Basic Synthesis on the JP-8000

The JP-8000 Music Synthesizer uses Roland's new Analog Modeling Technology to combine powerful sounds associated with vintage analog synthesizers with the flexibility of digital technology and MIDI. Like classic analog synthesizers of the past, the JP-8000 has numerous knobs and sliders for powerful realtime control, opening a brand new world of musical possibilities and expression. The following is a list of features on the JP-8000:

- DSP oscillators simulate 7 different analog waveforms, Oscillator sync, Cross and Ring modulation
- 8 voice polyphony
- Keyboard splits and layers
- 90 Arpeggiator styles, 48 Realtime Phrase Sequence (RPS) patterns
- Effects- EQ, Chorus, Flanger, Phaser, and Delay
- Sliders and knobs transmit MIDI data
- Arpeggiator, LFOs, and effects that sync to MIDI
- 256 Patches and 128 Performances
- New "Super Saw" waveform that models 7 saw waves using only one voice of polyphony
- Motion Control for storing slider and knob adjustments over time
- Ribbon Controller that can simultaneously control several specified parameters

Since the layout of the JP-8000 is similar to a conventional analog synthesizer containing knobs, buttons and sliders for all sound-related parameters, it is quite easy to move the front panel knobs and sliders to modify the JP-8000's sound. We hope that this document will provide a better understanding of what these knobs and sliders are capable of doing.
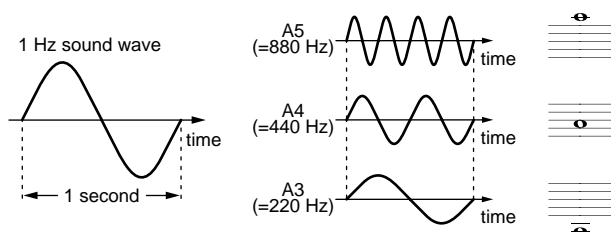
First, we will start by looking at elements that make synthesizers work. Then, we will discuss in-depth the waveforms that are available on the JP-8000. We will then cover the basic architecture and signal flow of the JP-8000. Finally, we will walk through the basic creation of a sound on the JP-8000 to give you some ideas you can work from yourself.
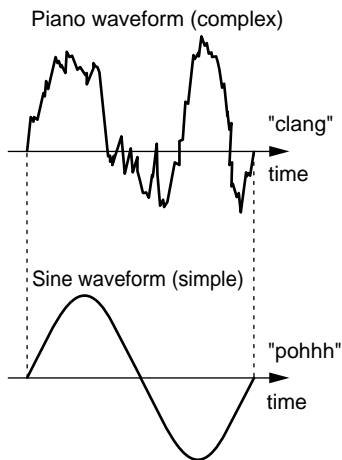
I.   Synthesis Overview

Developments in the science of musical acoustics in the second half of the nineteenth century coincided with discoveries in the field of electricity. In 1862, Hermann von Helmholtz published what would become a landmark paper called "Sensations of Tone" in which he demonstrated that a musical sound could be broken down to a few basic physiological principles. He showed that the quality (timbre) of a tone relied on the intensity, order, and number of harmonics present in the note. The single musical note consists of a fundamental tone and related vibrations (harmonics) above the fundamental. The fundamental tone and its harmonics create tone color (timbre).

We are surrounded by countless types of sound. Sound is interpreted by the ear as vibrations or waves in the air, and it is the shape of these vibrations that determine what type of sound you are hearing. Musical sound can be defined through an understanding and manipulation of five basic functions: frequency, timbre, amplitude, duration, and envelope. These terms are defined as follows:

