

**YAMAHA**

# Understanding Fractional Scalings



**DIGITAL PROGRAMMABLE ALGORITHM SYNTHESIZER**  
**SUPPLEMENTAL BOOKLET**

# Welcome

When you are creating new voices on the DX, one of the most important things to consider is making the voice sound “right” from the bottom of the keyboard to the top of the keyboard. On the original DX7 you could do this by using the level scaling parameters. On the DX7 II you can make even finer changes in volume and timbre over the length of the keyboard by using the new fractional level scaling parameters.

This is the first of two booklets on fractional level scaling. This first booklet presents background information on level scaling and describes the basic rules for creating your own fractional level scalings. The second booklet shows you how actual fractional scalings are created and includes a new fractional scaling for one of the DX7 II ROM voices. You will need to know the information presented in the first booklet in order to understand the examples in the second booklet, so read this booklet carefully before attempting the examples.

The first fractional scaling booklet is presented in three sections:

Section 1 is a basic introduction to the concepts of level scaling and the methods of level scaling available on the DX7 II.

Section 2 gives detailed descriptions of the level scaling displays and how they are used.

Section 3 presents the basic rules to remember when creating your own fractional level scalings.

For continuing information concerning the DX7 II FD/D, consult AfterTouch, the official publication of the Yamaha Users Group. Many advanced functions will be discussed in its pages in the coming months. There will also be information concerning the availability of other materials concerning more advanced applications. To receive a free copy of AfterTouch every month, send your request to AfterTouch, P.O. Box 2338, Northridge, CA 91323-2338. On your letter or postcard, be sure to indicate that you are the owner of a DX7 II FD/D.

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# 1

## Introduction to Level Scaling

*Level scaling parameters are your best tool for creating smooth sounding voices across the length of the keyboard. Without them, most synthesizer voices would be useful over only a very small part of the musical scale. This is an introduction to the basic concept of level scaling and a brief look at the two level scaling modes on the DX7 II.*

# Level Scaling Basics

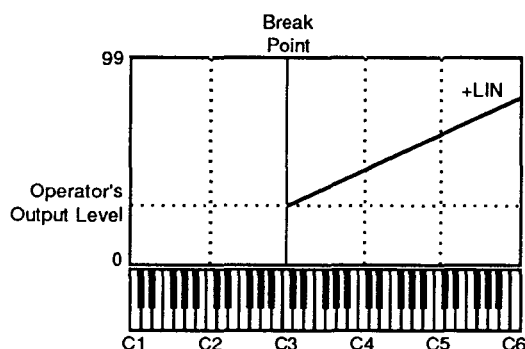
If you listen to any acoustic instrument you will hear the sound of the instrument change as it goes through its different ranges. For instance, listen to how harmonically rich the bottom notes on a grand piano sound compared to the notes at the upper end. This effect is imitated on the DX7 II by using level scaling parameters. These parameters let you change the volume and tone of a voice in specific ranges. If you wanted to imitate a grand piano scaling on the DX, for example, you would create a voice with all of the necessary harmonics for the lower notes and then use level scaling to gradually take out certain harmonics at the upper end of the keyboard.

In addition to increasing the useful range of imitative voices, level scaling is good for creating effects. You can exaggerate an odd harmonic over a small part of the keyboard or make drastic volume changes over the length of the keyboard. With judicious use of level scaling you can even create split keyboard effects.

## Normal Scaling Mode

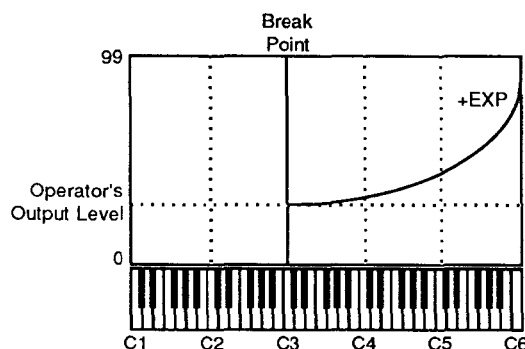
The normal scaling mode on the DX7 II is the same scaling that was first introduced on the original DX7. In the normal scaling mode you start out by choosing a break point between A-1 (A minus 1, which is 3 octaves and a minor third below middle C) and C8 (5 octaves above middle C). The break point is the point in a scaling that separates the left and right curves. You can then choose one of four different scaling curves for each side of the break point. The four scales are:

*Positive  
Linear*



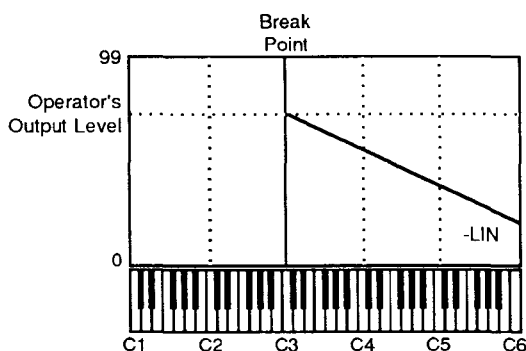
*the output level is raised in equal increments as you move away from the break point.*

