AES/EBU Low-cost DAC Performance Evaluation

By Bohdan Raczynski

The Audio Engineering Society (AES), together with the European Broadcasting Union (EBU), developed a digital audio transmission standard known as the AES/EBU standard as well as AES-1992, ANSI S.40-1992 or IEC-958. The transmission medium is wire, which has a wide bandwidth capability and allows for the bit-serial transmission of the digital audio data. A domestic version of the AES/EBU standard is known as S/PDIF.

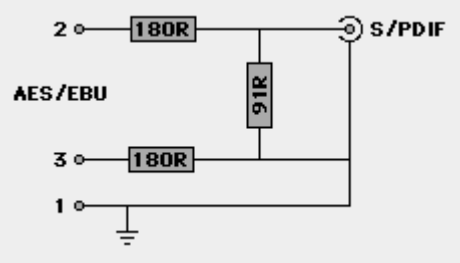
Main differences between AES3 and S/PDIF

(from: http://en.wikipedia.org/wiki/S/PDIF)

	AES3 balanced	AES3 unbalanced	S/PDIF
Cabling	110-ohm STP	75-ohm coaxial	75-ohm coaxial or fibre
Connector	3-pin XLR	BNC	RCA or TOSLINK
Output level	2 to 7 V peak to peak	1 to 1.2 V peak to peak	0.5 to 0.6 V peak to peak
Min. input level	0.2 V	0.32 V	0.2 V
Max. distance	100 m	1,000 m	10 m
Modulation	Biphase mark code	Biphase mark code	Biphase mark code
Subcode information	ASCII id. text	ASCII id. text	SCMS copy protection info.
Max. resolution	24 bits	24 bits	20 bits (24 bits optional)

AES/EBU to S/PDIF

The signal level used by the AES/EBU interface is meant to be between 5 and 10 volts peak-to-peak whilst that for S/PDIF is normally in the range of 0.5 to 1 volt. To convert from one to another you can use a simple *attenuator*, as shown below.



There are numerous DACs available as kits. One example are products available from this website: http://www.beis.de/Elektronik/ADDA24QS/Preview/ADDA24QS.html, or top quality http://www.esi-audio.com/products/drdacprime/

The SPDIF DAC employed in this project is a low-cost converter available from Altronics in Melbourne, Australia for $AUD59

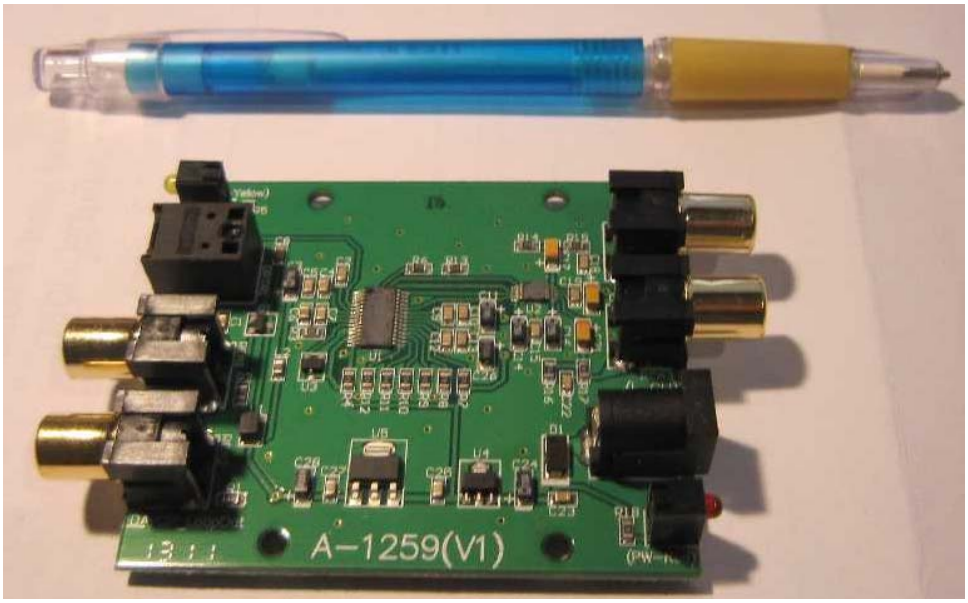
http://www.altronics.com.au/index.asp?area=item&id=A3199#

A quick eBay search is also very advisable, as perhaps cheaper alternatives can be found readily. The module has the following characteristics:

Input: SPDIF coaxial or Toslink
Audio format: LPCM
Input impedance: 75ohms
Minimum load impedance: 10kohms
Loopout function: yes
Sampling rates: 44.1-192kHz/24bit
Supply: +12VDC (power supply included)
Dimensions: 7cm x 6cm (without cover)

The module will deliver 3.2 Vpp of analogue signal for full DAC swing.