Frequency is the pitch of the sound. The pitch is determined by the speed at which the wave repeats or cycles per second. As the frequency increases or decreases, the pitch will raise or lower respectively. For example, A4 has a frequency of 440Hz. If this pitch is raised an octave, the frequency will double (A5=880Hz). If it is lowered by an octave, the frequency will be cut in half (A3=220Hz).
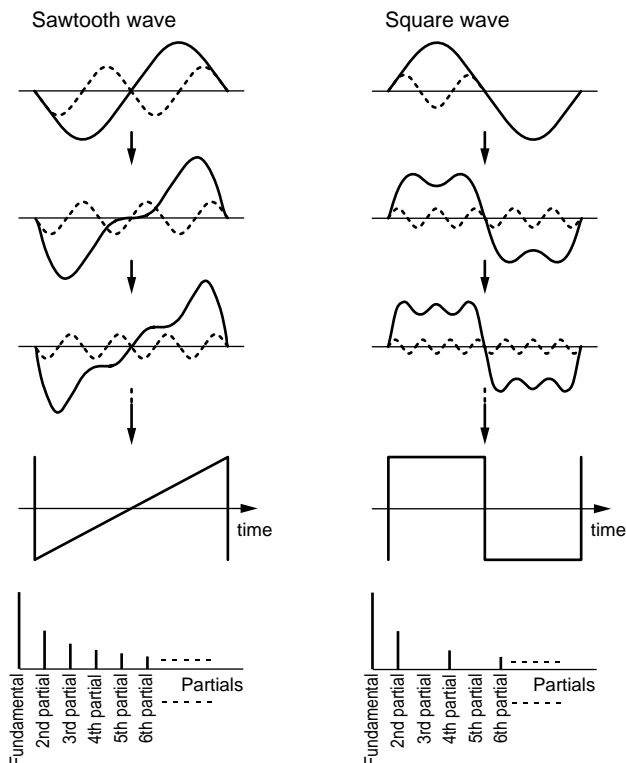
Timbre is the nature or quality of a sound. All sound waves are complex and contain more than one frequency. If one frequency is dominant, that sound can be related to a pitch of a musical scale. If frequencies are in competition with each other, a dense or unusual texture can occur. It is timbre that distinguishes a simple sine wave from a piano sound when the same pitch is heard.
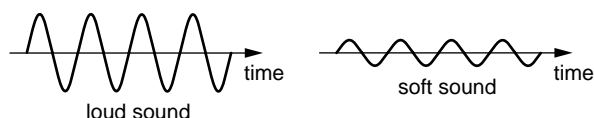
Piano waveform (complex)

"clang"

time

Sine waveform (simple)

"pohhh"

time

It is generally known that waveforms are made up of multiple sine waves. For example, a sawtooth or square wave consists of a fundamental frequency _plus_ integer multiples of the fundamental frequency such as 2x, 3x, etc. These multiples of the fundamental frequency are called _overtones_ or _partials_.

Partials that are even multiples of the fundamental are referred to as _harmonic partials_ and partials that are odd multiples of the fundamental are referred to as _enharmonic partials_. By combining these two partials, an infinite range of sounds can be created (see the following example).
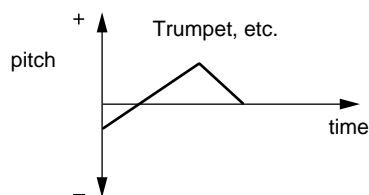
Sawtooth wave

Square wave

time

time

Fundamental | 2nd partial | 3rd partial | 4th partial | 5th partial | 6th partial — Partials

Fundamental | 2nd partial | 3rd partial | 4th partial | 5th partial | 6th partial — Partials

**Amplitude** is the volume or loudness of the sound. The loudness is determined by the size of the waveform. Larger waveforms result in louder volume and smaller waveforms result in softer volume.

**Duration** is the length of time that a sound is audible. Acoustic instruments like a piano have inherent duration limitations due to the mechanical nature of the instrument. However, electronic instruments have the ability to sustain a sound indefinitely. Duration is closely related to the principles of the sound envelope.
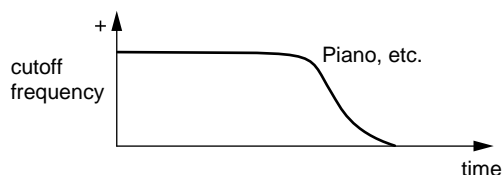
**Envelope** characterizes the way a sound changes over time. An envelope consists of two main components: attack and decay. The are three main envelopes on the JP-8000 - Amplifier Envelope (TVA), Filter Envelope (TVF) and Pitch Envelope. In the case of an amplifier envelope, attack refers to the time it takes for a sound to reach its maximum loudness and decay refers to changes in the sound after it reaches its maximum loudness. A string sound usually has a slow attack taking a long time to raise to full volume after the sound is triggered. On the other hand, a piano sound raises to full volume almost immediately after the sound is triggered. The following are examples of the three different types of envelopes: Pitch, Filter, and Amplitude.

