The New Sound Of Computerized Music

Digital synthesis and personal computers put composers in tune with a new kind of music

by Arielle Emmett, Associate Editor

It was a question of imagining his music: There were notes he could hear in his head that he couldn't play. It was a question of limitations: There were melodic lines he could hear in his head but couldn't play. There was the matter of sound being the product of the physical composition of instruments. So many instruments could produce so many wave forms, and no more.

For Bruce Hutcheon of Bayshore, L.I., a serious home musician and computer buff, the question ground down finally to need, and fulfilling that need, and it had bothered him in one way or another since his music study days at New College, Sarasota, Fla. (now part of the University of South Florida), where he had written string quartets and polyphonic exercises, several of which he had never heard played. He needed to find the right technology to help him compose, shape, and perform complicated works of music that were beyond his own technical capabilities as a performer. And he wanted to shape sounds with absolute mathematical precision—in his words, "to build (instrumental) voices" that had no counterpart in nature, or at least in the traditional lexicon of orchestral sound.

Hutcheon found the right technology, finally, through his own personal computer, an Apple II Plus, and a music synthesizer system. "I've been limited so long," admits the 31-year-old Hutcheon, a veteran of the cumbersome electronic music synthesizers of the 1960s. "Now," he says, "I really enjoy building sounds. When you start out on an older synthesizer and move over to a computer, it's very easy to create instrumental voices."

Hutcheon isn't unique. He's one of thousands of musicians throughout the country—from elementary school kids experimenting with their first electronic keyboards, to composers as advanced as he, even professional musicians—who are taking advantage of new and increasingly affordable hardware and software music systems that have filtered down from state-of-the-art digital technology. Digital synthesis is the means by which a computer can make and store a mathematical representation of a sound wave, and then reproduce it again as an audio signal. These systems, many of them ready to plug in and play, vary widely in sophistication, fidelity of sound, and price. But virtually all the systems make it possible for a home musician to wed a personal computer to keyboards, software, and, in the better systems, digital oscillator boards, and to make music.

"You can create up to 16 instrumental voices, so it's a symphonic effect plugged into your stereo," Hutcheon says of his own system, a combination of hardware and mu[illegible] scoring and performance softw[illegible] from Mountain Computer (San Cruz, Calif.) and Passport Desi[illegible] (Half Moon Bay, Calif.), two of t[illegible] leaders in the field. (See sideb[illegible] page 76.) In addition to creating d[illegible]ferent instruments with the sy[illegible]thesizer, a musician can also "d[illegible]sect" the shape, tone, and color o[illegible] musical note. This is done by mani[illegible]lating mathematical values of [illegible] note—its pitch, duration, freque[illegible] rate at which it is sustained or dec[illegible] numbers, and types of overton[illegible] etc.—or by drawing its wave f[illegible] with computer graphics, in which [illegible] musician actually "sees" the sound [illegible] is about to play.

Controlling the sound

"The essential issue is you have c[illegible]trol over the sound," declares Hut[illegible]eon's friend and fellow-musician K[illegible] Kohler, who by day shares busi[illegible] responsibilities with him in the t[illegible] communications and computeri[illegible] business accounting company t[illegible] run, Synergistic Communicati[illegible] Inc. "The music system not only p[illegible]vides complete flexibility in cont[illegible]ling the wave form," he says with [illegible] sober precision of the music [illegible]icionado, "but it can also offer im[illegible]diate feedback, do the work of m[illegible] performers," teach basics, and rec[illegible] in up to 16 tracks—a capability s[illegible]passed only by professional mu[illegible]

Hutcheon and Kohler (right) begin to define an instrumental voice by manipulating a wave form on the screen. As Kohler pla). Hutcheon enters different numerical values on his Apple II Plus which determine the unique sound qualitites of the note.

studios. What's more, a good home synthesizer can play back recorded music "literally thousands of times without distortion," Kohler says—and that is the essence and "beauty" of digital technology.

"The main difference is how the music is produced and stored," Kohler continues. Old-fashioned recording and synthesizing devices, such as the famous Moog synthesizer of the 60s and early 70s, were based on the idea of analog storage—that is, an audio signal was produced and stored in such a way that the physical pattern of its wave form was actually "captured" in a medium (such as the grooves of a record or magnetic tape). "The original Moog synthesizers were actually analog computers," Hutcheon adds. Instead of dealing in numbers, they dealt in continuous functions which produced a wave. This, in turn, was converted through an electronic circuit into a signal, and then amplified.

