YAMAHA Power User

VL PHYSICAL MODELING

VL - Virtual Lead
Why controlling a Virtual Acoustic "VL" Voice via Breath Control is so cool?

Acoustic instruments can be talked about from the perspective of how the musician interfaces with it to generate vibrations – how it creates the sound. We can divide musical instruments into two families. Each family defined by a similarity in approach in generating sound vibrations. One family are instruments where the musician is responsible to continuously apply a "pressure" to the instrument in order for it to continue making a sound. This is usually accomplished by blowing through it or bowing it. These are called "self-oscillating" instruments. The second family are instruments that have a triggering event that starts the vibration, and then it is time, gravity and friction that act upon the instrument to make the sound fade away (decay). These are called "forced excitation" instruments.

The hardware mechanism for generating the vibrations is called the "driver". The "self-oscillating" systems have an assortment of 'drivers': various mouthpieces and bows. The "forced excitation" systems have a variety of plectrum (picks), hammers, mallets, fingers, etc. These drivers have a profound effect on the attack portion of the instrument's sound, which in turn has a profound effect on how we hear and identify that sound. When trying to emulate other instruments from a keyboard synthesizer, we begin to run into limitations in controlling the subtle nuances of the different instruments. After all, the keyboard is just a set of off/on switches. Combine this with sample playback technology, which has to re-trigger with every note-on and it makes things like "hammer-ons" and legato trills impossible (particularly if the synth is polyphonic). The keyboard interface itself, in the acoustic world, is best suited to trigger "forced excitation" instruments, like the piano.

For example, one of the things that makes playing woodwinds less realistic from a sample playback based synthesizer is the keyboard having to re-trigger a recording of each note. In other words, the note is attacked (like a new breath) with each key on - making true legato playing (several notes from one breath) impossible. And besides, when playing a sampled recording you get the original attack of the acoustic player at each note on. The person playing each note originally attacked each note. The result is, to a great degree, predetermined. Some sample playback synths have an elaborate scheme where pitch bend is used to avoid attacking a new note but the harmonic content of the sound suffers because, unfortunately, the formants in the sound start to transpose giving the sound a chipmunk-like quality.

As a keyboard player you use the various physical MIDI controllers to help emulate other instrument techniques: the Pitch Bend wheel – for scoops and drop-offs, the Modulation Wheel – for vibrato, the Foot controller – for volume and timbre changes, Aftertouch, sliders, ribbon controller, etc. In fact, these techniques have been developed over the years to the point where keyboard players can manipulate these controls, in real time, to help mimic the performance of many acoustic instruments. Without these physical MIDI controls the performance is lifeless and stagnant. Therefore, as a synth player, a fair amount of time is spent practicing the movement of these devices. Much of music training is the practice of such physical gestures.

One other very significant problem with the keyboard as a controller in instrument emulation, is it becomes difficult to control the volume envelope in real time with any degree of acoustic realism. Your foot on a pedal or your hand on a slider cannot adjust the volume with any thing near the subtlety required to do a good job of acoustic instrument emulation. This is particularly evident when trying to emulate

woodwinds or brass. And velocity, the keyboard players main weapon for controlling loudness is inappropriate to control the volume of brass and woodwinds because velocity sends a single value at note-on and there it remains until note-off. Enter the Yamaha Breath Controller. One of the things that musicians all work on when first learning any instrument is how to control the **harmonic content**, **pitch** and **amplitude** of their instrument and to do these things related to some good rhythmic timing. Let's take a look at these components.

Harmonic content of the instrument accounts for what musicians refer to as "tone". You work long and hard in those early days to develop 'tone'. On woodwinds, this means hours of playing long whole notes, controlling the subtle changes that occur in the sound as you vary breath pressure through the horn. On piano, it means developing control over the sound of those 'inner' voices within a piece of music so that the counter melodies are heard. On violin, in means controlling the speed of the stroke, the downward pressure and the changes in direction while bowing etc., to bring forth a *musical* tone. As you well know, dragging a coarse horsehair bow across elongated cat gut strings, can be a frightening sound in the hands of a beginner, and a thing of beauty in the hands of a master. It is the practice of the physical gesture that makes the experienced player sound fluid on their instrument.

