TECHNICAL NOTE

Overview of IRIG-B Time Code Standard

Summary

The IRIG-B time protocol is widely used by electric utilities, industrials, and others to ensure precise time synchronization of power system devices, such as breakers, relays and meters.

This document describes the protocol, gives examples of how IRIG-B is used by Cyber Sciences products, and provides references for further study.

IRIG STANDARD 200-04

Range Commanders Council
TELECOMMUNICATIONS AND TIMING GROUP

Introduction

The IRIG time codes were originally developed by the Inter-Range Instrumentation Group (IRIG), part of the Range Commanders Council (RCC) of the US Army. The standard was first published in 1960 and has been revised several times by the Telecommunications and Timing Group (TTG) of the RCC. The latest version is IRIG standard 200-04, "IRIG Serial Time Code Formats," updated in September, 2004.

Available Formats

Although the "IRIG-B" time code is best known, the standard actually defines a family of rate-scaled serial time codes. The six code formats use different pulse rates, or bit rates, as shown in the table below.

IRIG Time Code Formats

Format	Pulse Rate (or Bit Rate)	Index Count Interval
IRIG-A	1000 PPS (pulse per second)	1 ms
IRIG-B	100 PPS	10 ms
IRIG-D	1 PPM	1 minute
IRIG-E	10 PPS	100 ms
IRIG-G	10000 PPS	0.1 ms
IRIG-H	1 PPS	1 second

Time Code Attributes

All IRIG time code formats use pulse-width coding. A "binary 1" pulse has a duration of 50% of the index count interval, and a "binary 0" pulse has a duration of 20% of the index count interval. In addition "Position Identifiers" have a duration of 80% and are used as reference markers.

IRIG time code signals may be:

- **Unmodulated** (DC level shift, no carrier signal)
- **Modulated** (amplitude-modulated, sine wave carrier).
- **Modified Manchester** (amplitude-modulated, square wave carrier).

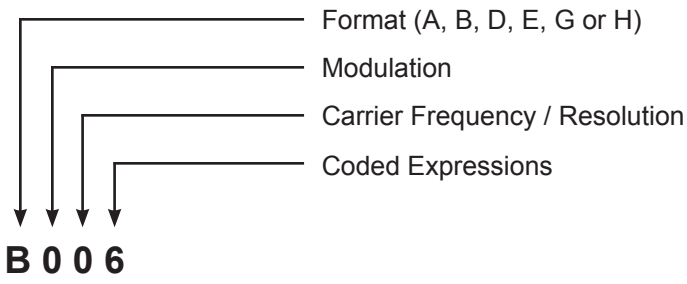
Three types of coded expressions are used in the IRIG standard:

- **Binary Coded Decimal** time-of-year (BCD_{TOY}) and year (BCD_{YEAR})
- **Control Functions** (CF), set of bits reserved for user applications
- **Straight Binary Seconds** (SBS) time-of-day (0 to 86400 seconds)

IRIG STANDARD 200-04 (Continued)

IRIG Time Code Designations

In addition to the letter used to designate one of the six IRIG code formats, signal identification numbers are used to further describe specific characteristics. Thus, the complete IRIG time code designation consists of a letter and three digits, as shown below.



IRIG time codes – naming convention

IRIG Signal Identification Numbers (3 Digits)

1st Digit	Modulation
0	Unmodulated – DC Level Shift (DCLS), pulse-width coded
1	Amplitude modulated, sine wave carrier
2	Manchester modulated
2nd Digit	**Carrier Frequency / Resolution**
0	No carrier (DCLS)
1	100 Hz / 10 ms resolution
2	1 kHz / 1 ms resolution
3	10 kHz / 100 microsecond resolution
4	100 kHz / 10 microsecond resolution
3rd Digit	**Coded Expressions**
0	BCD_{TOY}, CF, SBS
1	BCD_{TOY}, CF
2	BCD_{TOY}
3	BCD_{TOY}, SBS
4	BCD_{TOY}, BCD_{YEAR}, CF, SBS
5	BCD_{TOY}, BCD_{YEAR}, CF
6	BCD_{TOY}, BCD_{YEAR}
7	BCD_{TOY}, BCD_{YEAR}, SBS