*Positive  
Exponential*



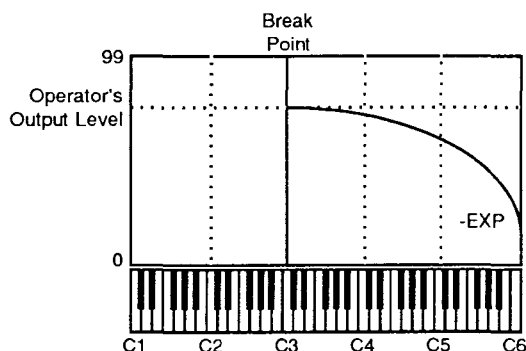
*the output level is raised in small increments close to the break point, and in increasingly larger increments as you move further from the break point.*

## Negative Linear



*the output level is lowered in equal increments as you move away from the break point.*

## Negative Exponential

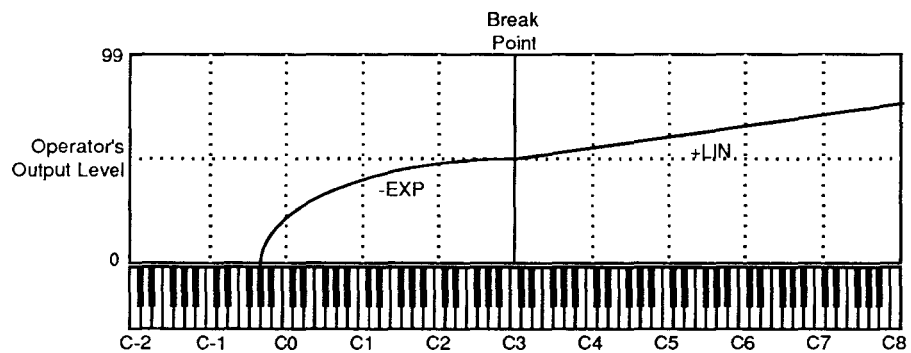


*the output level is lowered in small increments close to the break point, and in increasingly larger increments as you move further from the break point.*

Each operator can have a different break point and two different curves. If you change the scaling on an operator that is acting as a carrier, you will be changing the volume of that operator and all of the operators that are modulating it. When you change the scaling on an operator that is functioning as a modulator, you are still changing its relative volume across the keyboard, but because it is functioning as a modulator, the effect will be to alter the tone of the voice in different ranges of the keyboard. (For a more complete discussion of carriers and modulators and other FM theory, refer to one of the books recommended on page 83 of the DX7 II Owner's Manual).

Another thing to keep in mind is that the level curves don't sound exactly the same as they look. In fact, exponential changes in volume sound linear to the ear. This means that the exponential curves sound more natural to the ear, while the linear curves are effective for making more drastic level changes.

As an example of how normal level scaling works, let's say that you want to change the tone of a voice at middle C. First, you would choose the appropriate modulator and choose C3 as the break point. To make the sound brighter as you move up the keyboard, you could choose a positive linear scaling for the right curve and raise its depth until the sound brightens as you move up the keyboard. If you want to make the left side of the keyboard darker, but keep the change subtle, you would choose a negative exponential curve for the left curve and raise the depth slowly until you get the desired effect.

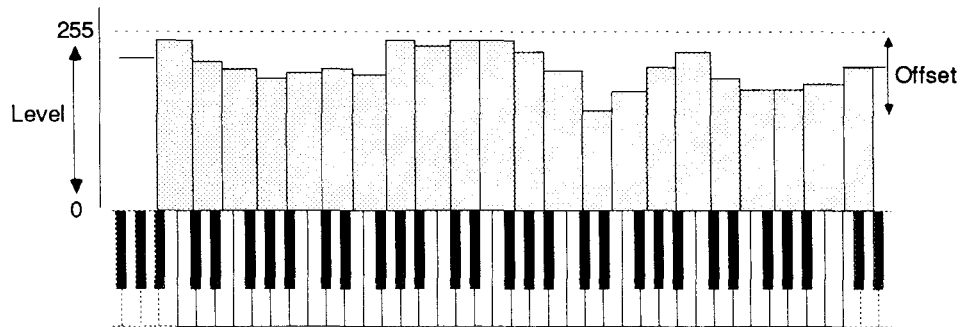


Notice that when you choose a negative curve the operator output level is scaled down as you raise the depth. If it sounds confusing, just think of it as applying more negative curve as you raise the depth.

As comprehensive as the normal scaling mode is, there are still certain situations that might require finer control. For instance, in the example above, what would happen if you wanted the octave between C4 and C5 to be brighter than the octave between C5 and C6? Since there are no curves that go up and then back down, you would be forced to move the break point somewhere around C5. As soon as you did that, everything between C3 and C5 would be darker than it was before. If you tried to brighten them back up by choosing a positive curve for the left curve, you would be making everything below C5 progressively brighter, which is just the opposite of what you set up originally on the left curve. The first time something like this happens you will be glad to have the fractional scaling mode.