Pitch Envelope

In the above example, you can see how Brass instruments, such as a trumpet, often have a slight variance in pitch when the sound is first heard. On a synthesizer, this "time-variant pitch change" can be created by using a _pitch envelope_.

Filter Envelope

The filter envelope can be used to determine the timbre of a sound. This can also be thought of as the color or "nature" of a sound. It is the timbre that distinguishes one sound from another when the same pitch is heard. The example above shows what the filter envelope might look like for a piano sound. Piano waveforms contain the most partials when a note begins. As the sound decays, the upper partials gradually diminish, causing the tone to become darker in quality. On a synthesizer, this "time-variant timbre change" can be created by using the _filter envelope_. The JP-8000 contains the following types of filters:

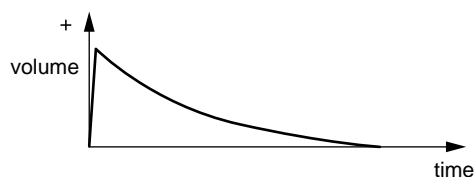**High Pass Filter (HPF)** This is a filter that allows higher frequencies to pass and restricts lower frequencies. The point that divides the high and low frequencies is referred to as the **cutoff**.

Low Pass Filter (LPF) This is a filter that allows lower frequencies to pass and restricts higher frequencies. The point that divides the high and low frequencies is referred to as the **cutoff**.
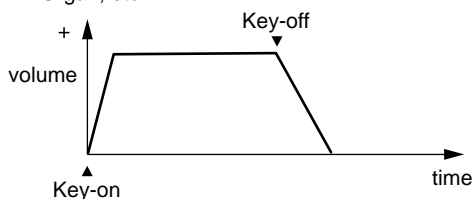
Band Pass Filter (BPF) This is a filter that allows only the selected frequency to pass and restricts frequencies that are above <u>and</u> below that frequency.

Amplitude Envelope

Piano, etc.

Organ, etc.

The way a sound's volume changes over time varies for different instruments. The examples above illustrate the differences in the amplitude envelopes for a typical piano sound versus that of a typical organ sound. The piano waveform reaches its maximum loudness the instant a key is pressed and the hammer contacts the strings. Then, it gradually diminishes in volume. On an organ, the same volume is sustained for as long as a key is pressed. On a synthesizer, this "time-variant volume change" is created by the *amplitude envelope*.

II.   Waveforms

A sound wave can be represented graphically according to its varying frequency and amplitude functions. Sound waves have two basic characteristics, frequency (defined by the number of vibrations per second) and loudness. While most of the sounds we hear in electronically produced music are combinations of multiple waves that may have been treated by adding tone color, it is possible to catalog the basic waveforms as well as introduce new waveforms. The waveforms in the JP-8000 are: sine, triangle, sawtooth, square, super saw, triangle modulation, feedback oscillator, noise, and sample and hold. In order for us to hear these waveforms, a device called an oscillator produces these waveforms in as pure a form as possible. The following is an explanation and graphic representation of these waveforms:

Sine -   The sine wave is the purest type of wave. This wave should contain no harmonic
                              overtones. Generally, all waveforms are made up of multiple sine waves.

Triangle -   The triangle wave is a fundamental sine-type wave, but with a number of harmonics added
                              producing more body and depth, thus creating a more hollow sound.

Sawtooth -   More complex than the triangle wave, this wave contains many more harmonics than the
                              simple sine wave resulting in a full sound.

Square -   The square wave is a sharp, angular wave with more overtones than a triangle wave, but
                              contains the "grittiness" and reedy feel of a sawtooth wave.

Super Saw -   The Super Saw is a new sawtooth-type waveform that Roland developed specifically for
                              the JP-8000. It simultaneously produces seven sawtooth oscillators using only one voice of
                              polyphony. The Super Saw wave is ideal for creating very thick textures never heard before.

Triangle - **Modulation**	This waveform is another new development from Roland for the JP-8000. It is a modification of the triangle wave with a large number of overtones added.
Feedback - **Oscillator**	The Feedback Oscillator is yet another new waveform from Roland similar to the sound of electric guitar feedback. When selected, only one voice will sound at a time. This waveform is great for solo-type sounds.
Noise -	A noise waveform is completely random, resulting in a "hissing" character. This waveform is generally used to create unusual sound effects, most commonly types of wind, ocean swells, etc.
Sample and Hold - ⊓⊔⊓⊔	This waveform samples an input source (typically a noise generator) and holds it at a particular voltage. Since it usually looks at a random source, the end result is also random.

