DIGITAL VOICE DECODER

Robert Myers
Telemetry Data Center
Naval Air Warfare Center
Aircraft Division
Patuxent River, MD 20670

ABSTRACT

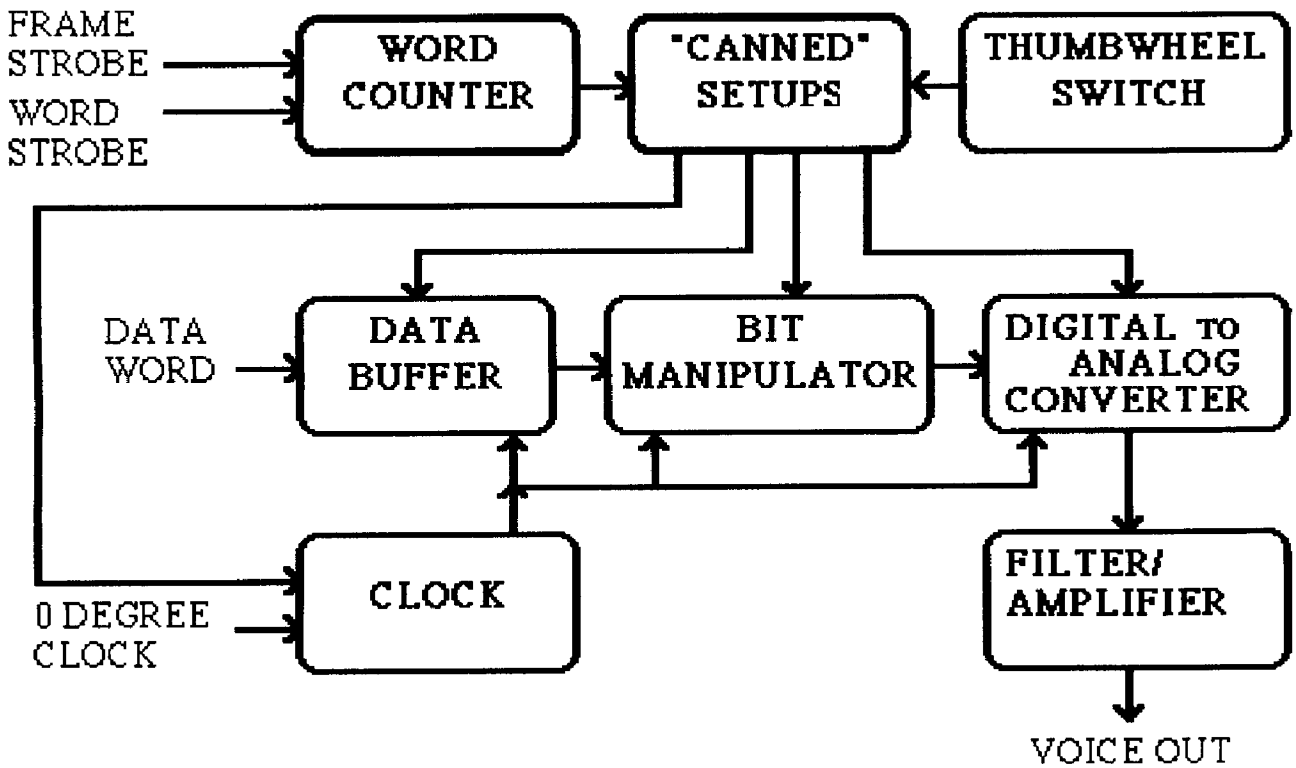
In the world of Real-Time Telemetry, a vital element is voice communications. Aircraft "hotmike" provides a continuous one way link from the aircraft to the Data Center, thereby allowing the flight test personnel to monitor all cockpit audio. Pulse Code Modulation (PCM) containing digitized hotmike is one method used to transmit voice. This paper details a device that extracts digitized voice words from a PCM stream and then converts this data to its original analog form.

INTRODUCTION

Through the years, various transmission techniques have been explored in search of an effective means of providing voice communications. Three criteria driving the search include quality, security, and ease of implementation. Digital voice communication clearly surpasses analog in quality and security. Its integrity is less susceptible to noise and distortion, thereby keeping quality high. For security, digital information lends itself to encryption. In fact, many analog signals are digitized prior to encryption. Ease of implementation is a toss up. When starting from scratch, analog technology is less complicated and more cost effective. However, the majority of the test aircraft equipped with cockpit hotmike are also equipped with telemetry instrumentation, including a PCM transmitter. Therefore, the digital voice can be mixed with existing transmitted data, reducing implementation cost and labor. W ith the three criteria satisfied, digital voice transmission has proven to be an effective communication media.

