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Measurements for the Benchmark DAC1 USB

By Chuck Hansen

SETUP

I used a 75Ω coax cable between my Alesis ML-9600 Masterlink recorder digital output terminated with a 75Ω BNC female to male RCA adapter, and the Benchmark DAC1 USB AES/SPDIF 75Ω BNC Input 1. While the DAC1 comes with an RCA female to 75Ω BNC male adapter to use with a conventional digital audio cable that is terminated on both ends with RCA plugs, I prefer to treat the digital AES/SPDIF signal as an RF signal (which it is) and use the 75Ω BNC terminated cable with my BNC to RCA adapter. I applaud Benchmark for providing the 75Ω BNC digital connector on the DAC1, and I would like to see it become standard in lieu of the inferior RCA jack.

CAUTION: Never use a 50Ω BNC plug on the DAC1 digital 75Ω BNC input jack. The center pin of a 50Ω BNC plug is slightly larger in diameter than that of a 75Ω BNC plug, and you could permanently expand the 75Ω female input pin enough that it will no longer make good contact with a 75Ω BNC plug center pin.

In order to provide a suitable warm-up before testing, I played over one hour of 16-bit and 24-bit audio test tracks. The DAC1 USB easily locked onto 16-bit 44.1kHz digital signals, as well as 48kHz, 88.2kHz, and 96kHz 16-bit to 24-bit signals (I don't have any 192kHz digital test data). There is no indication of the received data bit depth or sample rate on the front panel. If there is an error in acquiring digital data, the input LEDs on the front panel will flash to reveal various data error codes as listed in the very thorough instruction manual.

The DAC1 USB provides many internal jumper-selected settings, but I left them all as-received. I also left the rear panel Output Level switch in the calibrated (fixed output) position. I did not attempt to control the DAC1 USB by means of a computer connected to the USB port. The unit uses linear IC voltage regulators rather than a switching power supply, so the case temperature increased from 25° C to 36° C at the bottom of the chassis.

The DAC1 USB preserves normal polarity from all its analog outputs. The RCA jack analog outputs produced 2.004V RMS (L) and 2.007V RMS (R) at 1kHz, or an insignificant

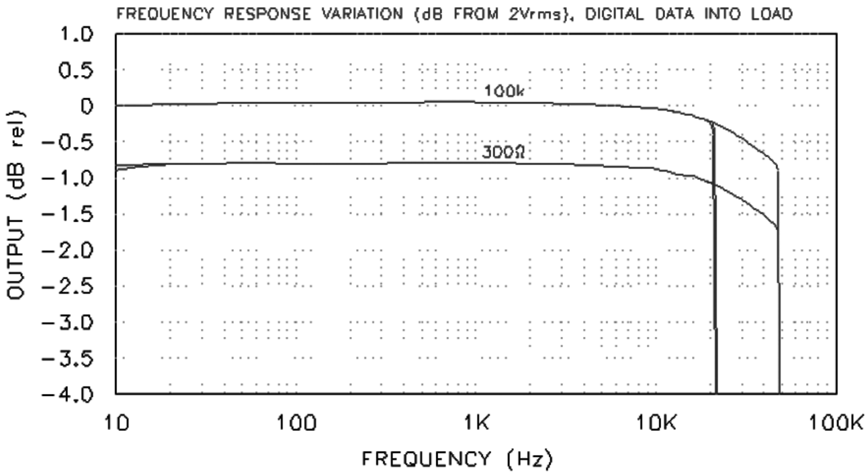

FIGURE 1: Frequency response.

