# SoundFont Synth Notes and Observations

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Here are my notes and observations on the SoundFont synths that I tested for my blog post [*Using SoundFonts in 2016*](https://schristiancollins.wordpress.com/2016/03/02/using-soundfonts-in-2016/). The test results can be found [here](https://docs.google.com/spreadsheets/d/1QzqA9IetT7MVDhG-oSFAWrciyg6O-oaQ_hGsl8fKeSo/edit?usp=sharing).

Here are some notes on each synth:

## Audigy 2 ZS

This is the hardware implementation that every SoundFont synth should strive to emulate. That being said, there are a few behavioral curiosities:

1. Envelope stage time values are not always rendered accurately. This is most noticeable when incrementing the hold value gradually up from 0. There seem to be jumps in the actually rendered values. I don’t have the exact numbers on hand, but we’ll say the range between 1-10 ms. would all render at 5 ms, the range between 2-20 ms. would all render at 15 ms., etc. So again, those aren’t the actual values, but the behavior is something like that.
2. Filter cutoff values lower than 100 Hz, all sound at 100 Hz (estimated). Also, the filter appears to be fully open at 8,000 Hz. With FluidSynth, there is an audible difference through the entire filter cutoff range.
3. Filter resonance appears to cap off at around 20 dB. Higher values all sound identical to 20 dB.

### Default velocity-to-filter cutoff modulator

The Audigy/SoundFont 2.01 default velocity-to-filter cutoff (vel-to-fc) modulator is a strange design decision. To fully understand its strangeness, let’s look at the evolution of this modulator beginning with the SoundFont 2.0 implementation found in the AWE32/64 and Live! sound cards:

* AWE32/AWE64/Live! (SF 2.0):
  + No vel-to-fc modulator present by default.
  + If an instrument’s attack is set to 6 ms or longer, a vel-to-fc modulator becomes enabled, smoothly scaling the filter cutoff down with lower velocities.
* Audigy/Audigy2/APS (SF 2.01):
  + Default vel-to-fc modulator applied regardless of instrument attack. However, in this implementation, there is a secondary modulation source (switch) which causes a very audible jump in the filter between velocities 63 and 64.

Not only did the SF 2.01 default vel-to-fc modulator break compatibility with earlier SoundFonts, it added a weird secondary modulation source that causes a huge jump in what would otherwise be a smooth velocity scaling of the filter from low to high velocities. I cannot see the logic behind this design!

In all fairness, it does appear that perhaps the implementation that made its way into the Audigy/Audigy2 wasn’t exactly what the designers were trying to achieve. Regarding the default vel-to-fc modulator, the [SF 2.01 spec](http://www.synthfont.com/SFSPEC21.PDF) reads, “The MIDI velocity number is also used as a secondary source for this modulator; it is a negative unipolar switch. This has the effect of turning off velocity-to-filter for velocity numbers less than 64.” This description is inaccurate to how the modulator works in its actual implementation. It is worth noting that the [SF 2.04 spec](http://freepats.zenvoid.org/sf2/sfspec24.pdf) (used in X-Fi sound cards) gets rid of the secondary modulation source altogether. Perhaps the designers recognized that using the secondary modulation source had not worked out as planned.

All of that being said, it is my recommendation that any SF 2.01/2.04 spec synth should ignore the default vel-to-fc modulator altogether, while still providing for custom vel-to-fc modulators to be set up by the user. FluidSynth has incorporated this approach at my suggestion, and I really think it is the ideal way to handle this going forward.

If testing these modulators out for yourself, please note that due to the Live!/Audigy filter being fully open at 8,000 Hz, the effect of this default modulator is only audible if the instrument’s initial filter cutoff value is set significantly lower than the default 20,000 Hz.

## bismark bs-1/bs-16 v4.1

Here are some of the issues I ran into using bs-16:

1. Doesn’t support SF 2.01 modulators.
2. The modulation attack envelope is linear. It should be convex according to the spec.
3. In my test, the initial cutoff set to 20 Hz resulted in a fully open filter. The next tested filter step, 50 Hz, and everything above that sounded correct (my test doesn't check 21-49 Hz).
4. Filter resonance appears to cap off at around 25 dB. Higher values all sound identical to 25 dB.
5. It sounds like there is always a velocity-to-filter cutoff curve applied to the sound. I find that I need to bump up the bs-16’s filter knob a bit to get the right sound, where things aren’t too muffled.
6. It sounds like the sample interpolation method is linear. I am a bit disappointed that a paid product such as this doesn’t offer a higher quality sample interpolation algorithm.