GENERAL

The Digital Voice Decoder (DVD) strips supercommutated voice words from a PCM data stream and then converts them to an analog signal. The digital to analog conversion is performed in two formats; continuous variable slope delta (CVSD) modulation and A-law companding. A decommutator provides the DVD with the necessary signals, which include the data word (16 bits or less), frame lock, frame strobe, word strobe, and clock. The supercommutated voice words are pulled from each frame of data as designated by one of eight "canned" setups selected by an octal thumbwheel switch. Figure 1, the block diagram, illustrates the DVD's basic architecture.



Block Diagram
Figure 1

WORD COUNTER

The Word Counter identifies the current word position of the decommutator. Frame strobe, indicating the beginning of a new frame of data, resets the word count to one. Then, with each word strobe, the count increments. Three 74LS161's readily perform this task. A total of ten bits are used, enabling a maximum count of 1023 words per frame of data.

"CANNED" SETUP

A 2764 8K byte EPROM is the main component of the "canned" setups. The three most significant EPROM address bits are provided by the thumbwheel switch. This divides the programmable memory into eight 1K byte sections selectable by the user. The remaining ten address bits are taken from the word counter. Voice word positions are identified by D0, the least significant EPROM data bit (l = voice, 0 = ignored). As the word count progresses, the "canned" setup strobes the data buffer on each voice word occurrence. The EPROM data also includes board setup information. The seven most significant bits of the first four bytes of each memory segment identify clocking, bit manipulation, and digital to analog conversion data as follows:

WORD	D7D6D5D4	D3	D2	D1	D0
1	Clocking 4 LSB's	MSB/LSB First	1	1	X
2	Clocking 4 MSB's	CVSD or Companded	1	0	X
3	Bit Pointer Start	1	0	1	X
4	Bit Pointer Stop	0	0	1	X
5…	0 0 0 0	0	0	0	X

The remaining bytes, 5 and greater, hold no information pertaining to board setup. Four D-type flip-flops (74LS174's) store the board setup throughout each frame of data. These are addressed by D1 and D2 for words 1 and 2. D3 provides additional addressing for words 3 and 4 since two bits, D1 and D2, only give four counts and a fifth condition is needed; idle operation, no infomation stored.

DATA BUFFER

Sixteen bit voice words from the decommutator are strobed into the Data Buffer by the "canned" setup, where they are stored until read by the bit manipulator. This data buffer consists of two eight bit "First In First Out" (FIFO) memories (IDT7202's) with a depth of 1024 words. The number of words in equals the number of words out for each frame of data; therefore, the FIFO's have ample depth to handle any setup.

CLOCK

The supercommutated voice words stored in the FIFO must be clocked out at the appropriate rate to properly reproduce the analog audio signal. The DVD Clock, a simple divider circuit consisting of two 4 bit counters (74LS161's) and two 4 bit comparators (74LS85's), counts the decommutator zero degree clock pulses then compares this to the divisor held in the "canned" setup. When the values are equal, the counters are reset and a DVD clock pulse is generated. Synchronizing the DVD to the decommutator guarantees that the DVD clock runs at the correct frequency. The divisor is derived as follows;

For CVSD,

Divisor = Words per Frame/Voice Words per Frame.

For Companding,

Divisor = Words per Frame/(2*Voice Words per Frame).