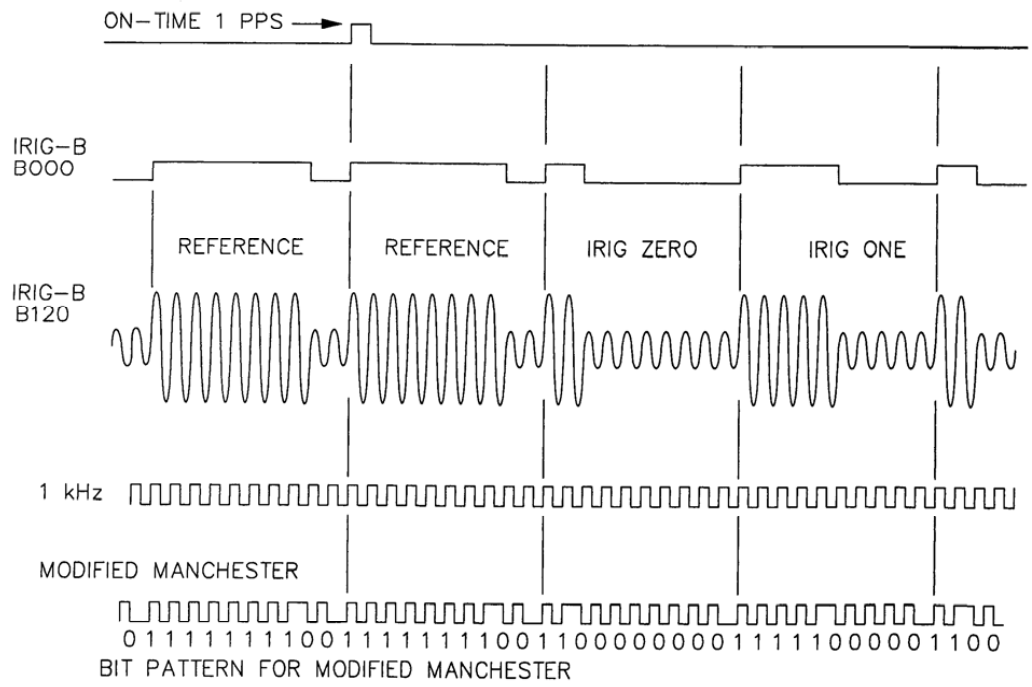
IRIG-B PROTOCOL DESCRIPTION

IRIG-B Overview

IRIG time code B (IRIG-B) is widely used in the electrical power industry. IRIG-B has a pulse rate of 100 pulses-per-second with an index count of 10 milliseconds over its one-second time frame. It contains time-of-year and year information in a BCD format, and (optionally) seconds-of-day in SBS.

IRIG-B Signals

IRIG-B is typically distributed as a DC level shift, pulse-width coded signal ("unmodulated IRIG-B") or as an amplitude-modulated signal based on a sine wave carrier with a frequency of 1kHz ("modulated IRIG-B"). Modified Manchester modulation is also specified in the standard but is less common. A comparison of IRIG-B coding methods is given in the figure below.



(source: IRIG Standard 200-04)

IRIG-B coding comparisons: level shift (unmodulated), 1kHz amplitude-modulated, and Modified Manchester

IRIG-B Reference Markers

IRIG-B uses reference markers called "Position Identifiers." The presence of two consecutive reference markers signifies the start of the time frame. The first reference marker alerts that the next rising edge will be the PPS marker. ("On-Time 1 PPS" shown above.)

IRIG-B PROTOCOL DESCRIPTION (Continued)

IRIG-B Encoding

IRIG-B consists of 100 bits produced every second, 74 bits of which contain various time, date, time changes and time quality information of the time signal. Consisting of logic ones, zeros and position identifier bits, the time code provides a reliable method of transmitting time to synchronize power equipment devices. There are three functional groups of bits in the IRIG-B time code: Binary Coded Decimal (BCD), Control Functions (CF) and Straight Binary Seconds (SBS).

The BCD group contains time information including seconds, minutes, hours and days, recycling yearly. The BCD time-of-year code (BCD_{TOY}) reads zero (0) hours, minutes, seconds, and fraction of seconds at 2400 each day and reads day 001 at 2400 of day 365, or day 366 in a leap year. The BCD year code (BCD_{YEAR}) counts year and cycles to the next year on January 1st of each year and will count to year 2099.

The (optional) SBS time-of-day code consists of the total elapsed seconds, recycling daily. SBS reads zero (0) seconds at 2400 each day excluding leap second days when a second may be added or subtracted.

The CF group contains year, time quality, leap year, pending leap seconds and parity. Other CF bits are reserved for user-defined purposes, depending on application.

Lastly, position identifiers separate the various components of the IRIG-B time code.