III.   Architecture of the JP-8000

The architecture of the JP-8000 is divided into three sections:

Controller section
The Controller section of the JP-8000 consists of the keyboard, front panel buttons, sliders and knobs, pitch bend/modulation lever, ribbon controller, and pedals connected to the rear panel. These are what play and modify the sound.

Sound Source section
The Sound Source section of the JP-8000 actually produces the sound. Messages from the JP-8000's Controller and Sequencer sections tell the sound source when and how to produce sound. MIDI messages from an external device can also control the sound source. The sounds of the JP-8000 are organized as follows:

Patches/Performances- There are 256 Patches in the Internal memory (128 Preset and 128 User) of the JP-8000. Two Patches are combined to make a *Performance*. A Performance consists of an Upper and Lower Part, which can either be layered (Dual mode) or set up as a keyboard Split. There are 128 Performances in the Internal memory (64 Preset and 64 User) of the JP-8000 (See section *V.* for details).
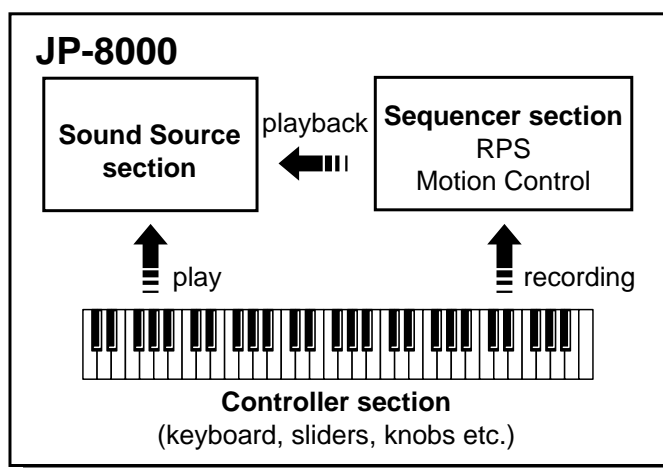
 Sequencer section
The Sequencer section of the JP-8000 records keyboard playing and slider movements as MIDI messages for playback. These messages can also be transmitted to external MIDI devices via the JP-8000's MIDI output. The Sequencer section of the JP-8000 is made up of the following three parts:
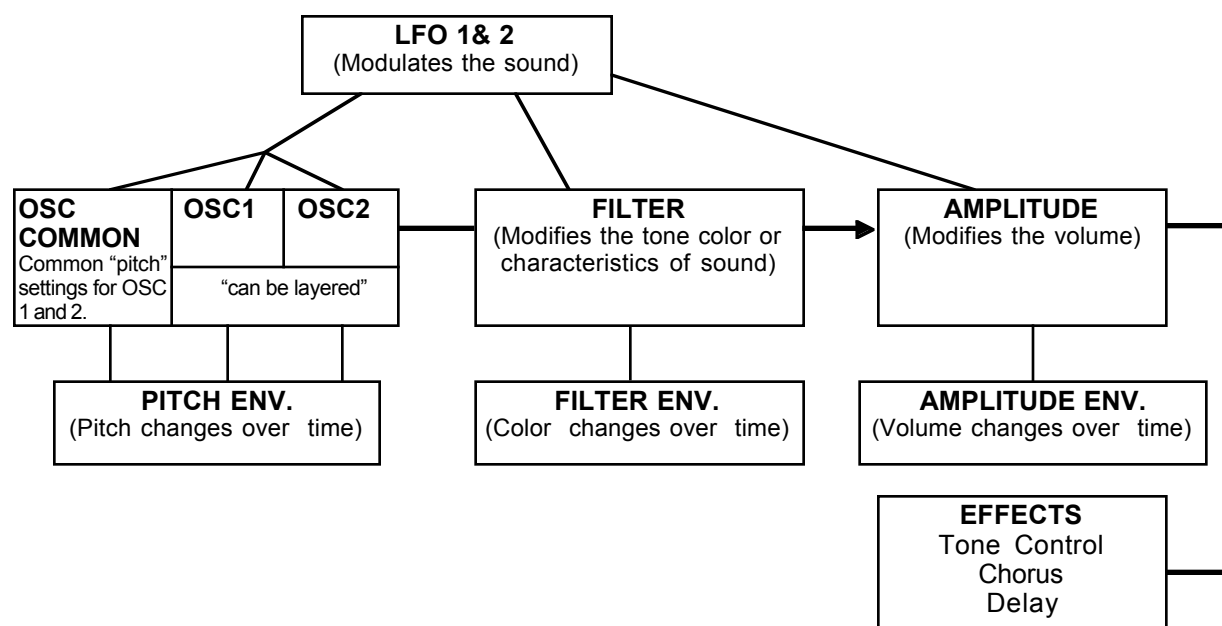
RPS (Realtime Phrase Sequence) - By pressing a key on the JP-8000, an original sequenced pattern can be played back. The 48 RPS patterns available in the JP-8000 are useful for constructing songs in realtime.

