White Paper on hiFace

hiFace comes after an idea by Pierre Bolduc, Audiophile Sound Chief Editor, during a conversation with Marco Manunta: to offer music lovers a high performance interface to listen to “liquid music” through a D/A converter, from their PC. The choice to make a new interface depends by the result of a comprehensive check of available digital outputs on commercial audio cards on both PC’s and Mac’s and after an analysis of similar products already available on the market.
We found that, without exception, all S/PDIF digital outputs presently available to users who want to listen to music using a PC as digital source, suffer from two heavy limitations: the undue interference by the Windows kernel mixer and a relevant jitter.
Moreover, with very few exceptions, all interfaces don’t go further than 96kHz with sampling frequency, thus can’t allow for listening to 176.4kHz or 192kHz files, which are now available on several websites.

Sampling frequency

Almost all PC sound cards don’t allow for more than 96kHz sampling frequency. There are many reasons for that, the main being the present audio specifications of Windows which don’t consider higher sampling rates: it is thus useless to produce, at higher cost, a hardware which can accommodate the highest sampling frequencies in a standard setup. This is the reason why even dedicated audio drivers don’t go higher than 96kHz.
Moreover, most of USB interfaces with either S/PDIF or optical digital output use commercial IC’s dedicated to audio which suffer the same limitations.
hiFace has been developed using a high performance generic USB interface IC which is able to overcome any performance constraint. By writing a proprietary driver, **hiFace** has been made appearing as an USB audio card capable of up to 192kHz/24bit.

Kernel mixer and Kernel Streaming

Windows XP operating system, and partly even Vista and 7, include an entity which manages audio streams towards peripherals dedicated to their conversion, called the kernel mixer. The kernel mixer comes into play every time a player interacts with a peripheral in Direct Sound mode. For example, this is the only mode presently Windows Media Player operates in. The kernel mixer makes various processing on the audio stream, thus modifying the samples taken from the file. Amongst the various processing, it operates two format changes, from integers (the format of samples in almost all audio files) to floating point and vice versa. This processing introduce unavoidable approximations due to the finite length math in all processors, which in turn produce noise, distortion increase, detriment of sound quality.
Moreover, the use of the kernel mixer leads to a heavy load on the CPU which use, when listening to music in Direct Sound mode, can reach nearly 100%. Best would be using a different mode of interaction between player and peripheral, called Kernel Streaming, which “jumps away” the kernel mixer. To this purpose specific drivers have been conceived. They allow to use in Kernel Streaming peripherals made to be used in Direct Sound mode. The problem is that these specific drivers also load the CPU; for this reason, not all PC’s can reproduce audio files higher than 48kHz. Moreover, these drivers are not available for all peripherals.
hiFace driver is a proprietary driver made to directly interact with a player in Kernel Streaming mode at a low level. It makes without any other driver and allows for audio data to reach the peripheral easily and without any undesired change by the system; moreover, small netbooks with Atom 270 CPU can also be used to listen to “bit perfect” 192kHz files without any problem.

We have so far told about problem and solutions related to Windows. We'll see that even with Mac's and Linux PC's, which don't have the kernel mixer, **hiFace** represents an improvement on internal audio cards.

Jitter, phase noise and sampling frequency precision

Jitter is a short-term variation of the sampling frequency in a digital audio transmission. Ideally, the time between the arrival of subsequent samples should be always the same, its value should be the inverse of the sampling frequency: roughly 22.67574us at 44.1kHz, roughly 5.2083us at 192kHz. Incidentally, this is also the time interval at which the various samples have been acquired while recording the track. For this reason, the DAC, to offer the best sound performance, must be able to receive and convert the sample with the same, identical rate. The sampling frequency stability in a transmission depends on the stability of the reference oscillator in the transmission IC. In audio cards and almost all USB interfaces, this reference is obtained from the only crystal oscillator present on the board via a circuit called PLL, which synthesizes the transmission frequency from the crystal's one. It is an useful and cheap solution, but one which doesn't allow for high stability of the synthesized frequency. For this reason, the jitter on audio cards' digital output is generally quite high. All the more when an optical output is used, because the limitations of the optical fibers used in Toslink standard and the jitter induced by the electrical/optical and optical/electrical converter add further instability to the transmission clock.

The jitter also depends on the interferences on the transmission line (a coax cable with S/PDIF) e on other problems like the line's impedance mismatch and the driving capability of the transmitting circuit.

A second drawback of PLL's is that they rarely come to synthesize the exact desired frequency when the reference crystal doesn't produce an integer multiple of the desired output frequency. As the base sampling frequencies of digital audio are 44.1kHz and 48kHz it's not possible, with a single reference, to obtain both frequencies with absolute precision.

hiFace uses, in place of a PLL, two highest stability, very low phase noise crystal oscillators. In standard environmental conditions, the precision is around 2,5ppm: this means that they derive no more than 2,5Hz for every MHz of their output frequency. The maximum error at 192kHz will thus be 0,5Hz! On the contrary, a PLL's error can be up to 2-5%: this means that at 192kHz a change of nearly 10kHz is not uncommon. We think we're listening to the right sampling frequency, but actually we listen to a different sampling frequency and all instruments are "out of tune". Another problem with PLL's is the phase noise. It is the main responsible for jitter. The oscillators used in **hiFace** have incredible performances on phase noise: -78dBc at 10Hz and as low as -140dBc at 1kHz. Thus, the signal S/PDIF out of **hiFace** suffers of almost no jitter, also thanks to the use of a high performance S/PDIF transmitter, the Burr-Brown/Texas DIT4192. Obviously, jitter can be worsened by using a non suitable cable (a non-75 Ohms one, and/or without a suitable shielding), or by the scarce performance of the DAC's S/PDIF receiver. For this reason, we do not suggest evaluating the interface jitter by analyzing sine tones out of the DAC: they could be affected by problems not due to the interface itself that overshadow its own performance. Best is to analyze the eye diagram on the line; alas, a dedicated laboratory instrument is required to do so. The suggestion is: trust your ears.