CZ-3000

SUMMARY/SUMARIO

The quick approach to sound synthesis
Una rápida aproximación a la síntesis sonora

英 西

CASIO

This booklet explains the operation of the Casio CZ-3000 from a different viewpoint than the Operation Manual.
It was written with people in mind who want to play their new instrument right away, who are less interested in theory and more in practical tips for creating new sounds.
For those who have no experience with synthesizers at all and are using one for the first time, the appendix "Synthesizer Sound Seminar" is recommended reading.

Contents

First, Let's Create Some Sounds!

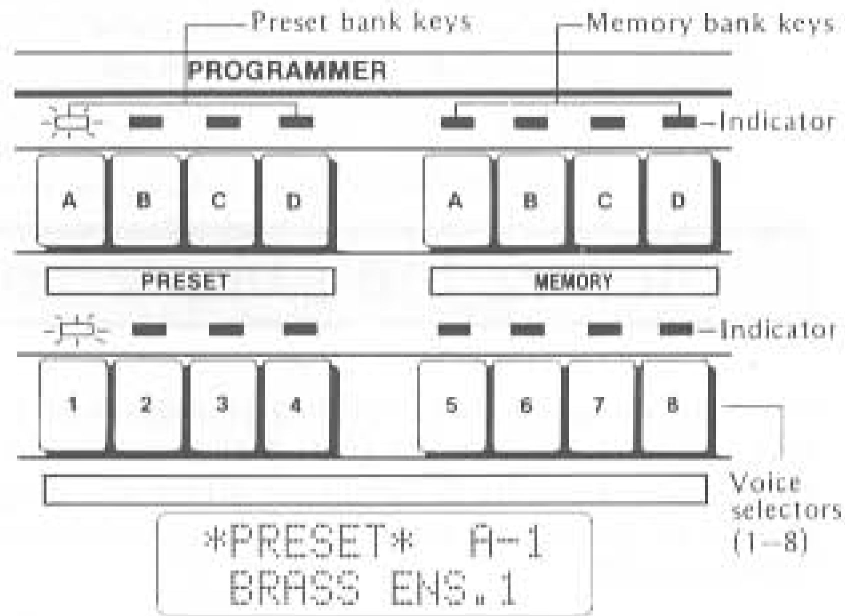
64 Sample Sounds

The CZ-3000 contains a total of 64 built-in sample sounds composed of 32 preset and 32 memory voices. Memory voice contents change when newly created sounds are stored to memory.
Use the following procedure to listen to the sample sounds.

> The CZ-3000 synthesizer is not equipped with speakers, so a keyboard amplifier and speakers, or earphones must be used to produce sound.

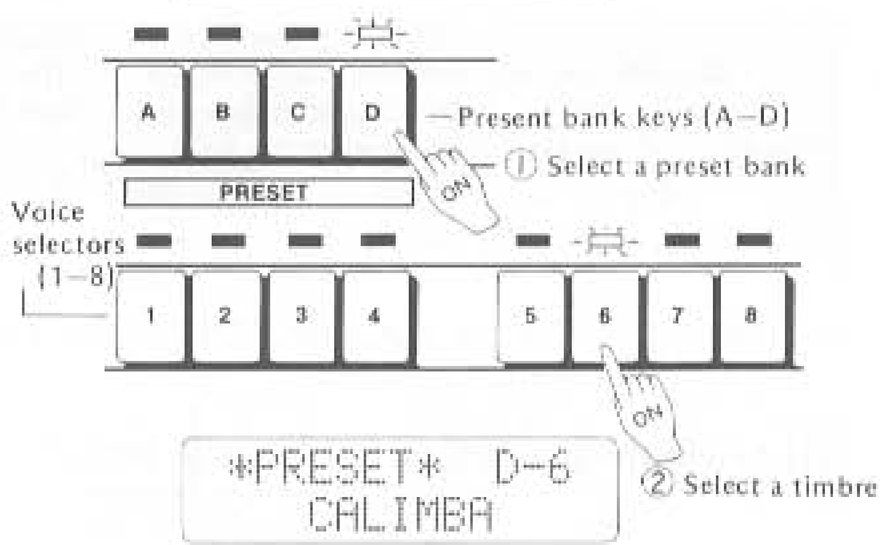
(1) Press the power switch to turn the instrument ON.

Immediately after power is turned ON, the synthesizer will be in the NORMAL mode and BRASS ENS. 1 (A-1 in the Programmer Section) will be selected automatically. Indicators will be lit above preset bank A and voice selector 1, while the LCD will appear as shown below.



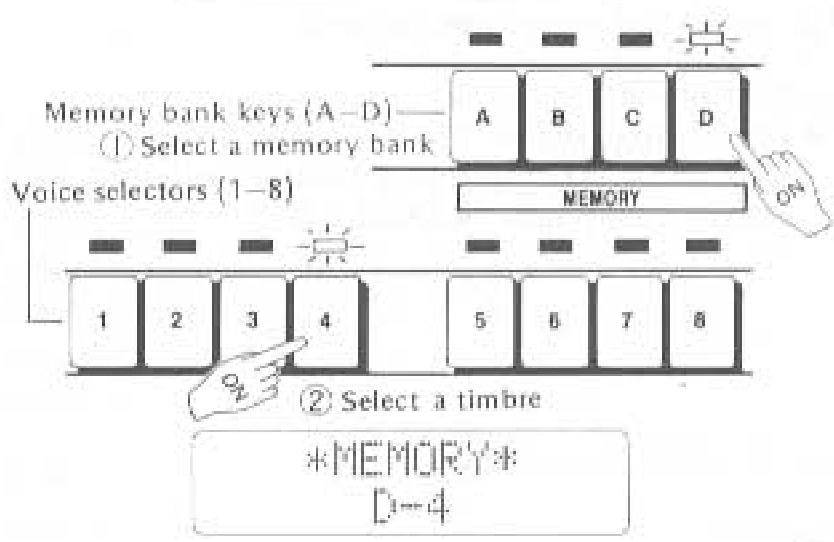
(2) Playing the 32 preset voices.

Use the voice selectors (1–8) for the first eight timbres, and then press preset bank key B for the next eight timbres. Repeat this procedure for each preset bank key (A–D). The LCD will show the name of each timbre selected, so sample each timbre while confirming its name on the LCD.



(3) Playing the 32 memory voices.

Use the voice selectors (1–8) for the first eight timbres, and then press memory bank key B for the next eight timbres. Repeat this procedure for each memory bank key (A–D). The LCD will show the name of each timbre selected, so sample each timbre while confirming its name on the LCD.



Preset Voices and Memory Voices

32 preset and 32 memory voices are preprogrammed into the CZ-3000. Any one of these 64 timbres can be selected using the keys in the Programmer Section.
The 32 timbres programmed into the memory bank are those included in the "DATA BOOK". Newly created timbres (by changing data using the Parameter Section) can be stored in memory erasing the previous contents and recording the new data in its place.

Preset Voice Table

* indicates 16-note polyphonic (1DCO).
Others are 8-note polyphonic (2DCO).

BANK / No.	A	B	C	D
1	BRASS ENSEMBLE 1	SYNTH. BRASS	BRASS ENSEMBLE 2	TRUMPET
2	STRING ENSEMBLE 1	STRING ENSEMBLE 2	SYNTH. STRINGS	VIOLIN*
3	JAZZ ORGAN	ELEC. PIANO	ACCORDION	FANTASTIC ORGAN
4	WHISTLE*	FLUTE*	BLUES HARMONICA	DOUBLE REED
5	FAT BASS	SYNTH. BASS	ELEC. GUITAR	METALLIC SOUND
6	VIBRAPHONE	CRISPY XYLOPHONE	SYNTH. GLOCKENSPIEL	CARIMBA
7	SYNTH. DRUMS	STEEL DRUM	SYNTH. PERCUSSION	CONGA
8	HUMAN VOICE	FAIRY TALE	CARILLON	TYPHOON SOUND

Altering the sample voices

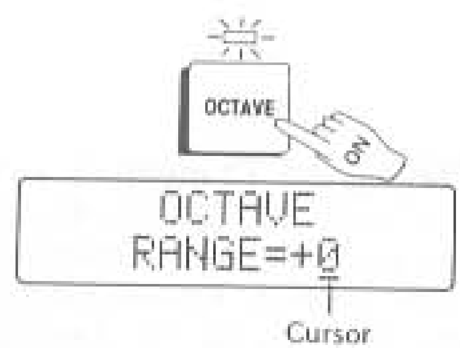
There are two methods for creating your own sounds with the CZ-3000. You can either select a sample sound that is already close to the kind of tone you would like and alter it to suit your taste, or else combine the various tone elements to synthesize a new sound right from the beginning. Here we will explain the first method of altering a sample sound to make it easier to understand how sound synthesis with the CZ-3000 actually works.

No detailed explanations will be provided for the various numeric values that appear in the following examples. Simply change the sounds as instructed to gain experience in creating new sounds. Refer to page 15 of the Operation Manual for details.

Example: Changing the preset tone B-1 "Synth. Brass" into an exotic "Oriental Brass" sound and storing it in internal memory D-8.

