Six-String

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NOAH - Tactive Instrument Modeller

Introduction

What does the Six-String give you?

Synthesizer developers are always looking for interesting new points of departure for the production of sounds. What analog systems have to offer; how other digital systems work; and, of course, how natural systems function—the developer investigates all these things when considering a new direction. With regard to the string model the developer sooner or later discovers that this apparently simple natural physical system is much more complex than he or she might have originally thought.

Some very bright minds, employing various approaches, have developed ingenious methods for producing convincing plucked-string emulations that can be computed and played in real-time. Two current techniques that work quite well are *Karplus-Strong synthesis* (named after the two developers of the algorithm) and the *Mass/Spring model*. However, none of these methods have duplicated exactly the physical characteristics of a ”real” string. Instead, they use mathematical ”tricks”, such as incorporating delay lines, to produce the tonal behavior of the virtual string.

Thanks to a completely new mathematical approach, the Six-String offers for the first time a true one-to-one emulation of a physical string. This algorithm allows for string characteristics to be specified comprehensively, exactly duplicating its real-world counterpart. Definable characteristics include inertia, material flexibility, string diameter, tension, and so on. Of course, with such a complex algorithm not all the parameters have to be specified by the user at the lowest levels, as the interactions among them could lead to confusing phenomena. Therefore, some values in the Six-String have been pre-configured and made available to the user as presets. For example, the user can make simultaneous adjustments for complete string sets, rather than having to define each string individually.

Some values, such as rigidity (inertia) or elasticity are adjustable only within meaningful or useful limits. The string sets can be fine tuned later, or even altered to such an extent that the resulting spectrum is reminiscent more of a bell than a typical string.

The Six-String allows for extremely versatile plucked-string synthesis, from the simulation of nylon or steel strings through to metal bars and even wood blocks. And because the Six-String was developed to imitate guitars in particular, additional parameters specific to guitars, such as those used to emulate acoustic guitar bodies or electric pickups, are also incorporated.

Synthesis Structure

As mentioned earlier, the synthesis structure of the Six-String begins with the definition of the strings (or the choice of a string set) and the basic decision whether to emulate an acoustic or electric guitar. These early choices are crucial to the subsequent structure of the model. Depending on which model you choose, the main screen displays one guitar type or the other. Ultimately what you see on the screen bears a direct relationship to what you should expect to hear.

The Acoustic model

With the acoustic model a simulation of the guitar body, using three band-pass filters to produce the most important resonant frequencies, immediately follows the string. This is ”only” an approximation; an actual guitar body exhibits somewhat more complex resonant behavior. The solution implemented here offers a very good, and at the same time, computationally economical way to incorporate the necessary resonant body. The vibrations of the strings are taken from one or two ”dry” positions and then combined with the body signal.

The Electric model

The structure of the electric model is similar to the acoustic model, but without the simulation of a resonant body. Instead, virtual guitar pickups follow the string in the algorithm. Here, too, a filter is used to approximate the pickup behavior—in this case a lowpass filter with adjustable resonance.

With the electric model, too, the string vibrations are picked up from one or two positions. The signal is then sent to the pickup filter. After the pickups you have the option of routing the electric guitar signal to a virtual amplifier. The amplifier has a fairly complex architecture with pre- and post-equalizers and an integrated analog tube emulator. The amplifier is also useful with a real guitar, producing authentic amp sounds - from smooth and round, to heavily distorted.

Presets

As usual with CreamWare instruments, the Six-String features a Preset List with which you can administer and recall sound settings. In addition to the the basic preset list, the Six-String adds Pluck, Body, and Amplifier preset sub-lists. Presets in these lists can easily be made globally available once you have established the settings. As soon as you have created a preset within a preset sub-list it is added into the list of selectable presets you can call up through the respective drop-down lists. The presets in these lists are not referenced, however; the values only are passed to the device. In other words, when you change a preset in a preset sub-list it does not have an effect on the primary presets supplied with the Six-String.

Operation

As you have seen, the adjustable parameters for each model (acoustic and electric) are similar in number and kind. Therefore, descriptions of the controls for both models are combined in the following chapters. Clarifying notes will describe any differences. The controls on the Main page are described first, then those of the Add page, first for the electric model and then the acoustic.

Global controls: The Title Bar

The Six-String interface appears as a graphic guitar case (as seen from directly overhead) with the cover open and slanting back at a slight angle. The cover area (or Title Bar showing the "Six-String" logo) contains the global controls and settings.

Type: This drop-down list (to the right of the Six-String logo) lets you select which model you want to use. Choose either the Acoustic or the Electric model.