Cutting out distortion

But gradually, Hutcheon continues, there was a progression from the old synthesizers—the kinds he and Kohler used in college to compose music—to various devices that represented "primitive forms" of digital control. These included paper tape devices with holes punched in them, much like teletype machine code and the keyboards themselves. The actual sound-producing circuits were still analog types—they produced sounds by control voltages going up an down—and the early synthesizers a so contained complex "sequencers" a bank of horizontal and vertic knobs controlling the pitch, volum and other parameters of the not Sound filters and patching cabl were also required. In all, a compl expensive, and time-consuming sy tem whose sound, if recorded, wou deteriorate over time, in the san way as records and tape deteriora because the analog "tracks" we out.

"But in digital synthesis ar recording," Kohler enthuses, " that's stored is a series of numeri values which can be used to create analog of the wave form," i.e., t actual audio signal. This, in essen is the synthesizer's precise mathematical rendering of every sound stored and played. Since there is no "track" or groove to wear out, the reproduction of the sound remains virtually distortion-free over thousands of playings.

Today, home digital synthesizers form a subset of a broader range of music systems owned by roughly 5 percent of all home-computer users, according to industry analysts; some of these systems still use analog oscillators to produce their sounds. (Examples include the three-voice analog synthesizer chip built into the Commodore 64.) In the very advanced digital systems, though, software—in conjunction with the computer and the digital oscillator board producing the audio signal—analyzes sound by literally "slicing up" a wave form—taking samples of it at a constant numerical rate; the more samples, the more precise the mathematical "representation" of the wave form. Once this representation—known as a cycle definition—is established, the computer can then play back the numbers at the same rate, producing an exact "copy" of the sound.

According to Chris Albano, vice president of marketing for Passport Designs Inc., the current intermediate-line home digital systems, such as Soundchaser and alphaSyntauri from Syntauri Corp. (Palo Alto, Calif.), do not feature sampling capability. Instead, current systems use "wave form approximation" in which, he says, "we copy a violin (numerically) and stick it into the software." Albano predicts sampling capability will be available in home synthesizers in the not too distant future.

While the industry is moving in that direction, says Ellen Lapham, president of Syntauri Corporation, she also cautions that this feature would be costly and suited only to consumers demanding professional sound-analysis standards. "What we give the user in lieu of expensive sam-

WHAT TO DO IF YOU WANT TO BUY

An important thing to remember in assessing your needs for a home music system linked to your personal computer is that there are as many varying levels of sophistication as there are types of musicians. On the most basic level, some personal computers, such as the Apple, are equipped with small speakers, or "beepers," which do not contain an actual synthesizer, but can produce rudimentary pitches when wed with the right software. On a slightly more advanced level are computers with various types of sound-producing chips built in—such as the digital chip for the Atari 400, 800, and the 1200 XL, which can produce four voices in a three and one-half octave range; and the analog-type synthesizing chip for the Commodore 64, which can produce up to 10 different musical instruments, three played simultaneously. These systems are controlled through software and the computer's keyboard; both Commodore and Atari feature add-on cartridges, allowing the musician to write music and learn music fundamentals.

To create a more sophisticated system, an operator can add to some computers a digital-to-analog converter board (DAC). Pure software music synthesis programs, such as Instrument Synthesis Music from Micro Technology, can run on computers with the DAC. Other systems are self-contained, such as Compu-Music from Roland Corporation (Los Angeles, Calif.), which features a six-voice music synthesizer that interfaces with many different personal computers. The Music Card from ALF Inc., offers a three- or nine-voice synthesizer board, a sophisticated music editor, and software which runs on Apple IIs and Apple II-compatibles only.

"It allows the students to write something, use the music editor, and play it right back," he says. He uses the system in conjunction with 42 Apple IIs to tailor his instruction to each student's individual level of musical training. This is facilitated by versatile software programs such as Apple Music Theory, available through the Minnesota Educational Computing Consortium (St. Paul, Minn.), which actually features 16 different graduated programs teaching key signatures, note types, counting, rhythm, scales, harmonics, and more complex subjects, as well as drill-and-practice sections. (Music Theory has also been configured to run on the Atari 400 and 800.) *The New York Times* recently called it "a real find for serious music students." By extension, Music Theory may also work well on the personal computer at home.

