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Sound Design for the Electronic Musician

Lesson 1: Overview of Synthesizers

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What's a Synthesizer?

A synthesizer is fundamentally different from any other technology tool because it's a musical instrument; musicians use it to generate a musical performance. What makes a synthesizer unique among other instruments is that it's a purely electronic instrument. Any other instrument we're likely to come across produces sound by responding to some physical stimulus. Even many instruments we think of as electric, such as the electric guitar, bass, and the Rhodes piano, are actually electro-acoustic instruments that amplify sounds produced physically. The synthesizer, however, produces sound by means of electronic circuits, which makes it the instrument of choice in the virtual world.

In thinking about synthesizers as electronic instruments, it's a good idea to think about how we use acoustic instruments. How do we get these physical objects to make sound? There are many different gestures we use to produce sound: plucking a sting, blowing air through a tube, or striking a membrane, and each causes a different type of sound.

In general, there are two main types of performance gestures: (1) articulation, the ability to control when and for how long we produce a musical note, and (2) dynamics, the ability to change loudness, as well as pitch and timbre. The most expressive instruments offer a tremendous amount of control over sound using these gestures. Compare, for example, the characteristics of the violin and piano. Although the piano is an expressive instrument in its own way, once we strike a key, the resulting note will immediately begin to decay, while a violin can sustain a note as long a bow moves across the string. Once we've struck a note on a piano, there's very little we can do to change it. We can't make it get louder, or change its tone color or pitch. All these things are easily done with the human voice, violin, or wind instruments.

The synthesizer is unique in that it's capable of giving a musician the ability to produce musical sound in a variety of ways. In a synthesizer we can have control over each individual element of sound, so we're able to design our own virtual instruments that can either emulate the performance characteristics of physical instruments or create entirely new ways of interacting with sound.

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Synthesizers come in a variety of shapes and sizes, and vary in how they produce sound and allow the musician to control that sound. Electronic instruments can generally be seen as having two separate functions: sound production, and control over sound. **Integrated instruments** have both components in one unit. **Sound modules** have just the sound-making component. **Controllers** produce no sound in and of themselves—they simply control what notes are produced and provide gestural control over musical performance.

Integrated Instruments

By far, the most common integrated instrument we see in the marketplace is the keyboard synthesizer. These usually have either 49, 61, 76, or 88 keys; some number of available controls like wheels, sliders, foot pedals, ribbon controllers, touch pads, and now even light beams; and a sound generation system. Figure 1.1 shows a typical integrated instrument.

Figure 1.1. A typical integrated instrument.

How these instruments produce their sounds (synthesis technique), the number of notes that may be sounded simultaneously (polyphony), the number of different timbres that may be sounded at once (multi-timbral capability), and the amount of onboard storage for sounds differentiate the instruments. These features are generally quite competitive between instruments these days, with advertisements reading like technical manuals with lists of specifications. However, to musicians, the more important factors are the overall sound quality and the ease of use the synthesizer provides. An instrument's ease of use is governed by the quality of the **user-interface** design.

The user interface is how the instrument presents its controls to the musician. In the instrument shown above, there are performance controls such as the keyboard, joystick-style pitch bender and modulation controller, ribbon controller, and switches, as well as inputs for foot pedals and switches. The devices above the keyboard provide control over the instrument's operation, determining how you create, edit, and manipulate its sounds. Let's look a little closer at this user interface.

Figure 1.2. A user interface.

Figure 1.2 shows the user interface for this instrument: a number of sliders, knobs, dials, buttons, and a large display. The display provides a window into the workings of the synthesizer, so the bigger the better. This one is also a touch screen, so that you may enter and control information by touching the item on the screen you wish to change, then either choose from menu items by touching the desired selection, or use the data entry devices to change the value for the chosen parameter.

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The following table shows a few of these common data entry devices and explains their use.

