IRIG 106-96 Chapter 4

TEC/NOT/027

This paper describes the IRIG 106-96 Chapter 4 standard. The following topics are discussed:

18.1 Overview

IRIG Standard 106-96 covers all aspects of Frequency Modulation (FM) and Pulse Code Modulation (PCM) telemetry, including transmitters, receivers, and tape recorders. Chapter 4 of IRIG Standard 106-96 is the primary telemetry standard used throughout the world by both government and industry.

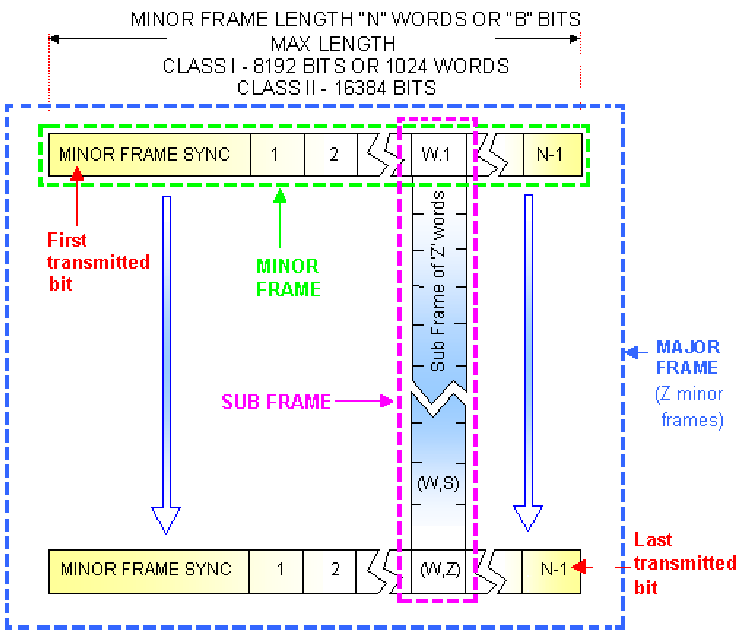

Figure 18-1: PCM frame structure

This is one of many comprehensive standards prepared by the Telemetry Group of the Range Commanders Council (RCC) to foster the compatibility of telemetry transmitting, receiving, and signal processing equipment at member ranges. Owing to its success as a proven standard and its wide support by telemetry equipment manufacturers, most commercial data acquisition systems also use the same IRIG standard PCM formats and definitions.

Because IRIG 106-13 concentrates on defining the essential data structures and serial codes, rather than the content of the data, it has become a recognized standard for PCM telemetry systems used worldwide.

18.1.1 Background

Rapid advances in digital technology, combined with its universal application to many fields, make it difficult to create standards that don't, just as rapidly, become obsolete. Serial data transmission, for example, is an essential element of the telecommunications and computer industries. As a result, industries have independently developed their own standards. Even within the telemetry industry, the many military and commercial aerospace programs, and the usual demand for secrecy, have discouraged the development of international telemetry standards.

18.1.2 PCM

PCM telemetry is a way of acquiring data in one location, converting the data samples to digital words, encoding the data in a serial digital format, and transmitting it to another location for decoding and analysis. PCM systems are less susceptible to noise than analog systems, and the digital data is easier to transmit, record, and analyze.

Telemetry systems are used to acquire data parameters in one location and encode them for transmission over a serial data link, such as a microwave transmitter of fiber optic cable. At the second location, the serial data is received and decoded to recover the individual data parameters. When making large numbers of measurements, it is desirable to squeeze the data into one signal or data link in order to simplify the transmission and recording.

Early telemetry systems transmitted analog voltages using a commutator (rotary switch) at one end and a synchronized decommutator at the other end. The words commutator and decommutator are still used though most telemetry systems today use electronic switches and send digital data.

The following figure shows the basic elements of a modern PCM telemetry system. A PCM encoder converts the input data signals into a serial data format suitable for transmission. At the receiving end, a PCM decoder (or PCM decommutator) converts the serial data back into individual output data signals.

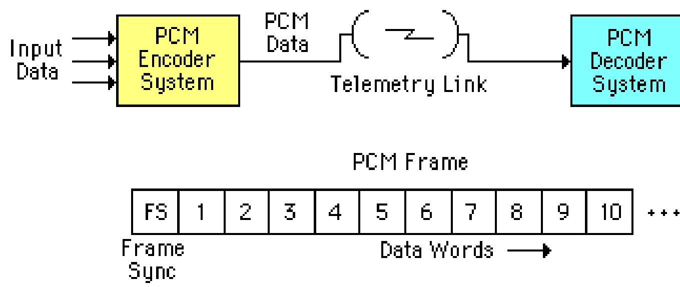

Figure 18-2: Basic elements of PCM system

The simplest PCM frame consists of a frame synchronization word followed by a string of data words. The frame repeats continually to provide new data samples as the input data changes. Frame synchronization enables the PCM decoder to easily locate the start of each frame.

