NOISE PROBLEM INDICATED IN COMPUTER SOUND CARDS USED AS HI-FI RECORDING DEVICES

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Abstract

A sound reception is one of important human perceptions and a contact with the surrounded world. Now computer devices are the main equipment to almost perfectly record and playback a wide range of sounds. Music or sound cards play the central role in this process.

The Author has tested several cards concentrating the attention specially on their external versions but internal versions were also investigated for comparison. Usually specially constructed external sound cards are better than much compromised internal versions built directly other electronic circuits on the computer mainboard. It was proved during experiments measuring noise parameters – not always. A simplicity of the construction and other digital circuits closeness create difficult conditions for a noiseless action but in a popular class equipment only.

Three external cards, one of PCI interfaces E-MU - 0404 for studio recording and two of USB interface, potentially worse designed by Creative Labs - Sound Blaster Connect and by Lexicon - Alpha. All Hi-Fidelity requirements are performed by each card but noise levels are different.

Conclusions are shortly presented here:

1. Built-in sound cards, specialized for Hi-Fi recording are better with noise parameters than external USB devices
2. The newer built-in card (Dell Studio laptop) is only a little bit worse than special professional card by Creative Professional (E-MU 0404)
3. USB cards include additional preamps (very useful) but present in noise charts ad-ditional interferences (peaks) and its noises are a few dB bigger
4. Newer USB cards (Lexicon Alpha) are much better than older (Sound Blaster Connect). The noise difference is up to 10 dB (abt. 3 times)

Results are clearly shown using tables, charts and mathematical formulas derived from own experiments.

Key words: computer sound card, electric noise, sound card DSP, sound card noise.

1 Bases of the electric noise

The electric noise is an electric current flow effect. The Joule heating is another known and normal result. The noise existing is mostly undesirable, unfortunately its reduction stais very difficult or plainly unworkable because of its wide frequency range and troubles with using specific filtering methods. The basic method remains to reduce noise levels in all low signal circuits mainly in preamplifiers. This follows a few electric noise definitions:

- **Thermal noise** (root mean square RMS voltage) represented by Johnson-Nyquist formula:

$$U_n = \sqrt{4kRT\Delta f}$$

where:

k – Boltzmann constant, $k = 1{,}38 \cdot 10^{-23}\,\frac{J}{K}$

R – an actual conductor resistance in ohms,

T – a temperature in Kelvins,

Δf – a frequency bandwidth in Hertz

The thermal noise presents constant noise voltage named "white noise".

- **Flicker noise** is only of low frequency (1/f dependence) and not so troublesome in audio frequencies (20 – 20,000 Hz), called as "pink noise"
- **Shot noise** has also a wide bandwidth, similar to the thermal noise but only present with active electronic parts (semiconductors, vacuum tubes).
- **Avalanche noise** – reversed biased Zener diodes (larger than shot noise).
- **Burst noise** – occurs in semiconductors (monolithic amplifiers), present noise crackle [1].

Concepts in noise measurements

There are two mainly used parameters to determine a noise level:

A. Equivalent Input Noise – EIN

A noise calculated for a device input is often impossible to measure (too low voltage level). In practice almost all voltage signals are compared to the "normal" signal in line tract equals 775 mV (effective). Bigger than normal signal levels cause an overdriving and consequently signal distortions. Compressing devices save circuits realized amplification decreases accompanying too big signals.

Signal levels may be calculated from the formula:

$$S_L(dB_u) = 20log\frac{U_s}{U_{sn}} = 20log\frac{U_s[mV]}{775}$$

Minimum theoretical EIN was solved calculating the thermal noise at input resistance of 200 ohm and the room temperature and this critical EIN equals -129dBu (minus 129 dBu). In the practice values of EIN less than 115 dBu are very good.

B. Signal to Noise ratio – S/N

Signal to Noise ratio is the older parameter assigned to the device output. Measurements can be made quite easily now because signals (also noises) present bigger levels. The main formula for the S/N parameter is:

$$S/N(dB) = 20\,log\,(Us/Un)$$

where:

Us – a signal voltage
Un – a noise voltage

Mostly equipment producers present S/N in a very optimistic version at maximal values supposing the signal has 775 mV (0 dB – normal level). Usually signals are much weaker and certainly S/N decreases.

