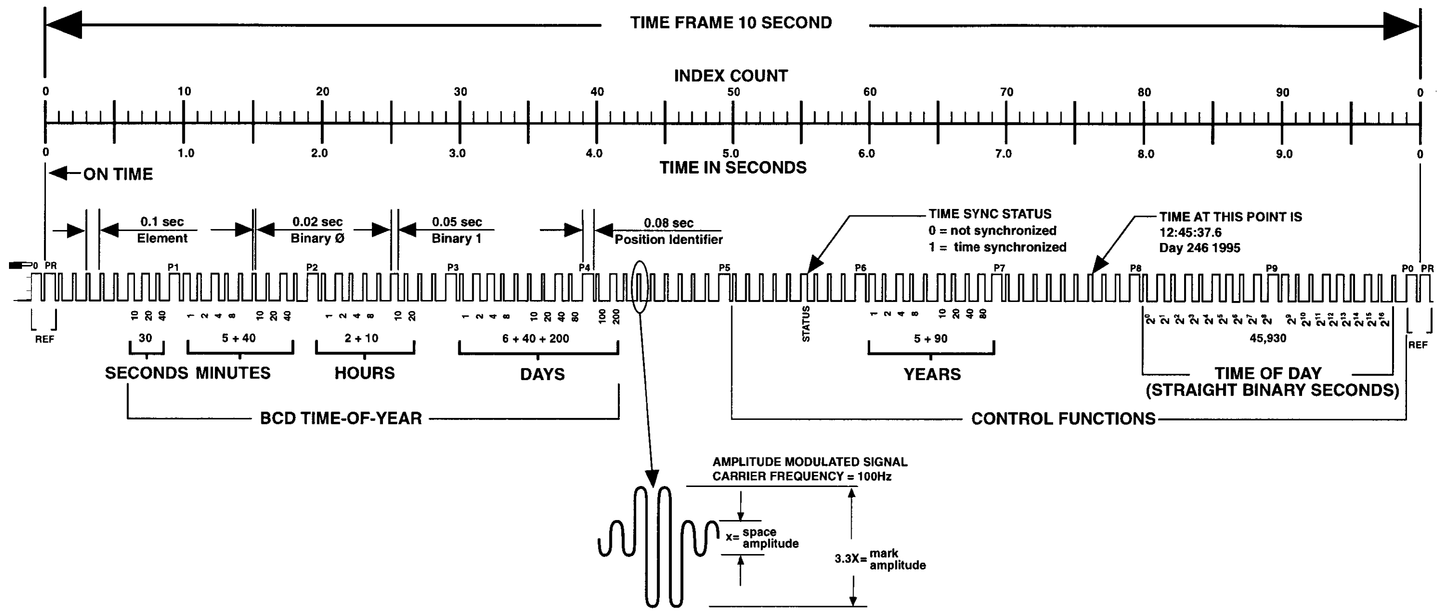
Year information consists of the last two digits of the current year (94, 95...00 = 2000). Elements 60 through 63 contain the binary equivalent of year units. Elements 65 through 68 contain the binary equivalent of tens of years.

Elements 80 through 97 are encoded with the Straight Binary Seconds (SBS) time data. The SBS time data is incremented in 10-second steps and recycles every 24 hours.

BIT #	*CF ELEMENT #*	*FUNCTION*
50	1	SPACE
51	2	SPACE
52	3	SPACE
53	4	SPACE
54	5	SPACE
55	6	TIME SYNC STATUS
56	7	SPACE
57	8	SPACE
58	9	SPACE
59	PID P6	POSITION IDENTIFIER
60	10	YEAR UNITS Y1
61	11	YEAR UNITS Y2
62	12	YEAR UNITS Y4
63	13	YEAR UNITS Y8
64	14	SPACE
65	15	YEAR TENS Y10
66	16	YEAR TENS Y20
67	17	YEAR TENS Y40
68	18	YEAR TENS Y80
69	PID P7	POSITION IDENTIFIER
70	19	SPACE
71	20	SPACE
72	21	SPACE
73	22	SPACE
74	23	SPACE
75	24	SPACE
76	25	SPACE
77	26	SPACE
78	27	SPACE
79	PID P8	POSITION IDENTIFIER
80	28	SBS 2^0
81	29	SBS 2^1
82	30	SBS 2^2
83	31	SBS 2^3
84	32	SBS 2^4
85	33	SBS 2^5
86	34	SBS 2^6
87	35	SBS 2^7
88	36	SBS 2^8
89	PID P9	POSITION IDENTIFIER
90	37	SBS 2^9
91	38	SBS 2^{10}
92	39	SBS 2^{11}
93	40	SBS 2^{12}
94	41	SBS 2^{13}
95	42	SBS 2^{14}
96	43	SBS 2^{15}
97	44	SBS 2^{16}
98	45	SPACE
99	PID P0	POSITION IDENTIFIER