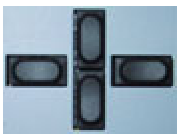
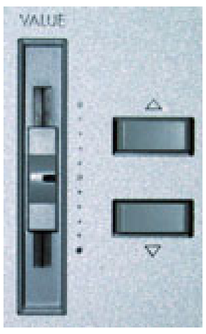
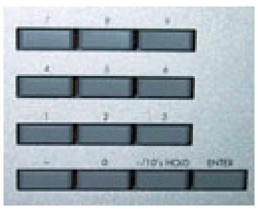
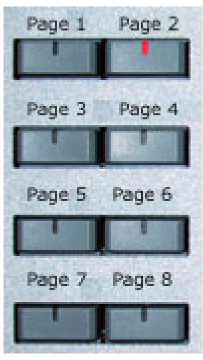
	**Display.** The display is the window into the operation of your instrument.
	**Cursor keys.** These four keys (often arrows) assist you in navigating around a menu screen.
	**Alpha dial.** This is a continuously turning knob that is used to scroll through information or change the value of a parameter.
	**Value slider and increment/decrement keys.** These devices are used to enter numeric values. The slider allows for large changes in a quick gesture; the increment/decrement keys are for fine tuning an entry.
	**Numeric keypad.** These keypads are used to quickly enter a specific numeric value by typing the numbers. If an Enter key is provided (as in this example) you press it when the desired number has been typed.
	**Page buttons.** Most instruments have more parameters than can be presented in a single screen. These buttons quickly take you to specific pages of the menu.

Figure 1.3. Various input control devices found in user interfaces.

By understanding how these control devices work, you can quickly learn to navigate any instrument's user interface.

As we have seen, an integrated instrument contains two main components--the sound engine and the musical controller, as well as the user interface that allows you to make it all work. Let's now look at those instruments that have only one of these two components.

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Sound Modules

These instruments have the necessary components for generating sound, and a user interface for controlling the overall functions of the instrument, but no physical control section. Generally, these have MIDI control inputs so that the sounds may be played by an external controller or through playback of a MIDI sequencer. Sound modules come in two basic shapes: desktop units and rack-mount units.

Figure 1.4. A desktop sound module.

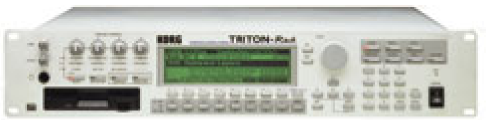

Figure 1.5. A rack-mount sound module.

Note that each of these instruments still has a collection of user-interface devices: display, page buttons, alpha dials, cursors, and increment/decrement keys. The way these are designed and laid out in conjunction with the available menu items governs the overall usability of the instrument.

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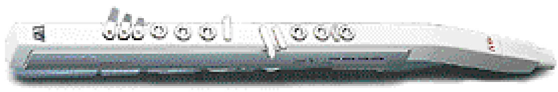
Controllers

There are many shapes and sizes of electronic instrument controllers, matching the corresponding acoustical instrument controllers. These generally have MIDI output or some kind of output that can be converted to MIDI information, so that the musician may perform on these instruments and control synthesizers (either sound modules or integrated instruments). The following are just a few of the instrument controllers available today.

Keyboard controller. These come with 24, 36, 49, 61, 76, or 88 keys. They also come in 8 keys, such as the Oxygen 8.

Guitar synthesizer. These often also play as standard electric guitars, as well as providing control over synthesizers.



Woodwind controller. Played like a saxophone or clarinet, these let woodwind players control synthesizers.

Drum set controller. These come as separate pad controllers, or as complete sets. Often a number of pads are combined in a single unit for controlling MIDI synthesizers or drum machines.

Violin controller. Played like a standard violin, these often have amplified violin sounds that may be mixed with the synthesizer output.

Figure 1.6. Some common instrumental controllers.

There are also unique controllers that do not mimic any standard acoustical instrument playing technique. These are generally available in limited quantity, and although very useful and musical, seem to fall outside the mainstream of music production.

As we see here, synthesizers come in a wide variety of shapes and sizes. They also make sound in some very different ways. Let's explore how synthesizers make sound.

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What's a Synthesizer?

As we have seen, synthesizers come in all shapes and sizes. Now let's look at how they also differ in the ways they create and manipulate sound.

Subtractive Synthesizers

The earliest analog synthesizers used a technique called subtractive synthesis, so called because it begins with sounds that are rich with content, and then changes the sound color by removing parts of the sound spectrum through the use of filters, thereby creating new sound colors. The old analog synthesizers (called analog because they processed electrical signals to create analagous changes in the sound) were comprised of many modules, each responsible for creating or modifying a signal. Musicians could configure these modular synthesizers to work in just about any way imaginable, providing they had enough modules and the correct patch cords. Figure 1.7 shows an early analog synthesizer built by Robert A. Moog, the man generally credited with creating the first commercially available synthesizer.