Summing up:

When the amplifier is EIN = - 125 dBu and its voltage gain is 35 dB then the output noise is – 90 dBu. This is the situation of 90 dB S/N, where the useful signal has the level of 0 dB (775 mV). More gain of an additional preamplifier (preamp) gives of course more output noise [3].

2 Noises of the Digital Signal Processing

A computer sound card is both analog and digital device. In most cases, an input analog signal has a microphone level only (Mic In), about 5 mV sensitivity and it is ready to cooperate with electret-condenser transducer. A classic dynamic microphone may also be used, but signals are weaker. An analog to digital converter needs a voltage input level abt. 1 V. This signs the microphone signal has to be gained 200 times (46 dB). This is another noisy electrical stage. Sound cards used in a recording studio have obviously less sensitivity input of about 1 V and called Line In. In this case, the noise problem stays outside of the sound card and the computer. All preamplification stages (preamps) must be specially constructed as a low noise devices. Its sensitivities have to be different depending on a signal source. A few cases have been presented below (table 1).

Table 1. Parameters of different signal sources dedicated to the sound card.

Source	Typical impedance (ohm)	Output voltage (mV)
Dynamic microphone	200 - 600	1 – 3
Electret microphone	1000	5
Condenser microphone	150 - 500	10 - 20
Guitar pickup	1000	100
Any device Line out	1000	1000

Figure 1. shows the block schematic of a typical sound card.

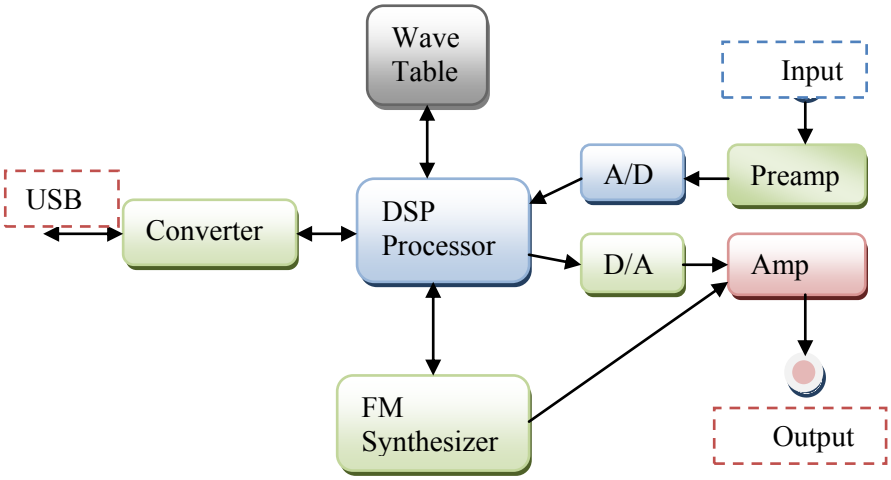

Figure 1. The block diagram of the standard sound card.

Another block that can generate a noise is an amplifier Amp. Because of a small voltage coefficient and relatively large signal level from the digital to analog (D/A) converter, the risk of a noise in this place is unimportant. Own noises of digital circuits can be omitted but interferences carried out on amplifiers and its signal connections can be problematic. Rich sound cards' producers take care of these specific places but in cheap devices not so much. Results are higher noise level with according power lines hum (50 or 60 Hz plus harmonics) [2].

3 Computer sound cards tested in the own experiment

For sound cards comparison, the author uses the software called Visual Analyzer by SillanumSoft (freeware). The whole program interface is presented in figure 2. And it shows a case of the internal sound card form Dell Studio 17" switched to the line input position [4, 5].