(1) Select the preset tone B-1 "Synth. Brass".

(2) Raise the range one octave.



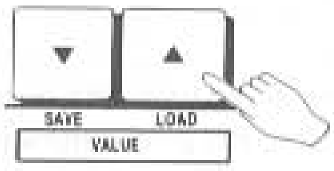
① Press the OCTAVE key.
➡ The display shown on the right will appear on the LCD. [This indicates that the octave setting for SYNTH. BRASS is currently "RANGE = 0".]

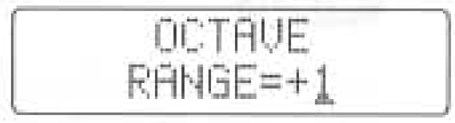
* The cursor is the mark that indicates the position at which a value can be changed.

NOTE

Whenever you press any key such as VIBRATO, WAVE FORM, ENV, etc., the respective value set for the selected tone will be displayed in the same manner as shown for the octave range setting above. Pressing these buttons again returns the LCD to the previous display.

② Press the ▲ LOAD key once.
➡ The value above the cursor changes to "+1" and the pitch range is thus shifted up by one octave.





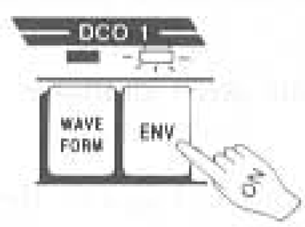
The COMPARE/RECALL Key

When you perform the operation described above in (2)–②, the indicator above the COMPARE/RECALL key will light indicating that a sample sound has been altered. (In our example, the pitch range of the tone "Synth. Brass" has been raised by one octave.) If you now press the COMPARE/RECALL key, the indicator will go out and you will be able to hear the original (unaltered) sample sound (i.e. in our case the Synth. Brass tone). Press the key to compare the sounds before and after alteration. By using this button and simply pressing a key on the keyboard, you can listen to the sound you are altering as well as the original sound any time.

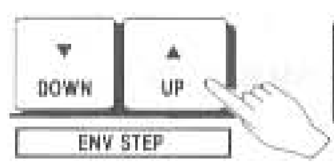
Note: Press the COMPARE/RECALL key again after comparing an altered sound with the original. This will return to the partially altered sound (indicator will light) and allow further modifications.

(3) Change the pitch envelope to achieve a wavering effect during the attack.

① Press the DCO 1 ENV key.
➡ The LCD will show the display on the right.
[The parameter values for Step 1 of the pitch envelope are "RATE = 99" and "LEVEL = 33". The cursor is positioned under the RATE value.]

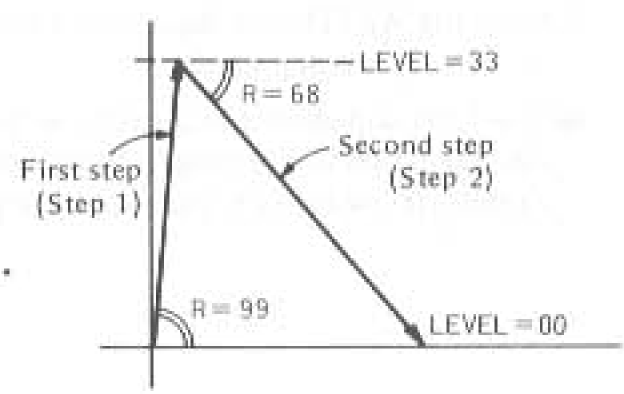


② Press the ▲ UP key to display Step 2 of the envelope.
➡ The LCD will show the display on the right.

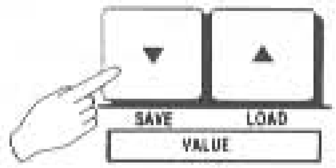


NOTE

By performing the operations explained in the steps above, the parameter values for "Synth. Brass" are RATE = 99, LEVEL = 33 for Step 1 and RATE = 68, LEVEL = 0 for Step 2, producing the envelop shown on the right. The "rate" parameters indicate the "attack angle" while the "level" parameters show the "height" of the envelope for the respective steps. The maximum value for each of these parameters is 99 while the minimum value is 0.
→ See page 15 ~ 19 of the Operation Manual for details.



③ Press the ▼SAVE key to set the value to 50.
* Each time the ▼SAVE key is pressed, the value will decrease by 1. Keeping this key depressed will cause the value to decrease continuously. If the value has decreased beyond the desired point, simply press the ▲LOAD key to increase it again.

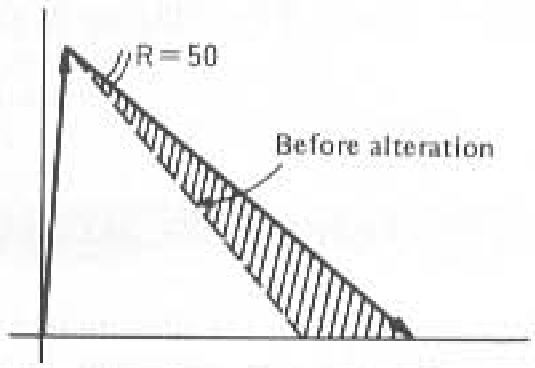



```
PITCH STEP2  END
RATE=50 LEVEL=00
```

NOTE

The operation explained in ③ changes the rate (slope) of Step 2 from 68 to 50, producing the pitch envelope illustrated on the right.

* The wavering effect, which is determined by the angle of the slope, will now be stronger due to the gentler slope of the envelope (indicated by the shaded section).



* Press the COMPARE/RECALL key in order to compare the altered sound with the previous one. After comparison, return to the altered sound by pressing the compare/recall key again. (The indicator will light.)

(4) Change the DETUNE value to add a perfect fifth harmony.

① Press the detune key.
➡ The LCD will show the display on the right.

```
DETUNE(+)   OCT=0
NOTE=00   FINE=06
```

② Press the ▶ key to move the cursor to the position below the NOTE value.

```
DETUNE(+)   OCT=0
NOTE=00   FINE=06
```

③ Press the ▲LOAD key to change the NOTE value from 00 to 07.

```
DETUNE(+)   OCT=0
NOTE=07   FINE=06
```

NOTE: A perfect fifth is the note seven semitones above the root (basic note).

* Play something on the keyboard to listen to the new tone, a brass sound with an oriental feeling to it.

(5) Store the sound in MEMORY D-5.

① Set the PROTECT switch on the back of the synthesizer to OFF.

② Keep the WRITE key depressed until the operation of step ④ is completed.

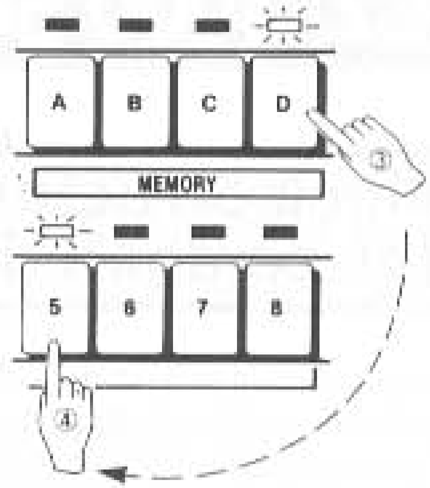
➡ The LCD will show the display on the right.
All indicators in the Programmer section except the COMPARE/RECALL indicator will go out.

```
     WRITE
SELECT MEMORY!
```

③ Press the D key in the memory bank.
The indicator will light.

④ Press voice selector key 5. When "OK" appears on the LCD, the WRITE key and voice selector key can be released.

WRITE
OK!



* The newly created memory timbre can be recalled using the same procedure outline previously.
* The 32 timbres in the memory bank can be stored to separately available cassette tape or an optional RAM cartridge. See "TIMBRE DATA WRITE/SAVE/LOAD" in the user's manual.

CZ-3000 Sound Synthesis

Block Structure of the CZ-3000 (as compared to an Analog Synthesizer)

The fascinating thing about the CZ-3000 is not only its realistic, clear sound, but also the simplicity of sound creation it offers. The CZ-3000 eliminates one of the major drawbacks of previous digital synthesizers, namely that it was extremely difficult to actually synthesize the kind of sound one had in mind. You can now easily create any sound you want as you please. The secret behind this ability is that the CZ-3000 has inherited the basic easy-to-understand structure of sound synthesis from the analog synthesizer. In other words, the CZ-3000 combines the superior sound quality of a digital synthesizer with the easy-to-understand principles of sound synthesis offered by analog instruments.
In the following, we will explain the block structure of the CZ-3000 while comparing it to that of an analog synthesizer.