IEEE-1344 Extensions

Year information was not specified in the IRIG standard prior to its 2004 revision. Before 2004, the IEEE adopted a standard (IEEE-1344) which included year data as part of the IRIG-B signal. This variation came to be known as “IEEE-1344 extensions.”

Note: IEEE standard 1344 was updated and replaced by IEEE C37.118-2005. Nevertheless, the term “IEEE-1344 Extensions” is still used.

IEEE-1344 extensions use extra bits of the Control Functions (CF) portion of the IRIG-B time code. Within this portion of the time code, bits are designated for additional features, including:

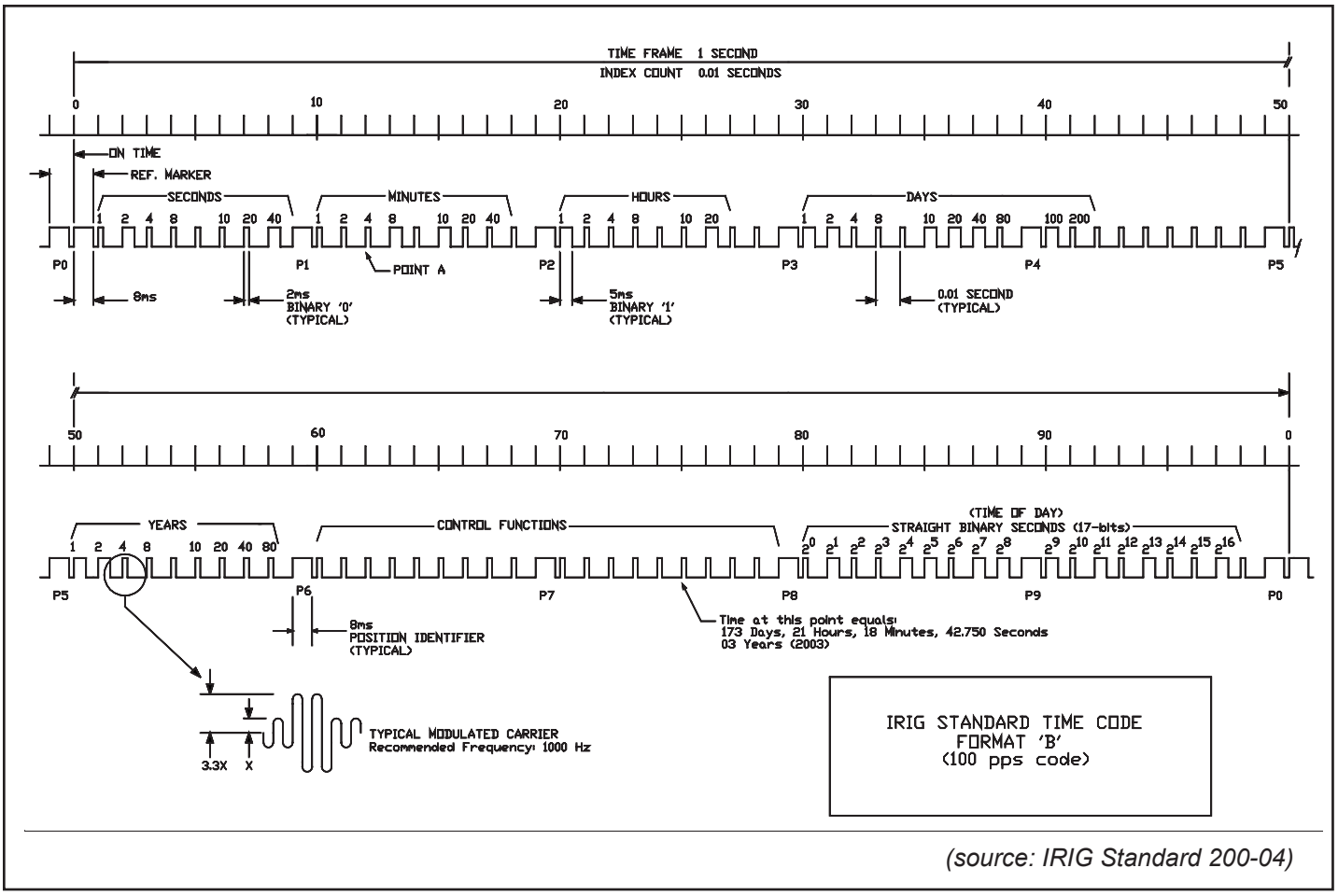
- Calendar Year (now called BCD_{YEAR})
- Leap seconds, and leap seconds pending
- Daylight Saving Time (DST), and DST pending
- Local time offset
- Time quality
- Parity
- Position identifiers

To be able to use these extra bits of information, power system devices and other equipment receiving the time code must be able to decode them. Refer to individual product manuals to determine whether IEEE-1344 extensions are supported.

