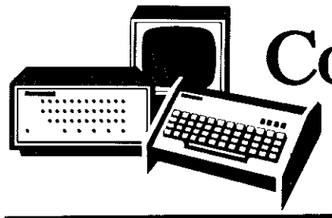


Computer Bits

By Hal Chamberlin

DIGITAL MAGNETIC RECORDING

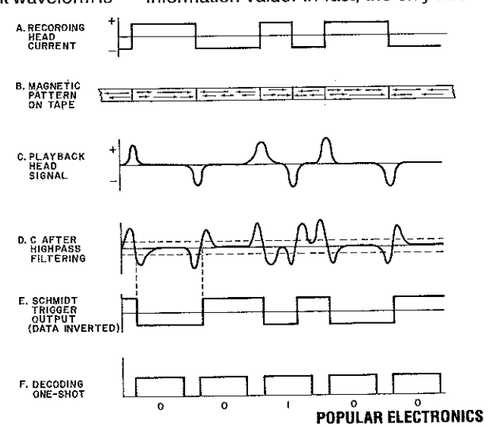
IN AN EARLIER column, many different *audio* data recording techniques were described. One feature all of them had in common was the overriding requirement for compensation for waveform distortion and frequency-response limitations of audio cassette recorders. The consequence is low speed (typically between 100 and 1000 bits per second) and an unsatisfactory reliability factor for serious personal or business use. Both of these problems can be overcome through the use of direct *digital* recording on the tape, thereby bypassing the audio circuitry.

Saturation Recording. Direct digital recording is also called saturation recording because the magnetic coating on the tape is fully saturated by the recording process. Normal audio recording uses only a small portion of the tape's "magnetic energy" to reduce harmonic distortion to acceptable levels. By magnetically saturating the tape, however, variations in tape sensitivity are masked and the higher-level playback is better able to overcome noise.

With saturation recording, referring to the waveform of the signal is no longer meaningful since everything is distorted into square waves. The basic signal element is the flux transition. As shown at (A) in the figure, the current waveform is either fully positive for north-south magnetization of the tape or fully negative for south-north magnetization. The actual magnetic pattern recorded on the tape is shown at (B).

When playing back the illustrated pattern, one would expect the playback head's signal to closely resemble the square-wave signal recorded on the tape. Actually, the action is similar to that of an induction coil so the signal on the playback head appears as at (C). A signal is produced in the coil only when the magnetic field is changing. Thus, portions of the tape with a constant magnetic field produce no signal when they pass the playback head gap. The boundary separating opposite magnetic directions, however, will produce a pulse in the playback head when it passes. As illustrated, a transition from north to south produces a positive-going pulse, while a transition from south to north produces a negative-going pulse.

At first glance, it would seem that encoding bits into flux transitions would be simple: provide a north-south (positive playback pulse) for a one and a south-north (negative pulse) for a zero. Further thought, however, reveals that it would be impossible to obtain two ones or two zeroes in a row since pulse polarity always alternates and, therefore, has no information value. In fact, the only information content in the playback waveform is the relative timing of playback pulses.



Waveforms involved in direct digital recording (or saturation recording), from current in the recording head to decoded digital pulses.

Waveforms (D) and (E) in the figure show how these playback pulses are accurately detected and converted into digital pulses for use by a computer or logic circuit. Since information is encoded in the pulse timing, it is desirable to find the center of the playback pulse, which corresponds to the actual point of flux transition. High-pass filtering of the playback waveform (D) produces a double pulse that crosses zero at the exact center of the playback pulse. Accuracy of this center point is largely unaffected by the amplitude of the playback pulse. Final recovery of the original recorded square wave is accomplished by passing the filtered signal through a symmetrical Schmitt trigger that converts it into a logic signal suitable for computer use.

For maximum speed and data capacity, it is desirable to be able to pack flux transitions as close together as possible. The limit is reached when they are so close together that adjacent playback pulses interfere excessively with each other. The result of such interference is called peak shift since peaks of the playback pulses shift position slightly while trying to equalize their density. The effect of peak shift is to reduce data recovery reliability because timing, which contains the information, is distorted.

Encoding Bits. The information content of the playback square wave is in the timing of transitions from 1 to 0 and from 0 to 1. There are several ways to encode bits into transition timing, but the most popular is called "double-frequency encoding." In this case, a bit cell always starts with a transition. A 1-bit is signified by the occurrence of another transition a short time later. A 0-bit consists of just the initial transition. (The data pattern shown in the figure illustrates the double-frequency encoding method.) The transitions that always occur at the beginning of the bit cell are termed *clock* transitions since they mark boundaries between bits. The transitions that may occur in the middle of the bit cell are termed *data* transitions since they contain the binary information.