## Fractional Scaling Mode

With the fractional scaling mode you can change the level of each operator in three note groups over the entire range of the keyboard.



This immediately takes care of the problem in the previous example since you can easily change the level of the octave between C4 and C5 without ever disturbing any of the other ranges. In addition, each keygroup has a range from 0-255 so that you can make very precise adjustments to the level. After you have created a fractional scaling you can use the offset parameter to change the level of the entire scaling by a value of  $\pm 127$ . Like the normal level scaling parameters, you can set up a different fractional scaling for each operator.





# 2

## The Scaling Displays

*Before you can begin editing the level scaling parameters, you must first learn to use the level scaling display. Both fractional and normal scaling displays are easy to use, and accessed from the same front panel switch.*

# Reading the Level Scaling Displays

## *How to Initialize a Voice*

To keep the examples in this booklet simple, you will be using an Initialized voice. When you initialize the voice you will be hearing a single operator (operator 1) and all level scaling will be turned off.

1	<div>COMPARE EDIT</div>	Press Edit to enter the edit mode.
2	<div>TUNE 14 46</div>	<div>Initialize ■VoiceA &gt;VoiceB &gt;Performance</div> Press Tune until you see Initialize Voice A.
3	<div>YES +1/ON</div>	<div>Initialize ■VoiceA &gt;VoiceB &gt;Performance ** Are you sure?</div> Press YES.
4	<div>YES +1/ON</div>	<div>Initialize ■VoiceA &gt;VoiceB &gt;Performance ** Completed!</div> Press YES. The Voice is now initialized.

Play a key. You are hearing a single sine wave that plays at full volume when you press the key down and immediately stops playing when the key is released. It doesn't sound very exciting, but it's great for examples. Now, follow the instructions in the following diagram to look at the normal scaling display.

## How to Enter the Normal Scaling Display

1

OUTPUT  
LEVEL

10 42

OP# Outlvl ■Scaling mode  
a19 1 111111 normal

Press Output Level until you see this display.

2

1 33

OP1 Outlvl ■Scaling mode  
a19 1 111111 normal

Press Operator Select 1 to select operator 1 for editing.

3

OUTPUT  
LEVEL

10 42

OP1 Outlvl ■Level>Ld >Lc >BP >Rc >Rd  
a19 1 111111 99 0 -lin C3 -lin 0

Press Output Level to see the normal scaling display.

## The Normal Scaling Display

### Normal Scaling LCD Display

OP1 Outlvl >Level>Ld >Lc >BP >Rc >Rd  
a19 1 111111 99 0 -lin C3 -lin 0

Output Level  
Left Depth  
Left Curve  
Break Point  
Right Curve  
Right Depth

This is the normal level scaling display. All of the parameters that were discussed in the introduction are in this display, even though that might not be obvious at first glance.

When you first see the level scaling display the cursor will be blinking over the Level parameter. If you want to change a different parameter, use the Cursor keys to move the blinking cursor to one of the other available parameters. Once you have selected a parameter, use the Data Entry buttons or Data Entry slider to change the value. In the normal level scaling display there are six parameters that you can change:

**Level** This is where you adjust the overall Output Level of the operator. The range is 0-99.

- Ld** You set the Left Depth here. This determines how much the left scaling curve affects the operator Output Level on the left side of the break point. The kind of affect the scaling will have is determined by the type of curve assigned to the left curve.
- Lc** Lc stands for Left Curve (you're probably getting the idea by now). There are four curve types: - lin (negative linear), - exp (negative exponential), + exp (positive exponential), and + lin (positive linear).
- Bp** When the cursor is blinking on this parameter, you can change the Break Point with the data entry slider. The range is A-1 to C8.
- Rc** This is where you set the Right Curve. The choices are the same as they were for the Left Curve.
- Rd** You set the Right Depth here. This determines how much the right scaling curve affects the operator Output Level on the right side of the break point. The kind of affect the scaling will have is determined by the type of curve assigned to the right curve.

You'll be working with the normal level scaling display a little later so that you can get a better idea of how it works. For now, take a look at the fractional scaling display.

### How to Enter the Fractional Scaling Mode

1

OUTPUT LEVEL  

10
42

OP1 Outlvl ■Scaling mode  
 al9 1 111111 normal

Press Output Level to see this display.

2

YES  
 +1/ON

OP1 Outlvl ■Scaling mode  
 al9 1 111111 fractional

Press YES to select the fractional scaling mode.

3

OUTPUT LEVEL  

10
42

OP1 Outlvl ■Ofst > C-2-> C#-1->  
 al9 1 111111 + 0 255 255

Press Output Level until you see the fractional scaling display.