Since year information is now considered part of BCD (denoted as BCD_{YEAR}), what was formerly considered B002 and B122 (with IEEE Extensions ON) would now be denoted as B006 and B126.

IRIG-B Type with IEEE 1344 Extensions

IRIG-B TYPE	IEEE 1344	
	OFF	ON
Unmodulated, B00x	B002	B006
Modulated, B12x	B122	B126



(source: IRIG Standard 200-04)

IRIG-B BCD time-of-year (in days, hours, minutes, seconds) and year and straight binary seconds-of-day and control bits

WIRING

Unmodulated or Demodulated?

An IRIG-B time signal can be modulated (over a carrier signal) or unmodulated (no carrier signal).

In some manufacturers' literature the term "demodulated" is used to describe an IRIG-B signal with no carrier signal. However, the term "demodulated" does not appear in the IRIG standard. In most cases, it may be assumed that this term is synonymous with unmodulated.

IRIG-B Implementation

The IRIG 200-04 standard does not define specific signal levels for IRIG-B.

Typical techniques for transmission of **unmodulated IRIG-B** include:

- TTL-level signal over coaxial cable or shielded twisted-pair cable
- Multi-point distribution using 24 Vdc for signal and control power
- RS-422 differential signal over shielded twisted-pair cable
- RS-232 signal over shielded cable (short distances only)
- Optical fiber

Typical techniques for transmission of **modulated IRIG-B** include:

- Coaxial cable, terminated in 50 ohms or higher.
- Shielded twisted-pair cable

APPLICATION OF IRIG-B IN CSI PRODUCTS

STR-100 Satellite Time Reference

STR-IDM
IRIG-B Distribution Module

CyTime Event Recorder, SER-3200

STR-100

The Cyber Sciences STR-100 Satellite Time Reference accepts a GPS smart antenna input or a modulated IRIG-B signal to provide a precision time reference. The IRIG-B input supports type B122 (1kHz modulated signal with BCD encoding of time of year).

STR-100/IRIG-B

Like the base model, the STR-100/IRIG-B Satellite Time Reference accepts a GPS smart antenna input, but its output is an unmodulated IRIG-B signal, type B002 (unmodulated signal, DC level shift pulse, BCD_{TOY}) at 5 Vdc nominal.

STR-IDM

The STR-IDM Satellite Time Reference IRIG-B Distribution Module is a companion product to the STR-100/IRIG-B and enables the distribution of an unmodulated IRIG-B signal over long distances and to multiple devices. It also is used to distribute 24 Vdc control power.

The IRIG-B signal levels between the STR-100/IRIG-B and the IDM (as well as to other IDMs) are 24 Vdc nominal, along with 24 Vdc control power. Each STR-IDM provides 8 additional IRIG-B outputs, type B002 (unmodulated signal, DC level shift pulse, BCD_{TOY}) at 5 Vdc nominal.

SER-3200

The CyTime™ Sequence of Events Recorder, SER-3200, accepts an unmodulated IRIG-B signal to provide its precision time reference, and supports IEEE-1344 extensions, type B006 (unmodulated signal, DC level shift pulse, BCD_{TOY} and BCD_{YEAR}).

REFERENCES

For More Information (CSI)

STR Instruction Bulletin (IB-STR-01)
STR/IRIG-B Addendum (IB-STR-02)
STR-IDM Instruction Bulletin (IB-IDM-01)
SER-3200 Instruction Bulletin (IB-SER-01)
SER-3200 Reference Guide (IB-SER-02)
Tech Note: SER System Architectures (TN-101)

Doc. no: TN-102R1
Jan-2011

Cyber Sciences, Inc. USA

References

IRIG Standard 200-04: “IRIG Serial Time Code Formats.” September, 2004. Range Commanders Council, U.S. Army White Sands Missile Range, New Mexico 88002-5110

IEEE C37.118-2005 (replaced IEEE Standard 1344). IEEE Standard for Synchrophasors for Power Systems. Institute of Electrical and Electronics Engineers (IEEE). January 1, 2006.

Dickerson, Bill, P.Eng., Arbiter Systems, Inc. “Time in the Power Industry: How and Why We Use It.”

Dickerson, Bill, P.Eng., Arbiter Systems, Inc. “IRIG-B Time Code Accuracy and Connection Requirements with comments on IED and system design considerations.” Publication PD0037300.