The SPDIF DAC is actually very small (see below without a cover), and can be conveniently built-in the amplifier enclosure.

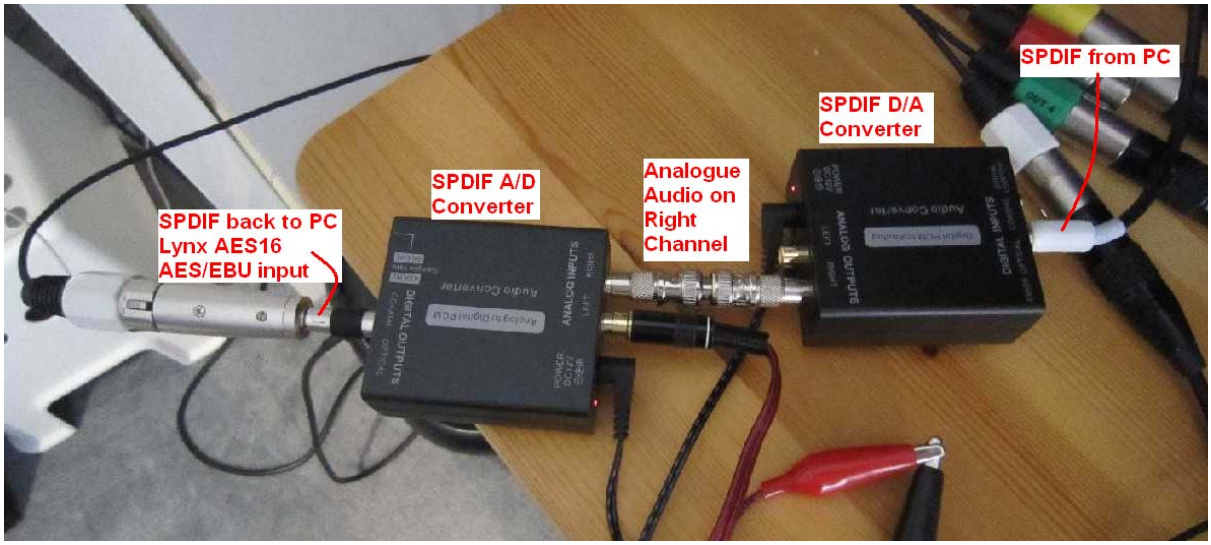


Measurement Method

The internal sound card (motherboard SPDIF output) is used to output 1000Hz tone from Signal Generator of SoundEasy V19. This SPDIF digital stream is directed to the SPDIF DAC to obtain analogue audio. Next, I used SPDIF A/D converter to return the analogue audio back to SPDIF. Finally this new SPDIF data stream is directed to the AES/EBU input of the LynxAES16 sound card, and used for input in SoundEasy Spectrum Analyser - all with 24-bit depth. This way, I tested both processes: DAC on the Generator side, and ADC on the Analyser side. **Yes, I introduced two conversions at the same time**, which is the worst-case scenario from signal quality point of view.

It is likely, that two conversions reduced the SNR by 2-3dB. Also, I have not used the recommended A-weighting filter. Again, it is likely, that the A-weighting filter would improve the SNR by 2dB or more. As a result, we would be entitled to add 4dB to whatever SNR measurement is obtained in this test.

A picture of the cascaded SPDIF converters is shown below.

