Sound card Velocity Response

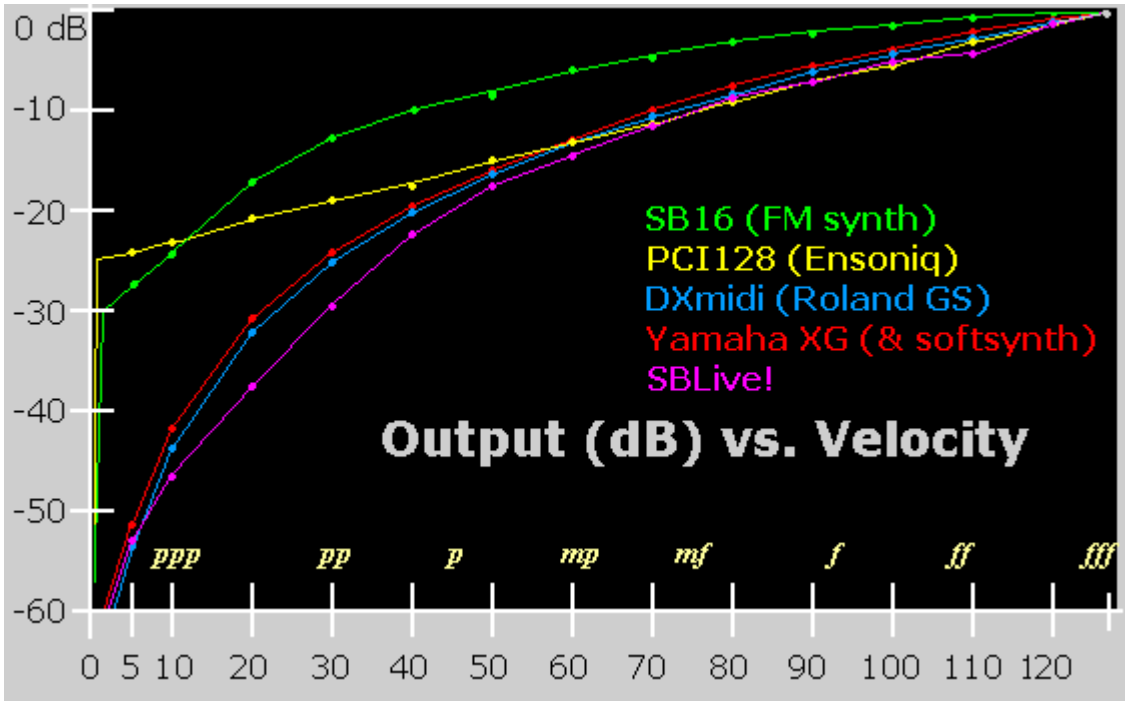
The graph below documents the loudness vs. velocity response of various common sound cards and synthesizers.

The vertical scale is in decibels (dB), which is a measure of the human ear's response to loudness. One dB is generally considered to be the minimum volume difference perceptible to most people, and even trained ears will rarely hear a volume difference of less than 0.5 dB. As a point of reference, each 3 dB increase represents an approximate doubling of power, or an increase of 40% in voltage.

The horizontal scale is calibrated in note velocity, i.e. "dynamics" as implemented by NoteWorthy Composer. The default values at the various dynamic levels are:

ppp	- 10
pp	- 30
p	- 45
mp	- 60
mf	- 75
f	- 92
ff	- 108
fff	- 127

The instrument patch employed was "Whistle", General Midi patch #79, since it's the one that's closest to a sine wave (making it a reasonable assumption that peak value is proportional to total sound energy), also it seems the most consistent from one sound card to another. Also, the "whistle" patch has a velocity-independant timbre on all the cards tested, making comparison a lot easier than with, say, piano patches where different samples are used for different velocity ranges. Single notes on middle C were employed for the tests.



Points of Interest:

• The response of Yamaha softsynths is almost exactly the same as the DB50XG hardware XG implementation. It's so close you would be hard pressed to see the difference, so they're shown as the single red line in the graph. The dynamic range is also excellent, approaching 60 dB (the practical limit of 16-bit sound).

• The DirectX "DirectMusic midi" response (blue line) is almost identical to XG. Perhaps this is no surprise, considering that it's based on the Roland GS midi extension.

• The SB16 (green) is way out there in left field, with little change at the high end, a sudden drop at the bottom, and without the wide dynamic range of XG/GS which makes the argument for non-linear response at least tenable.