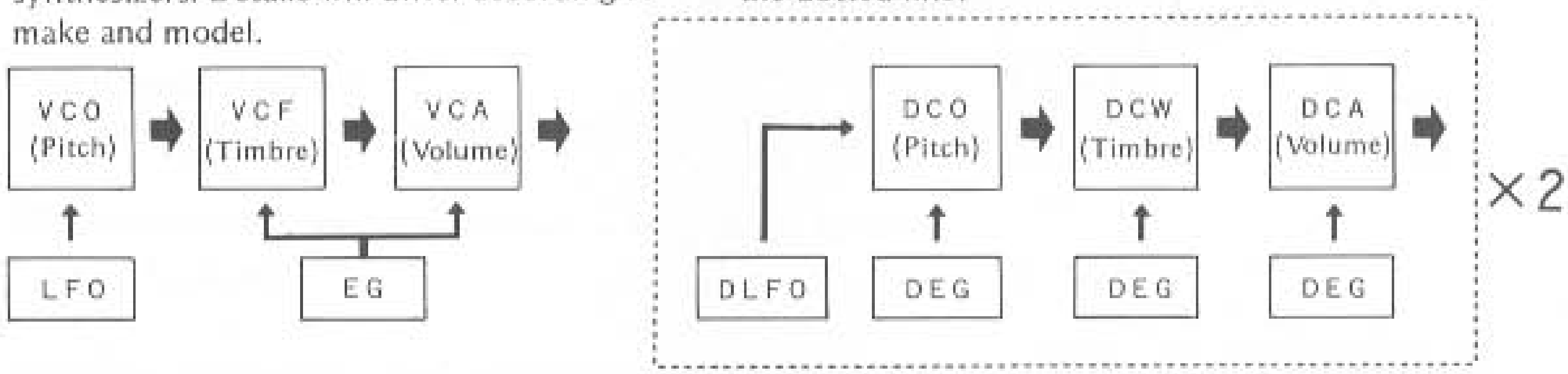
Note: To those of you who have never used synthesizers before, we strongly recommend reading the appendix "Synthesizer Sound Seminar" first.

Analog Synthesizer

*This is the basic general structure of analog synthesizers. Details will differ according to make and model.

Digital Synthesizer – CZ-3000

*There are two blocks such as the one enclosed by the dotted line.



➡ analog sound signals
→ analog control signals

➡ digital sound signals
→ digital control signals

Looking at the above diagram, it is evident that the CZ-3000 has practically the same block structure as analog synthesizers.

- **DCO (Digital Controlled Oscillator)**
  – A digital circuit that corresponds to the VCO (Voltage Controlled Oscillator) of an analog synthesizer, and determines the pitch and the basic wave form* of a sound.

* The CZ-3000 offers about 10 times as many basic wave forms as a normal analog synthesizer.

- **DCW (Digital Controlled Wave)**
  – A digital circuit that corresponds to the VCF (Voltage Controlled Filter) of an analog synthesizer, and controls the timbre of a sound.

- **DCA (Digital Controlled Amplifier)**
  – A digital circuit that corresponds to the VCA (Voltage Controlled Amplifier) of an analog synthesizer, and controls the volume of a sound.

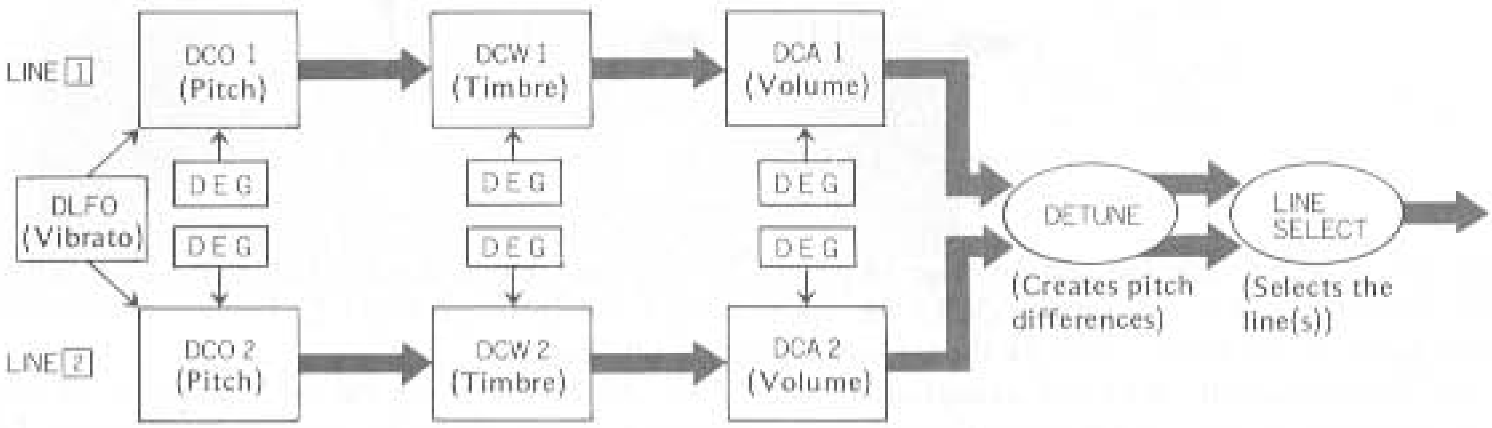
- **DEG (Digital Envelope Generator)**
  – Corresponds to the EG (Envelope Generator) of an analog synthesizer, and controls the change of pitch, timbre and volume over time according to a maximum of 16 parameters.

- **DLFO (Digital Low Frequency Oscillator)**
  – A circuit that corresponds to the LFO (Low Frequency Oscillator) of an analog synthesizer, and generates low frequency waves for vibrato effects.

This shows how easy it is to view the various blocks of the CZ-3000 along the lines of analog synthesizers, meaning that it is possible to create totally new sounds without having to learn any new kind of synthesis. Note that the CZ-3000 offers a dual line systems consisting of the blocks shown above, resulting in the block structure shown below.

Detune and Line Select

The CZ-3000 has a dual line structure (Line [1] and Line [2]):



After sounds have been created on Line [1] and/or [2], pitch differences can be obtained with the Detune function and line outputs can be designated with Line Select.

- **Detune** . . . . . . Determines the pitch difference between Line [1] and Line [2]. (Note 1)
  The pitch difference can be designated in units of one octave, one semitone or 1/60 semitone. It is also possible to designate whether the pitch is raised (+) or lowered (–).

- **Line Select** . . . Determines which lines are output or which lines are combined. (Note 2)
  [1] : Outputs Line [1] only.
  [2] : Outputs Line [2] only.
  [1] + [2'] : Line [1] is output together with detuned Line [2].
  [1] + [1'] : Line [1] is output together with detuned Line [1].
  * [1'] and [2'] indicate detuned lines.

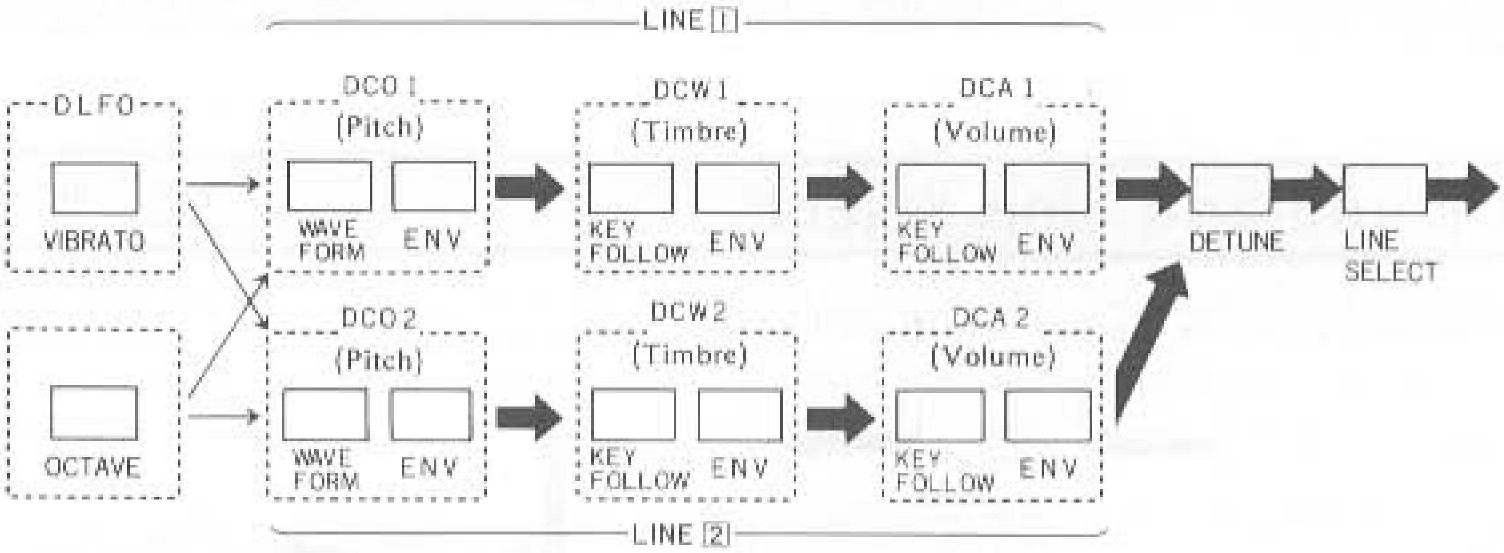
Note 1: When [1] + [1'] is designated with Line Select, Line [1] is output together with detuned Line [1'] (Line [1] with an altered pitch). In other words, setting a Detune value will detune Line [2] when [1] + [2'] is designated and Line [1] when [1] + [1'] is designated.

