

CHAPTER 7

CREATING SOUND

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USING SOUND IF YOU'RE NOT A COMPUTER "PROGRAMMER"

Most programmers use computer sound for two purposes: making music and generating sound effects. Before getting into the "intricacies" of programming sound, let's take a quick look at how a typical sound program is structured . . . and give you a short sound program you can experiment with.

STRUCTURE OF A SOUND PROGRAM

To begin with, there are five settings which you should know in order to generate sound on your **COMMODORE 64: VOLUME, ATTACK/ DECAY, SUSTAIN/RELEASE(ADSR), WAVEFORM CONTROL** and **HIGH FREQUENCY/LOW FREQUENCY**. The first three settings are usually set ONCE at the beginning of your program. The high and low frequency settings must be set for EACH NOTE you play. The waveform control starts and stops each note.

SAMPLE SOUND PROGRAM

Before you start you have to choose a **VOICE**. There are 3 voices. Each voice requires different sound setting numbers for Waveform, etc. You can play 1, 2 or 3 voices together but our sample uses only **VOICE NUMBER 1**. Type in this program line by line . . . be sure to hit the RETURN key after each line:

First clear sound chip.

```
5 FORL=54272TO54296:
```

```
POKEL,0:NEXT
```

1. Set **VOLUME** at highest setting.

```
10 POKE54296,15
```

2. Set **ATTACK/DECAY** rates to define how fast a note rises to and falls from its peak volume level (0 to 255):

```
20 POKE54277,190
```

3. Set **SUSTAIN/RELEASE** to define level to prolong note and rate to release it.

```
30 POKE 54278,248
```

4. Find the note/tone you want to play in the **TABLE OF MUSICAL NOTES** in Appendix M and enter the **HIGH-FREQUENCY** and **LOW-FREQUENCY** values for that note (each note requires 2 POKEs).

```
40 POKE54273,17:POKE54272,37
```

5. Start **WAVEFORM** with one of 50 POKE54276,17
4 standard settings (17, 33, 65
or 129).
6. Enter a time loop to set the 60 FORT=1TO250:NEXT
DURATION of the note to be
played (a quarter note is approx.
"250" but may vary since a longer
program can affect the timing).
7. Turn off note. 70 POKE54276,16

To hear the note you just created, type the word RUN and then hit the **RETURN** key. To view the program type the word LIST and hit **RETURN**. To change it, retype the lines you want to alter.

MAKING MUSIC ON YOUR COMMODORE 64

You don't have to be a musician to make music on your COMMODORE 64! All you need to know are a few simple numbers which tell your computer how loud to set the volume, which notes to play, how long to play them, etc. But first . . . here's a program which gives you a quick demonstration of the COMMODORE 64's incredible music capabilities, using only ONE of your computer's 3 separate voices.

Type the word NEW and hit **RETURN** to erase your previous program, then enter this program, type the word RUN and hit the **RETURN** key.

```

5 REM MUSICAL SCALE ←————— Title of program.
7 FORL=54272TO54296:POKEL,0:NEXT
10 POKE 54296,15 ←————— Sets volume at highest setting (15).
20 POKE 54277,9 ←————— Sets Attack/Decay
30 POKE 54276,17 ←————— Sustain/Release level (each note)
40 FORT=1TO300:NEXT ←————— Determines waveform (type of sound).
50 READ A ←————— Duration (how long) each note plays.
                    Reads first number in line 110 DATA.
```

```

60 READ B ←————— Reads second number in line 110 DATA.
70 IFB=-1THENEND ←————— ENDS when it READS -1 in line 900.
80 POKE 54273,A:POKE54272,B ←————— POKES the first number from DATA in line 110 (A= 17)
                                         as HIGH FREQUENCY and second number (B=37)
                                         as LOW FREQUENCY. Next time program loops
                                         around it READS A as 19 and B as 63, and so on,
                                         and POKES these numbers into the HIGH and LOW
                                         FREQUENCY locations. The number 54273=HIGH
                                         FREQUENCY for VOICE1 and 54272=LOW FRE-
                                         QUENCY for VOICE1.

85 POKE 54276,17 ←————— Start note.
90 FORT=1TO250:NEXT:POKE54276,16 ←————— Let it play then stop note
95 FORT=1TO50:NEXT ←————— Time for release.
100 GOTO20 ←————— Loops back to reset CONTROL and play new note.
110 DATA17,37,19,63,21,154,22,227 ←————— Musical note values from note value chart in Appendix
120 DATA 25,177,28,214,32,94,34,175 ←————— M. Each pair of numbers represents one note. For
                                         example, 17 and 37 represent "C" of the 4th oc-
                                         tave, 19 and 63 represent "D" and so on.

900 DATA-1,-1 ←————— When program reaches -1 it turns off HIGH/LOW
                                         FREQUENCY settings and ENDS as instructed in
                                         line 70.