For more advanced musical capability, though, a home user may consider graduating to full-scale digital systems, including the electronic keyboard. Soundchaser, in conjunction with Mountain Computer's MusicSystem, is an example. Its standard four-octave keyboard, plus interface card, four-track polyphonic sequencer, and the Mountain MusicSystem retails for $1190. An additional software package called Turbotraks can boost Soundchaser's recording capability to up to 16 tracks. The more expensive, and well-reviewed, alphaSyntauri Synthesizer System from Syntauri Corp. (Palo Alto, Calif.) is a high-end consumer musical product that has many professional features, according to Syntauri's president Ellen Lapham. One of them is Syntauri's five-octave velocity-sensitive keyboard, which responds to a player's particular touch—i.e., it acts somewhat like a piano keyboard, and by the same token, offers the instrumental capabilities of the organ. Thus the keyboard can be electronically "divided" into different instrumental voices. In addition, Syntauri offers METATRAK II, featuring 16 separate polyphonic tracks of recording capability. The full five-octave keyboard system costs $1995 ($1795 for a four-octave keyboard system). Both ear-training (called MusicMaster, $295) and a scoring system (Composer's Assistant, $395) are available.

Composers using synthesizers are creating new and challenging forms of music.

pling hardware is a lot of software to create his own sounds," Lapham explains.

Since the systems are digital, the composer can manipulate the sounds by manipulating numbers, adds Kohler; it gives a composer the leverage to increase the volume or alter any other mathematical value that shapes the note, so that you can literally "break out of the limitations of the physical universe," he says.

Seeing notes as shapes

In real terms, this translates into note "shapes" which have never been heard before from conventional orchestral instruments. In Hutcheon's and Kohler's experience, these "shapes" suggest strange musical qualities, some of them tinny, some frankly honky-tonk, ragtime, avant-classical, harpsichord-like or oom-pah-pah, some defying labels. There is also the "schmaltz" element, Hutcheon concedes. Though he is a staunch admirer of Bartok's impressionistic techniques—the "greatly extended harmonies" and string quartets that "crawl over themselves getting to places you'd never expect," he says, Hutcheon still spends long hours "perfecting the cello voice" on the synthesizer because of its romantic, even "sloppy" qualities that lend themselves to such long compositions as "Carlaluna," which, he says, is "named after a fictitious woman."

Kohler, by contrast, seems to defend the more non-conventional acts of the music. "I wouldn't say the experience was intentionally recreating the past," he says, referring to his own work, "The March of the Mixed Vegetables," a selection *Personal Computing* listened to on Hutcheon's system (it was recorded and played back). "I conceived it as a multimedia event.... Ideally, there would be vegetables walking down the street," as the music played, "but failing that, a film would be it," Kohler says.

Unfortunately, the film was never made. But listening to the composition did confirm that Kohler had achieved quite a "squishy" quality in the music; it had a feel of parade, ragtime, sluggish vegetable matter, and tubas, all rolled into one. To be fair, it was comic and subtle, but the sound quality, especially in the percussive sections, was surprisingly weak. And the tempo seemed to drag—deliberately or not. Kohler admitted that percussive sections, including the so-called "piano" voice of most current home synthesizers, are weak—possibly because the synthesizers do not have the capability to exactly create noisy or irregular wave forms. But he believes that will change over time. Also, he says, "Synthesized music has an artificial quality to it—it's hard to overcome.... It's difficult to simulate the sounds of a physical instrument."

New forms of music

"But my response to that dilemma," he continues, "is, 'Why bother?' That's one of the mechanisms of creating new things.... Who cares if it doesn't sound like an orchestra?" The fact remains that composers using synthesizers are creating new and challenging forms of music, he says.

So how, exactly, do they do it? What does it mean to shape a note, much less a musical voice? According to Hutcheon and Kohler, tones are defined not only by their pitch and duration (we know pitch because it's defined by notes on a scale, such as A flat, C sharp, etc.; duration is how long a note is held), but also by the wave form—its size and shape. A clarinet's high reedy sound, for example, looks a lot like a square wave when seen on a CRT; a cello resembles a saw-toothed wave with plenty of jagged spots, and these are known as "overtones," or harmonics, which give each musical voice its unique sound character.

In addition, there is something called the sound "envelope," which is also a measure of how a note sounds as it is played on a particular instrument. It consists of four major values which can be manipulated numerically on the Apple board and then "fed" as hexadecimal information in-