The main advantage of double-frequency encoding is in the ease with which it can be generated and decoded. Decoding is simple and can be done with a one-shot circuit. The trick is to use a one-shot that will trigger whenever its input changes, unless it is already trig-

gered. For accurate recovery of data, the one-shot's pulse width is set to 3/4 of the bit-cell time. When driven by the recovered square wave, the one-shot will fire on the clock transitions. If another transition occurs while the one-shot is fired, a 1-bit is recovered. If the one-shot times out before the next transition, then a 0-bit has been recovered.

Encoding methods can be characterized by their encoding efficiency ratio. This is the ratio of the total bit-cell to the minimum spacing between flux transitions. Since the maximum density of flux transitions is limited, a higher ratio means more data storage capacity and higher speed. The encoding efficiency ratio of double-frequency encoding is ½, which is not very good. Other methods, called "double density" encoding, exhibit ratios as high as 1.0. They are much more difficult to encode and decode, however, and are more susceptable to defects in the maghetic media.

Formats. In both cassettes and floppy disks, the record data is organized into blocks called records. On cassettes, records may be any length and, in fact, are usually entire programs. On floppy disks, however, the records are fixed in size to allow easy addressing and updating of data. A typical record size is 128 bytes, which is large enough to minimize the percentage of "overhead" yet small enough for convenient use.

On a disk, data records are called sectors. Some method of marking off sector boundaries and separating them is necessary if an individual sector is to be updated without disturbing adjacent sectors. The simplest method of doing this is called *hard* sectoring because holes punched into the disk itself determine the sector boundaries by means of a light and photocell arrangement. Another method uses special patterns in the data itself to mark sector boundaries and is, therefore, called *soft* sectoring. Since these special patterns take additional space, the overhead associated with soft sectoring is greater. In fact, a full-size floppy disk using hard sectoring can put 32 sectors on a track, while a soft sector disk can manage only 26—a 23% difference.

Besides a reduction in capacity, the soft sector format is much more difficult to decode. The use of integrated circuits specifically designed to handle soft sectoring, however, effectively masks this complexity from the user. Today, most floppy-disk systems use soft sectoring in spite of the data capacity reduction. ◇

Software Sources

By Leslie Solomon
Technical Director

MBS BASIC. Written for the Fairchild F8 processors, this BASIC occupies 16K including code, work area and text buffer. It features 9-digit precision and a full complement of BASIC statements, functions, operators, variables and has special control characters, commands, and some planned enhancements that include file handling capability. $175 on Fairbug format paper tape. Further information from Micro Business System, Inc., Box 8255, JFK Station, Boston, Mass. 02114 (Tel: 617-682-1854).

Disk Payroll. Written for the TRS-80, this interactive payroll system has automated file handling and an output for the TRS-80 line printer. It includes quarterly summaries. $59.95. Hebbler Software Services, 7142 Elliot Dr., Dallas, TX 75227.

PET BASIC Compleat. This program features 20 lessons on PET BASIC, cursor control, screen editing, and the use of graphic characters. Over 400 screenfulls of information are contained in the two cassettes. The manual is 170 pages. $39.95 from ARESCO, Box 43, Audubon, PA 19407 (Tel: 215-631-9052).

IDSWORD. Written in North Star BASIC (version 6), and DOS (release 4.0), this word processor features: insertion, deletion and block moves of text; global searches; complete text editing; variable speed scrolling; page number and titling (top or bottom); reformatting data for maximum line size; control of merging and justification; processing of non-IDSWORD files; merging of up to 10 files; form letter printing with justification and text insertion from up to 20 mailing list files; and sorting and printing of mailing labels. Basic system is $125, complete word processor is $245 (CRT) and $220 (printer). Add $50 for form letter, labels and name/address file maintenance and sort modules. CW Applications, 1776 E. Jefferson St., Rockville, MD 20852 (Tel: 301-468-0455).

General Catalog. A number of programs ranging from games to financial packages for just about any computer and disc or cassette interface is covered in a catalog from Soft-One, 315 Dominion Drive, Newport News, VA 23602.

TRS-80 Cassette. Running in any 4K, Level-II TRS-80, this cassette includes a financial program with amortization, interest, etc., a biorhythm program including a perpetual calendar, a doodle program that uses TRS-80 graphics, a decision-making program, and a Mastermind program. $12.95. Complete Computer Services, 8188 Heather Drive, Newburgh, IN 47630 (Tel: 812-853-5140).

Speech Vocabularies. An application note describing how to swap, save and restore vocabularies is now available. Written for users of the Model 20 speech recognition systems as used in Apple II and S100 systems, the approach enables recognition of multiples of 32 words, thus providing virtually unlimited vocabulary size. Heuristics, Inc., 900 San Antonio Road, Los Altos, CA 94022 (Tel: 415-948-2542).

Accounting Package. Version 1.0 of the Alpha Accounting software package includes general ledger, inventory control and payroll. Full documentation and test data is included. The package is designed for use with systems using the Alpha AM-100 CPU board. Alpha Micro, 17881 Sky Park North, Irvine, CA 92714 (Tel: 714-957-1404).