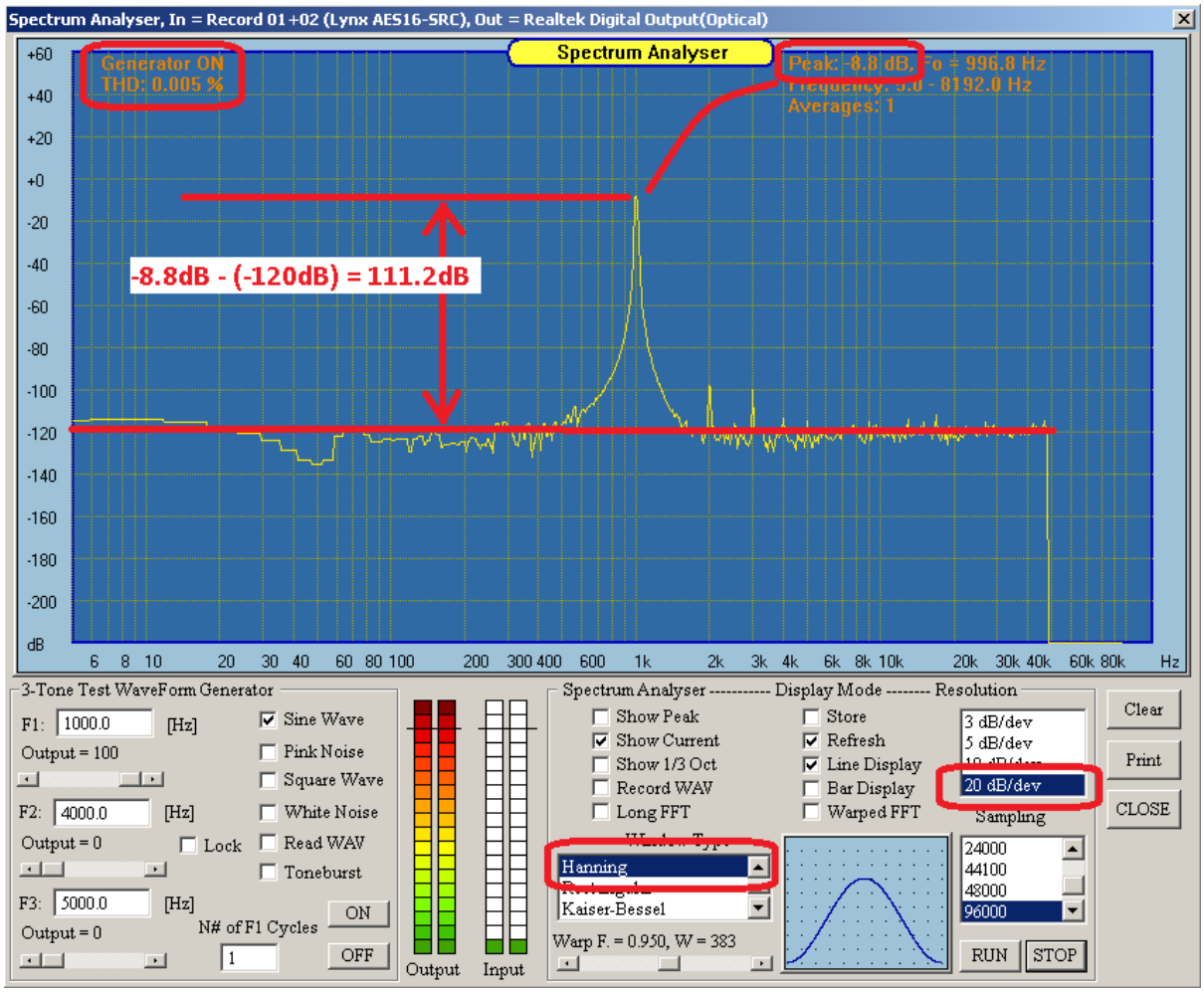


SNR Results

The Spectrum Analyser was set as follows: Sampling = 96kHz, Hamming window, 20dB/div vertical scale.

The test returned SNR = 111.2dB for A/D + D/A dual conversion, and THD = 0.005%.

Adding the estimated 4dB to the SNR for single DAC conversion with A-weighting filter brings the achievable **SNR to 115dB**.



Conclusions

A low-cost SPDIF converters tested above exhibit SNR exceeding that of a typical Hi-Fi CD player. The SPDIF DAC, when equipped with the resistive attenuator described on page 1, can be connected to AES/EBU digital line, and work as AES/EBU dual-channel DAC.

With this in mind, a complete, low-cost AES/EBU amplifier module can be designed. One would simply connect two amplifiers of suitable output power each, to the SPDIF decoder, and add a power supply – that's all.

The above test also concludes, that SPDIF A/D converter can be used to create AES/EBU data stream, and transmit such stream over a short distances.