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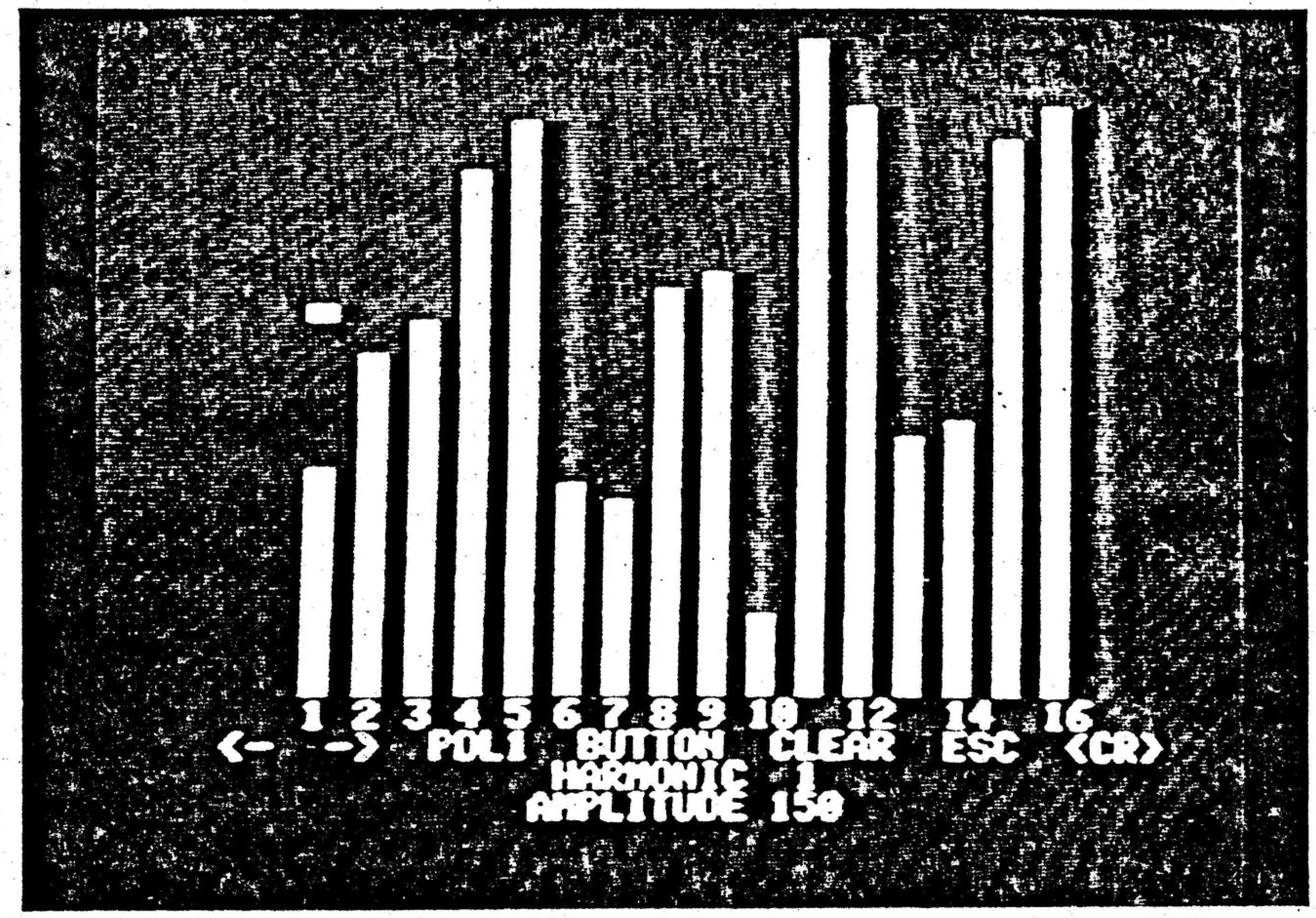

Defining an instrumental voice by manipulating the intensity of the overtones on a bar graph is part of the Soundchaser software Kohler and Hutcheon use.

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to the digital oscillators. These values are defined as Attack, Decay, Sustain, and Release. When a piano key is struck, for example, the attack—or how fast the note comes on—is relatively fast, and the decay is slow, meaning the amplitude of the note diminishes gradually. There is practically no sustain—that is, the note does not "hold" at a constant value. An organ, by contrast, will have a very high sustaining value, and almost no decay. Each musical voice then will have its own particular "wrap." Says Hutcheon: "It gives you a lot more flexibility in controlling the voices." By entering slightly different "envelope" and waveform values on each oscillator—two oscillators make up a musical "voice" (this is done to enrich the sound, much the way two strings on a piano make up one musical key)—"I can do very interesting things," Hutcheon says. He can not only alter the size of the waveform but also "make the sound transfer from one speaker to the other." This is known to experts as spatial modulation. It's all part of the challenge of regulating the data—the envelope, the wave form, and the musical score.

There is much data to generate, Hutcheon admits, that as yet most home synthesizing systems—be they digital or analog—cannot do synchronously, in real time. "The software is way behind the hardware," Kohler adds. "The interface between composer and hardware is so individual no one could write a program that would relate to each individual composer."