4

PAN  

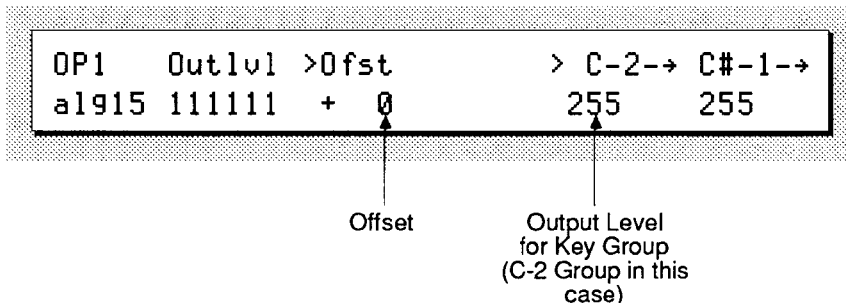
▶

OP1 Outlvl >Ofst ■ C-2-> C#-1->  
 al9 1 111111 + 0 255 255

If the cursor is on Ofst, press the right cursor button to move the cursor to the note group parameters.

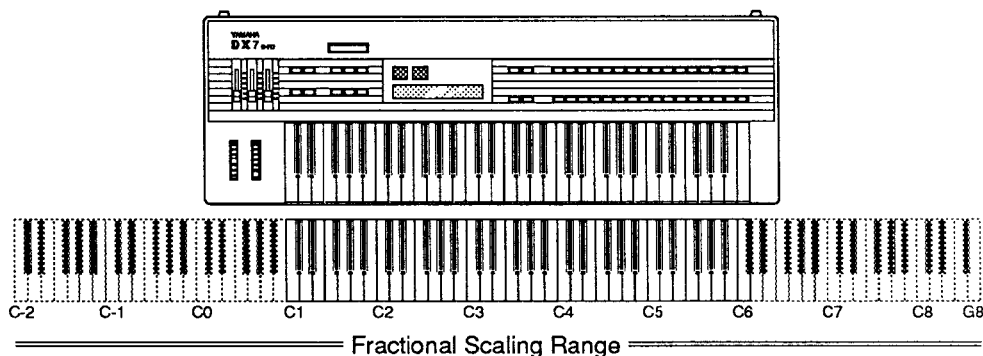
## The Fractional Scaling Display

### *Fractional Scaling Mode Display*



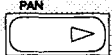
This is the fractional scaling mode display. When you first enter, the cursor will be blinking on the lowest keygroup you can edit. With the exception of this keygroup (the lowest one covers an octave) all of the keygroups are in groups of three keys. You can scale any operator over the entire MIDI key range (C-2 ~ G8).

### *DX Keyboard in Relation to the Entire Scaling Range*



*Moving the Cursor in the Fractional Display*

When you want to edit a different keygroup, you can choose one of two methods to move the cursor:

**1**  Press the right cursor button to select the Note Group Edit parameter.

OPERATOR SELECT / EQ COPY

1	2	3	4	5	6
1	2	3	4	5	6

Use the Operator Select buttons (#1~6) to choose the operator whose scaling you wish to edit.

**3** Press and hold a key in the note group you wish to edit.

INTERNAL

or

CARTRIDGE

Press the Internal or the Cartridge button. The note group you have selected will be shown next to the > indicator in the LCD.

OR

---

**3** FRACTIONAL / MICRO TUNE

◀

KEY SET

▶

INTERNAL

CARTRIDGE

Use the Internal and Cartridge buttons as left and right cursors to move the desired note group into position next to the > indicator in the LCD.