```

To change the sound to a "harpichord," change Line 85 to read POKE54276,33 and Line 90 to read FORT=1TO250:NEXT:POKE54276,32 and RUN the program again. (To change the line, hit the **RUN/STOP** key to stop the program, type the word LIST and hit **RETURN**, then retype the program line you want to change; the new line will automatically replace the old one). What we did here is change the "waveform" from a "triangular" shaped sound wave to a "sawtooth" wave. Changing the WAVEFORM can drastically change the sound produced by the COM-MODORE 64 . . . but . . . waveform is only one of several settings you can change to make different musical tones and sound effects! You can also change the ATTACK/DECAY rate of each note . . . for example, to change from a "harpichord" sound to a more "banjo" sound try chang- ing lines 20 and 30 to read:

```

20 POKE54277,3
30 POKE54278,0 ←————— Sets no sustain for banjo effect.

```

As you've just seen, you can make your COMMODORE 64 sound like different musical instruments. Let's take a closer look at how each sound setting works

IMPORTANT SOUND SETTINGS

1 VOLUME—To turn on the volume and set it to the highest level, type: POKE 54296,15. The volume setting ranges from 0 to 15 but you'll use 15 most of the time. To turn "off" the volume, type:

POKE 54296,0

You only have to set the volume ONCE at the beginning of your program, since the same setting activates all three of the Commodore 64's VOICES. (Changing the volume during a musical note or sound effect can produce interesting results but is beyond the scope of this introduction.)

2. ADSR and WAVEFORM CONTROL SETTING—You've already seen how changing the waveform can change the sound effect from "xylophone" to "harpsichord." Each VOICE has its own WAVEFORM CONTROL SETTING which lets you define four different types of waveforms: Triangle, Sawtooth, Pulse (Square) and Noise. The CONTROL also activates the COMMODORE 64's ADSR feature, but we'll come back to this in a moment. A sample waveform start setting looks like this:

POKE 54276,17

where the first number (54276) represents the control setting for VOICE 1 and the second number (17) represents the start for a triangular waveform. The settings for each VOICE and WAVEFORM combination are shown in the table below.

ADSR AND WAVEFORM CONTROL SETTINGS

	CONTROL REGISTER	Note Start/Stop Numbers			
		TRIANGLE	SAWTOOTH	PULSE	NOISE
VOICE 1	54276	17/16	33/32	65/64	129/128
VOICE 2	54283	17/16	33/32	65/64	129/128
VOICE 3	54290	17/16	33/32	65/64	129/128

Although the control registers are different for each voice the waveform settings are the same for each type of waveform. To see how

this works, look at Lines 85 and 90 in the musical scale program. In this program, immediately after setting the frequency in Line 80, we set the CONTROL SETTING for VOICE 1 in Line 85 by POKEing 54276,17. This turned on the CONTROL for VOICE 1 and set it to a TRIANGLE WAVEFORM (17). In Line 70 we POKE 54276,16, stopping the note. Later, we changed the waveform start setting from 17 to 33 to create a SAWTOOTH WAVEFORM and this gave the scale a "harpsichord" effect. See how the CONTROL SETTING and WAVEFORM interact? Setting the waveform is similar to setting the volume, except each voice has its own setting and instead of POKEing volume levels we're defining waveforms. Next, we'll look at another aspect of sound . . . the ADSR feature.

3. ATTACK/DECAY SETTING—As we mentioned before, the ADSR CONTROL SETTING not only defines the waveform but it also activates the **ADSR**, or **ATTACK/DECAY/SUSTAIN/RELEASE** feature of the COM-MODORE 64. We'll begin by looking at the ATTACK/DECAY setting. The following chart shows the various ATTACK and DECAY levels for each voice. If you're not familiar with the concepts of sound attack and decay, you might think of "attack" as the rate at which a note/sound arises to its MAXIMUM VOLUME. The DECAY is the rate at which the note/sound falls from its highest volume level back to the SUSTAIN level. The following chart shows the ATTACK/DECAY setting for each voice, and the numbers for each attack and decay setting. Note that YOU MUST COMBINE ATTACK AND DECAY SETTINGS BY ADDING THEM UP AND ENTERING THE TOTAL. For example, you can set a HIGH ATTACK rate and a LOW DECAY rate by adding the high attack number (64) to the low decay number (1). The total (65) will tell the computer to set the high attack rate and low decay rate. You can also increase the attack rates by adding them together ($128 + 64 + 32 + 16 = \text{MAX. ATTACK RATE of } 240$).