For now, most composers using either a computer keyboard that defines pitch and duration, or a piano or organ-like keyboard which attaches to the personal computer as a peripheral must experiment and create their "musical voices" in advance of the actual performance. This is done through software packages known as "instrument definers," which allow the user, depending on the type of program, to define a wave form and its overtones either by manipulating that form on the monitor or by specifying numbers in a bar graph. In addition, some programs allow the composer to define the "envelope" numerically, as the music is being played (the Soundchaser system from Passport Designs is an example). In general, though, creating instrumental voices is still a difficult job. Says Kohler: "No one has yet come up with a satisfactory type of wave form definition. It's only been a recent capability that you can hear what you can see. People don't have visual analogs to what they hear. Drawing the wave form takes a lot of learning to know what different wave forms make different sounds."

Choosing the system

Kohler, for one, sticks to composing on a Hammond organ. Although he is very adept at the synthesizer, and has composed many works Hutcheon himself has recorded, he says the lure of the musical tinkering could take up all his time. Hutcheon, though, has responded to the challenge of synthesis in some very inventive ways: first, by choosing the right hardware and peripherals, and second, by tinkering with some of his own software.

"Even before I bought the Apple, I looked at all the computer accessories for music that I could buy," he says. His research began as early as 1980, when he started scouting around for a system. He considered buying an S-100 bus type computer, he says, but it had "nowhere near the software or the peripherals" of an Apple. A brochure from Mountain Computer introducing its first MusicSystem convinced him to take the plunge. It was an integrated system, "a real bargain," he says, for $500 (a price that has since dropped to $395), consisting of a digital synthesizer board patch cables, and software.

That system, though, was not designed for an electronic keyboard—Hutcheon had to use his regular Apple board to compose and enter all his musical data. A year later, though, he bought a four-octave Soundchaser keyboard from Passport Designs, which also included a four-track polyphonic synthesizer, interface cards, and software. This enabled him to compose and play on a more familiar interface, he says, and made it possible to manipulate the sound "envelope" of all his musical voices while he played. He saw this as a real advantage, although he still couldn't manipulate the wave form function and hear it at the same time. So Hutcheon tried something else—a software package called Instrument Synthesis (from Micro Technology Unlimited) designed to synthesize music numerically. This package requires its own digital-to-analog convertor board. "The program generated wave forms through numbers," Hutcheon explains. Those numbers were stored, and yet another program "defined the score (by entering) numbers" also, he says. "The music it can produce is very amazing," and the price was inexpensive, he adds. But it lacked a usable scoring interface.

New challenges

So now he is onto new things. His most challenging project right now is designing what he calls MusiCalc, a spreadsheet program which, "instead of producing a table of numbers, will produce music," he says. This is a way of managing the batches of complex musical data generated by all the other programs. Eventually he hopes it will allow him to "define" the musical event—any increment of music he chooses—and store it as a series of values for wave form, envelope, volume, etc., on a mathematical spreadsheet loaded onto diskettes. The format would be layered, he says; for example, the bottom layer would define the waveform, the next cell the note, and on up.

The interface between composer and hardware is very individual.

"I haven't found any hardware problems along the way," Hutcheon concludes, and software bugs have been minimal. They've been mostly constituted as limitations: Mountain software, for instance, only allows him to play about three-minutes of composition at one time. In the Mountain MusicSystem, a composer can't change voices in the middle of the piece. "All the voices must start from the beginning," Hutcheon says, even though a composer can eliminate the apparent presence of a certain instrument, such as a flute, for example, by scoring with musical "rests." Hutcheon found that the Soundchaser digital filter, which filters out high harmonics, also produces some distortion. But overall, he believes his more than $3000 investment (including roughly $1500 for the Apple and $1200 for the Soundchaser, in addition to the Mountain MusicSystem) was well worth it.

But Hutcheon is quick to caution that his is the satisfaction of an experienced musician. Systems as advanced as his, he believes, are most useful for people who really have interest and expertise in the field, though many manufacturers are indeed touting extremely sophisticated synthesizers as strong teaching tools with tutorial software and "canned" music. Hutcheon, though, believes an inexperienced user should definitely investigate the "simpler add-on" systems for Apple and other personal computers before making a larger investment.

Still, for those ready for the challenge, Hutcheon's energy and commitment to his home computer music system should serve as a model. Not only is he readying two major synthesized quartets—his "Carlaluna," and another, called "Product 19"—but he is still experimenting with those elusive voices he hears.

"If I had my choice, I'd be a music producer," Hutcheon says. "But working with the synthesizer fulfills my fantasy." ■