On the "self-oscillating" family instruments, the attack is very often varied for the purpose of phrasing. Each successive note might have a slightly different attack in terms of intensity or physical approach. A wind player can attack a note with the tongue, without the tongue, double tonguing, even growl; a violinist can apply a light downward pressure but quick stroke, etc. Each gesture change changes the physics, which causes a change in the harmonic content. This important fact is elegantly addressed by Yamaha's VL technology via Breath Control. You will experience a difference in the sound with VL technology as you vary your playing gesture.

Pitch: Any discussion of the pitch of an instrument brings us to a fundamental music rule (pun intended): Play the right notes, man. The mapping of pitches is handled slightly differently on the various acoustic instruments. The musician's task of ensuring that the right pitch is triggered is handled differently for each musical instrument. For the pianist tuning the instrument is handled differently than for a violinist. The pianist has someone come in and tune the instrument so that when the key C is hit, a C is heard. The violinist has no frets and must be a good judge of distance and have a feel for pitch (that's probably why they hold and 'couple' with the instrument under their chin - to better 'feel' the pitch. Subtle variances in pitch are very important - vibrato, pitch bends, etc.

One of the keys to realistic acoustic emulation is to accurately mimic the change in harmonic content that occurs in most instruments when the pitch is varied. Digital sampling technology is limited to a device called a "filter" when trying to do emulate timbre change. But the filter can only change along a predetermined snapshot of the sound. Not very realistic. The Physical Model in VL technology, for example, recreates the physical conditions that exist in the playing of the instrument, mathematically. When you change the conditions, the behavior will change in a similar, very realistic, manner.

Volume and the control of loudness is important in most instruments - only a few have a fixed volume output: harpsichord and electric guitar (which are always played at maximum) (☺). Control over volume in a performance can make a real emotional impact on the listener - a primary goal of the musician. Here again, the "self-oscillating" family of instruments differs from the "forced excitation" family of instruments. There is very little control over the volume of a note once it has started on a "forced excitation" instrument. Think of a percussionist with a pair of orchestral cymbals, or striking a piano note - once you commit to an amount of physical force to trigger the musical event, that's it. That note is out there in the air, so to speak. You could stop it, but you cannot raise and lower the volume during its duration. The "self-oscillating" musician, on the other hand, has continuous control over volume change during a note.

Now let's apply this knowledge to some different forms of synthesis via the Breath controller. This will apply to the older BC1 and BC2 and the current model, BC3 Yamaha Breath Controllers. Even the WX7, WX11 and WX5 Wind Controllers have basic similarities to this system. Breath Control is a MIDI Control Change message similar to the messages sent by the Modulation Wheel (control message 001) or Foot controller (control message 004). It sends values from 0....127 and can be assigned to effect any number of synthesizer parameters. It is important to note that not all manufacturers have implemented Breath control in their synthesizers. If you make the overall volume

(amplitude) of the sound sensitive to BC control (control change message #002) then striking a key will **only** cause a note to sound if you are **also** blowing into the breath controller. After all striking a key on a saxophone does not make a note - you also have to blow. If you additionally make the cutoff frequency of your filter sensitive to BC control, then you can also manipulate the harmonic content of the sound over time.

If you are controlling a sample playback-based instrument sound, BC can help overcome only some of the inherent limitations of that technology. Certainly, the control of volume over time (handled by the amplitude envelope generator, AEG) is one very important component when it comes to accurately emulating an acoustic instrument with a synthesizer. Assigning control of the AEG to Breath Control is the first step in gaining continuous volume control. In a typical sample based sound, the amplitude envelope is predetermined and can only be varied in a limited number of ways. It is a general rule of thumb that the more energy applied to playing an acoustic instrument the brighter the sound. Often a lowpass filter is assigned to be controlled with BC. When you increase the breath pressure not only does the sound get louder but also it gets richer in harmonics (brighter). This occurs along a pre-determined path because the data is sampled.

