CHAPTER 5

Digitized Audio Telemetry Standard

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Acronyms

CVSD	continuous variable slope delta
kb/s	kilobit per second
LSB	least significant bit
MSB	most significant bit
PCM	pulse code modulation

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CHAPTER 5

Digitized Audio Telemetry Standard

5.1 General

This chapter defines continuous variable slope delta (CVSD) modulation as the standard for digitizing audio and addresses the method of inserting CVSD encoded audio into a PCM stream. Additional information and recommendations are provided in Appendix F, which was extracted from the applicable sections of Military Standard 188-113, which has been canceled with no replacement.

5.2 Definitions

For the purpose of this standard, the following definitions apply.

Band-Limited Audio: An audio signal (typically consisting of voice, tones, and sounds) that is limited to a subset of the audio spectrum. For most aircraft audio applications, the spectrum between 100 and 2300 hertz is adequate.

Continuous Variable Slope Delta Modulation: The CVSD modulation is a method of digitizing a band-limited audio signal. The CVSD modulator is, in essence, a 1-bit analog-to-digital converter. The output of this 1-bit encoder is a serial bit stream, where each bit represents an incremental increase or decrease in signal amplitude and is determined as a function of recent sample history.

5.3 Signal Source

The signal to be encoded shall be a band-limited audio signal. The source of this signal may be varied. Some examples are microphones, communication systems, and tones from warning systems. This standard applies to audio signals only.

5.4 Encoding/Decoding Technique

The technique to encode and decode the band-limited audio signal is CVSD modulation. This technique is to be implemented in accordance with Appendix F.

A CVSD converter consists of an encoder-decoder pair. The decoder is connected in a feedback path. The encoder receives a band-limited audio signal and compares it to the analog output of the decoder. The result of the comparison is a serial string of "ones" and "zeros." Each bit indicates that the band-limited audio sample's amplitude is above or below the decoded signal. When a run of three identical bits is encountered, the slope of the generated analog approximation is increased in its respective direction until the identical string of bits is broken. The CVSD decoder performs the inverse operation of the encoder and regenerates the audio signal.

NOTE	A qualitative test of CVSD with a tactical aircraft intercom system yielded the following results: (1) intelligible, robotic sounding audio at 12 kilobits per second (kb/s); (2) good quality audio at 16 kb/s; and (3) audio quality did not significantly improve as the bit rate was increased above 32 kb/s.

5.5   CVSD Encoder Output Bit Rate (CVSD Bit Rate)

The CVSD bit rate for encoding the band-limited audio signal is a function of the desired audio quality and the PCM format characteristics. The minimum and maximum CVSD bit rates will not be specified.

Appendix F contains performance criteria for the CVSD encoder and decoder when operated at 16 or 32 kb/s.

5.6   CVSD Word Structure

The digitized audio signal from the CVSD encoder's serial output shall be inserted into the PCM stream as shown in Figure 5-1. The most significant bit (MSB) shall be the most stale sample (first in). The least significant bit (LSB) shall be the most recent sample (last in).
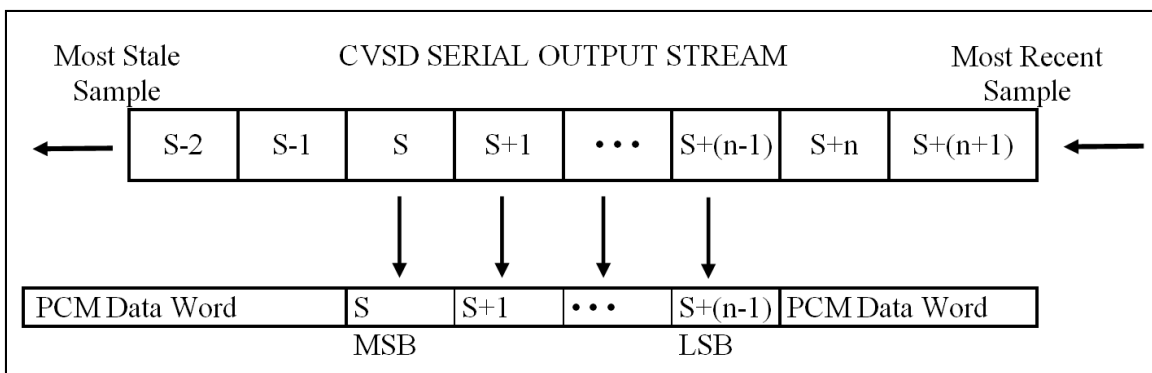

Figure 5-1.   Insertion of CVSD-Encoded Audio into a PCM Stream

5.7   CVSD Word Sample Rate

The CVSD word sample rate is dependent on the minimum desired CVSD bit rate, the PCM word length, and the PCM word sample rate. Once the CVSD word sample rate is determined, the actual CVSD bit rate can be calculated. The decoder must be run at the same CVSD bit rate as the encoder.

