How To Program The CZ-101

By Jerry Kovarsky & Jim Aikin

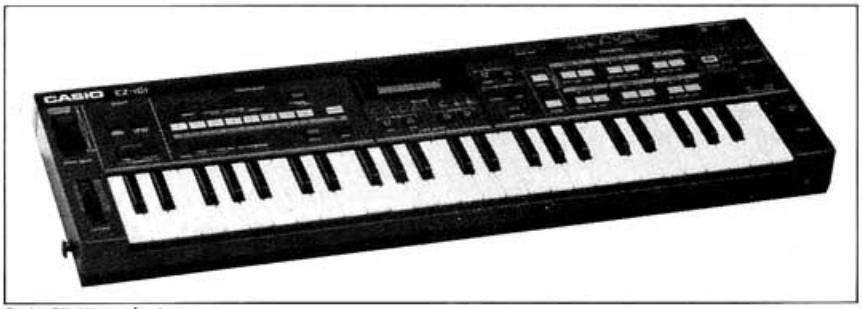
PRICES HAVE BEEN COMING DOWN all over, but for many people the era of truly affordable digital synthesis began in late 1984, with the introduction of the Casio CZ-101. While Casio had already been making digital keyboards for several years, the CZ-101 was their first foray into complete user-programmability, and unlike their previous instruments was aimed primarily at the pro musician market. Because it could be played using MIDI, the 101 quickly found a home in many keyboardists' setups in spite of its mini-keyboard.

The entire CZ series—the 101, the 1000, the 3000, and the 5000—are identical in the way they synthesize tones, differing only in their other features (full-sized as opposed to mini-keys, on-board sequencing, and so on). The type of synthesis used is a bit different from what musicians are used to, so *Keyboard* asked me to put together an article explaining how to program the CZ voice. The on-board sounds don't really show everything the CZ can do, and alternate sounds are just beginning to show up on the market. While this article cannot address every possible question or programming situation, I hope to give you a clearer picture of how to work with the machine.

The CZ voice is divided into two lines located on the right side of the machine. You can think of these, if you like, as separate audio signal paths. You can listen to either line by itself, or mix them at the output for richer, more complex layered sounds. Each line consists of a digital oscillator (DCO), a waveform shaper (digitally controlled waveform, or DCW), and a digital amplifier (DCA). Each of these elements has its own eight-stage envelope generator.

This layout should be familiar to anybody who has worked with an analog synthesizer. The DCW is very similar in function to a lowpass filter. Its envelope shapes the tone color, while the DCA envelope shapes the overall loudness and the DCO envelope affects the pitch. We'll go into more detail about the waveforms and waveshaping below.

Operations. Editing parameters on the CZ is simply a matter of selecting a parameter by hitting its button and then using the up/down, cursor movement, and envelope step buttons to change the data shown in the LCD display. Holding down either of the up/down buttons will cause the data to change very swiftly. As you are learning to program the CZ, it's probably best to use the line select button to select either line 1 or line 2 and then edit its parameters by themselves. This will help you hear the changes in the sound more clearly. If you don't hear any changes, check to make sure you're listening to the same line you're editing. When you find some settings you like, hit the line select button another time or two to hear how the line you're working on combines with the other line.



Casio CZ-101 synthesizer.

Closeup of the voice programming section of the CZ-5000, which is electronically identical to that on the CZ-101.

Envelopes. An envelope generator is a controller which allows you to shape the characteristics of a tone as a function of time. That is, envelopes cause changes during the course of each note. This is absolutely crucial in synthesis, because real-world sounds aren't static, the way raw electronic signals are; they change constantly in complex ways. To create a reasonable-sounding piano, guitar, marimba, or any other instrument, you must be able to duplicate these changes. This is where envelope generators come in.

Each CZ envelope can have up to eight segments, each with its own settings for *rate* and *level*. Some typical envelope shapes are shown in Figure 1. Both rate and level can be adjusted from 00 to 99 for each envelope segment. With levels, obviously, 99 is high and 00 is low. In the case of rates, 99 is fast and 00 is slow.

For many types of sounds, you won't need all eight segments. A standard ADSR envelope shape, for example, can be created with only three of the segments. It may help you understand the CZ's envelopes if we compare them to an ADSR. This common envelope shape has four controls, and is fixed in shape. By this I mean that after the maximum level is reached at the end of the attack time, the envelope must

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drop down during the decay until it reaches a plateau (the sustain point). When you release the key, the sound will drop back to zero at the rate determined by the release. Thinking of this in terms of rate and level, rate 1 is set by the attack control, while level 1 is determined (in the case of a filter envelope) by the filter cutoff and EG amount controls. The sustain point on an ADSR is fixed at level 2 (unlike the CZ's variable sustain point), making the decay rate control rate 2. Level 3 in an ADSR is always zero, and rate 3 is controlled by the release parameter. In creating patches, you can draw on all the information on programming that is already available in *Keyboard* and elsewhere by using these three envelope segments. When you're ready to go on to more complex envelopes, the CZ will be ready for you.