If you are controlling a VL Virtual Acoustic instrument model via Breath control the experience is heightened a thousand-fold. The VL Virtual Acoustic Physical Models actually recreate, via mathematics, the physics involved in the acoustic behavior of the instrument being modeled. The relationship between applying pressure to the model is much more a 1:1 experience with what happens acoustically. Beyond that, you are not triggering pre-recorded samples, the sound is determined by the interaction of you, the player, and the mathematics that represents what goes on in the instrument. The interaction between the mouthpiece and the horn, the thickness of the reed, the position of the virtual player's tongue and the effect of throat formants, etc. are all modeled by VL technology. And the sound comes to life as you control it. Your input determines how it sounds, you will sound different from anyone else playing the same Voice! Very much like each musician that picks up a saxophone would have a different sound.

Breath Control of VL sounds versus samples. With Samples → Filter → Amp based sample players, Breath Control only does real-time control of the filter cutoff frequency and the amp volume. The sample is started with note on, and then it loops. The harmonic structure is *completely* predetermined. The only timbral 'behavior' is in the sample at note-on (tonguing attack) through the loop start point. Thus Breath Control with samples only works well with sforzando swell articulations. Players blow maximum Breath Control, play the notes like on any keyboard, then while holding a note, back off the BC pressure to bring the volume/brightness way down, then crescendo the BC back up to maximum. This could be accomplished with aftertouch or a foot controller.

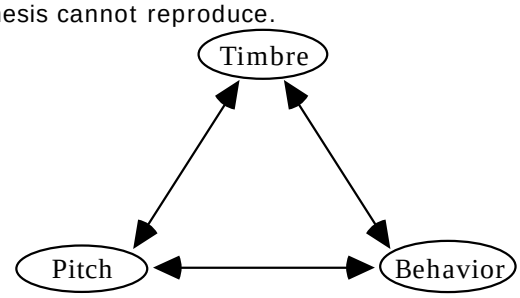
With samples, no matter what you do, holding the same note-on and tonguing the BC only gives a gated 'ga ga ga' type response of the loop timbre. The VL gives *completely interactive timbre and behavior response* to BC pressure as the Virtual Acoustic algorithm dictates the physics of the instrument's response to the BC input. If you tongue hard while holding a note on the keyboard, you get a crisp, new attack transient. Tongue a little softer, you get a new softer attack. Continuously vary the pressure up and down and the harmonic structure and volume follow along. The harmonic structure is different at different pressures.

The fact the VL has envelopes that are triggerable from note-ons is really not needed in the strict Virtual Acoustic sense, though it does greatly enhance the conventional synthesis power of the machine, as well as increasing the mono and legato response possibilities.

Playing PCM samples with Breath Control is an eye opening experience but when you experience controlling a Virtual Acoustic VL sound via BC, you begin to understand why it was invented. The VL rewards your breath input in a totally organic way! The relationship of pressure increase to harmonic content and pitch change is often so realistic that if you do not see the VL player, you accept it as the real thing. We call this the "blindfold test". The "behavior" is correct. It squeals, squeaks, and honks like the real thing under similar circumstances. You 'learn to play' each VL Voice as a separate instrument. You start to understand from a totally different perspective why horn players practice holding whole notes. (Not something you practice much on piano). Any change in breath pressure causes the appropriate behavior in the model ... a change in pitch, volume and harmonic content in the proper mathematics according to the laws of

acoustics. When playing a VL sound, think about emulating what a wind player does. You have control over breath pressure, embouchure, tonguing, throat formant, growl, scream, vibrato, not to mention phrasing. If you just play on the keys like a keyboard player, without manipulating the available MIDI physical controls, your playing will be uninspired. Do not blame VL technology for the lifeless sound, it is very much your fault!

Excerpt taken from VL Programming Guide by Dr. Manny Fernandez:
Virtual Acoustic synthesis is unlike traditional types of synthesis because you are programming the physics of instrument behavior and construction (not the sound!). This reproduces in the holistic interaction of pitch, timbre and behavior which occurs in acoustic instruments. Indeed, it is the skillful control of pitch, timbre and behavior which allows acoustic instrumentalists to create nuances and expression in their playing that traditional synthesis cannot reproduce.



This is because traditional synthesis is based on the reduction of sounds into *discrete* pitch, timbre and behavior components i.e. Assign a tuning (pitch), choose a waveform or sample (timbre), then alter with filter and amplifier envelopes (behavior). There is the ability to modify behavior with real-time controllers like Mod Wheel for vibrato, Foot Controller for filter sweeps and the Pitch Wheel for bend articulations, but each of the effects is discrete and does not recreate the *interdependent interactions* that happen in a acoustic instrument.