Figure 4-3 IRIG E CONTROL FUNCTION FIELD

IRIG E TIME



Specific
The beginning of each 10 second time frame is identified by two consecutive 80 ms elements (P_O and P_R). The leading edge of the second 80 ms element (P_R) is the "on time" reference point for the succeeding time code. 1 pps position identifiers P_0, P_1......P_9 (80 ms duration) occur 0.1 second before 1 pps "on time" and refer to the leading edge of the succeeding element.

The time code word and the control functions presented during the time frame are pulse width coded. The binary "zero" and index markers have a duration of 20 ms, and the binary "one" has a duration of 50 ms. The leading edge is the 10 pps "on time" reference point for all elements.

The binary coded decimal (BCD) time-of-year code word consists of 26 digits beginning at index count 6. The binary coded subword elements occur between position identifiers P_0 and P_5 (3 for seconds; 7 for minutes; 6 for hours; 10 for days) until the code word is complete. An index marker occurs between the decimal digits in each subword to provide separation for visual resolution. The least significant digit occurs first. The BCD code recycles yearly.

Forty-five control functions occur between position identifiers P_5 and P_0. Any control function element or combination of control function elements can be programmed to read a binary "one" during any specified number of time frames. Each control element is identified on the Control Function Field Table.

0

Figure 4-4 IRIG E TIME CODE

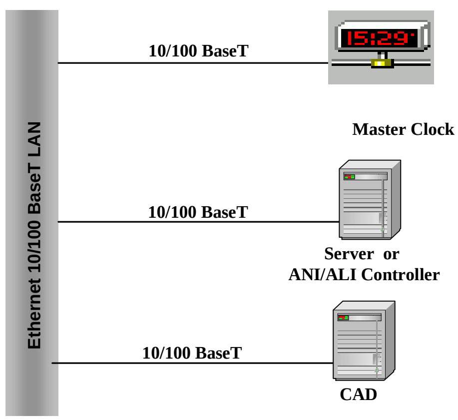
5. Ethernet 10/100 Base-T Network Time Protocol

The Ethernet 10/100 Base-T network interface will support NTP (**N**etwork **T**ime **P**rotocol) and SNTP (**S**imple **N**etwork **T**ime **P**rotocol). For a complete description of the NTP and SNTP protocols, refer to the Information Sciences Institute RFC: 1305 – NTP and RFC: 2030 – SNTP documents and any subsequent RFCs that supercede these references.

Sample Ethernet Interfaces:

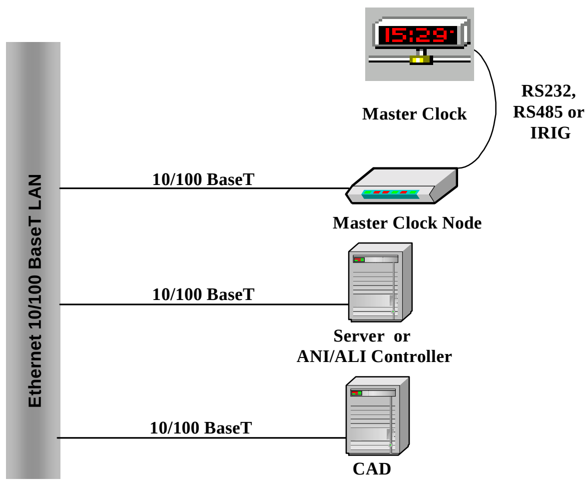
Scenario 1: Integrated Ethernet connection within the Master Clock device