Note 2: When [1] or [2] have been designated with Line Select, the synthesizer is 16-note polyphonic. When [1] + [1'] or [1] + [2'] have been designated, it is 8-note polyphonic.

The Detune and Line Select functions let you create a variety of effects by combining the different sounds on each line or detuned and normal-pitch tones for a fatter, spacier sound, or to obtain various naunces. For example, by combining a normal-pitch string tone with a slightly detuned string tone, you can achieve an even more realistic sound. Another interesting example is the combination of an organ tone with key click noise for a funky jazz organ sound. As you can see, the Detune and Line Select functions play important parts in CZ-3000 sound synthesis.

Key Relationship and Operation

To get an idea about the relationship among the various keys, first look at the following diagram:



Compare this diagram with the one on page 16. The DEG for each block is indicated by the ENV (envelope) keys for DCO 1, DCW 1, etc. Also, OCTAVE controls both DCO 1 and DCO 2. The key layout more or less corresponds to the block structure shown in the diagram on page 16.
There are 16 keys in all. With the exception of the LINE SELECT key on the extreme right, all other 15 keys cause the values set for the respective blocks to be displayed on the LCD when pressed. These 15 keys are called parameter keys.
CZ-3000 sound synthesis is accomplished by displaying the values for the blocks you want to alter on the LCD by pressing the respective key and then altering the displayed values with the CURSOR keys (◀ and ▶), and the VALUE keys (▼ SAVE and ▲ LOAD).

Basic Procedure for Sound Synthesis

* Procedure for altering sample sounds.

Operation Example in Part 1

1

Select the timbre you want to use as the basis for your sound from among the sample sounds (preset and memory voices).

(1)

2

Press the respective parameter key to display the values for the block you wish to change on the LCD.

(2) – ①
(3) – ①
(4) – ①

3

Use the CURSOR keys and VALUE keys to change the displayed values.

(2) – ②
(3) – ② ③
(4) – ② ③

When you want to alter more than one block, repeat steps 2 and 3.

4

Select the line(s) you want to output with LINE SELECT.

*This operation is not explained in Part 1 since the output line is not changed in the example.

5

Store the synthesized sound in the internal memory or cartridge memory.

(5) – ①②③④

* The settings for RING and NOISE are performed in 2 ~ 4.

The notations to the right of the diagram refer to procedures explained in Part 1: "First, Let's Create Some Sounds!" See the respective sections for detailed operational procedures. Refer to the Operation Manual for the meanings of the settings for each block.

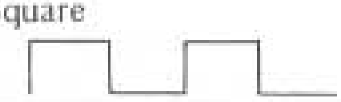
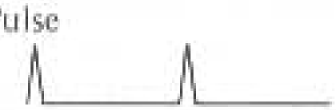
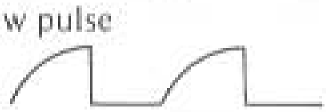
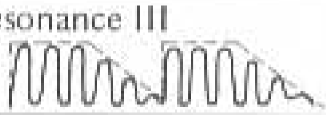
PART3

Sound Synthesis Tips

Sound Synthesis Tips

(1) Choosing the Waveform

The waveform is one of the most important factors which determine a sound. The first step to successful sound synthesis is therefore to understand the characteristics of the various waveforms.
The following table shows the major characteristics of each wave form preset on the CZ-3000 synthesizers. (Select preset tone No. 1 "Brass Ens 1" and switch to the waveforms indicated below.)

Waveform	Characteristic
1. Saw-tooth 	A bright timbre suited to strings and brass sounds.
2. Square 	A simple timbre suitable for woodwinds such as clarinet and oboe.
3. Pulse 	A sharp timbre for funky sounds.
4. Double sine 	A shrill, bright timbre.
5. Saw pulse 	A brassy, metallic timbre.
6. Resonance I 	A funky timbre with characteristics depending on the WAVE ENVELOPE setting.
7. Resonance II 	A funky timbre with characteristics depending on the WAVE ENVELOPE setting.
8. Resonance III 	A funky timbre with characteristics depending on the WAVE ENVELOPE setting.

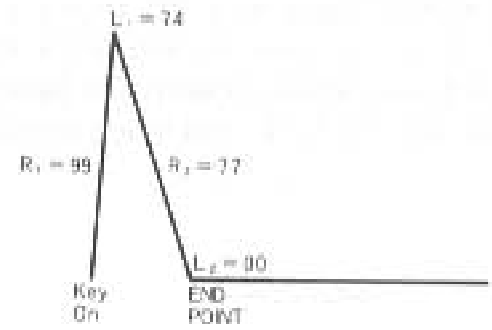
Selecting any one of the waveforms 1 to 5 and setting the wave envelope level set to 0 outputs a sine wave. This technique is used to output sine waves when necessary.

* As already noted, the DCO waveform setting determines the basic waveform. With the CZ-3000, this basic waveform actually varies over time, controlled by the wave envelope (DCW). (With the PD sound source, the variation is between a sine wave and the basic wave. See "PD Sound Source and Waveform Variation" on page 14).

(2) Using the DCO Envelope Generator (Pitch Envelope)

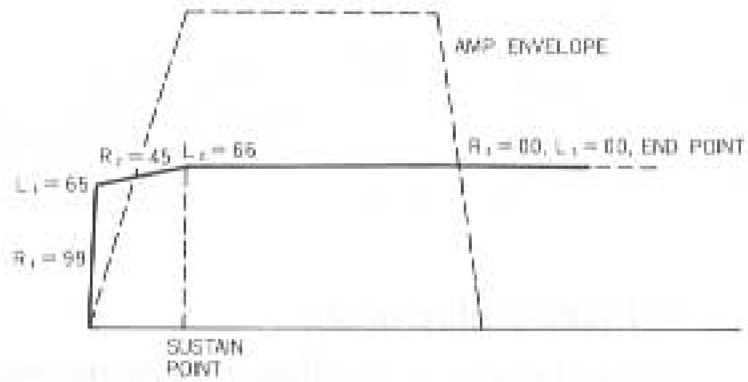
① Percussive attack using the pitch envelope

Setting a fast attack (rise) and decay (drop) time for the pitch envelope creates a sound with a percussive attack. Note, however, that this percussive attack will not be audible if the attack of the DCA envelope is too slow.



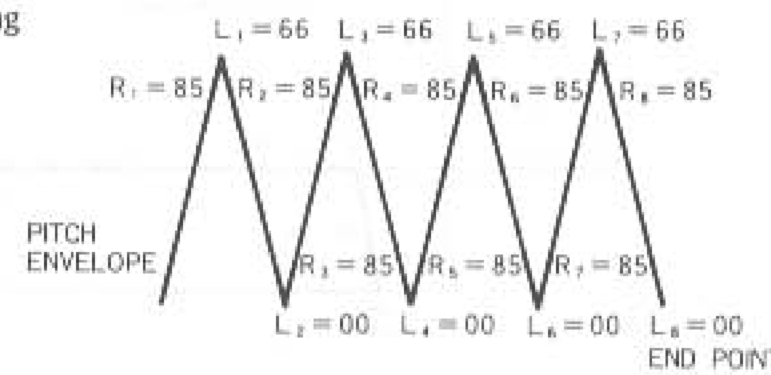
② Auto glide effect using the pitch envelope

First, the pitch envelope is set so that it rises very quickly to a point just below one octave in Step 1. The Step 1 rate of the DCA envelope is set to about 60 so that the first step of the pitch envelope cannot be heard.
The second step of the pitch envelope is set so that the envelope slowly approaches the one octave (L = 66) pitch and then a sustain point is specified.
This setting produce an auto glide effect causing the pitch to slowly rise when a key is pressed.



③ Using the pitch envelope to produce a guitar sound with distortion and picking effects

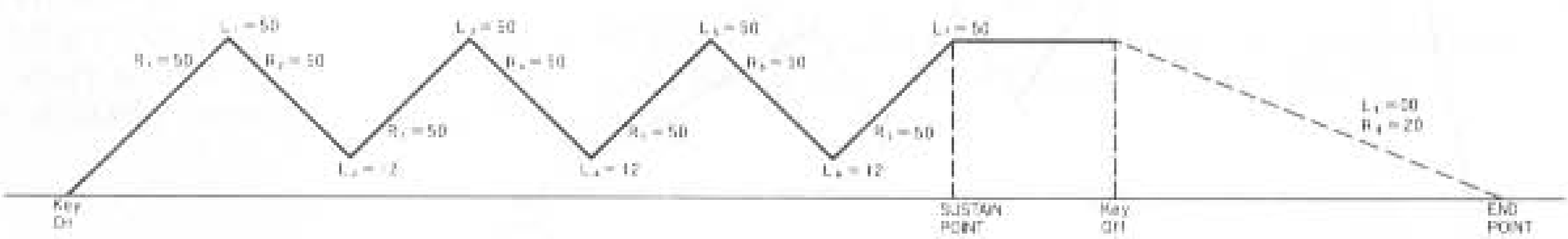
Causing the pitch to oscillate rapidly within a one-octave range produces a distorted guitar sound with picking effects.



(3) Using the DCW Envelope Generator (Wave Envelope)

① Wah-wah sound

Select any of the resonance wave forms (I–III).
By setting the wave envelope as shown below, a wah-wah effect can be achieved.