**4** DATA ENTRY

NO

YES

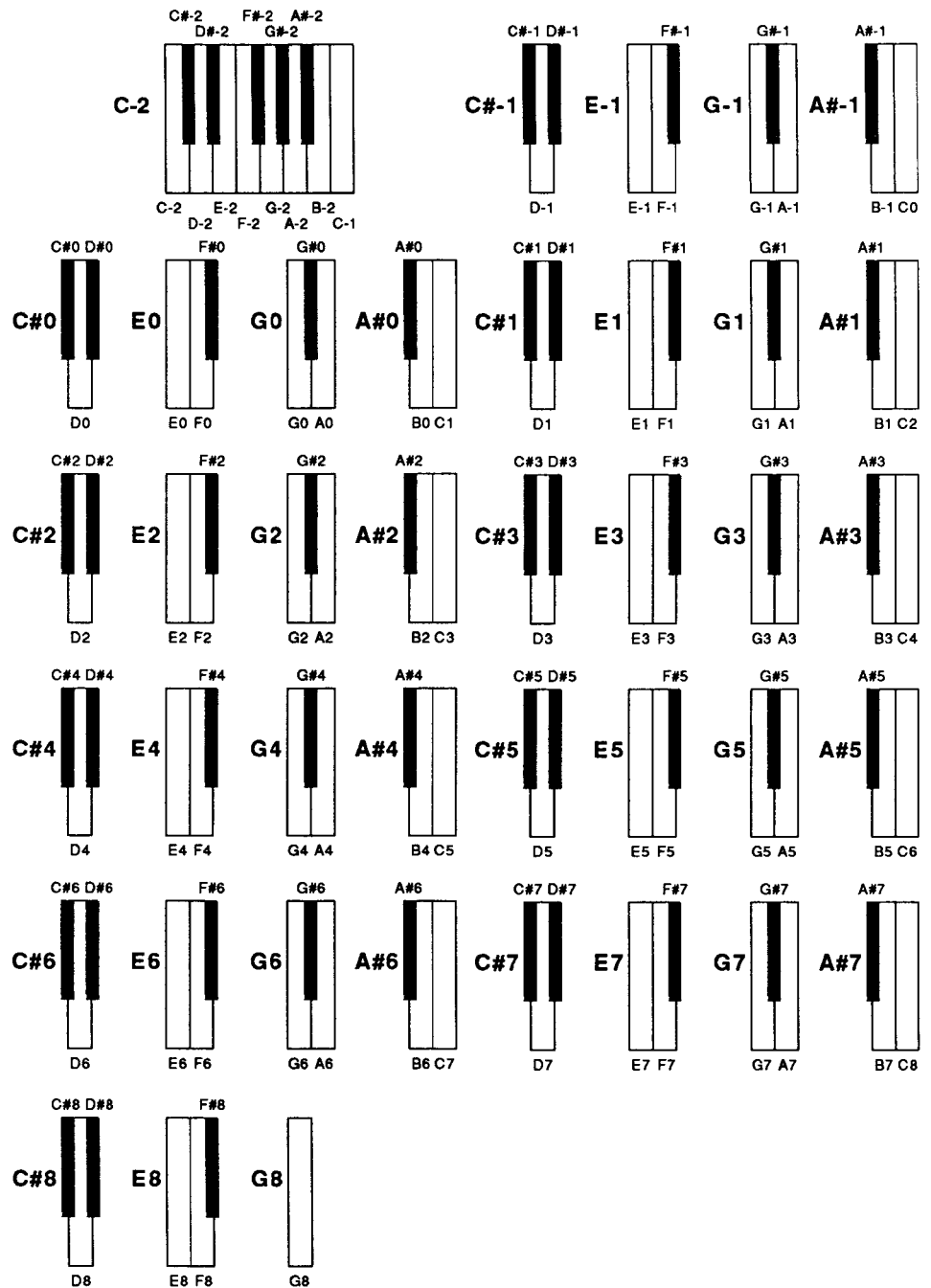
-1/OFF

+1/ON

Use the data entry slider or the +1/-1 buttons to edit the value for the selected note group.

Notice that when you play C3 and move the cursor using the first method described above (holding down C3 and pressing INTERNAL or CARTRIDGE), A#2 appears in the LCD. That is because you are editing in three note groups, and the lowest note is always the one that is shown in the LCD. There is an arrow to the right of the A#2 so that you have a graphic representation of this idea. So, when you edit the keygroup at A#2, you will affect A#2, B2 and C3. As you would expect, the next note showing in the display is C#3, since the next keygroup begins at C#3.

# *The Key Groups*





Once you have moved the cursor to the correct keygroup, you can change the value by moving the data entry slider. The level of the keygroups is variable between 0 and 255. This is an extremely large range so you can really fine tune a voice to make it sound smooth across the entire keyboard.

There is one more parameter in the fractional scaling display. If you press the < Cursor button, the cursor will move to Ofst. This is an offset feature for the fractional scaling and, sooner or later, you will find it very handy. There are 40 keygroups in a fractional scaling. If you changed all 40 and got the right curve but the wrong overall level, you wouldn't want to go back and change the level of each keygroup again. The offset control lets you avoid this problem. As soon as you have the correct curve, you can move all of the keygroups up or down in level without changing the basic curve. In other words, this is a global level control for the entire scaling. The range is +127 to -127, so you have a wide offset range.

# 3

## Fractional Scaling Basics

*Working with fractional scalings is simple as long as you remember a few basic rules. In this final section you will be going through some examples to become familiar with the most important aspects of programming fractional level scaling.*

# The Big Two Rules

There are two basic rules that you should keep in mind when you are working with fractional scales. The first rule is fairly obvious and will be easy to remember. The second rule is not quite as intuitive and things can get confusing if you forget it. Each rule will be followed by an example so that you can see what will happen first hand.

## Rule 1:

*Level Scalings set in the Normal scaling mode will also be applied in the Fractional scaling mode.*

This may seem strange at first, but it can really help you get started. If you know you are going to want an operator scaled down on the bottom half of the keyboard, you can set up a negative linear scaling in the normal scaling mode. If you want more control, you can then go into the fractional mode without losing the work you have already done. All of the keygroups on the left side of the break point will be descending in level. This saves you the effort of having to change each keygroup manually. This will normally be the starting point for all of your scaling work.