Page switches: These switches (Main, Add) open the Six-String's two control panels (pages).

The Main page contains the most important parameters. Add contains additional parameters for pitch modulation, body, pickup etc.

PresetList: Opens the Six-String's top-level Preset List.

On Top ("=" button): With On Top enabled, the window always remains in the foreground. Several windows can remain in the foreground if On Top is enabled for each of them.

Close: The Close button closes the window and any open Preset list.

The Guitar controls

Some controls are located either directly on or ”above” the respective guitar. Those above the guitar surface control the string excitation characteristic (pluck position) and the pickup positions.

PosVel: Determines whether or how strongly the strength of the plectrum stroke (velocity) modulates the position of the plectrum. Positive values shift the plectrum to the right towards the bridge, negative values to the left. The maximum modulation depth depends on the basic position of the plectrum. In any case, with full modulation the position shifts to the maximum deflection—either to the bridge or to the center position.

Plectrum: Adjusts the position of the virtual pick. Adjustable from the bridge to half the length of the string.

Mikrophone (P1/2): With the acoustic model you can place two virtual microphones to pick up the guitar signal. You can position each microphone independently anywhere between the bridge and the middle of the strings, and each microphone can have its own volume level.

PU Link: With the Pickup Link switch in the upper left corner you can synchronize the positions of the two microphones. When the option is enabled only a single microphone is displayed.

P1/P2: Adjust the volumes of the respective pickups.

Stereo: With the acoustic model this control adjusts the stereo spread of the two microphones. In the 0 position both mics are merged to mono. At the Max position pickup 1 is routed hard left and pickup 2 hard right.

> **Important: With the acoustic model, the stereo width control is disabled when the pickups are linked.**

Force: Adjusts the strength of the string excitation. This is a global setting that can be specified in detail in the **Pluck** control group.

The Strings control group

Strings: You can select from among various supplied string sets:

Bass Nylon	*(105 mm Mensur - 0,114/0,079/0,063/0,047)*
Bass Double	*(130 mm Mensur - 0,114/0,079/0,063/0,047)*
Bass Steel	*(81 mm Mensur - 01,106/0,07/0,056/0,043)*
Guitar Electric	*(65 mm Mensur 0,042/0,032/0,024, 0,016, 0,011, 0,009)*
Guitar Jazz	*(65 mm Mensur- 0,059/0,044/0,036/0,026/0,017/0,013)*
Guitar Nylon	*(65 mm Mensur - 0,045/0,036/0,028/0,037/0,029/0,023)*
Guitar Western	*(65 mm Mensur - 0,05/0,04/ 0,03/0,022/0,014/0,011)*
MonoString	*(0,1)*

The settings for the string sets contain string-specific parameters that are not user-accessible. Also, the Damping parameter is set to values typical for the strings.

Skip Harm. (onics): The basic string model computes the first 70 partial tones in the normal harmonic sequence. However, the Skip Harm. adjustment allows you to compute only every second partial from a specified starting point. This makes it possible to generate partials above the standard 70th partial normally computed.

Example: With Skip Harm. set to 50, even-numbered partials only are computed above the first 50 in the normal sequence—that is, the sequence after the 50th becomes 52, 54, 56 and so on. Because you always have 70 available, this means that partials up to the 90th partial will be computed. This is of particular value with bass tones in which the upper partials remain within the audible range. With higher notes the upper partials lie above the audible spectrum and it makes no difference whether the 90th partial is computed or not.

If you set Skip Harm. to very small values you can create some very interesting synthetic-sounding spectra reminiscent of organ or square waves.

Boost Harm.: When you omit partial tones using Skip Harm. you can use Boost Harm. either to compensate for the missing harmonics or simply to add more highs. Note that if you've used a low Skip Harm. setting the result will sound more synthetic with increasing Boost Harm. values.

Inertia: This parameter represents the moment of inertia and is derived from the string geometry. A value of 0 indicates a normal (correct) value for the string. As you increase the value the string becomes more rigid and "mutates" gradually from a string to a rod.

Elasticity: This value represents the flexibility of the string material. This parameter is defined such that the string set responds normally at a value of 0. Increasing the value reduces the elasticity and the result begins to sound more and more metallic.

Volume: This control adjusts the overall volume of the guitar model.

> When using the Electric model the amplifier can provide yet another substantial increase in volume.