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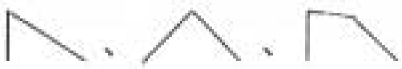
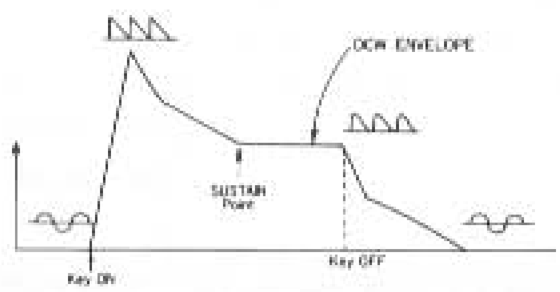
PD Sound Source and Waveform Variation

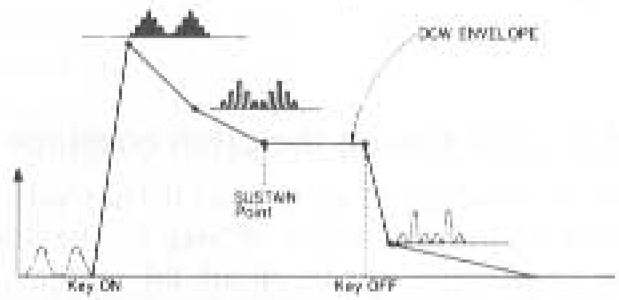
The CZ-3000 features a PD sound source that produces a variety of waves by controlling the speed at which a sine wave is read from ROM. (See User's Manual for details.) In actual practice, the wave is altered over time between the basic waveform and a sine waveform in accordance with the envelope formed with the ECW envelope generator. (Fig. 1)



WAVEFORM 1

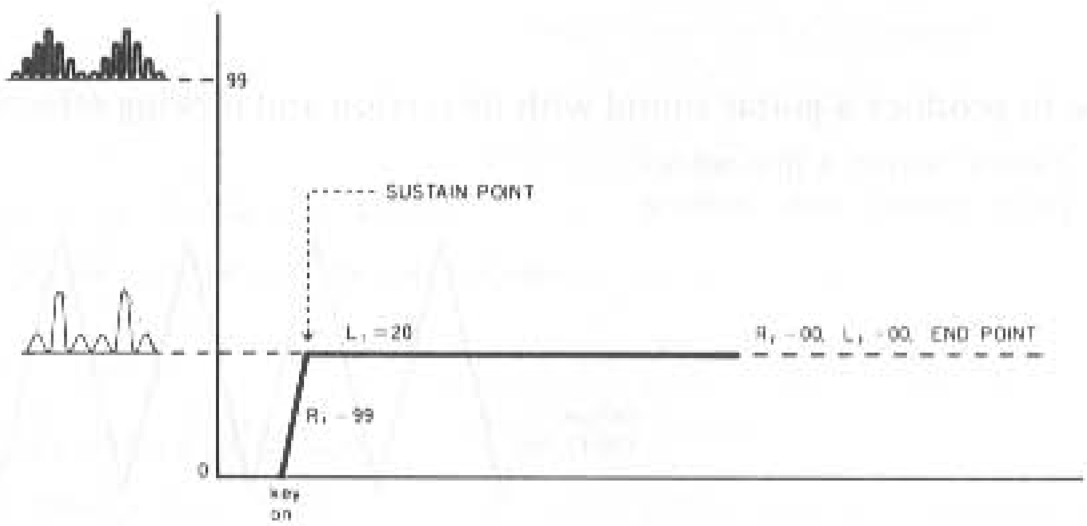


WAVEFORM 7 (RESONANCE II)



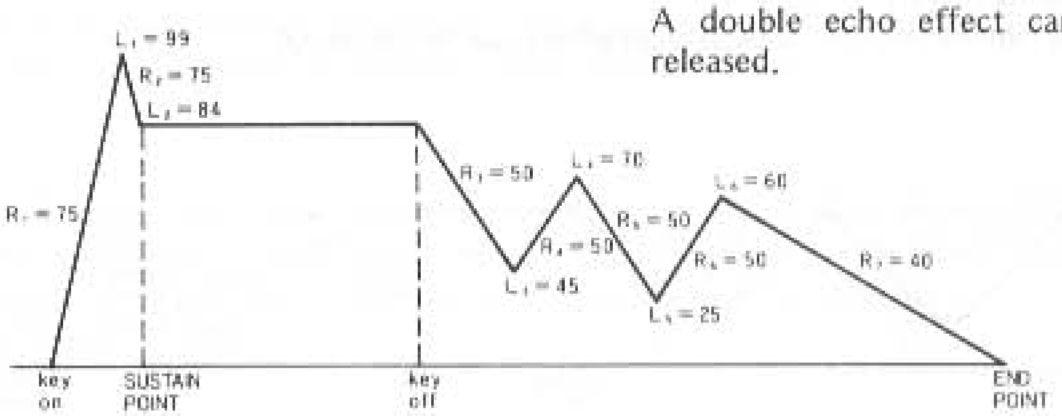
② Fixed timbre organ

As can be seen in the figure, fixing the wave envelope at a constant level produces a specific waveform irregardless of time (like an organ).



(4) Using the DCA Envelope Generator (Amp Envelope)

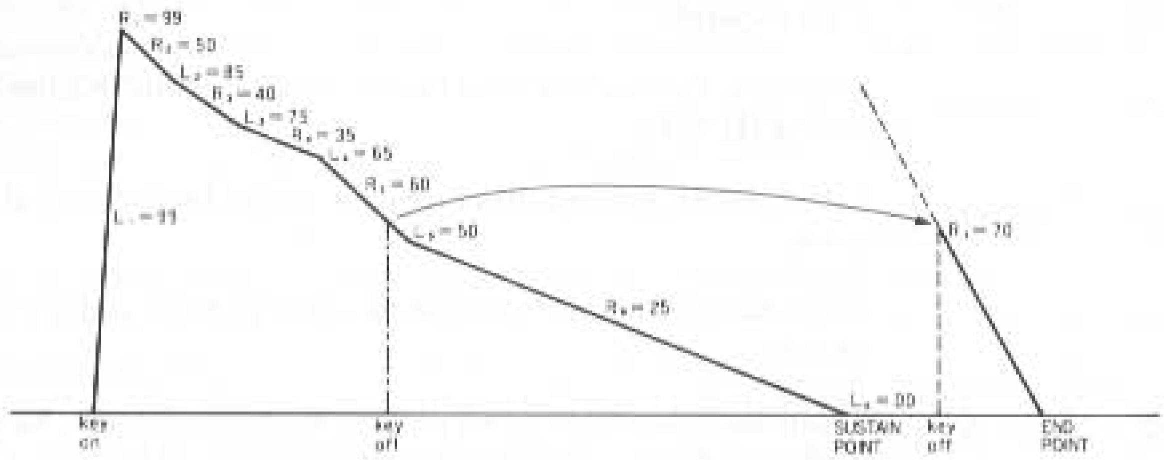
① Echo effect



A double echo effect can be obtained when a key is released.

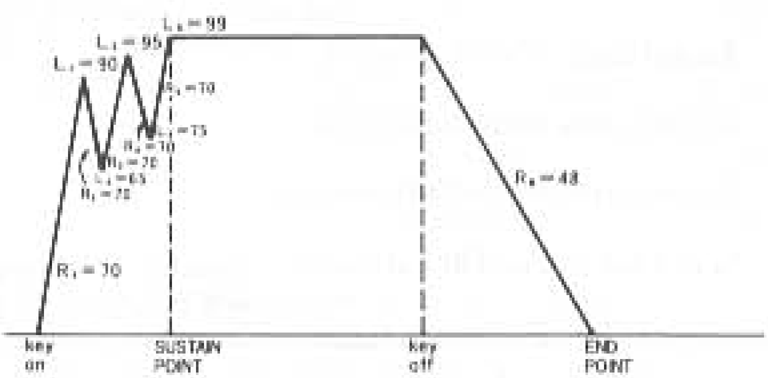
② Piano-like envelope with sudden decay

If a key is released before the Sustain Point is reached, the envelope jumps to the step where the End Point is designated. This can be achieved by setting the Sustain Point in a step where the decay is complete (level = 00) and entering a relatively fast rate for the following step, where the End Point is set.
With this kind of envelope, the sound will expand as long as the key is pressed and decay suddenly when it is released.



③ Brass wind instruments with a tonguing effect

Setting the attack of the envelope as shown below produces the kind of tonguing effect typical of brass wind instruments.



(5) Using key follow

Besides altering the timbre and volume over time in DCW and DCA, key follow also produces change in the timbre in accordance with the pitch of the keyboard key. In the case of a piano timbre, for example, the higher the pitch, the rounder the timbre and the faster the decay.

① DCW Key Follow

The higher the pitch the lower the timbre modulation factor. A sine wave is approached, so a round timbre is gradually formed. The higher the range value, the greater the effect.

② DCA Key Follow

The higher the pitch, the larger each step rate (slope) in the amp envelope. The enveloped is reduced over time, so decay is faster. The higher the range value, the greater the effect. This setting is very effective in producing the plucked string effect of the guitar and piano.

