DSD over SPDIF and a little trip to the pirates' land

I'm sure I'm not the first who thought about this: to use S/PDIF as a transport for DSD stream.

A stereo DSD64 stream has a bit rate of 2x64x44,100=5.6448Mbps, equivalent to a 176.4KHz/ 16bit PCM stereo stream. The S/PDIF standard provides 24 bit slots per PCM sample, where the DSD stream can fit comfortably. To make this transport fault tolerant with PCM system, the Validity bit can be set so that a properly designed DAC will mute when receiving such a stream. The DSD payload can be allocated in the least significant 16 bits of the 24 slots, so that even if an improperly designed DAC tries to convert the stream as PCM, its output will be a noise at about -46dBFS, with a DC offset around half of that, which is pretty safe for your audio gear and most importantly, your ears.

There are several ways to align the DSD data in the 16 bit slots. Assuming DSD is not transported in I2S before encoded into S/PDIF, the following scheme looks natural: (L[7:0] and R[7:0] are DSD data, where MSB is the oldest sample in time)

<preamble> L[7] R[7] L[6] R[6] …… L[0] R[0] 0 0 0 0 0 0 0 0 V U C P

If DSD is transported in I2S then encoded into S/PDIF, and received as I2S then translated back to DSD, the reverse sequence is better, because I2S has MSB first while S/PDIF has LSB first:

<preamble> L[0] R[0] L[1] R[1] ..... L[7] R[7] 0 0 0 0 0 0 0 0 V U C P

Neither is straight forward if you want to process it on a computer. Something like this is preferable:

<preamble> L[0] L[1] …… L[7] R[0] R[1] ..... R[7] 0 0 0 0 0 0 0 0 V U C P

When such a stream is recorded in 176.4k/24bit and saved in Windows 24bit packed format, the resulting data would be like: L R 0 L R 0……

After adding a proper file header (DSDIFF or DSF) and removing the extra zeroes, the resulting DSD file can be played back on PC, with Windows Media Player + Sony DSD plug-in, KORG AudioGate or the recently released, foobar2000 DSD plug-in.

I made this little conversion board that taps into the I2S/DSD signals between the decoder/ processor and the DAC chip in the universal disc player. The conversion board consists of a Xilinx XC9572XL CPLD, a driver (NC7SZ125), transformer and of course, a 75-Ohm BNC jack. There are enough resources in the CPLD for an S/PDIF encoder, a 24-bit PCM data buffer, DSD data buffer and miscellaneous clock processing logic.

The original idea was to let the CPLD handle both DSD and PCM, however the Denon DVD-2900 that I installed the conversion board wasn't easy to play with.

First of all, there is no 3.3V digital power supply available on the audio DAC board that I want to attach the wires. I had to add a LDO to the conversion board.

Then there is trouble with clocks. DVD-2900 uses SM8707E PLL IC, which generates 27/22.5792/24.576 and 33.8688MHz clocks. CD, DVD-V and DVD-A uses the switchable 22.5792/24.576MHz but the DSD processor (CXD2753) works on the 33.8688MHz clock, which the PCM/DSD switch did not pass to the DAC board, simply because the DAC chip does not require a master clock when converting DSD. And the 33.8688MHz clock is 192 times of 176.4KHz, the sample rate for DSD over S/PDIF transport. People who are familiar with S/PDIF transmitters should know that the 33.8688MHz clock would have to be divided by 1.5 to get 22.5797MHz for the S/PDIF encoding, which involves some nasty clock generation scheme.

After adding a clock driver chip and some blue wires to the DVD-2900 main board, I was able to get the 33.8688MHz clock to the audio DAC board in DSD mode. Then I found, in CD-audio mode the I2S uses 48fs bit clock and right-justified data; while in DVD-V and DVD-A mode it uses 64fs bit clock and left-justified data. And the master clock does not change frequency between 48KHz and 96KHz sample rates, which calls for additional sample rate detection. The 48fs bit clock also requires additional buffer. Too much to deal with for such a small CPLD. I finally decided to pass thru the original S/PDIF signal from the DVD processor to the jack. The reason I wanted to use the conversion board for PCM is that the original S/PDIF output on the DVD-2900 would be disabled when playing copy-protected DVD-A discs. Fortunately I only have a handful of DVD-As.

After getting rid of the PCM support, there are enough resources in the CPLD to play with different DSD data alignments on S/PDIF, or to encode 6-channels of DSD streams, output through 3 synchronous S/PDIF (drivers/transformers/jacks are not onboard though).

The raw data is recorded with M-Audio Audiophile192 and Adobe Audition at 176.4KHz/24bit. Now it's time for some software work. Simply put, to add a proper file header (I only tried DSDIFF) and to remove the extra zeroes. I also added a feature to detect mute patterns between songs so that the entire disc can be recorded in one pass and then split to several smaller files, one song for each file. It wasn't very effective, so I ended up with some files containing one song and others containing several songs. I guess the KORG AudioGate would do a better job splitting the DSD file, but I'm too cheap to fork out $250 for a used MR-1 just to activate the software, since I don't think I'd use that cute recorder to record anything.

Anyway, here it is, the entire stereo layer of an SACD copied to the hard drive, in DSD. It sounds pretty good thru the foobar2000+DSD plug-in, converted to 88.2KHz PCM. I wouldn't do it again, unless there is some out-of-print SACD I really like, or some one-of-a-kind discs I had to have (like the SACD DAC test disc from SONY/Philips). How about multi-channel/DST? Even though we can't

get compressed DST data directly from the disc, we can record the synced multi-channel DSD output with an audio card like Lynx AES-16, and then compress the DSD into DST. The stereo DSD can also be compressed into DST to save space. The DST compression is part of IEC14496-3 and the reference code can be obtained for a small fee. The good part is that DST is lossless, so you are not missing anything…

I can see the slippery road this is leading to. After all, this conversion board is just an accessory to the DIY project I'm doing. It's time to get back to the main track. Hope one day I can post more details about my main project.

Don't ask… for obvious reasons, I'm not able to make this board available.