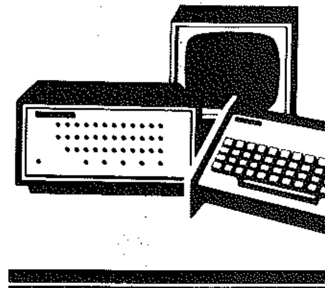

Computer Bits

By Hal Chamberlin

COMPUTER MUSIC

COMPUTERS can create music either by controlling external (usually bus-connected) sound-synthesizer hardware or by using software to create the desired waveforms within the computer. Although the software approach has the greater potential, at this time, better results are obtained using hardware synthesis.

Probably the first software synthesis "music" program was written for the original Altair-8800 computer. It allowed the minimal 256-byte machine to play a simple melody a few dozen notes long using an AM radio in close proximity to the computer or an audio amplifier connected to a front-panel LED as the output method. A more sophisticated program along these lines, called the Music System, was later offered by Processor Technology. It allowed three *simultaneous* tones to be synthesized using the Interrupt Enable line of the S-100 bus as the output signal. Using three independent tones, it was possible to create chords, the melody line, counterpoint, or bass parts of music.

Although these purely software techniques required little or no hardware for sound generation, they invariably created buzzy reed-like tones. It is safe to say that every computer on the market (and even one brand of hand-held calculator) has a music program of this sort available for it. Although sound quality is extremely limited, some of the software for entering notes into the computer is quite imaginative.

The better software synthesis systems make use of a digital-to-analog converter (DAC). Basically, a DAC is a device that can accept a high-speed data stream from the computer and generate a waveform directly corresponding to those numbers, much like plotting a graph. Though DAC's used to be very expensive devices, one can now be built from scratch for a few dollars (see "Computer Bits," Sept. 1976) or purchased ready to plug into a computer for about $50.

The secret of success when using a DAC is to write a program that can compute the data corresponding to desired sounds at a rate high enough (8000 numbers/second or more) for acceptable sound quality. The October 1976 "Computer Bits" column in fact gave a listing of a program that could synthesize accurate telephone TouchTones complete with the necessary sine waveshape using nothing but a DAC. Since TouchTones are actually two tones sounding simultaneously, producing waveshapes other than square or pulse, this was the first step toward improved microcomputer music synthesis.

The sine waveform was actually obtained from a table in memory. Knowing this, it should therefore be possible to change the stored waveform to anything desired and thus add the dimension of *timbre* to low-cost microcomputer music synthesis. This in fact is exactly what Newtech Computer Systems, Inc. did with its model 80 music board for S-100 bus computers and associated software. In addition, the TouchTone program was modified for three simultaneous tones with greater pitch accuracy and routines were added for computing waveforms having desirable harmonic content. The most important point, though, is that these two systems represented a quantum leap in microcomputer software synthesis sound quality.

A couple of years ago, Micro Technology Unlimited announced its DAC based music synthesis system for the KIM-1 microcomputer. The DAC board supplied with the system was an improved design with full 8-bit resolution, a sophisticated low-pass filter (essential to realize the full potential of 8-bit conversion), and a low-power audio amplifier.

HUH Electronics, with its "Petunia," was the first source to offer a DAC-based music system to Commodore PET users. Although the DAC hardware and associated software were below the level established by Newtech and Micro Technology, they nevertheless gave PET owners much better sound quality than previously. Now Micro Technology Unlimited has adapted its KIM-1 system to the PET, giving the latter's user a "state-of-the-art" software synthesis system. Apple II users can get substantially the same system under the name "Micro Composer" from Micro Music, Inc. The big difference is an extremely sophisticated music-entry program which makes full use of Apple II high resolution graphics capability to display the actual music score *in motion* while the music is being played!

Hardware Synthesizers. During the last three years, several hardware music synthesizers have been introduced. When using a hardware synthesizer, the computer needs only to instruct it as to the desired tone frequency, amplitude, timbre, etc., and the board takes over actual waveform generation. The main advantage of these boards is that the computer has lots of time for other functions such as updating a video display, scanning a keyboard, or directly interpreting a score. In fact, it is even practical to control a hardware synthesizer from BASIC, an impossibility with a software synthesis system. Another advantage is that more sophisticated tones with amplitude and even timbre envelopes can be easily synthesized.

For S-100 users there are two hardware synthesizer boards currently available. Each can synthesize only one tone, but that tone can be controlled with a great deal of precision. Thus, chords and multi-part music will require three or more boards.

The Solid State Music SB1 synthesizer board, for example, offers a 9-octave range and a waveform memory capable of holding 8 different, 32-step waveforms. While playing a note, the board is capable of automatically sequencing through four of these waveforms, which results in a more interesting and realistic timbre. A hardware envelope generator with programmable shape is also present.

The ALF Products AD8 synthesizer board spans only 7 octaves, but gives more accurate pitches while the timbre is stored as a single 128-point waveform. A sophisticated four-part envelope generator in which each part is independently programmable is also provided. A distinct advantage of the ALF board is that its digitally synthesized waveform is filtered by a programmable lowpass filter which gives it a cleaner sound quality.

Hardware synthesizers for other computers are not nearly as comprehensive as the preceeding two, but they do exist. ALF has a synthesizer board for the Apple II which can generate three tones at once (see Computer Bits, October 1979 for details). The tones are limited to rectangular waveforms, but independent envelopes are provided. The RCA COSMAC VIP is endowed with a synthesizer accessory as well. This board can produce two square-wave tones with amplitude envelopes. A companion board can produce percussive sounds, such as drums, under program control.

Future Prospects. Future prospects for microcomputer synthesized music are exciting indeed; most of the activity is likely to be in the DAC-software area. New developments will be fueled primarily by continuing decreases in the cost of memory and disk storage coupled with increases in microcomputer speed. An experimental PET-based music system using DAC hardware has been demonstrated which can give an independent amplitude envelope to each *harmonic* in a tone. This results in fairly realistic instrument sounds as well as increased ability to conjure up new sounds. The technique requires a lot of memory, but "fully-stuffed" systems are becoming quite common these days.

By now most readers have read about the advantages of digital audio. Digital audio playback systems using home video recorders are being brought to market, and systems using video disks are expected in the future. These promise fidelity significantly higher than that available from today's tapes and disks.

The significance of this is that digital audio systems are nothing more than DAC's being fed a string of numbers—although more bits and higher speeds are used than have been discussed. With the increasingly common *double-density* floppy disks and even hard disks being used with microcomputers, it becomes feasible to use software to compute highly accurate sound waveforms and write resulting numbers on the disk.

After the numbers are written (which may take many times the duration of the piece), they can be read back at high speed and sent to the DAC. The synthesized sound quality possible with this approach is so high that there is essentially no limit as to what can be achieved in this way. ◇