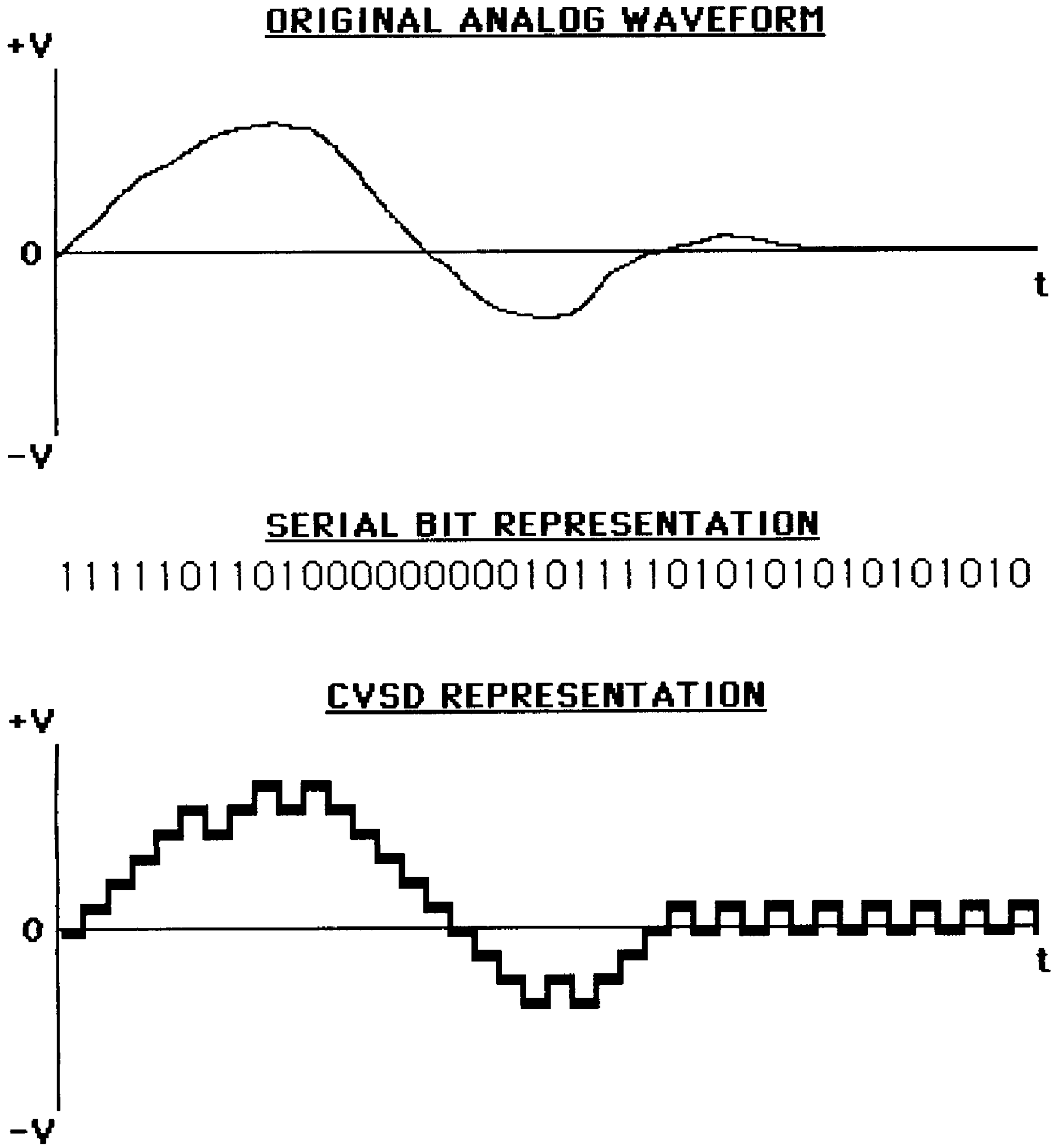
The CVSD decoder requires only one clock pulse per voice data bit while the decoder handling the companded audio requires two.

BIT MANIPULATOR

The Bit Manipulator also operates based on values defined by the "canned" setup. Driven by the DVD clock, a 4 bit up/down counter (74LS169) addresses a 16 to 1 multiplexer (74150) that serializes the current data buffer output word. The counter loads the bit pointer start value then counts up or down (MSB/LSB first) until it reaches the bit pointer stop value. At this point, a 4 bit comparator (74LS85) recognizes the equality and, upon the next DVD clock pulse, reloads the counter with the start value and reads another voice word from the data buffer. This method of bit manipulation allows full flexibility when converting the parallel data words to serial data.