The Pluck control group

For a string to vibrate it must first be excited. This excitation is usually a short impulse produced by an agent such as a fingertip, fingernail or plectrum (pick). The agents differ in various aspects. For example, a fingertip will rub longer against the string than a plectrum which engages the string only very briefly. Because it is very difficult to define the simulation of a fingertip in a mathematical formula that can be steplessly changed to a plectrum, some other excitation formula had to be implemented. The excitation component therefore consists in principle of an AD (attack-decay) envelope in which the excitation comprises basic energy (Global) and noise energy (Pluck). The times of this curve are freely adjustable and can be modulated by MIDI velocity. Therefore a range of excitation characteristics is possible, all of which can be dynamically controlled through velocity. Because configuring the excitation component is not trivial, the Pluck group provides two views, **Easy** and **Pro**. While the Easy view is preset-oriented and offers little in terms of detailed control, the Pro page provides all the parameters necessary to create the most diverse string excitation characteristics.

Easy view

Pluck type: Click in this text field to open a list containing the excitation presets. These presets contain values for **Global** and **Pluck** (below).

> **You can extend the available presets with your own creations. To do this, go to the Pro view to open the Pluck control group's preset list.**

Global: Controls the basic excitation energy.

Pluck: Controls the energy of the noise component.

To get an idea of the contributions of the two components, set one to zero and vary the other. As you raise the Global control you'll hear the basic tone of the string increase. Increasing Pluck produces more of the overtones. Most often a combination of the two is best.

Pro view

LowCut: Frequencies of the noise component can be attenuated by means of two filters. The LowCut filter attenuates all frequencies below the adjusted frequency value. It operates with a 12 dB/ octave slope.

HighCut: The HighCut filter cuts frequencies above the adjusted frequency. It also operates with a slope of 12 dB/ octave.

Attack: Controls the rise rate of the excitation A/D curve. The control ranges from 0 to 100 ms.

Decay: Controls the fall rate of the excitation A/D curve. The control range is from 0 to 100 ms.

Global: Controls the basic excitation energy.

Pluck: Controls the energy of the noise component.

Vel on Attack: The attack time can be modulated by the strength of the excitation. It is possible to extend or shorten the attack time by a factor of 100 at maximum velocity.

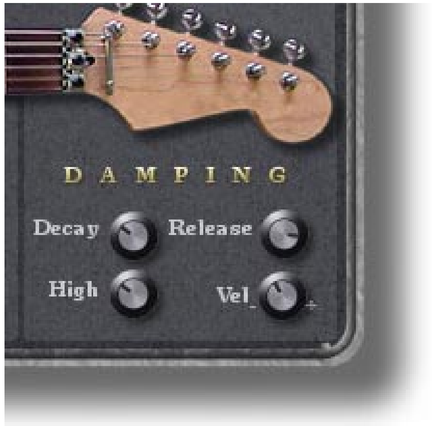
> **Example:** With an attack time of 10 ms and Vel on Attack set to maximum positive, the attack time at maximum velocity will be 1000 ms and 10 ms at minimum velocity. With Vel set to maximum negative, the attack time at maximum velocity will be 0.1 ms.

Vel on Decay: The decay time can be modulated by the excitation strength. The decay time can be extended or shortened by a factor of 100 at maximum velocity.

Vel on Pluck: If the control is set to 0, the noise portion is always present with a level independent of the MIDI velocity at the adjusted volume. As you increase the value the noise component decreases with low velocity values and increases with high values.

The Damping control group

After its initial excitation, a string vibrates without an additional supply of energy. The vibration decreases over time due to friction with the air and energy absorption at the nut and bridge. The volume of the signal falls over time, but not proportionally for all frequencies. High frequencies generally fade away more quickly than lower frequencies whose oscillations contain substantially more energy to be absorbed by friction. Damping modifies this behavior.



Decay: The frequency-independent energy loss of the string—controls the overall decay time for a string while a key is pressed.

Relase: Controls the frequency-independent energy absorption when the key is released.

High: Controls frequency-dependent damping of the string. The higher the value, the more quickly high frequencies relative to the fundamental fade away. Moderate settings produce a natural harmonic attenuation while others produce effects of strongly damped strings.

Vel: Adjusts the influence of MIDI velocity over harmonic damping. In the center position velocity has no influence. Turning the controller clockwise increases the damping of overtones by velocity, while turning it to the left reduces the damping.

Add page

With a device as complex as the Six-String it is not possible to represent all adjustable parameters on a single page as they would occupy the entire screen. Therefore the parameters are grouped together and distributed over several pages. The ***Add*** page contains several Additional parameters for global settings such as pitch modulation and model-dependent settings related to guitar body or pickup simulation.