Master Clock - Scenario 1



Scenario 2: External Ethernet connection to the Master Clock device

Master Clock - Scenario 2



6. Glossary Of Terms

Term	***Definition***
Alarm Dry Contacts	A set of relay contacts which are caused to either open or close when an alarm condition occurs.
Amplitude Modulated	The encoding of a carrier wave by variation of its amplitude in accordance with an input signal.
ASCII	A standard for defining codes for information exchange between equipment produced by different manufacturers. A code that follows the **A**merica **S**tandard **C**ode for **I**nformation **I**nterchange
Baud Rate	The specified maximum rate of data transmission over an interconnection.
BCD	Abbreviation for **B**inary **C**oded **D**ecimal. A coding system in which each decimal digit from 0 to 9 is represented by four binary (0 or 1) digits.
Carrier Frequency	The frequency of the unmodulated IRIG B or E signal.
Data Bit	A binary digit, either a zero (0) or a one (1).
Free Run	The operating condition of a clock in which the local oscillator is not locked to an external synchronization reference, and is using no storage techniques to sustain its operating frequency.
Internal Clock	A time-of-day reference source for timing information in equipment or systems.
IRIG	**I**nter-**R**ange-**I**nstrumentation **G**roup. This group, in 1959, proposed a series of time code formats now known as IRIG or NASA time codes.
Master Clock	An accurate timing device that generates synchronous signals to control other clocks or equipment.
Millisecond (ms)	One-thousandth of a second (0.001 s)

Term	***Definition***
NTP	**N**etwork **T**ime **P**rotocol is a powerful utility for synchronizing system clocks over a TCP/IP network.
On-Time-Point	The leading edge of a pulse which occurs coincident with the beginning of a second.
Position Identifier	A pulse in the IRIG time code which has a predetermined duration and rate that is used to identify location of time code information.
Pulse Width Coded	Modulation of a carrier by the digital representation of an analog signal.
RS-232	An electrical and mechanical standard for the serial transfer of digital information between digital systems, such as computers, printers, or communications equipment.
SBS	Abbreviation for **S**traight **B**inary **S**econds. A binary number that appears in the IRIG time code which represents the total number of seconds since midnight.
Signature Control	A means to control the output of a time code signal based on the sync or lock status of the PSAP master clock.
SNTP	**S**imple **N**etwork **T**ime **P**rotocol is a utility for synchronizing system clocks over a TCP/IP network. This protocol is similar to NTP and is used when the ultimate performance of the full NTP implementation is not needed.
Start Bit	In asynchronous transmission, the first element in each character that prepares the receiving device to recognize the incoming information.
Stop Bit	In asynchronous transmission, the last transmitted element in each character, which permits the receiver to come to an idle condition before accepting another character.
Sync	Abbreviation for synchronized or synchronization.
Synchronization	In the context of timing, synchronization means to bring clocks or data streams into phase so they agree with the PSAP master clock.
Time Code	A series of pulses or characters which represent a digit such as a 4. The location of a particular binary digit in the code defines its meaning, 4 hours, 4 minutes, or 4 seconds.
Time Sync Status Character	A specific character location in the ASCII time code data stream which changes dependent on the lock or unlock status of the PSAP master clock to its' source.

Term	***Definition***
Traceable UTC source	Traceable sources of UTC time are available from various time services of the **N**ational **I**nstitute of **S**tandards and **T**echnology (NIST) and **US** **N**aval **O**bservatory (USNO). These services include telephone dial-up, low and high frequency radio transmissions, and **G**lobal **P**ositioning **S**ystem (GPS).
TTL	**T**ransistor to **T**ransistor **L**ogic.
UPS	Uninterruptible Power Supply. A backup system designed to provide continuous power in the event of a commercial power failure or fluctuation.
UTC	Abbreviation for **U**niversal **C**oordinated Time. Also known as Zulu or GMT. Time provided by NIST and USNO