Overall, this is probably the best SoundFont VST available.

## DLSMusicDevice (Mac)

Apple’s SoundFont synth has pretty atrocious SoundFont support, failing almost all of my tests.

## FluidSynth 1.1.6

FluidSynth is the best software SoundFont synth available, in my opinion. It is the only one I know that implements the entire SF 2.01 spec including modulators and NRPNs. There are a number of ways that FluidSynth’s implementation of the SoundFont spec exceeds that found in the Audigy cards:

* Better-sounding lowpass filter (to my ears).
* Audible changes to filter cutoff through the entire range (20 Hz - 20 KHz). The Audigy’s filter can’t go lower than 100 Hz and sounds fully open at 8,000 Hz.
* Full range of filter resonance available (0-96 dB). The Audigy can’t go higher than 20 dB, regardless of the value set.
* Correct interpretation of time values set for each envelope stage. The Audigy often jumps between certain values, making the intermediary values useless. Read the Audigy 2 notes above for a better explanation of this.
* Ignores the default velocity-to-filter cutoff modulator, which is my recommendation for handling what is a somewhat messy situation due to inconsistent implementations throughout the evolution of the SoundFont standard. Please read the section “Default velocity-to-filter cutoff modulator” in the notes for the Audigy 2 ZS above. NOTE: The version of FluidSynth included in the Swami SoundFont editor does *not* ignore this modulator.

There are also a few issues I have discovered as well:

* The modulation envelope uses a linear attack curve, but the spec calls for a concave curve to be used here. While a linear attack curve does make sense for a modulation envelope, this does cause compatibility issues with some SoundFonts.
* The built-in reverb and chorus effects leave something to be desired. The reverb tends to sound somewhat cheap/metallic, and while the chorus doesn’t sound bad, it lacks the stereo field that really brings warmth to a good chorus.

## Jeskola XS-1

This SoundFont VST is actually quite flexible, but suffers from a few major flaws:

* Using multiple instances of the plugin in a project can cause audio dropouts.
* The attenuation amount used to set the volume of a SoundFont instrument or layer is interpreted incorrectly, causing instruments/layers to be out of balance with each other.
* Incorrect root key / scale tune support means that some instruments will play at the wrong pitch.

There are other issues as well, which can be seen on the test results sheet, but these three issues are real showstoppers for me.

## LinuxSampler 2.0.0

The SoundFont support in LinuxSampler is pretty weak.

## sfz

Originally by rcg:audio, then purchased by Cakewalk, sfz (and the non-free sfz+) has been used for a long time to bring SoundFonts into the DAW workflow. I have long despised this plugin because of the way it destroys the instruments I make with its super-shallow velocity curve. Its SoundFont support is decent, otherwise.

If you want to use this plugin, you will need to hunt down the version that works with multi-core processors. I don’t remember the version, or where to find it, I just know that I had to do this at some point. And as far as I remember, the sfz+ version, which has since been released for free as well, was never updated to support multi-core processors.

## SynthFont2 v2.0.2.2

I am unable to more thoroughly investigate some of the test results as my trial period for SynthFont2 has expired.

Some issues I ran into:

* Key number to decay/hold appears to not be implemented.
* The last two steps of my filter cutoff test play a note with the filter cutoff set to 17,500 Hz and 20,000 Hz respectively. For some reason, SynthFont2 plays the 20,000 Hz test at a quieter volume than the 17,500 Hz test.
* Sample offset seems to be working, but the offset amount is incorrect.
* It would be nice to have a higher quality sample interpolation method. It sounds as though linear interpolation is being used here.

It is interesting that removing the velocity-to-attenuation modulator actually worked, which means at least partial modulator support seems to be implemented. None of my other modulator-related tests passed, however. (Note: removing the modulator actually means creating a duplicate of the default modulator with the amount set to 0.)

## Timidity++

No notes at this time.

## VirtualMIDISynth 1.16.0

Apart from the missing SF 2.01 modulator support, VirtualMIDISynth seems to have a pretty decent SoundFont engine, even emulating some of the quirks of the Sound Blaster hardware filter (cutoff and resonance caps, fully open at 8,000 Hz, etc.).