Before you start the following example, move the cursor with the Cursor > button so that you can scroll through the keygroups in the fractional scaling display—if you followed the previous steps, you will already be on the right display. Press INTERNAL and CARTRIDGE to scroll through the keygroups. Notice that all of the keygroups are set to a level of 255. Now, change the normal scaling:

*Returning to  
Normal Scaling Mode*

1

OUTPUT  
LEVEL  

10
42

OP1 Outlvl ■Scaling mode  
 al9 1 111111 fractional

Press Output Level until you see this display.

---

2

NO  
 -1/OFF

OP1 Outlvl ■Scaling mode  
 al9 1 111111 normal

Press NO to select the normal scaling mode.

---

3

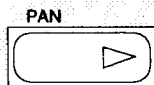
OUTPUT  
LEVEL  

10
42

OP1 Outlvl ■Level>Ld >Lc >Bp >Rc >Rd  
 al9 1 111111 99 0 -lin C3 -lin 0

Press Output Level to see the normal scaling display.

1



```
OP1  Outlvl >Level█Ld >Lc >Bp >Rc >Rd
a19 1 111111      99 0 -lin C3 -lin 0
```

Press the right cursor button to move the cursor to Ld.

2

DATA ENTRY	
NO	YES
-1/OFF	+1/ON

```
OP1  Outlvl >Level█Ld >Lc >Bp >Rc >Rd
a19 1 111111      99 99 -lin C3 -lin 0
```

Use the Data Entry buttons or slider to change the depth of the left curve to 99.

*Returning to  
Fractional Scaling Mode*

**1** OUTPUT  
LEVEL  
10 42 OP1 Outlvl ■Scaling mode  
a19 1 111111 normal

Press Output Level until you see this display.

**2** YES  
+1/ON OP1 Outlvl ■Scaling mode  
a19 1 111111 fractional

Press YES to select the fractional scaling mode.

**3** OUTPUT  
LEVEL  
10 42 OP1 Outlvl >Ofst C#2 --■ E2 -- G2 --  
a19 1 111111 + 0 255 255 255

Press Output Level to see the fractional scaling display.

Press and hold C3.

**4** INTERNAL  
or  
CARTRIDGE OP1 Outlvl >Ofst G2 --■A#2 -- C#3 --  
a19 1 111111 + 0 255 255 255

Press Internal or Cartridge. This selects the keygroup for C3.

**5** INTERNAL OP1 Outlvl >Ofst ■ C-2-- C#-1--  
a19 1 111111 + 0 17 33

Press Internal repeatedly to examine the settings for the keygroups below C3.

The levels gradually decrease as you move down the keyboard, corresponding to the negative linear scaling that you set up in the normal scaling mode. You could now go through and make adjustments to the keygroups to fine tune your scaling.

There is one small danger in this system that you should keep in mind. If you work up a brilliant fractional scaling and then go to the normal scaling mode and make changes to the normal scaling, you will destroy the fractional. This happens because the fractional scaling will once again conform to the scaling you set up in the normal scaling mode. It's not likely that you will go back to the normal scaling mode and begin editing after you have already set up a good fractional scaling, so this usually won't be a problem. But, be careful!

You can always avoid this and other related problems by frequently saving your work to a cartridge (see the section on Fractional Scaling Memory in the "Programming Fractional Scalings" booklet). Then, even if you accidentally destroy your fractional scaling, you can retrieve it from the cartridge and continue your work.

**Rule 2:**

*The position of the keygroups in relation to the DX keyboard changes according to the transposition of the voice.*

It sounds tricky and it is tricky. Go through the example so that you can see what this really means.

*Transposing the Voice*

1

ALGORITHM

7
39

>A19>Fb1>Osc.sync >Transpose >Voice name  
1 0 on midC= C3 INIT VOICE

Press Algorithm to see the Algorithm display.

---

2

PAN

▶

>A19>Fb1>Osc.sync ■Transpose >Voice name  
1 0 on midC= C3 INIT VOICE

Press the right cursor button 3 times until the cursor is beside Transpose.

---

3

>A19>Fb1>Osc.sync ■Transpose >Voice name  
1 0 on midC= C4 INIT VOICE

Init Voice is now transposed up an octave.

*Returning to  
Fractional Scaling Mode*

1

OUTPUT  
LEVEL

10
42

OP1    Outlv1 >Ofst    ■ C-2→ C#-1→  
 a19 1 111111 + 0            17    33

Press Output Level to return to the scaling display.

---

2

Press and hold C3.

INTERNAL

or

CARTRIDGE

OP1    Outlv1 >Ofst    G2 →■A#2 → C#3 →  
 a19 1 111111 + 0    255    255    255

Press Internal or Cartridge. This selects the keygroup for C3.

---

3

DATA ENTRY

NO  
-1/OFF

YES  
+1/ON

OP1    Outlv1 >Ofst    G2 →■A#2 → C#3 →  
 a19 1 111111 + 0    255    0    255

Use the Data Entry buttons or slider to change the level of the A#2 keygroup to 0.