The following table provides a summary of relevant PCM specifications.

Specification	Class I	Class II
Class format support	Class I (simple formats) supported on all ranges	Class II (complex formats) requires concurrence of range involved
Binary bit representation (PCM codes)	NRZ-L, NRZ-M, NRZ-S, RNRZ-L (per Appendix D), BiØ-L, BiØ-M, BiØ-S	Same as Class I
Bit rate	10 bps to 5 Mbps	10 bps to > 5 Mbps
Bit rate accuracy and stability	0.1%	Same as Class I
Bit jitter	±0.1 bit	Same as Class I
Bit numbering	Most significant bit is bit number 1	Same as Class I
Word length (data)	4 to 16 bits	4 to 64 bits
Fragmented words	Not allowed	Up to eight segments each; all segments of a word must be located in the same minor frame
Word numbering	First word after synchronization is number 1. Following words are numbered sequentially within each minor frame	Same as Class I
Frame structure	PCM data is formatted into fixed length frames containing a fixed number of equal duration bit intervals	Same as Class I
Binary bit representation (PCM codes)	NRZ-L, NRZ-M, NRZ-S, RNRZ-L (per Appendix D), BiØ-M, BiØ-M, BiØ-M	Same as Class I

Specification	Class I	Class II
Bit rate	10 bps to 5 Mbps	10 bps to > 5 Mbps
Minor frame length	Up to 8192 bits or 1024 words including sync word	Up to 16384 bits including sync word
Minor frame composition	Minor frame synchronization pattern, data words, and sub-frame synchronization if used	Same as Class I plus other words such as frame format identifiers
Minor frame synchronization	Minor frame sync pattern is 16 to 33 bits long	Same as Class I
Transmitted frame counter (optional)	Binary count located in fixed word position increments to indicate minor frame number. Can use sub-frame ID counter	Same as Class I
Major frame length	Up to 256 minor frames	Same as Class I
Minor frame numbering	First minor frame in each major frame is number 1	Same as Class I
Subcommutation (sub-frames)	Parameters may be sampled at submultiple rates (1/D) where D is an integer between 2 and Z, the number of minor frames in each major frame	Same as Class I
Sub-frame synchronization (sub-frame ID counter)	Standard method is to use a Sub-frame ID counter, a binary count located in a fixed position in every minor frame and which increments or decrements at the minor frame rate and is reset to max or min count at the start of each major frame	Same as Class I
Supercommutation	Parameters may be sampled at a multiple of the minor frame rate (supercom) or at a multiple of the sub-frame rate (supercom on a sub-frame); samples must be evenly spaced	Samples should be as evenly spaced as practical
Format change	Not allowed	Frame structure is specified by frame format identification word in every minor frame
Asynchronous embedded format	Not allowed	Up to two embedded formats per major frame; embedded formats must occupy same word locations in every minor frame
Tagged data formats	Not allowed	Alternating tag and data, or MIL-STD-1553 data blocks

Specification	Class I	Class II
Time words	Standardized time format uses three 16-bit words designated high order time, low order time and microsecond time. It is recommended that the time words be inserted before the first data word in the minor frame. For PCM word sizes other than 16 bits, the data must be inserted into the PCM stream as 48 contiguous bits with zeros added at end to fill any unused bits	Same as Class I
Asynchronous data merge	Regarded as Class II feature	External sequential data (such as RS-232) can be inserted into the PCM frame format in fixed word positions

18.1.3 IRIG PCM codes

The only codes allowed by IRIG 106-96 for PCM bit streams are: NRZ-L, NRZ-M, NRZ-S, RNRZ-L, BiØ-L, BiØ-M, and BiØ-S. For tape recording PCM data, the only permissible codes are: RNRZ-L, BiØ-L, BiØ-M, and BiØ-S (see the *Reference* chapter of *Applications Handbook*).

Randomized NRZ-L code (RNRZ-L) is not illustrated since it is derived from NRZ-L code by using the randomizer circuit defined in Chapter 6 and Appendix D of IRIG 106-96. Despite its name, RNRZ-L is not truly random because it is completely predictable. The main advantage of RNRZ-L code is that it prevents the occurrence of long strings of consecutive ones or zeros that would make it difficult to decode or record the PCM signal. It is also a low bandwidth code for economical PCM tape recording.

NOTE: Bi-phase codes can be derived from NRZ codes by inverting the level for the last half of each interval.

18.2 Conclusion

This paper gave an overview of the IRIG 106-96 Ch. 4 standard. It described the basic structure of a PCM frame and the elements of a PCM system. It outlined a brief summary of PCM specifications and listed the PCM codes used worldwide in industry and government systems.

18.3 References

1. IRIG STANDARD 106-99, Telemetry Standards, January 1999, Prepared by: Telemetry Group, Range

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Missile Range, New Mexico 88002-5110

2. FAS Military Analysis Network - EC - 18 ARIA

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