The Body control group

With the acoustic model a group of controls labeled ***Body*** is available in the Add page. The controls produce an approximate emulation of a guitar body by means of three bandpass filters. This arrangement lets you define three frequency ranges to characterize a particular guitar body. One of the most important resonant frequencies is the *Helmholtz frequency*, known as such because it is the frequency at which a Helmholtz resonator resonates. A Helmholtz resonator can be described as a tube closed at one end. When air inside the tube is excited it produces an oscillation, or steady pitch, at the Helmholtz frequency. A familiar example of this is when you blow across the top of an empty bottle to produce a tone. Now transfer this idea to the action of the strings across the bridge and to the guitar body; the air inside likewise resonates at the guitar's Helmholtz frequency. The exact frequency depends on the size of the resonant cavity. With steel-string guitars the frequency is approximately 55 Hz. Classical guitars resonate at 103.8 Hz and flamenco guitars usually somewhere between 92.5 and 98 Hz.

Other resonant frequencies are a function of the construction of the guitar body and normally range below 1000 Hz.

As mentioned earlier, simulating a guitar body following accurate scientific principles is only one possibility. The model also permits settings that a physical body cannot produce, thereby extending the range of sonic possibilities once again.

Type: Click on the text field next to the Body section designation to open a list from which you can select a body type. Note that, also with this sub-preset list, presets are basically copies of settings, not a fixed direct reference. If you change a Body preset, none of the previously configured Six-String primary presets will be affected. Only the new preset will take over the updated values when it is called. When you change a parameter in a preset, an asterisk appears next to the preset name to indicate that at some point the parameter was changed—the preset contains values different from the original. To use a changed Body preset in another Six-String preset save it as a new preset.

On/Off: Enable or disable the body simulation. When disabled, the simulation program is unloaded from the DSPs and requires no processing time.

Formants: For each field enter a frequency at which the body is to produce a resonance.

Level: Enter the respective volumes of the individual resonant frequencies.

> **Note that you can quite easily generate undesirable distortion by adjusting the filter frequencies very close to each other, and/or by setting high levels. Also, the volume depends on the stimulation of the guitar body, that is, how much of the respective resonant frequency range is present in the string signal.**

Relation: Sets the string to body signal ratio. At the minimum setting only the string signal component is produced, and at maximum only the body component.

> **The body component is monophonic (as is appropriate) and mixed evenly to both channels.**

The Pickup control group

With Electric model, a simulation of the pickups, rather than a guitar body, is available. The pickups are implemented with a highpass, and, more important, a resonant lowpass filter. The highpass filter ensures that low frequencies can be cut when desired to prevent boominess from deep frequecies. The lowpass filter ensures that higher frequencies can be dampened, exactly as with physical pickups. Of course, different pickups with different characteristics are available. Most pickups, for example, exhibit a critical resonant frequency—yet another frequency you can adjust.

Type: Select here one of the pickup presets. As above, these presets are not referenced; the values are transferred to a local copy when you select the preset. Also, as above, you can save changed settings as a new preset in the preset list. To do this, open the Preset list.

Open PresetList: Opens the Preset list in which you can administer (load, save etc.) individual presets.

On/Off: Enables/disables pickup simulation.

High Pass: Sets the frequency below which the signal components are attenuated. The slope of the attenuation is 12dB/octave.

Low Pass: Sets the frequency above which the signal is attenuated. The slope of the attenuation is 12dB/octave.

Frequency values of approximately 2kHz produce warm, soft tones. At 3kHz, the tone is somewhat brighter, and at 4kHz even more brilliant. Settings above 5kHz produce a distinctly bright, sharp tone quality. Adjust the resonance afterward to suit your taste.

Resonance: Adjusts the amount of reinforcement around the cutoff frequency value.

The Slap control group

The Slap section controls the behavior of the string with regard to the fingerboard. You can adjust the distance of the strings from the frets, and also the vertical deflection of the string when it is plucked. The material of the fingerboard and frets can also be adjusted to six different types. This section therefore controls the amount of impact of the string on the frets/fingerboard which, of course, changes the resulting sound dramatically. This behavior is always coupled to Velocity.

Frets: Selects a fret type. The hardness of the fret material is adjustable from Hard 1, 2, 3 to Soft 1, 2, 3. While the Hard types are appropriate for simulating metal frets, the softer types allow for softer materials, such as is the case with a fretless fingerboard in which the string strikes wood rather than metal.

Deflection: This setting describes the vertical deflection of the string as a function of Velocity. The higher the value, the greater the deflection. The text field always indicates the resulting deflection.