(6) Effective Use of the Detune Function

Select Electric Piano B-3 and set the Detune parameters as follows.

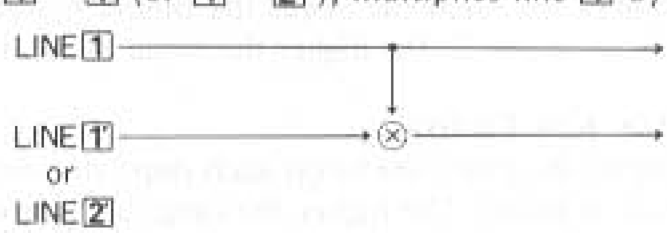
+/−	Octave	Note	Fine	Effect
−	2	00	00	Fatter sound.
−	1	00	00	Fatter sound.
−~+	0	00	01~07	Ensemble. Particularly effective in combinationwith Line Select setting [1] + [1'].
+	1	00	00~07	Fatter sound. Accentuates harmonic one octave above basic pitch.
+	1	07	00	Accentuates third harmonic. Well suited to brass and organ sounds.
+	2	00	00~07	Accentuates harmonics two octaves above basic pitch. Suited to electric piano sounds and electric organ sounds.
+	2	03	48	Accentuates fifth harmonic. (Sound of hitting wood)
+	2	09	36	Accentuates sixth harmonic.
+	3	00	00	Accentuates seventh harmonic.
+	3	00	00	Accentuates harmonic three octaves above basic picth.
+	3	02	00	Accentuates ninth harmonic.
+	3	03	48	Accentuates tenth harmonic.
+	3	05	30	Accentuates eleventh harmonic.
+	3	07	00	Accentuates twelfth harmonic. (Sound of hitting glass)
+	3	08	24	Accentuates thirteenth harmonic.
+	3	09	36	Accentuates fourteenth harmonic.
+	3	10	54	Accentuates fifteenth harmonic. (Metallic sound)

Note: The values for the FINE setting are included as examples and do not have to be followed precisely.

(7) Modulation

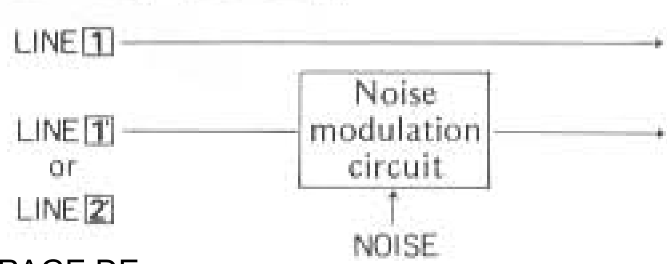
① Ring Modulation

Turning ring modulation ON while the line select is set to [1] + [1'] (or [1] + [2']), multiplies line [1] by line [1'] (or [2']), and a timbre modulated by line [1'] (or [2']) is produced. The ring modulated tone includes the pitch of line [1] and pitches not included in line [1'] (or [2']) (non-integral multiples) for a metallic sound, such as bell.



② Noise Modulation

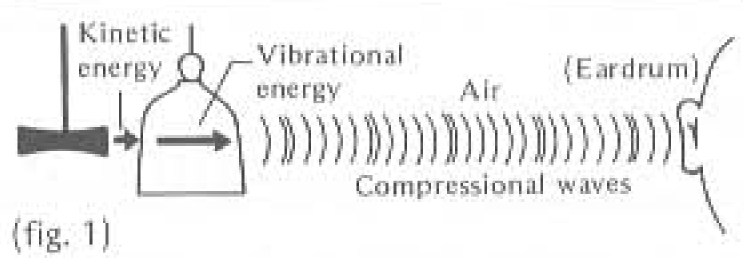
Turning noise modulation ON while the line select is set to [1] + [1'] (or [1] + [2']) produces a timbre in which [1'] (or [2']) is modulated by noise. This is effective for producing wind or wave effects.



"The Synthesizer Sound Seminar"

1 Sound

Every day, we hear a great variety of sounds. Voices, the noise of car engines, doors opening and closing, footsteps, rain . . . and music. In other words, we live our lives surrounded by sound. We can't see sound, so how can we describe it?
Physics tells us that "Sound is vibration". Taking the sound of a bell as an example, we will try to pursue the basics of sound as it is produced and as it is heard.
When kinetic (motive) energy is applied to a bell with a bell hammer as shown in figure 1, a "deformation" of the bell occurs causing energy to work trying to restore the bell to its original state. A periodic repetition of deformation and restoration commences. This is called vibration.
This vibration causes pressure changes in the air. These are called compressional waves. They are similar to the ripples that occurs when a stone is thrown into water.
These compressional waves are transmitted to the human ear where they cause the eardrum to vibrate. These vibrations are picked up by nerves so we hear them as "sound". If the vibrating body differs, so will the vibrations, meaning that we also hear a different kind of sound. Outer space, where there is no air, is a world altogether without sound.



(fig. 1)

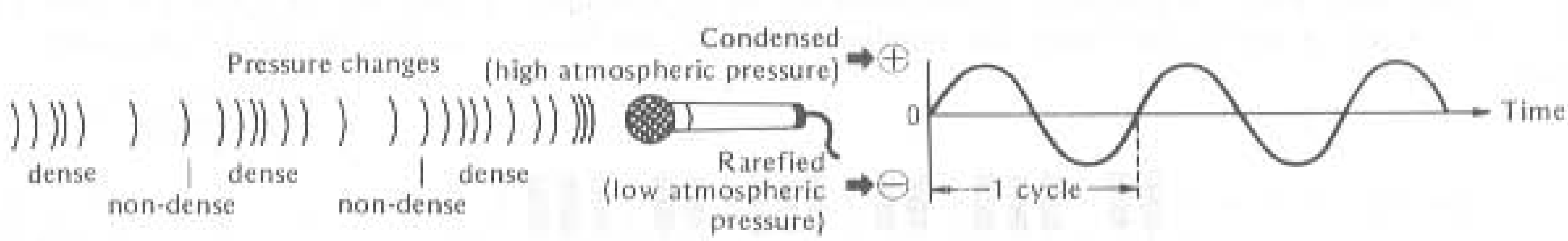
Remember

Sound is vibration of the air.

2 Wave Forms

—— Seeing Sounds With Our Eyes ——

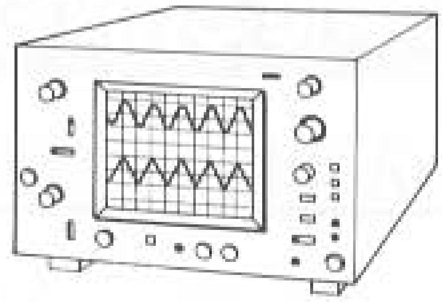
As explained above, sounds cannot actually be seen since they are vibrations of the air. However, you will often hear expressions such as "the wave form is different" or "this is almost a pure sine wave" concerning sounds. What is meant by "sound waves"?



Let's consider the mechanism of a microphone which is used as a means for picking up sound. A microphone converts sound into electrical signals which can be then transmitted to an amplifier and speakers. As shown in the illustration, these electrical signals are simple conversions of the vibrations of the air (the changes in atmospheric pressure) into electrical ⊕ and ⊖. When these changes are presented graphically, they can be interpreted as "wave and displays then as waveforms on a television screen. If we use this kind of a device, we can see sounds with our own eyes.
What we see are "waveforms". These waveforms differ greatly according to the sound and have various characteristics. These points will be explained later on in the Appendix.

Remember

If sounds are converted into electrical signals, they can be made visible as waveforms.



Oscillosope

3 Three Basic Elements of Sound

We now know that sound is vibration and that these can be seen by the eye as waveforms. But we have been talking about "sound" in general up to now without taking into consideration that there are high sounds and low sounds, loud sounds and quiet sounds, mellow sounds and sharp sounds . . . that is to say a great variety of sounds which we perceive very differently. In general, sounds can be classified according to "pitch", "volume" and "tone quality", which are called the "three basic elements of sound". In other words, sounds are determined by these three basic elements.

Remember

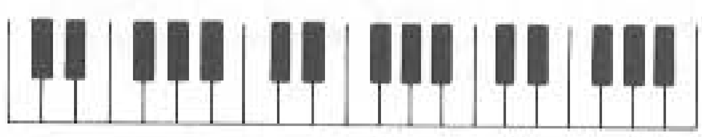
The "three basic elements of sound" are "pitch", "volume" and "tone quality".

We can now have a look at how these three basic elements are connected with the various waveforms.

4 Pitch

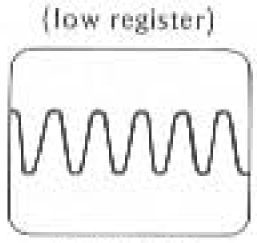
——The "first basic element of sound"——

When you hit the keys of a piano, you will notice that the sounds get higher the further to the right a key is located and lower the further to the left a key is located. This "altitude" of a sound is called "pitch".
When sounds with differing pitches are compared on an oscilloscope, the number of waves per time unit differ. The higher a sound, the larger the number of waves; the lower a sound the smaller the number of waves.