Programming the VA system will put you in the role of instrument designer, and you will need a new paradigm in your approach to creating and editing sounds. Namely, you are no longer directly dealing with the 'sound' itself, but instead are dealing directly with the ***instrument***. Thus you change the construction of the instrument to indirectly affect the desired change in the 'sound.' For example, you are no longer making the 'sound' brighter by opening a filter. You are now making the 'sound' brighter by increasing the airflow speed through the instrument, widening the flare of the bell and changing the dampening characteristics of the wood, metal or plastic body. The essence of VA synthesis dictates that now the 'sound' is brighter, but it now also has a slightly different harmonic structure, the pitch and scale temperament is altered, and the attack/decay and legato/staccato articulation behavior is different as well. The fact that VA synthesis always responds with this interaction between pitch, timbre and behavior gives it the ability to recreate the nuances and expression of acoustic instruments.

By it's design, VA synthesis emulates the real physics, so you can easily create instruments that don't, won't or can barely play. Traditional acoustic instrument designs were created and refined over generations, and reflect refinements in design to maximize specific physical behaviors. The first time Adolphus Sax tried to create a metal woodwind, it was a far cry from a Selmer Mark VI !!

-----To program VL Voices from scratch get the latest version of the Yamaha VL70-m Expert Editor from the Yamaha website. Version 1.2 beta for Macintosh will work with the EX5 and EX5R. EX5's with version 1.07 and later can load 16 custom "wave" locations. Numbered 257-272 on the VL type Element list. There are several PC versions of the editor available on the Internet (made by end users).

Yamaha BC3 Breath Controller ($119.95 MSRP). Setting up a VL+AWM Voice in the EX5/EX5R is easy. Navigate to the Controller Set page and press the [REMAP] button [F3].

- From VOICE mode Press [EDIT]
- Press [F7] Ctrl
- Press [F8] Set, if necessary.

Setting up the BC3 for use with your Yamaha EX5 keyboard:

There are 2 settings on the side of the BC3. One for OFFSET and the other is GAIN. Here's how to setup the BC for comfortable play:

Select **Pre 1 077: Br: Trumpet**. This Voice is a VL+AWM type that has a single VL element in it. To reprogram it for Breath Control operation, is easy. Plug in the BC3 to the EX (very important).

- Press [EDIT]
- Press [F7] Ctrl – Controller Parameters
- Press [F8] Set – Controller Sets (there are 16 possible)
- Press [F3] REMAP – this automatically remaps the basic controller assignments of VL Voices to BC control. (It does **not** do the same thing for AWM, AN or other technologies). You will want to learn from the different assignments. Notice how you can scroll through the different Controller Sets and see what SRC (source) or Physical Controller is assigned to what DST (destination), EX parameter. BC is assigned to control VL PRESSURE – this is applying air pressure to the mouthpiece of the virtual horn.

Blow a puff of air into the BC3 mouthpiece to initialize it. Now, **without blowing into the mouthpiece** (very important) hold a note down on the keyboard. Adjust the OFFSET parameter up and down. Notice how the sound can be made to disappear (remember you are **not blowing**). This is a critical setting – you want to turn this back and forth so that you are resting at a point where the sound has just reached the OFF point. Stop. You should now here absolutely no sound when you play on the EX keyboard. (The sound is said to be “biased” to breath control). It will now take blowing into the mouthpiece of the BC3 **and** playing a key to turn on a note. Save the Voice to an appropriate Internal location – you may want to change the name to reflect that it has been reprogrammed for Breath Control.

Now, what about that GAIN control. This is set to your playing style. If you are just starting with breath control and have no background with blowing an instrument, then you will want to set this sensitivity control for lighter response. You are changing how much effort it takes to reach 127. As you gain more and more confidence in your ability to ‘blow’ notes, you will find yourself actually increasing the amount of air it takes to play. Please take your time. In 3 weeks re-evaluate your playing and make adjustments. Remember that the BC3 mouthpiece has an air release valve (drain cap) that also changes how the BC feels as you play. Like any ‘horn’ player you will naturally develop over time.

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