Arpeggiator - There are 90 different rhythmic or "cyclic" patterns that can be selected for play back of Patches. This is a great source for musical ideas such as creating bass lines and glissando-type effects.

Motion Control - Much like a conventional sequencer records notes to create a phrase, movements of the JP-8000's front panel knobs and sliders can also be recorded to create interesting realtime effects during a performance. There are a total of 4 recordable Motions in the JP-8000.

IV. Signal Path of the JP-8000

```
                          ┌─────────────────────┐
                          │      LFO 1& 2        │
                          │ (Modulates the sound)│
                          └─────────────────────┘
```

OSC COMMON Common "pitch" settings for OSC 1 and 2.	OSC1	OSC2 "can be layered"	FILTER (Modifies the tone color or characteristics of sound)	AMPLITUDE (Modifies the volume)

PITCH ENV. (Pitch changes over time)	FILTER ENV. (Color changes over time)	AMPLITUDE ENV. (Volume changes over time)

EFFECTS
Tone Control
Chorus
Delay

The signal path of the JP-8000 is defined as the processing order of a sound from the time a key is pressed on the JP-8000's keyboard until it becomes audible to the ear. When a key is pressed, it triggers a sound source called an *oscillator.* In the case of the JP-8000, there are two oscillators, each containing a selectable waveform as the basis of its sound. These two oscillators (OSC 1 and OSC 2) can be layered, detuned, and even synced together. The Oscillator Common section provides parameter settings for both oscillators and pitch related settings. The pitch can be further modified over time by the pitch envelope.

When all of the aspects of pitch are determined, the filter then modifies the timbre of the sound. The filter is commonly used for adding brightness to a sound or to create a mellow, hollow-type sound.
Like the pitch envelope, the filter envelope modifies the timbre over time and can be used to create many familiar effects such as a guitar "wah" or a keyboard "swell."

The sound then travels to the amplifier where modifications to the volume or loudness of the pitch and filter are made. The amplitude envelope modifies how you will hear the changes made in amplitude over time. LFOs 1 and 2 can be used to create expressive modifications to the sound such as vibrato and modulation. LFO 1 can have independent settings that can be applied to the pitch, filter, and amplitude sections.

Tone controls (bass and treble) and effects such as delay and chorus can then be added to further contour the sound.

V.   Memory

Memory is where settings such as Patches and Performances are stored. The JP-8000 includes four types of memory:

System memory -   This memory location stores MIDI related settings and other System parameters which affect the overall operating environment of the JP-8000.

User Memory -   This memory location stores settings you create. It contains 128 Patches, 64 Performances, 48 RPS patterns, and 4 Motions.

Preset Memory -   This memory location contains 128 Patches and 64 Performances that cannot be modified.

Temporary Memory - When you select a Patch or Performance, it is called into Temporary Memory to be edited and played. Any changes you make to the Patch or Performance are not permanent. If you would like to save your edits, your modifications can be written into a permanent User Memory location by using the Write procedure. *(see VI. Storing a Patch)*.

In the case of RPS pattern, Motion, and System settings, your settings are written directly into memory. There is no need to perform a separate operation to save the data.

VI. Basic Sound Manipulation on the JP-8000

This section is a hands-on tutorial intended to provide you with information needed for basic "analog" synthesizer programming. The JP-8000 is loaded with amazing Patches and Performances that utilize complex programming. Since the intended goal of this document is to understand the "basic" principles of synthesis, we will use an Initialized Performance as the basis for the following experiments.