> **NOTE**   Because of the nature of CVSD encoding, over and under sampling of the CVSD output will have unpredictable results.

> **NOTE**   To simplify the reconstruction of the audio signal and minimize all encoding/decoding delays, it is STRONGLY recommended that the digitized audio words be inserted in the PCM stream at evenly spaced intervals.

5.8   CVSD Bit Rate Determination

The following discussion provides a procedure for determining the CVSD bit rate based on the desired minimum CVSD bit rate and information given in the host PCM format. Note that this procedure assumes the CVSD words are inserted in a class I PCM format with constant word widths and are not subcommutated. The CVSD bit rate can be obtained by multiplying the minor frame rate by the number of times the CVSD words appear in the minor frame by the word

width used for the CVSD words in the minor frame. This relationship is expressed in equation (5-1).

CVSD Bit Rate = Minor Frame Rate • #CVSD Words per Minor Frame • Word Width   (5-1)

Knowing the details on the host PCM format, equation (5-1) contains two unknowns: CVSD bit rate and #CVSD words per minor frame. One of these unknowns must be chosen by the user; then the other one can be calculated. The recommended procedure is to choose the desired (target value) CVSD bit rate and solve equation (5-1) for #CVSD words per minor frame. This relationship is expressed in equation (5-2).

$$\text{\#CVSD WORDS PER MINOR FRAME }_{\text{CALCULATED}} = \frac{\text{DESIRED CVSD BIT RATE}}{\text{MINOR FRAME RATE} \bullet \text{WORD WIDTH}}$$ (5-2)

Next, round up (if required) the result of equation (5-2) to the nearest integer. To satisfy the evenly spaced recommendation, round up (if required) to the nearest integer that divides evenly into the number of PCM words per minor frame.

Finally, for either case, substitute the result of equation (5-2) back into equation (5-1) to determine the actual CVSD bit rate. To illustrate this procedure, consider the following numerical example for determining the CVSD bit rate. An existing PCM format has the characteristics:

> Bit rate = 192,000 bits/second
> Word width = 12 bits/word
> Minor frame rate = 100 frames/second
> Words/ minor frame = 160 words/minor frame

To insert a serial CVSD bit stream with a desired (target value), CVSD bit rate of 16,000 bits/second will require the following procedure. Based on the information given, use equation (5-2) to calculate the #CVSD words per minor frame.

$$\text{\#CVSD WORDS PER MINOR FRAME }_{\text{CALCULATED}} = \frac{\text{DESIRED CVSD BIT RATE}}{\text{MINOR FRAME RATE} \bullet \text{WORD WIDTH}}$$

$$\text{\#CVSD WORDS PER MINOR FRAME }_{\text{CALCULATED}} = \frac{16\,000\,(bits/\sec)}{100\,(frames/\sec) \bullet 12\,(bits/word)}$$

#CVSD WORDS PER MINOR FRAME$_{\text{CALCULATED}}$ = 13.3 words/frame

Rounding up the #CVSD words per minor frame to the nearest integer yields 14. In this example, there are 160 PCM words in the minor frame. If the user needs to satisfy the evenly spaced criteria, then by inspection, the #CVSD words per minor frame will be rounded up to 16. For comparison, both cases will be substituted into equation (5-1) to yield the actual CVSD bit rate.

CASE 1: (unevenly spaced CVSD samples, NOT RECOMMENDED)

$$\text{\#CVSD WORDS PER MINOR FRAME }_{\text{CALCULATED}} = 14\,(words/frame)$$

CVSD BIT RATE = MINOR FRAME RATE • #CVSD WORDS / MINOR FRAME • WORD WIDTH

$$\text{CVSD BIT RATE }_{\text{ACTUAL}} = 100\,(frames/\sec) \bullet 14\,(words/frame) \bullet 12\,(bits/word)$$

$$\text{CVSD BIT RATE}_{\text{ACTUAL}} = 16\,800\,(\textit{bits}/\text{sec})$$

CASE 2: (evenly spaced samples, RECOMMENDED)

$$\text{\#CVSD WORDS PER MINOR FRAME}_{\text{CALCULATED}} = 16\,(\textit{words}/\textit{frame})$$

$$\text{CVSD BIT RATE} = \text{MINOR FRAME RATE} \bullet \text{\#CVSD WORDS PER MINOR FRAME} \bullet \text{WORD WIDTH}$$

$$\text{CVSD BIT RATE}_{\text{ACTUAL}} = 100\,(\textit{frames}/\text{sec}) \bullet 16\,(\textit{words}/\textit{frame}) \bullet 12\,(\textit{bits}/\textit{word})$$

$$\text{CVSD BIT RATE}_{\text{ACTUAL}} = 19\,200\,(\text{bits/sec})$$

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