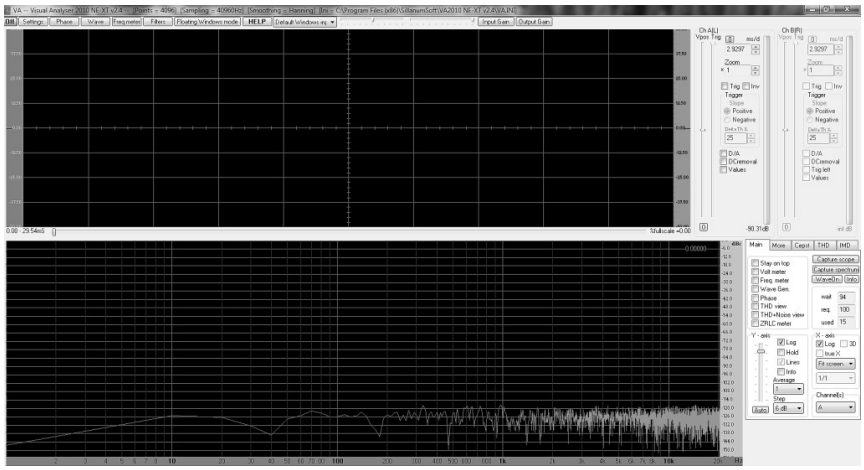

Figure 2. The internal sound card with line input activated - the Dell Studio.

All measurements were performed with open audio inputs. This situation may cause some interferences inducted from external electromagnetic fields. The program presents the useful input signal or as shown in figure 2 the spectrum of a noise signal only, the input gain is set at the maximum value. This situation is a good equivalent of the EIN measurement. The bottom chart will be selected for the noise evaluation. The prepared noise view for the described card is shown in figure 3.

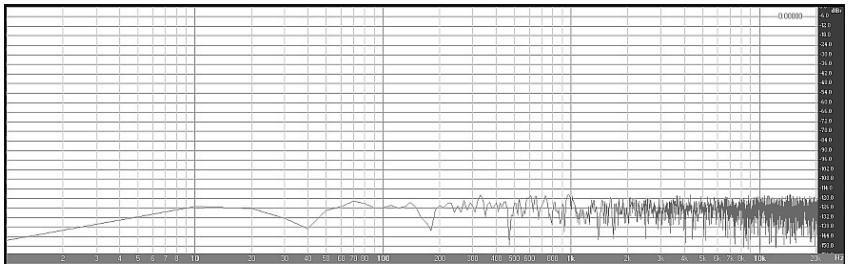

Figure 3. Open input signals for the Dell Studio internal sound card [5].

The noise characteristics is quite constant in a wide range of audio frequencies at maximum values of about -120 dB. It is a very good result, 5 dB better the – 115 dB a good limit for Hi-Fi recordings. Because of significant hearing the noise frequencies are between 1 kHz and 10 kHz and the best sensitivity of the human hearing is 3 kHz. The author proposes a following formula for the evaluation of noise parameters (n_c – noise calculated as a mean for chosen frequencies):

$$n_c = \frac{n(1kHz) + n(3kHz) + n(5kHz) + n(10kHz)}{4}$$
$$\text{or } n_c = 0.25(n_1 + n_3 + n_5 + n_{10})$$

where lower indexes equal numbers of kilohertz.

The presented formula for n_c calculating is the first approximation of the noise parameter calculated on the acoustic band. More precise measurements and calculations will provide better formulas.

The next presented sound card is also internal but specially produced as a studio sound card: E-MU 0404 with PCI interface. The chart for this card is shown in figure 4.

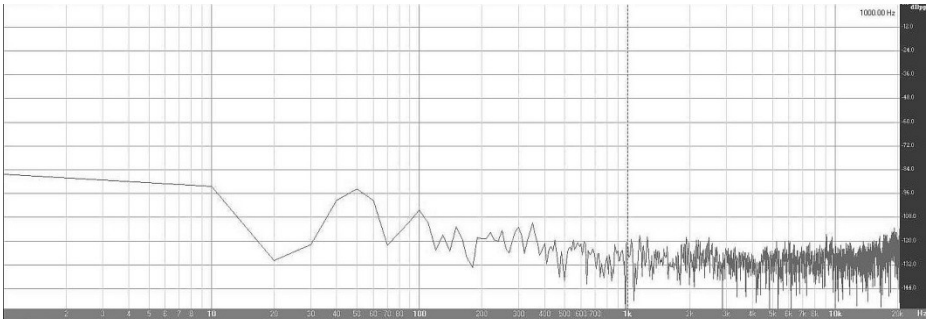

Figure 4. The input noise signals for E-MU 0404 PCI sound card [7].