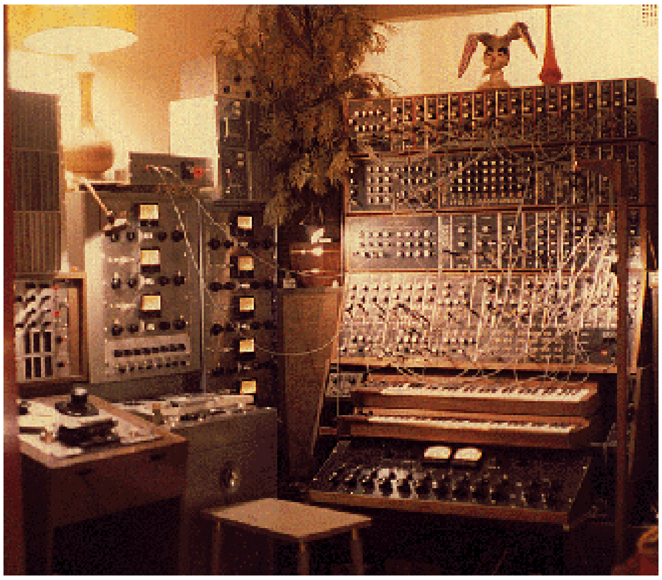

Figure 1.7. A Moog analog subtractive synthesizer.

PLAY IT! Listen to the subtractive synthesizer sounds.

Subtractive synthesizers are great for creating sounds that are not normally available from acoustic instruments: sound effects, background pads, very deep bass sounds, and so on. Some acoustic instrument sounds may also be emulated by subtractive synthesizers, but for very realistic replication of complex acoustic instrument sound, samplers are the usual choice. Let's take a quick look at how samplers work.

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Samplers

Samplers are electronic instruments that use as their sound source digital recordings of acoustic sound. They are called samplers because the technology used to record the sounds involves "sampling" the level of incoming signal from a microphone or line input at regular intervals (usually 44,100 times per second) and storing the result as a stream of digital numbers. These samples are then played back to re-create the original sound. We will look at this process in greater depth in lesson 7. Since their sound sources come from digital recordings, samplers are the first choice for emulating acoustic instrument sounds, as well as for sound effects (door slams, car crashes, baby cries) for film and video work. The better instruments will also include some sound design techniques borrowed from subtractive synthesis, as well. Here is a currently available sampler:

Figure 1.8. A typical sampler.

PLAY IT! Listen to the digital sampler sounds.

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Physical Modeling Synthesizers

Another kind of synthesis technique gaining popularity is called physical modeling. Rather than using digital samples to emulate acoustic instruments, researchers have created mathematical models for how certain sounds in nature are produced. These include models of a plucked string, a vibrating reed, column of air through a brass tube, and others. By combining these models and controlling the parameters of these models (length of string, shape of brass tube [conical or cylindrical], length of tube, size of reed, etc.), they can create very expressive and unusual acoustical sounding instruments. Also, since these sounds are not digital recordings, they can be shaped in real-time by performance gestures, so they can be very expressive. Figure 1.9 shows a physical modeling synthesizer.

Figure 1.9. A typical physical modeling instrument.

PLAY IT! Listen to the physical modeling sounds.

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FM Synthesis

Frequency Modulation (FM) is a process by which two simple sounds are combined to create a new, more complex sound. Using this FM technique, Yamaha created one of the most successful synthesizers of all time, the DX7. Through a variety of instruments in the 1980s, Yamaha saturated the market with FM synthesizers, and by the 1990s, they began to disappear from popular use. However, this synthesis technique is making a comeback through software instruments, notably the very popular FM7 from Native Instruments. FM synthesis is a great way to make percussive sounds, bell-like sounds, and plucked string sounds. Electric pianos and many acoustic sounds such as harmonica, harp, bells, and many electronic sound effects are available through FM.

Figure 1.10. FM7, a virtual FM synthesizer.

Let's review what we have learned so far about the various kinds of synthesizers, and then do a short activity to put what we've learned to use.

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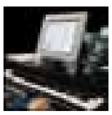

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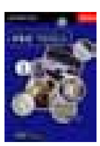

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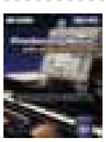

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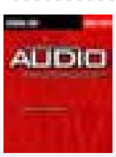

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