Getting Started
Before we proceed, execute the following procedure to "Initialize" a Performance:

1) Press the PERFORM/PATCH button until "PERFORM" is in the left corner of the display.
2) While holding the SHIFT button, press the INT/UTIL ([7]) button until "Initialize" is displayed.
3) Use the BANK/VALUE buttons to display "Initialize PERFORM: TEMP."
4) Press the WRITE button to execute the Initialization. When complete, the display should will read "INIT PERFORMANCE."

When you play the keyboard of the JP-8000, you will hear a sawtooth waveform produced by OSC 1 and a triangle waveform produced by OSC 2.

> *NOTE: The Initialized Performance resides in the Temporary Memory Area and does not affect the previous Performance settings. To recall the previously "saved" Performance settings, simply press the corresponding number button under the display. The original Performance will then be re-called to that memory location.*

Waveforms
It is a good idea to get accustomed to the sound of the different waveforms in their purest form. Select the different waveforms by pressing the WAVEFORM button in the OSC 1 section and play a few notes on the keyboard of the JP-8000. When finished listening to the waveforms, return to the sawtooth waveform and proceed with the tutorial.

OSC Common Section
Let's start by setting the OSC Balance and LFO 1 knobs to the 12 o'clock position and set the X-MOD Depth all the way to the right. The sound should be very "basic" and have no movement. Now we're ready to manipulate the sound.

1) While holding a key on the JP-8000, turn the OSC Balance knob all the way to the left and listen to the sound generated by OSC 1.
2) Press the OSC 1 WAVEFORM button to listen to the different waveforms in the OSC 1 section.
3) Rotate the OSC Balance knob all the way to the right to hear the sound generated by OSC 2.
4) Press the OSC 2 WAVEFORM button to listen to the different waveforms of the OSC 2 section.
5) Use the RANGE and FINE tune knobs to detune OSC 2.
6) When finished, return to the triangle waveform in OSC 2 and the sawtooth waveform in OSC 1 and set the OSC Balance knob back to 12 o'clock. The sound should now be back to its original settings.
7) Rotate the LFO 1 Depth knob a little to the right or left and notice the sound now has vibrato.
8) Set the LFO 1 Depth knob to the 2 o'clock position and experiment with the Rate and Fade knobs of the LFO 1 section. The Rate sets the speed of LFO 1 and Fade reflects the time it takes for LFO 1 to reach the Rate after a key is pressed.
9) Hold a key down on the JP-8000 and use the WAVEFORM button (in the LFO 1 section) to listen to the different waveform types that can be assigned to LFO 1.
10) When finished, return the LFO 1 waveform to the triangle wave and set the LFO 1 Depth (in the OSC Common section) to 12 o'clock.

Pitch Envelope
Next, let's alter the pitch over time by using the Pitch Envelope.

1) Move the Attack and Decay sliders of the pitch envelope all the way down and set the ENV Depth knob to the 2 o'clock position.
2) Move the Attack slider about 3/4 of the way up and then play a note on the JP-8000. Notice that the pitch rises and then drops to the Decay point where it stabilizes at the correct pitch.
3) Move the Decay slider about 1/2 of the way up and play the note again. The pitch rises as before, but now it settles down to the correct pitch in a more gradual manner.

> NOTE: Turning the ENV Depth knob to the left inverts the effect of the pitch envelope.

Pulse Width and Pulse Width Modulation
Use the following procedure to experiment with the Pulse Width and Pulse Width Modulation parameters:

1) Select the square waveform for both OSC 1 and OSC 2 and set the Rate in the LFO 1 section all the way to the left.
2) While holding down a key on the JP-8000, sweep the PULSE WIDTH and PULSE WIDTH MODULATION (PWM) sliders to hear the re-shaping of their square waveform. Also, listen for the addition of new overtones.

   NOTE: Because of all of the adjustments made to the sound, it may be helpful to repeat the Initialization procedure (steps 1-4 under "Getting Started" p.7) as when we started the tutorial. This will make it easier as we discuss the filter and amplitude sections.