If you want the string to slap against the frets, the values here must be greater than the distance of the strings to the fingerboard (as adjusted under Distance, below).

Distance: Adjusts the distance of the strings to the fingerboard.

Strength: To use this parameter effectively you must know that pickup #2 is used to implement the slap function. Therefore the position of the pickup relative to the strings, and the amount of signal energy at that point are important. The Strength control limits this energy so that it is sufficient to produce the Slap but not so strong that the string strikes too much on the fingerboard.

To simulate a fretless instrument, set the distance to a low value, select a Soft fret type, turn the Velocity down somewhat, and experiment with the Strength control until you achieve the desired result.

The Global control group

This section lets you adjust various parameters relating to the global control of the instrument.

Coarse: Sets the overall tuning of the Six-String within a range of -12 to +12 semitones.

Fine: Adjusts the fine tuning within a range of +/- 100 cents.

Pitch Wheel Range: Sets the maximum value in semitones of the pitch modulation controlled by the Pitch Wheel.

Portamento: When Portamento or Glissando is switched on, the pitch will either glide (Portamento), or progress in a stepwise fashion (Glissando), from one note to the next over a fixed ***time*** period (adjustable - see next section).

You can adjust this parameter to ***Off, Portamento, Glissando, fingered portamento (Fing. Portameto)*** or ***fingered glissando (Fing. Glissando).***

> Note that Portamento/Glissando is effective only when playing in a legato style.

Time: Used in conjunction with the Port/Gliss option, above. This sets the amount of time to glide or gliss from one note to the next.

Aftertouch on Pitch: Allows MIDI Aftertouch to control pitch modulation. The value represents the maximum deflection with full Aftertouch (in semitones).

> You can use this to simulate a tremolo arm ("whammy bar") very nicely without having to remove your hands from the keyboard to move the Pitchbend Wheel.

Single Voice Mode: This option switches the Six-String to Mono mode without reducing the number of Device voices. This means that although there may be moments of higher DSP load, faster preset and program changes are possible as the work of DSP code reorganization is accomplished by the hardware.

The Pitch Envelope control group

The Six-String includes an A/D pitch envelope to modulate pitch. This is used to create various effects, such has having the initial pitch start a little lower or higher as it does frequently in the real world. A Slap Bass is a good example. A convincing slap effect results only if the tension of the string increases, with a corresponding increase in pitch, at the onset of the note and then quickly drops back down to normal. The curve can also be used to produce performance-controlled slap deflections. For this a Threshold parameter is available that starts the envelope from a specific MIDI velocity value.

Attack: Sets the time the envelope takes to reach its maximum value.

Decay: Sets the time the envelope takes to return to 0 from its maximum value.

Threshold: Sets a MIDI velocity value at which the envelope will start. The effect of the envelope curve will only become audible if this value is reached or exceeded.

EnvDepth: Controls the strength with which the envelope modulates the pitch. The value can be positive or negative. With positive values the pitch rises and then drops back to its original pitch. With negative values the pitch falls and then returns to 0.

VelSens: Controls how strongly MIDI velocity affects the envelope. At a value of 0, velocity has no influence. With higher values, the envelope is modulated more strongly. Small values produce weak envelope modulation; large values produce strong modulation.

Time KF Note: The expansion or contraction of the envelope (in time) can be linked to the note played (*key follow*). The note selected here is the note at which there is no expansion or contraction. The envelopes of notes above or below this note are expanded or contracted, much like KF Sens would do.

KF Sens: Controls the compression/ expansion of the envelope (decrease/ increase of overall envelope time) as a function of the note played. Positive values expand the envelopes of notes above the KF Note and compress the envelopes of notes below it. Conversely, negative values expand the envelopes of notes below the KF Note and compress the envelopes of notes above it.

You can use this parameter to adjust low notes to take longer to reach the normal pitch, and high notes to reach it very quickly, as is the case with real strings in the real world.

The Pitch LFO control group

The Six-String includes an integrated LFO for pitch modulation. The LFO intensity can be modulated by various controllers. You can choose whether to produce a vibrato using aftertouch or the modulation wheel, or whether vibrato should always be in effect.

Frequency: Sets the frequency of the LFO.

Level: Sets a permanent (fixed) LFO pitch modulation level.

AT Level: Controls the increase in intensity of the LFO through MIDI aftertouch.

MW Level: Controls the increase in intensity of the LFO through the Modulation Wheel.

ModWheel: Represents an external modulation wheel connected as MIDI Controller #1.

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