ATTACK/DECAY RATE SETTINGS

	ATTACK/DECAY SETTING	HIGH ATTACK	MEDIUM ATTACK	LOW ATTACK	LOWEST ATTACK	HIGH DECAY	MED. DECAY	LOW DECAY	LOWEST DECAY
VOICE 1	54277	128	64	32	16	8	4	2	1
VOICE 2	54284	128	64	32	16	8	4	2	1
VOICE 3	54291	128	64	32	16	8	4	2	1

If you set an attack rate with no decay, the decay is automatically zero, and vice-versa. For example, if you POKE 54277,64 you set a medium attack rate with zero decay for VOICE 1. If you POKE 54277,66 you set a medium attack rate and a low decay rate (because $66=64+2$ and sets BOTH settings). You can also add up several attack values, or several decay values. For example, you can add a low attack (32) and a

medium attack (64) for a combined attack rate of 96, then add a medium decay of 4 and . . . presto . . . POKE 54277,100.

At this point, a sample program will better illustrate the effect. Type the word NEW, hit **RETURN** and type in this program and RUN it:

```
5 FOR L=54272TO54296:POKE L,0:NEXT ←———— Duration the note plays.
10 PRINT"HIT ANY KEY" ←———— Screen message.
20 POKE54296,15 ←———— Set volume at highest level.
30 POKE54277,64 ←———— Set Attack/Decay.
40 POKE54273,17:POKE54272,37 ←———— Poke one note into VOICE 1.
60 GETK$:IFK$=""THEN60 ←———— Check the keyboard.
70 POKE54276,17:FORT=1TO200:NEXT ←———— Set Waveform control (triangle).
80 POKE54276,16:FORT=1TO50:NEXT ←———— Turn off settings.
90 GOTO20 ←———— Loop back and do it again.
```

Here, we're using VOICE 1 to create one note at a time . . . with a MEDIUM ATTACK RATE and ZERO DECAY. The key is Line 40. POKEing the ATTACK/DECAY setting with the number 64 activates a MEDIUM attack rate. The result sounds like someone bouncing a ball in an oil drum. Now for the fun part. Hit the **RUN/STOP** key to stop the program, then type the word LIST and hit **RETURN**. Now type this line and hit **RETURN** (the new line 40 automatically replaces the old line 40):

```
40 POKE 54277,190
```

Type the word RUN and hit **RETURN** to see how it sounds. What we've done here is combine several attack and decay settings. The settings are: **HIGH ATTACK (128) + LOW ATTACK(32) + LOWEST ATTACK (16) + HIGH DECAY (8) + MEDIUM DECAY(4) + LOW DECAY(2) = 190**. This effect sounds like a sound an oboe or other "reedy" instrument might make. If you'd like to experiment, try changing the waveform and attack/decay numbers in the musical scale example to see how an "oboe" sounds. Thus . . . you can see that changing the attack/decay rates can be used to create different types of sound effects.

4. SUSTAIN/RELEASE SETTING—Like Attack/Decay, the SUSTAIN/RELEASE setting is activated by the ADSR/WAVEFORM Control. SUSTAIN/RELEASE lets you "extend" (SUSTAIN) a portion of a particular sound, like the "sustain pedal" on a piano or organ which lets you prolong a note. Any note or sound can be sustained at any one of 16 levels. The SUSTAIN/RELEASE Setting may be used with a FOR . . . NEXT loop to

determine how long the note will be held at SUSTAIN volume before being released. The following chart shows the numbers you have to POKE to reach different SUSTAIN/RELEASE, rates.

SUSTAIN/RELEASE RATE SETTINGS

SUSTAIN/ CONTROL	RELEASE SETTING	HIGH	MEDIUM	LOW	LOWEST	HIGH	MED.	LOW	LOWEST
		SUSTAIN	SUSTAIN	SUSTAIN	SUSTAIN	RELEASE	RELEASE	RELEASE	RELEASE
VOICE 1	54278	128	64	32	16	8	4	2	1
VOICE 2	54285	128	64	32	16	8	4	2	1
VOICE 3	54292	128	64	32	16	8	4	2	1