Filter
Use the following procedure to experiment with the Cutoff Frequency, Resonance, Slope, and filter type parameters:

1) While holding a key on the JP-8000, sweep the Cutoff Frequency and Resonance sliders. These are perhaps the most commonly used parameter sliders, so it is a good idea to become familiar with their sound.
2) Press the SLOPE button and listen to the effect of the different settings (-12dB /-24dB).
3) Press the TYPE button and experiment with the various filter types (HPF, BPF, and LPF). Experiment with different combinations of these parameters.
4) When finished, return the Slope to -24dB (lit red) and the Filter Type to LPF.
5) Move the Cutoff Frequency, Resonance, and ADSR sliders (under FILTER) all the way down.
6) Rotate the KEY FOLLOW, LFO 1 DEPTH, and ENV DEPTH knobs to the 12 o'clock position. You should not hear any sound when you play the keyboard of the JP-8000.
7) Set the Cutoff Frequency slider 1/2 of the way up.
8) Rotate the Key Follow knob all the way to the right. Play on the JP-8000's keyboard, starting on the upper section and moving down to the lower register. The sound should start with a bright quality and become more mellow, decreasing the number of partials.
9) Rotate the Key Follow knob all the way to the left and again play downward on the keyboard. The sound should now start with a mellow quality and become more bright, increasing the number of partials.
10) When finished, set the Key Follow knob to the 12 o'clock position and keep the Cutoff Frequency slider 3/4 of the way up.

Filter Envelope
Use the following procedure to experiment with the filter envelope parameters:

1) Rotate the ENV Depth knob to the 2 o'clock position and move the attack slider (under FILTER) 3/4 of the way up. As you hold a note on the keyboard, notice there is a swell in "brightness" to the sound and then an abrupt drop.
2) Move the decay slider to half the amount of the attack slider and play a note on the keyboard. The slope of the "brightness" in sound becomes more smooth because the distance between the attack and decay has been cut in half.
3) Move the sustain and release sliders to the same value as the decay. The character of the sound will now remain at the decay amount for as long as you hold the note on the keyboard.
4) Rotate the ENV Depth knob to the 10 o'clock position and listen to the shape of the same envelope now inverted. Experiment with different filter combinations to become familiar with their functionality.
5) When finished, return the ENV Depth to the 2 o'clock position, the attack slider to 3/4 of the way up, and the decay, sustain, and release sliders to half the amount of the attack slider.

Amplitude Envelope
The final experiment in this tutorial involves the amplitude envelope. This effects the volume of the sound over time.

1) Move the A, D, S, and R sliders (under AMP) all the way down (you should only hear a brief "attack" sound when you play the keyboard).
2) Rotate the LFO 1 Depth knob to the 12 o'clock position and enable it by pressing the Auto/Manual button so that it is not lit.
3) Move the attack slider 3/4 of the way up and hold a note on the keyboard. Notice the swell in volume as the sound reaches the attack time then suddenly drops off to the decay time (which is zero).

Amplitude Envelope (continued)

4) Move the decay slider to half the amount of the attack slider and hold a note on the keyboard. Once the sound reaches the decay point, the sound then drops in level to the sustain amount.
5) Move the sustain slider to the same position as the decay slider and listen to the difference.
6) Move the release slider to 1/2 of the way up and hold a note on the keyboard. After the sound completes the effect created by the attack, decay, and release, lift off the note and listen to the sound gradually fade away.

   NOTE: Experiment with the LFO 1 Depth effect by turning the knob to the left and right. This will add a vibrato effect based on the waveform selected in the LFO 1 section.

Storing a Patch
Once you are finished creating a Patch, it is necessary to store it in the JP-8000's Internal memory. Use the following procedure to write a Patch into one of the 128 User locations:

1) Press PERFORM/PATCH to access the "Patch Select" display.
2) Press WRITE.
3) Use the DOWN/UP and [1]-[8] buttons to select the desired User Patch destination.
4) Press NAME (PERFORM/PATCH).
5) Use the NAME button to move the cursor and the DOWN/UP buttons to select the desired character.
6) Press WRITE. The Patch will now be saved to that User location.

VII.   Summary

The JP-8000 is a "new generation" synthesizer that bridges the gap between analog and digital synthesizers. It uses Roland's Analog Modeling Technology instead of sampled waveforms, in combination with front panel knobs and sliders to create incredible new sounds. The JP-8000 represents a "new beginning" for synthesists, composers, programmers, and performers. The JP-8000 captures the power, flexibility, and nuance of its ancestors, but also forges ahead with new features like Realtime Phrase Sequencing (RPS) and Motion Control to set the "new standard" in synthesizers.

Now that we have covered some basic synthesis principles and worked through creating a sound from scratch, take some time to apply these principles to your own Patch creation. Remember, there are no rules to sound creation, so don't be afraid to experiment and have fun!