• The PCI128 (aka Ensoniq) card (yellow) is even worse as regards dynamic range (only about 25 dB) but is very linear over the narrow range it does support. As far as we've been able to determine, this is incidentally the same sound driver that is used on the SBLive! "Creative SW Synth" setting.

The SBLive! curve (magenta) was derived from recordings by two different users, Sue Morton and Ertugrul iNANÇ, half a world apart. Two completely different soundfonts were employed (the 8meg "standard" font, and the General User GS 1.3 25 meg font). The same NWC source file was used as in the other tests, and the resulting wav file encoded into 128kbps mono mp3's, decoded back to wav, and analysed using CoolEdit as per the other samples.

• The close agreement of Sue and Ertugrul's samples (as regards ***relative*** loudness) verifies that the loudness vs. velocity curve is indeed independant of the soundfont used. (Note that this does ***not*** apply to absolute loudness of a given patch, or even to the loudness of a given patch relative to others in the same soundfont.) The timbre, however, was - as expected - very different. In fact, the GU sample had a very pronounced attach spike compared to the smoother 8 meg default font.

• Another one in the "no surprise" department was that the SBLive!'s channel volume response was very similar to the velocity response, as was the case for the other cards.

• What ***was*** a bit surprising was the pronounced dip near the top end, and another broader dip (relative to the XG/GS curves) near the bottom, deviating from the XG/GS curve by as much as 6 decibels before converging again at the very bottom. This is ***not*** a measurement error, as mentioned above both samples agreed with each other within 0.5 dB over most of the range.

Conclusions:

I don't know if any hard-and-fast conclusions can be drawn from this little study, except perhaps to reassure that files are roughly interchangeable (from a velocity and channel volume standpoint) between SBLive! and XG/GS over most of the dynamic range. This does ***not*** mean, however:

1: That timbres will be anything close to what is intended/expected.

2: That instrument balance will be the same on the various systems. (e.g. your flute might be overpowering on SBLive! and barely audible on XG, etc.)

3: That instruments with velocity-dependant timbres (pianos, guitars, just about anything even remotely percussive) will track in the same way.

Q & A

from Stephen Randall:

Presumably the softsynth examples had to go via a sound card. Does it make a difference which sound card is used?

I don't think the difference would be significant; the main differences that would throw off the computations would be noise level (which is typically quite low) and D-A linearity (which again would, I feel, not make a significant difference).

It seems obvious that a large dynamic range is a Good Thing, but what about linearity? When playing, my subjective impression is that it is easier to make or hear a distinction between ppp, pp and p than it is between f, ff and fff and from the graphs it seems that this experience would be modelled better by the non-linear cases than the linear ones. Of course, there is no reason why dynamic markings should correspond to any particular midi velocity.

My preference is for dynamic range over linearity, but given a choice I'd have to say that in an ideal world the note velocity would be directly proportional to loudness in decibels. However, any standard is better than none, and I was personally gratified to find such a close correspondence between the GS-based DirectMusic driver and the XG-based ones. Then there's Creative/Ensoniq....

Your graphs seems to say that the main difference between the responses of SB128 and the other systems occurs at dyamics less than p - is this because the output from the PCI128 has a large constant noise component?

No. Before analysing the waves I applied noise reduction. While the PCI128 is definitely noisier, the difference is only about 3 dB (reduced to about 1 dB after broad-band noise filtering)

I have a PCI 128 and find the bass end of most PCI128 patches very quiet. I had suspected that my speakers aren't up to the job but the bottom end of the piano patch sounds fine. It would be interesting to see how the graphs would look at different pitches and with different instruments.

There's probably enough there for a PhD thesis.

Yes, and then some. There could even be a practical result to such a study, in that it would make it possible to write software that would tweak midi files to suit the sound card on which it was played. Given the "source" synth and the "destination" synth, it should be possible to achieve a much better degree of sound matching.

So, in the odd free moment when you are not composing new works, transcribing Mozart, hacking PCs, contributing to the NG and being a generally all round good guy, how about undertaking a little research project?

Sorry, it's not for me. I didn't even graph the results of channel volume vs. output level (mainly because for all the devices I tried, the results were - as expected - quite close to the velocity vs. output curves). This could very quickly become a very time-consuming project, and I'm not about to go there...