As an example, if you're using VOICE1, you can set a HIGH SUSTAIN LEVEL by typing: POKE 54278,128 or you could combine a HIGH SUSTAIN LEVEL with a LOW RELEASE RATE by adding 128 + 2 and then POKE 54278,130. Here's the same sample program we used in the ATTACK/DECAY section above . . . with a SUSTAIN/RELEASE feature added. Notice the difference in sounds.

```

5 FORL=54272:Ø54296:POKE,L,0:NEXT ←—————Duration the note plays.
1Ø POKE54296,15 ←—————Set volume at highest level.
2Ø POKE54277,64 ←—————Set Attack/Decay.
3Ø POKE54278,128←—————Set Sustain/Release
4Ø POKE54273,17:POKE54272,37 ←—————POKE one note into VOICE 1.
5Ø PRINT" HIT ANY KEY" ←—————Screen message.
6Ø GETK$:IFK$="" THEN6Ø ←—————Check the keyboard.
7Ø POKE54276,17:FORT=1TO2ØØ:NEXT ←—————Set Waveform control (triangle).
8Ø POKE54276,16:FORT=1TO5Ø:NEXT ←—————Turn off settings.
9Ø GOTO6Ø ←—————Loop back and do it again.

```

In Line 30, we tell the computer to SUSTAIN the note at a HIGH SUSTAIN LEVEL (128 from chart above) . . . after which the tone is released in Line 80. You can vary the duration of a note by changing the "count" in Line 70. To see the effect of using the release function try changing line 30 to POKE54278,89 (SUSTAIN = 80, RELEASE = 9).

5. CHOOSING VOICES AND SETTING HIGH/LOW FREQUENCY SOUND VALUES—Each individual note on the Commodore 64 requires TWO SEPARATE POKE COMMANDS . . . one for HIGH FREQUENCY and one for LOW FREQUENCY. The MUSICAL NOTE VALUE table in Appendix M shows you the corresponding POKES you need to play any note in the

Commodore 64's eight octave range. The HIGH and LOW FREQUENCY POKE COMMANDS are different for each VOICE you use—this allows you to program all 3 voices independently to create 3-voice music or exotic sound effects.

The HIGH and LOW FREQUENCY POKE COMMANDS for each voice are shown in the chart below, which also contains the NOTE VALUES for the middle (fifth) octave.

VOICE NUMBER & FREQUENCY	POKE NUMBER	SAMPLE MUSICAL NOTES—FIFTH OCTAVE													
		C	C#	D	D#	E	F	F#	G	G#	A	A#	B	C	C#
VOICE1/HIGH	54273	34	36	38	40	43	45	48	51	54	57	61	64	68	72
VOICE1/LOW	54272	75	85	126	200	52	198	127	97	111	172	126	188	149	169
VOICE2/HIGH	54280	34	36	38	40	43	45	48	51	54	57	61	64	68	72
VOICE2/LOW	54279	75	85	126	200	52	198	127	97	111	172	126	188	149	169
VOICE3/HIGH	54287	34	36	38	40	43	45	48	51	54	57	61	64	68	72
VOICE3/LOW	54286	75	85	126	200	52	198	127	97	111	172	126	188	149	169

As you can see, there are 2 settings for each voice, a HIGH FREQUENCY setting and a LOW FREQUENCY setting. To play a musical note, you must POKE a value into the HIGH FREQUENCY location and POKE another value into the LOW FREQUENCY location. Using the settings in our VOICE/FREQUENCY/NOTE VALUE table, here's the setting that plays a C note from the 5th octave (VOICE1):

POKE 54273,34:POKE 54272,75.

The same note on VOICE2 would be:

POKE 54280,34:POKE 54279,75.

Used in a program, it looks like this:

```

5 FORL=54272TO54296:POKEL,0:NEXT
10 V=54296:W=54276:A=54277: ← Set numbers equal to letters.
   S=54278:H=54273:L=54272
20 POKEV,15:POKEA,190:POKES,89 ← POKE volume, waveform, attack/decay.
30 POKEH,34:POKEL,75 ← POKE hillo freq. notes
40 POKEW,33:FORT=1TO200:NEXT ← start note, let it play
50 POKEW,32 ← stop note

```

PLAYING A SONG ON THE COMMODORE 64

The following program can be used to compose or play a song (using VOICE1). There are two important lessons in this program: First, note how we abbreviate all the long control numbers in the first line of the program . . . after that, we can use the letter W for "Waveform" instead of the number 54276.

The second lesson concerns the way we use the DATA. This program is set up to let you enter 3 numbers for each note: the HIGH FREQUENCY NOTE VALUE, the LOW FREQUENCY NOTE VALUE, and the DURATION THE NOTE WILL BE PLAYED.