You can save time on the CZ by programming only the segments you actually need for an envelope. This is done by setting the sustain and end points. The end point level must always be 00, but the levels before the end can be anything you like. Hitting the 'end point' button will cause the currently displayed envelope step to be the last one; hit the same button again, and the end point will be cancelled.

The same goes for the sustain point. Any point can be the sustain point, unlike an ADSR envelope. With eight steps on each envelope, it can get hard to keep track of where the sound is at any given time, so I like to put the sustain point on whatever step I'm currently editing. By holding down the key, I can hear where the level is for this step, make whatever adjustments are necessary, and then move on to the next step. Selecting sustain for a new step automatically cancels it for the previous step.

The strength of having eight steps and a variable sustain point is that you can let the sound travel over more peaks and valleys. Looking again at Figure 1, you'll see that the first envelope has a triple attack, while the second has some unusual peaks during its release. Many other shapes are possible, including slow swells during the "sustaining" portion of the envelope. Setting the DCW and DCA envelopes to different values multiplies the possibilities still further. And that's only for one line! By setting the DCW envelope for line 2 so that its peaks occur during line 1's valleys and vice-versa, you can put together sounds that pan back and forth between two different timbres.

By the way, the envelope rate data on the CZ actually determines the *slope* of the envelope segment. In other words, if you leave a rate at the same setting and move its level farther from the previous level, the envelope will take longer to get to the new level.

Waveforms. Each DCO in the CZ offers eight waveforms, and these can be combined in pairs for a total of 33 possible combinations. Numbers 1 through 5 sound more like conventional analog waves, while 6 through 8 have a built-in "filter resonance" effect. Filter resonance, which is found in analog synthesizers, emphasizes certain frequencies to give a nasal quality to the sound. The familiar quacking synth sound that comes from filter resonance was beaten to death in the '70s, but it still has uses today.

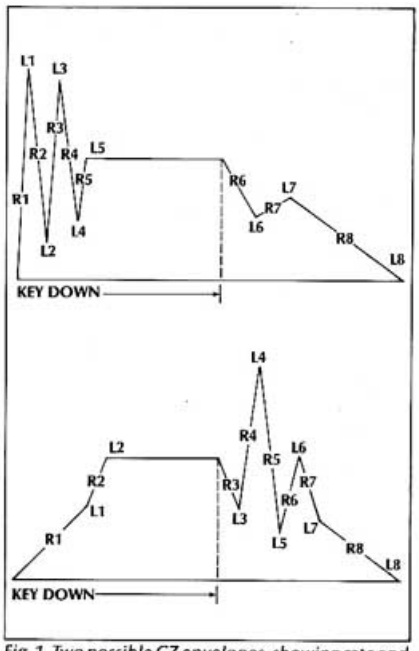

Fig. 1. Two possible CZ envelopes, showing rate and level settings. Level 5 is the sustain level in the first envelope, while level 2 is the sustain level in the second envelope.

You can combine any two waveforms in a CZ oscillator except 6 through 8, which cannot be combined with one another. When you combine two waves you don't get a single composite wave, as on many synths. Instead, you get a dual waveshape that consists of one cycle of the first wave followed by one cycle of the second, alternating back and forth. This naturally produces a subharmonic an octave below the basic note you're playing. If you don't want the subharmonic, you can use the octave control to raise the pitch of both DCOs, or the detune setting if you only want to raise one of them.

To find the best waveform for your sound, you should first get familiar with the sounds of all of them. Take a preset, select line 1, and keep changing the waveforms to hear how the sound changes.

The CZ oscillators generate their tone colors by a process called phase distortion. While this works somewhat differently than the FM process used in other digital synthesizers, the musical effect is often similar. Phase distortion creates overtones by distorting the waveforms of sine and cosine waves.

When the DCW is at its highest setting (sustain at 99), the sound of the wave will be at its brightest. As the DCW begins to close down, the sharp edges of the wave are gradually rounded off. At very low DCW settings, all the waves approach sine waves. That is, they have no harmonics at all. You'll notice that as combined waveforms approach this point, the sub-octave disappears.

Many synthesizers don't let you control the pitch of the oscillator with a separate envelope, and you may find yourself wondering what exactly this envelope is for, as most music calls for steady pitches. Some percussion patches (electronic tom-toms, for example) call for a falling pitch. Another trick is to use a very rapid rise and fall at the beginning of each note to produce a click. By varying the height of level 1, you can produce various effects from clicks and pops to dull thuds. This can be useful for organ key clicks, drum and mallet patches, or the snap of a guitar pick. The pitch change occurs so fast that the ear only hears a disturbance of the waveform, not a gliding effect. It's a great way to add attack transients to a sound without tying up the DCW or DCA.