Play C3 (middle C). C3 is just as loud as ever, even though you thought you had turned its volume all the way down. Now play C2 (an octave lower). There is no sound when you play C2. If you play C2 as you slowly raise the Data Entry slider, you will hear the sound return, even though the cursor is on A#2 (indicating that you have chosen the C3 keygroup). Be sure to replay the note as you move the Data Entry slider so that you can hear the changes. Changes made to fractional keygroup levels won't be heard until you replay a note.

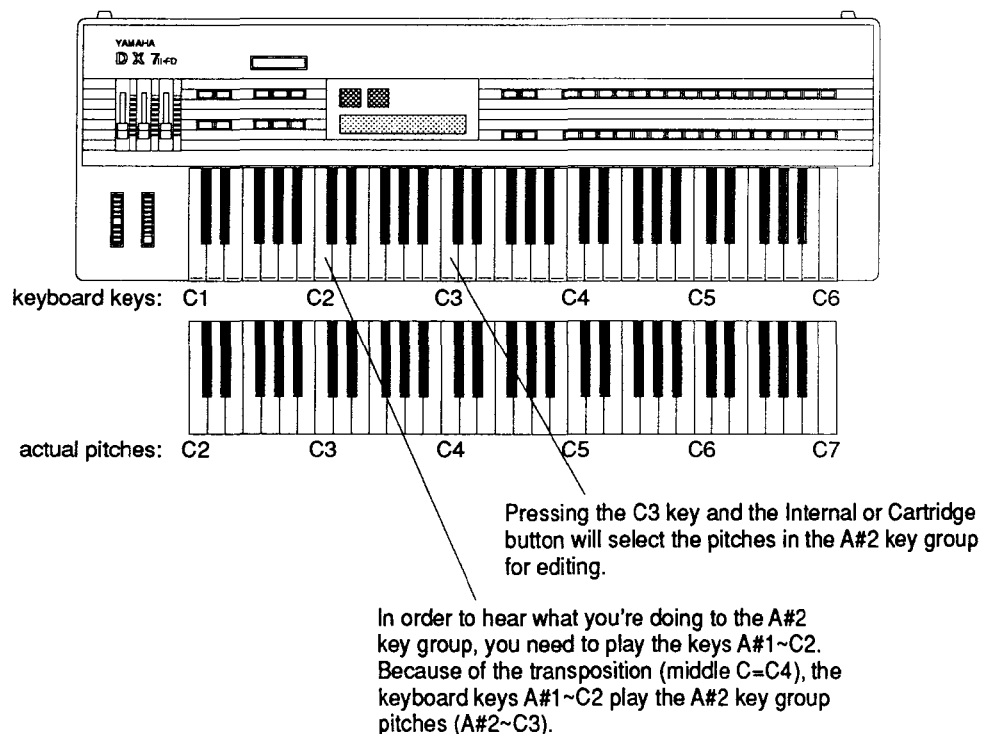
If you don't care why this happens, you can skip the following explanation. Just remember that every time you transpose a voice up an octave, all of the keygroups will be located down an octave from their marked location and vice versa.

## Keygroup Locations and the DX Keyboard

To understand why the keygroups seem to move, think back to the way the transpose display looked when you transposed the voice. The display read midC= C4. This means that the middle C on the keyboard (C3) will play a C4 pitch (up an octave from normal pitch) whenever it is played. But if middle C is playing C4, that means that you will have to play the C below middle C (which is C2) to hear C3. No matter where you go on the keyboard, there will never be a match between the keyboard location and the keygroup being edited. As it turns out, the source of confusion is in the fact that the same identifications are being used for two different systems:

The DX keyboard	This refers to the physical DX keyboard. The identifications are fixed in this system. The lowest note on the DX keyboard is always C1 and the highest is always C6.
The actual pitch being played	When the transposition of a voice is C3 and you play middle C (C3 on the DX keyboard), you will get the pitch of middle C on the piano. When you transpose a voice its relationship to the DX keyboard changes. If you transpose a voice up an octave, C3 (the pitch) will actually be located at C2 (the DX keyboard location).

### *Actual Pitch vs. the DX Keyboard*





Normally, the keygroup identifications on the top row of the fractional scaling display refer to pitch. When you edited the keygroup for C3, you actually changed the level of the notes around the pitch C3, or middle C. However, when you are holding down a key and using the INTERNAL and CARTRIDGE buttons to scroll to a particular location, the keygroup identifications refer to the DX keyboard location. If you hold down middle C, the DX will always jump to the keygroup that begins with A#2 no matter what kind of transposition is applied to the voice.