For this song, we used a duration "count" of 125 for an eighth note, 250 for a quarter note, 375 for a dotted quarter note, 500 for a half note and 1000 for a whole note. These number values can be increased or decreased to match a particular tempo, or your own musical taste.

To see how a song gets entered, look at Line 100. We entered 34 and 75 as our HIGH and LOW FREQUENCY settings to play a "C" note (from the sample scale shown previously) and then the number 250 for a quarter note. So the first note in our song is a quarter note C. The second note is also a quarter note, this time the note is "E" . . . and so on to the end of our tune. You can enter almost any song this way, adding as many DATA statement lines as you need. You can continue the note and duration numbers from one line to the next but each line must begin with the word DATA. DATA-1,-1,-1 should be the last line in your program. This line "ends" the song.

Type the word NEW to erase your previous program and type in the following program, then type RUN to hear the song.

MICHAEL ROW THE BOAT ASHORE-1 MEASURE

```
2 FORL=54272TO54296:POKEL,0:NEXT
5 V=54296:W=54276:A=54277:HF=54273:LF=54272:S=54278:
  PH=54275:PL=54274
10 POKEV,15:POKEA,88:POKEPH,15:POKEPL,15:POKES,89
20 READH:IFH=-1THENEND
30 READL
40 READD
60 POKEHF,F:POKELF,L:POKEW,65
80 FORT=1TOD:NEXT:POKEW,64
85 FORT=1TO50:NEXT
```

```
90 GOTO10
100 DATA34,75,250,43,52,250,51,97,375,43,52,125,51,97
105 DATA250,57,172,250
110 DATA51,97,500,0,0,125,43,52,250,51,97,250,57,172
115 DATA1000,51,97,500
120 DATA-1,-1,-1
```

CREATING SOUND EFFECTS

Unlike music, sound effects are more often tied to a specific programming "action" such as the explosion made by an astro-fighter as it crashes through a barrier in a space game . . . or the warning buzzer in a business program that tells the user he's about to erase his disk by mistake.

You have a wide range of options available if you want to create different sound effects. Here are 10 programming ideas which might help you get started experimenting with sound effects:

1. Change the volume while a note is playing, for example to create an "echo" effect.
2. Vary between two notes rapidly to create a sound "tremor."
3. Waveform . . . try different settings for each voice.
4. Attack/Decay . . . to alter the rate a sound rises toward its "peak" volume and rate it diminishes from that peak.
5. Sustain/Release . . . to change sustain to volume of a sound effect, and rate it diminishes from that volume.
6. Multivoice effects . . . playing more than one voice at the same time, each voice independently controlled, or one voice playing longer or shorter than another, or serving as an "echo" or response to a first note.
7. Changing notes on the scale, or changing octaves, using the values in the MUSICAL NOTE VALUE table.
8. Use the Square Waveform and different Pulse Settings to create different effects.
9. Use the Noise Waveform to generate "white noise" for accenting tonal sound effects or creating explosions, gunshots or footsteps. The same musical notes that create music can also be used with the Noise Waveform to create different types of white noise.
10. Combine several HIGH/LOW frequencies in rapid succession across different octaves.
11. Filter . . . try the extra POKE setting in Appendix M.

SAMPLE SOUND EFFECTS TO TRY

The following programs may be added to almost any BASIC program. They are included to give you some programming ideas and demonstrate the Commodore 64's sound effect range.

Notice the programming shortcut we're using in Line 10. We can abbreviate those long cumbersome sound setting numbers by defining them as easy-to-use letters (numeric variables). Line 10 simply means that these easy to remember LETTERS can be used instead of those long numbers. Here, V = Volume, W=Waveform, A=Attack/Decay, H=High Frequency (VOICE1), and L=Low Frequency (VOICE1). We then use these letters instead of numbers in our program . . . making our program shorter, typing faster, and the sound settings easier to remember and spot.

DOLL CRYING

```
10 V=54296:W=54276:A=54277: H=54273:L=54272
20 POKEV,15:POKEW,65:POKEA,15
30 FORX=200TO5STEP-2:POKEH,40:POKEL,X:NEXT
40 FORX=150TO5STEP-2:POKEH,40:POKEL,X:NEXT
50 POKEW,0
```

SHOOTING SOUND . . . USING VOICE1, NOISE WAVEFORM, FADING VOLUME

```
10 V=54296:W=54276:A=54277:H =54273:L=54272
20 FORX=15TO0STEP-1:POKEV,X:POKEW,129:POKEA,
  15:POKEH,40:POKEL,200:NEXT
30 POKEW,0:POKEA,0
```