←Low sounds
(low register)

High sounds→
(high register)



Few waves

Many waves

The number of waves is actually the number of the vibrations causing the sound. For example, if we are listening to a violin, it would be the number of vibrations of the strings within a certain period of time. The higher the sound the larger the number of vibrations per time unit; the lower the sound the smaller the number. The number of vibrations within the space of one second is generally called the frequency and expressed in units called Hz (Hertz). 100 Hz indicates that vibrations occur at the frequency of 100 times per second. The larger the number of Hertz, the higher the sound. Also note that doubling the frequency of a sound will raise it by one octave, so we can say that frequency and pitch are related logarithmically.
The range of frequencies that can be heard by the human ear depends on the individual but is generally considered to be in the approximate range of 20 Hz to 20,000 Hz.

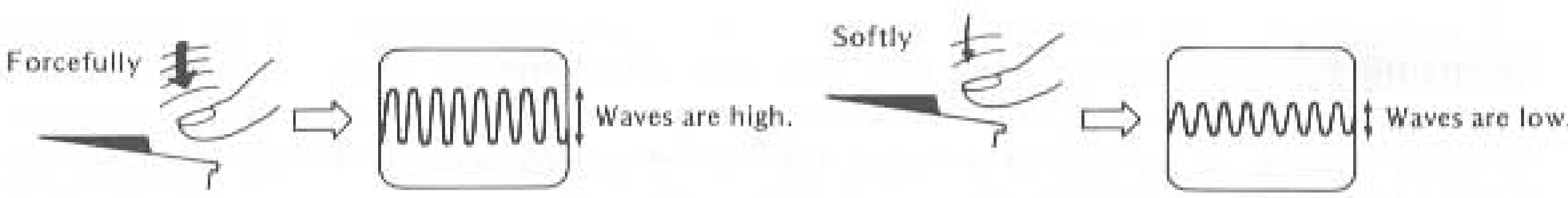
Remember

The pitch of a sound depends on the number of waves per time unit (the vibration frequency) and becomes higher as the frequency increases.

5 Sound Volume

——The "second basic element of sound"——

If you hit a piano key forcefully, the sound will be loud. If you hit it softly, the sound will be soft. When viewed on an oscilloscope, this change in sound volume can be seen as a difference in the height of the waves. The height of the waves is called their amplitude. The larger the amplitude the louder the sound.



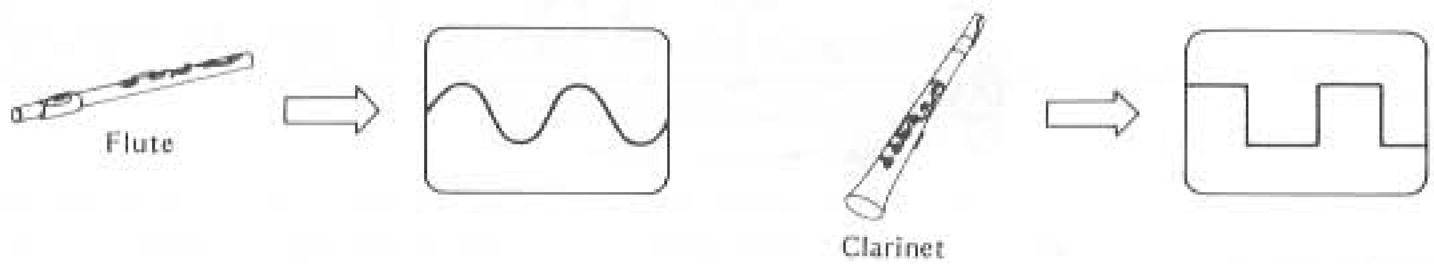
Remember

The sound volume is determined by the amplitude (height of a wave) – the larger the amplitude the larger (louder) the volume.

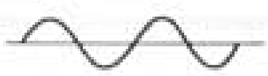
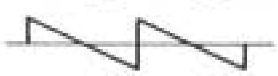
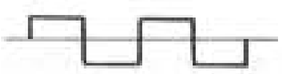
6 Tone Color or Timbre

—— The "third basic element of sound" ——

Even if you play a flute and a clarinet with the same pitch and about the same volume, you will not hear the same sound. That is because there is still one more distinguishing factor for sounds besides pitch and volume, known as "timbre".



When sounds with different timbres are viewed on the oscilloscope, it can be seen that the waveforms themselves differ. It is this difference in waveform that causes the difference in timbre. Generally speaking, rounded waveforms result in softer timbres, while "pointed" waveforms result in hard, brilliant timbres. Very basically, waveforms can be divided into the three types shown in the diagram below – sine waves, saw-tooth waves and square waves.

Wave form	Name	Timbre	Instruments
	Sine wave	Soft	Flute, whistle
	Saw-tooth wave	Bright	Violin, trumpet
	Square wave	Simple	Clarinet, oboe

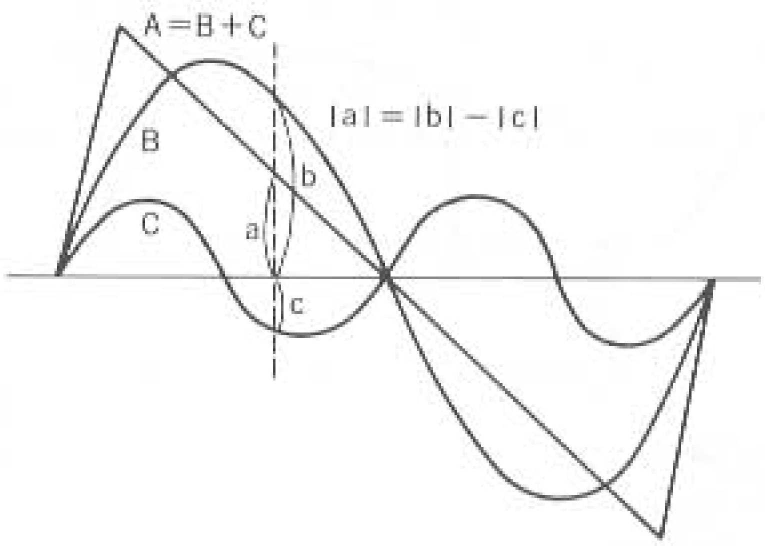
The CZ-5000 offers 8 basic waveforms. However, in order to understand the functioning of timbres as well as basic sound creation with the synthesizer, it is very important to first understand the three waveforms shown above.

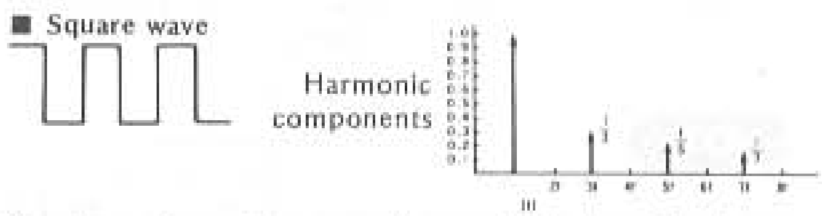
Remember

The timbre depends on the form of the wave. There are three basic waveforms – sine wave, saw-tooth wave and square wave.

7 Basic Waves and Harmonics—Shaping the Timbre

Now you would probably like to know how you can determine the shape of a wave (= timbre) in order to create the kind of sound you want. Have a look at the diagram on the lower left first. It illustrates the process of combining two sine waves to form a saw-tooth wave. B is the basic sine wave while C has twice the frequency of B (it is thus one octave higher in pitch) and only half its amplitude (volume). When B and C are combined, the result is the waveform A. A is still not a perfect saw-tooth wave, but it will infinitely approach a perfect saw-tooth shape if sine waves with triple (3x), quadruple (4x), quintuple (5x) etc. frequencies are added. If, on the other hand, only sine waves with odd numbered frequency multiples are added, the basic sine wave will gradually approach a square wave.
In this manner, any waveform can be created by adding a number of sine waves to a basic sine wave. Waves such as C with frequencies that are integral multiples of the frequency of the basic wave (in our case B) are called harmonics. In other words, the waveform and thus the timbre are determined by the kind of harmonics added to the basic sine wave. Put differently, almost all sounds with their different timbres that reach our ears include a variety of different harmonics, and it is these harmonics which are responsible for the countless characteristic timbres.





*Graphs such as the ones above which show the harmonic components of a wave form are called "harmonic spectrums".

NOTES

● **Music and noise**

Depending on its main kind of vibrations, sound is divided into "musical" and "noise". Sounds with regular vibrations (i.e. sounds in which components other than harmonics are very few) are considered to be musical, while sounds caused by complicated irregular vibrations (i.e. sounds with many components that are not harmonics) whose pitch can therefore not be measured are noise.
Most of the sounds used in music are of course musical sounds, but various kinds of noise such as that produced by percussion instruments are also used to highten the musical effect.

● **Pure Tones**

Sounds which have no other components such as harmonics at all and consist of only one simple frequency are called pure tone. The wave form of a pure tone is always a perfect sine wave. The timbre of a tuning fork or the telephone time tone are almost pure tones (perfect sine waves), but a truly pure tone does not exist in the natural world. Pure tones, therefore, can only be created artificially (e.g. electronically).