ANALOG TO DIGITAL CONVERTER

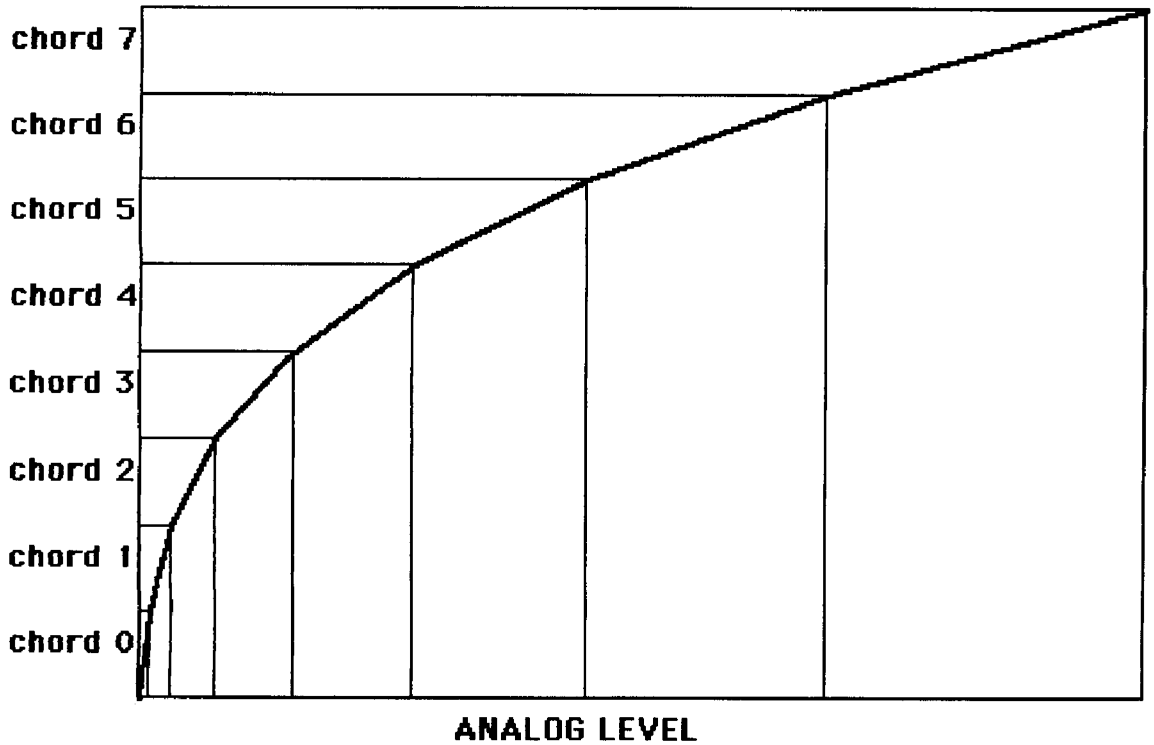
At this stage, the Digital to Analog Converter restores the serial stream of voice bits to an analog form. CVSD or Companded decoding is selected by an analog switch (MCl44066) as designated by the "canned" setup. The CVSD decoder (HC55564) accepts the digital data one bit at a time. A low (0) bit causes the output voltage to drop by a small amount (negative delta). On the contrary, a high (1) bit causes a slight increase (positive delta). Over time, as the series of bits are clocked into the decoder, continuous minute changes are made to the output voltage of the chip, hence the name continuous variable slope delta, or CVSD (see Figure 2).



CVSD Encoding

Figure 2

The other decoder, an MC 145505, utilizes A-law companded audio guidelines set by the CCITT (Comite Consultatif Intemationale de Telegraphie et Telephonie), a committee responsible for setting international communication standards. Companding is the digital compression (encoding) and expansion (decoding) of analog information. A-law standards specify a nonlinear companding process. The 8 bit word representing each analog data point is broken into three parts; (1) a sign bit, (2) three chord select bits, and (3) four step select bits. The sign bit identifies signal polarity, (1) positive or (0) negative. The three chord select bits combine to identify one of eight segments, with each successive chord encompassing a range of analog voltage levels, creating a nonlinear digital representation (Figure 3).



A-Law Companding
Figure 3

The four step select bits evenly divide each chord into sixteen sections. In addition, A-law specifies that all odd bits be inverted (zero, 00000000, appears as 01010101), creating a greater number of transitions in the digital data stream.

FILTER/AMPLIFIER

The raw outputs of the digital to analog converter must be smoothed and then adjusted to the appropriate level. This is the function of the Filter/Amplifier, the final stage of the Digital Voice Decoder. A two pole low-pass filter having a cutoff frequency of 7.2 KHz rounds the stepped corners of the signal. Then, an amplifier allows adjustment of the final voice output to three volts peak to peak. A dual operational amplifier (1458) supported by discrete components performs both tasks.

CONCLUSION

The Digital Voice Decoder has existed in printed circuit board form for two years and, used on a regular basis, has exhibited no hardware failures. Its size, 4.5 X 7 X .75 inches, allows the DVD to be chassis mounted in some PCM decommutators. Durability and compactness stem from efforts taken during design and build-up. Two considerations taken to mind were simplicity and flexibility. Most PCM formats can be accommadated while CVSD and A-law companding are the two most widely used voice digitizing processes for cockpit hotmike. Even with the availability of digital voice quality and security, most aircraft still utilize analog FM for cockpit voice transmission. This is partially due to a lack of standards. Once developed, standards will further reduce size, complexity and cost, thereby promoting greater usage of digitized voice technology.

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