The Sound Blaster Connect is several years old sound card dedicated to an external use with the USB computer port. Conditions of measurement are the same: a line input and the maximal gain settings in the Visual Analyzer software. Fig. 5 presents the noise chart for this card.

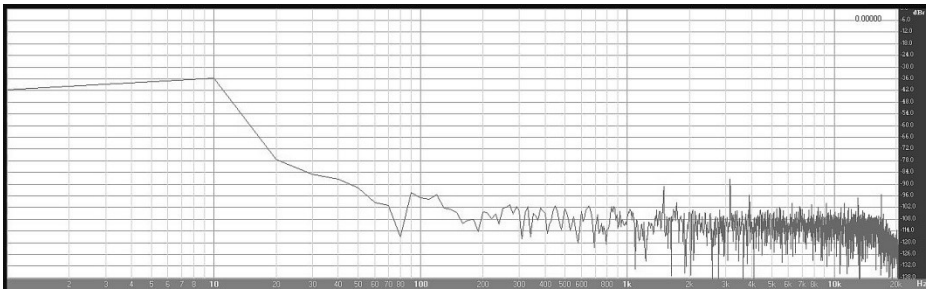

Figure 5. The noise chart for the Creative Labs. Sound Blaster Connect [6].

The last tested card was the Lexicon Alpha from a current production. It has apart a line stereo input also a dynamic microphone and an instrument (an electric guitar f.e.). The fig. 6 shows its noise parameters as a chart.

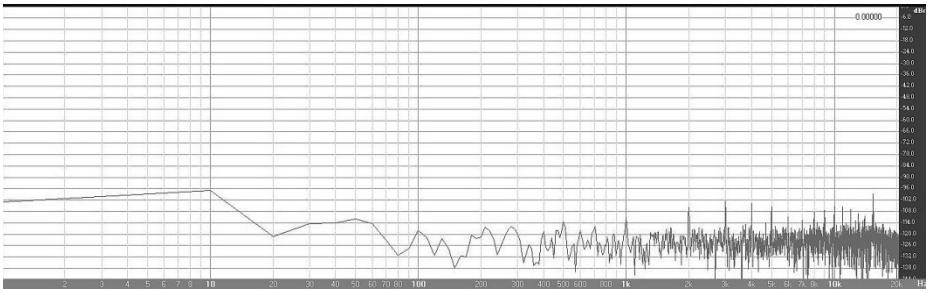

Figure 6. The Lexicon Alpha external card and its noise parameters [8].

Results of measurements including calculations of n_c parameters are presented and discussed in the next point of the paper.

4 Results

The parameter n_c inserted at the last part may be calculated for each noise chart. Table 2 includes data for all specific frequencies and calculated n_c parameters linked with each sound card.

Table 2. Noise parameters ni in dB for different sound cards.

Sound card type	n_1	n_3	n_5	n_{10}	n_c (dB)
Dell Studio internal	-118	-126	-123	-120	-122
E-MU 0404 internal PCI	-120	-124	-123	-120	-122
SB Connect external USB	-103	-108	-106	-106	-106
Lexicon Alpha external USB	-116	-116	-116	-116	-116

Performed tests have proved that the best solutions for studio audio recording were:
- E-MU 0404 – quite old but specially constructed for studio recordings
- Dell Studio – new in the present production, on the board

The result nc equals -122 dB for both cards is very good. The theoretical limit -129 dB means more than twice smaller noise level (6 dB equals the ratio twice). That will be very difficult to perform such low noise level. The worst card was Sound Blaster Connect but it is a several years old device and dedicated for low-end users.

5 Conclusions

The comparison of four different sound cards gives better effects for built in devices because (from charts above):
- The noise characteristics is more even
- No on charts impulses (specific peaks)
- Noise levels are lower of several dB

Anyway in some cases USB sound cards can be much more comfortable in use because include some additional circuits: preamplifiers for microphones condenser (with phantom supply 48V) and dynamic, inputs for instruments (guitars) and headphones amplifiers and switches. They can also work as hardware mixers.

USB sound cards designed for Hi-Fi recordings (Lexicon Alpha) and newer are significantly better than older ones (Creative SB Connect). The difference is: -116 dB for Alpha and – 106 dB for Connect, noises lower abt. 3 times. The progress in the computer devices technology is very clearly visible.

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