A pitch envelope can also be helpful in synthesizing vocal sounds. Most singers don't hit all their notes dead center. They often slide into notes from slightly below. (Please, no irate letters from vocalists!) The pitch EG allows you to create this effect easily. A level of 00 is concert pitch, however; the CZ pitch envelope cannot drop below this point. So you will want the sustain level of the pitch EG to be at 66, which is one octave above concert pitch. (You can transpose back down with the octave parameter.)

Set level 1 at 65 or 64 (one or two whole-steps below 66), and rate 1 at 99. With level 2 (sustain) at 66 and rate 2 between 43 and 48, you will achieve a glide effect. Since the envelope will automatically return to a level of 00 when the key is released, you will hear some sliding off of the note if your DCA envelope has a long release time. By setting the rate to 00 and using a short release on the amplitude envelope, you can keep this from being audible.

Key Follow. The DCW and DCA each have associated with them a parameter called key follow. Some confusion might arise because the two key follow parameters don't do quite the same thing, though they both affect their associated envelopes. Both types of key follow are based on which key is being played; in general, key follow has no effect at the lower end of the keyboard and progressively more effect as you move up the keyboard. How much effect it will have depends on the setting of the key follow parameter, with 0 being no effect and 9 being the maximum.

The DCW key follow has the effect of

lowering the envelope levels as you move up the keyboard. Sounds that have lots of overtones can easily become too bright in the higher octaves, and choosing the proper key follow value allows you to tailor them so that the high notes are more muted. Note that as the envelope levels are lowered, the rate parameters stay the same. Each level is reached more quickly, thus shortening the envelope.

The DCA key follow also shortens the envelope (in this case, the amplitude envelope) as you move up the keyboard. But it does so by speeding up the rates rather than by lowering the levels.

Key follow can be very useful in imitating acoustic instruments. Typically a low-pitched resonating object, such as a bass string or the column of air in a tuba, takes longer to start vibrating than a high-pitched object, such as a violin string or the column of air in a piccolo. This is because of the amount of physical material that must be moved to get the vibrations going. When programming a sound, you may want to make sure that the key follow is turned off before setting up your envelope values. When you've got the envelope right for the bass register, move to the treble register and shorten the values as needed using key follow.

Envelope Shapes. Much has been written elsewhere about envelope shapes. Briefly, percussive sounds such as mallet instruments and guitar strings call for rapid attacks. The early part of the sound should be bright (high DCW level), and the bright overtones should drop away faster than the fundamental does (DCW should have faster decay rate and/or lower sustain level than DCA).

For sustained sounds such as organ, brass, and string orchestra, a slower attack and a higher sustain on the DCW would work best. The release segments (whatever happens after the sustain) are also important. A slow release is not good for a xylophone, while a fast release is wrong for a gong or chime.

If you look at the DCA envelope on preset A-1, you'll see how to simulate room reverb. After a sustain level (level 3) of 91, the envelope drops very quickly (rate of 79) to a level of 59, after which it moves down to a level of 00 at a much slower rate. By playing with the release rates of the DCW and DCA together, you will be able to shape the harmonic content of the "reverb." Try mixing in a second line with still more release segments and see what happens. You'll notice that if you release the key before the envelope reaches its sustain point, your complex release will not be heard. This allows you to fashion one type of release for staccato playing and a slightly different type for sustained notes on the same patch.

Lines & Tone Mix. One of the strengths of the CZ is that it allows you to mix several oscillators with individual tone colors and envelopes onto a single keystroke. Lines 1 and 2 are combined using the line select switch. If you need an even thicker composite sound, two separate patches can be layered using the tone mix feature.

In some cases, one of the lines will be creating the percussive attack portion of a sound—for example, the ringing sound of a hammer hitting a metal tine in an electric piano patch. This dies out quickly while the other line provides the sustaining element. For an electric piano sound, the tine sound may work best when detuned up a couple of octaves to some unusual interval. With organ patches, both lines may have very similar envelopes, but one may be tuned an octave or more above the other to provide specific overtones.

Programming one line louder than the other is sometimes useful when mixing overtones. Especially when using noise or ring modulation, full volume will give you a windstorm when you only want a subtle chiff. While there is no separate output volume control for an individual line, you can adjust the volume by lowering the levels of the DCA envelope. (Remember, this will shorten the envelope as well, so you may want to slow down the rates accordingly.)

While many overtones sound best when mixed in at intervals of an octave, there will be occasions when you want to