Remember

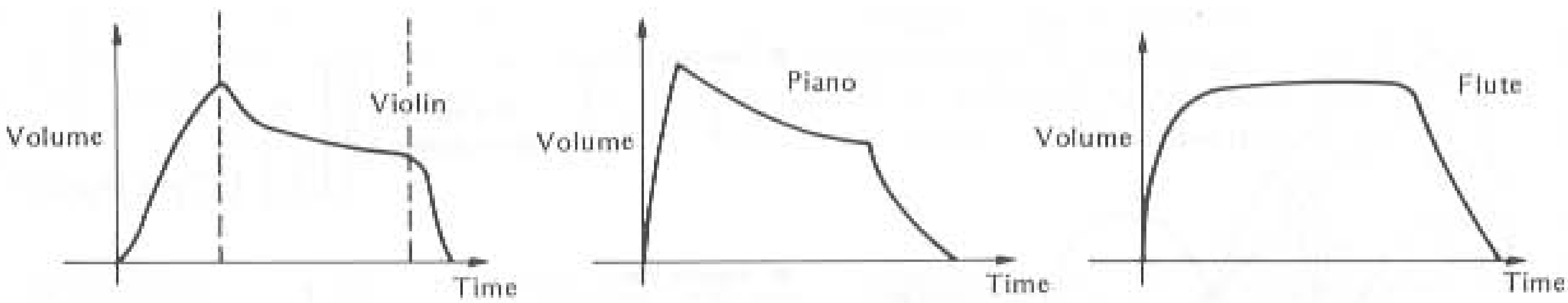
- Frequencies which are integral multiples of a basic wave with a certain frequency are called harmonics.
- The timbre (waveform) is determined by the harmonic components.

8 Envelopes

—— Other Factors Determining a Sound ——

Besides the three basic elements of sound already explained, pitch, sound volume and timbre, there is another important factor which determines a sound. This is the variation of the sound over time. More precisely, it is the variation of each of the three elements over time from the beginning of the sound up to the point in time where it disappears completely. If a violin is played with a bow, for instance, the sound volume usually increases gradually while the timbre and pitch also change slightly. These changes over time are what determines the characteristic timbre of a violin. On the other hand, if the sound of a piano were to continue without decaying, it would be very difficult to distinguish it from the the sound of a flute. These variations over time are called envelopes. Envelopes expressed graphically such as those in the diagrams below are called envelope curves.

Envelope Curves of Various Instruments (Sound Volume)



NOTE

The change of volume over time can also be called an envelope.

Remember

The changes over time of pitch, volume and timbre are called envelopes. Envelopes are among the most important factors determining a sound.

9 Basic Principles of Analog Synthesizer Structure

When people talk about synthesizers, you will often hear expressions such as VCO and VCF. Many who have heard such difficult words will therefore find it difficult to approach synthesizers, believing they are too complicated. Actually, though, synthesizers are not that difficult to understand at all.
Analog synthesizers in general consist of various blocks which correspond to the three major elements of sound and the envelopes explained above.

- **VCO (Voltage Controlled Oscillator)**

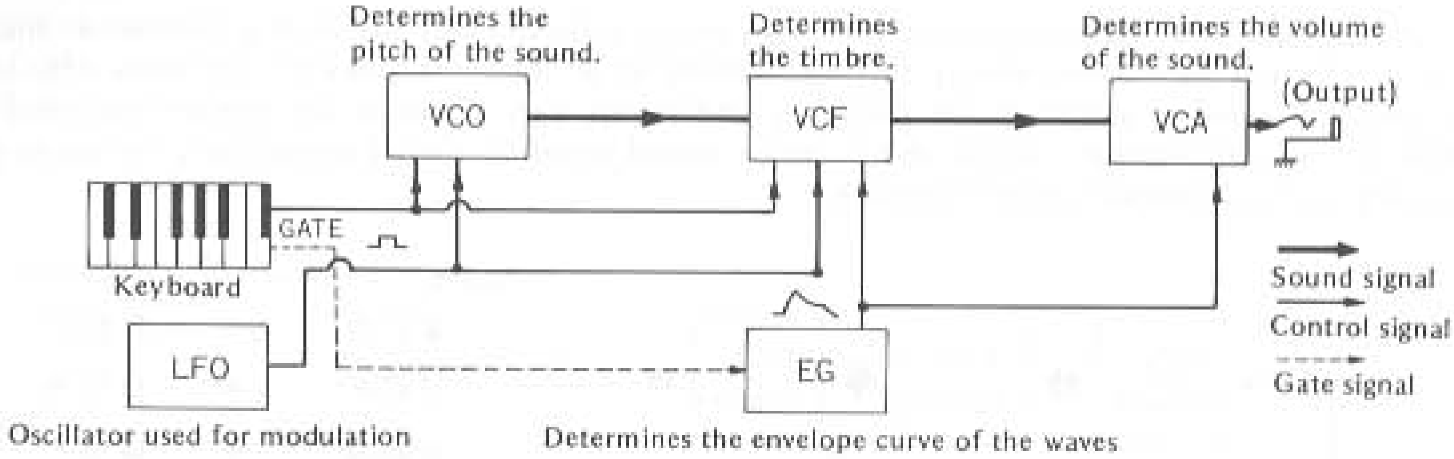
This circuit corresponds to determines the pitch of a sound by controlling voltage. This block is also used to create basic waveforms such as saw-tooth waves or square waves.

- **VCF (Voltage Controlled Filter)**

This circuit alters the timbre by accentuating or filtering out certain harmonics of the waveforms created by the VCO. The VCF might be called the most important part of an analog synthesizer.

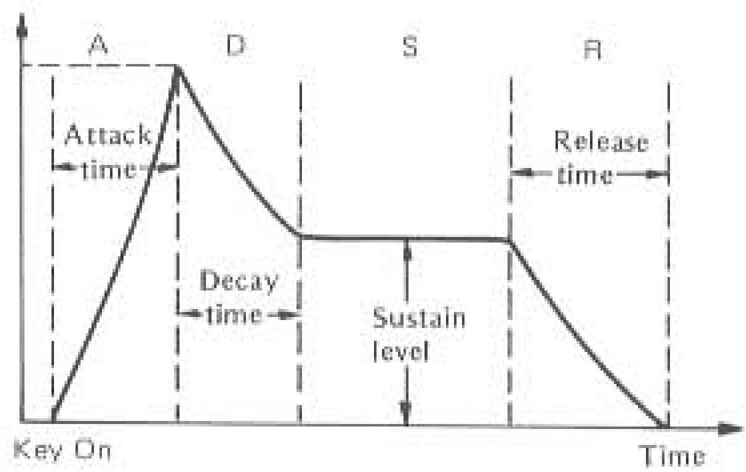
• VCA (Voltage Controlled Amplifier)

This circuit controls the volume of the sound created by the VCO and VCF.



• EG (Envelope Generator)

Controls the change over time of the volume, timbre etc.; in other words the envelopes. The basic envelope curve consists of the four elements shown in the diagram below which can be controlled independently. The EG block is thus capable of creating a great variety of curves.



• LFO (Low Frequency Oscillator)

As this term indicates, the LFO is an oscillator operating at low frequencies. It can be used to control various other blocks to create such effects as vibrato.

Remember

The basic structure and functions of an analog synthesizer:

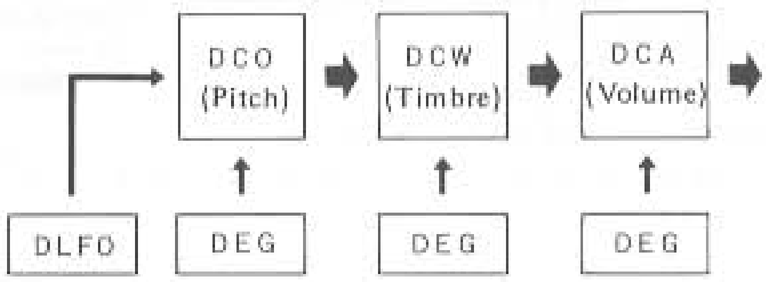
- **VCO:** Determines pitch (basic waveform)
- **VCF:** Creates the timbre
- **VCA:** Determines sound volume
- **EG:** Determines the envelope
- **LFO:** Used for various effects

Note

The above is meant only as a general idea of how an analog synthesizer works. Of course, there are considerable differences according to the manufacturer and model.

⑩ Structure of the CZ-3000

While the CZ-3000 is a digital synthesizer, it is as easy to understand as any analog synthesizer since it consists of blocks that correspond closely to those making up an analog synthesizer. Anybody who knows the basics concerning analog synthesis will therefore find it very easy to create any sounds they want with the CZ-3000. Even total beginners will be able to enjoy sound synthesis almost immediately by simply mastering the contents of this "Sound Synthesis Seminar".



<Analog Synthesizer>		<CZ-3000>
VCO	↔	DCO
VCF	↔	DCW
VCA	↔	DCA
E G	↔	DEG
LFO	↔	DLFO

* For more details on the structure of the CZ-3000, see Part 2, "CZ-3000 Sound Synthesis" (page 6).

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