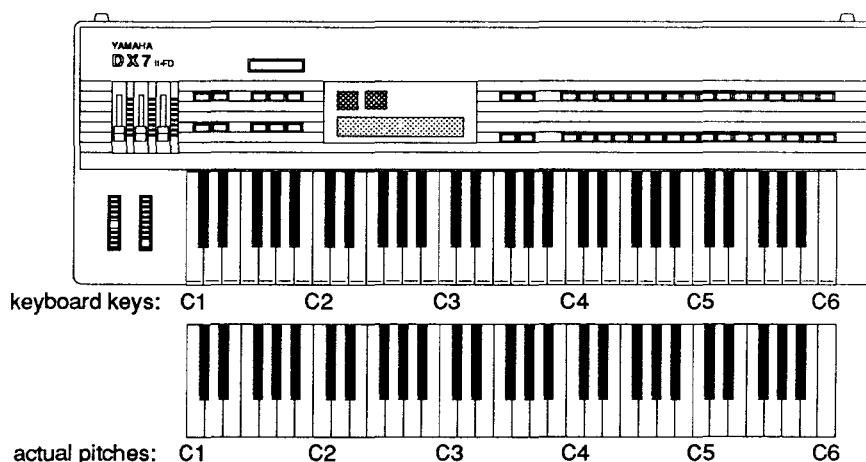
The basic thing to remember is that when you are using the DX keyboard to locate a particular place on the keyboard for editing, the keygroup identifications on the top row of the LCD refer to the DX keyboard location. When you actually begin editing the level of a keygroup, the keygroup identifications refer to the pitch of the keygroup. Whenever you're in doubt you can always transpose the voice to C3 so that the keyboard location and the pitch will match. If you do this, remember to transpose the voice back to its proper transposition when you're finished.

## Voice Transposition

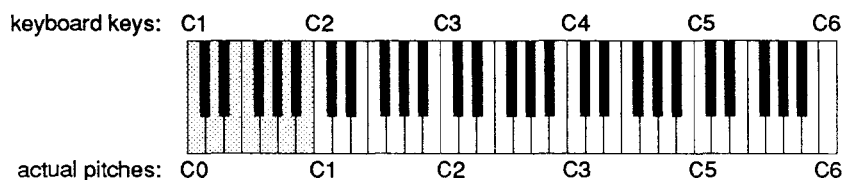
Before you move on, there is one more thing you should keep in mind about voice transposition. If you have already created fractional scales for a voice and have scaled only over the five octave DX keyboard, you will run into problems when you transpose the voice. For example, let's say that you scale a voice over the entire DX keyboard. If the voice is transposed to C3, it will be scaled from the pitch C1 to the pitch C6. If you now transpose the voice to C2, the pitch range becomes C0 to C5. Since you didn't scale anything below the pitch C1, the bottom octave may sound fairly strange.

If you are going to want to transpose a voice or you need to scale pitches that fall outside the key range of the DX (C1-C6), you will have to transpose the voice so that the desired pitch range is on the DX keyboard.

### *Transposed and Non-Transposed Voices on the DX*



Let's assume you have created a voice that is not transposed (middle C=C3) and that you have edited fractional scaling for one or more operators covering only the range of the playable keyboard (C1~C6).



If you later transpose the voice down an octave (middle C=C2), the keyboard keys C1~C6 will play the pitches C0~C5. Because fractional scaling was originally edited only for the pitches C1~C6, the pitches C0~B0, now playable at the keyboard (with keys C1~B1), will not have fractional scaling.

## Copying Fractional Scalings

### *Copying the Fractional Scaling from Operator 1 to Operator 3*

Once you have completed a fractional scaling for an operator, you can copy it to another operator by using the EG copy function. For instance, you could copy the fractional scaling from operator 1 to operator 3 and use it as a starting point for a new fractional scaling. Remember that all of the envelope generator settings are also copied when you use this function.

1

EG COPY

STORE

OP1 Outlv1 >Ofst G2 ->A#2 -> C#3 ->  
\*\*\*\* EG & Scaling Copy OP1 to OP? \*\*\*\*

Press and hold Store to see the EG Copy display.

2

3 35

OP1 Outlv1 >Ofst G2 ->A#2 -> C#3 ->  
\*\*\*\* EG & Scaling Copy OP1 to OP3 \*\*\*\*

While still holding Store, press 3, then release. The fractional scaling information from operator 1 is copied to operator 3.

3

3 35

OP3 Outlv1 >Ofst G2 ->A#2 -> C#3 ->  
a19 1 111111 + 0 255 255 255

Press 3 again to select operator 3 for editing.

4

FRACTIONAL / MICRO TUNE



KEY SET



INTERNAL

CARTRIDGE

OP3 Outlv1 >Ofst A#1 ->C#2 -> E2 ->  
a19 1 111111 + 0 209 225 241

Use the Internal and Cartridge buttons to look at the keygroups. The values will be identical to the keygroups for operator 1.

That's it for the basic rules. The second fractional booklet, "Programming Fractional Scalings," gives a detailed look at creating fractional scalings based on the rules you have learned here. Keep these rules in mind as you go through the examples in the second booklet.

## Notes

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## Notes

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