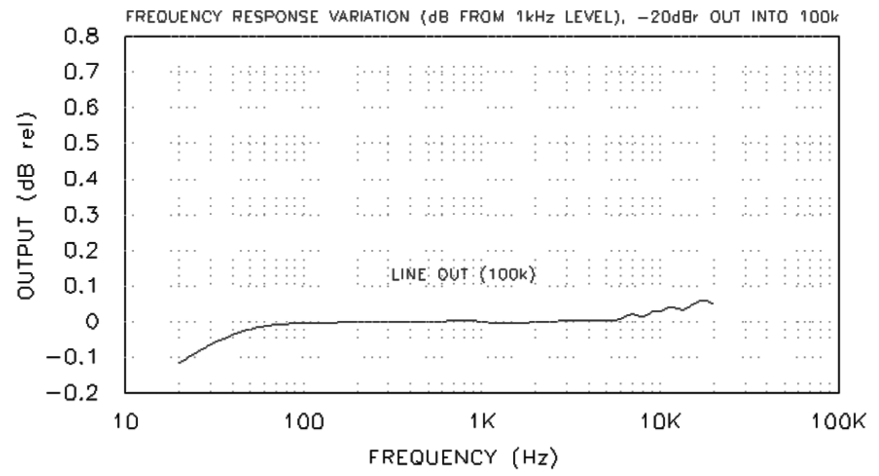

FIGURE 2: De-emphasis error.

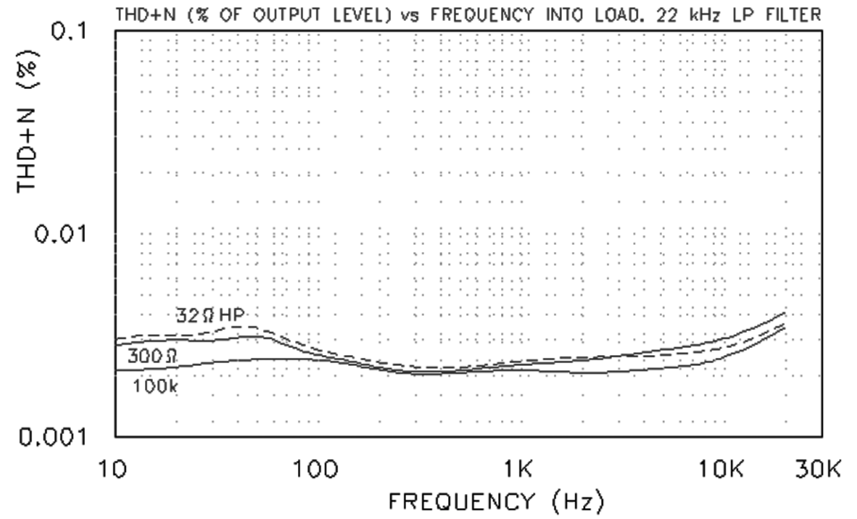

FIGURE 3: THD+N vs. frequency.

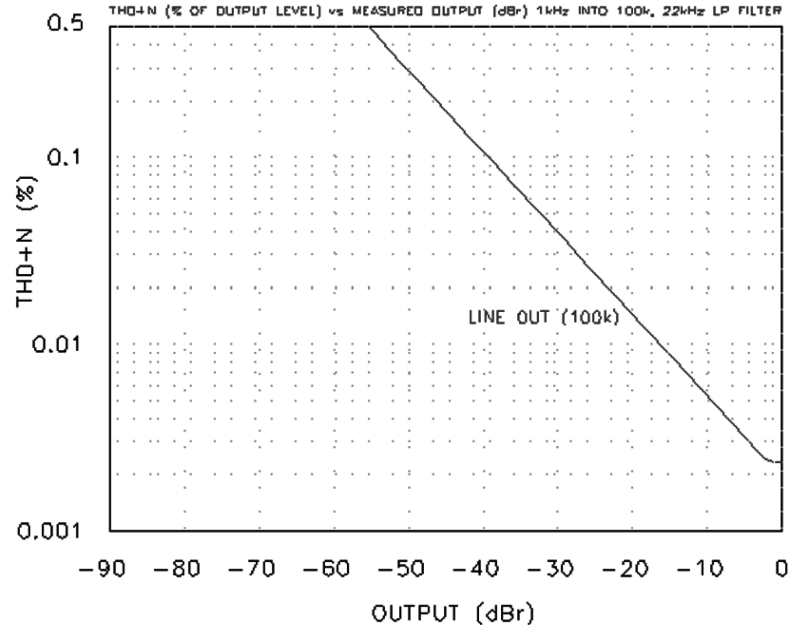

FIGURE 4: THD+N vs. output.

0.03dB maximum above the Red Book Standard of 2V RMS. The balanced XLR outputs both produced 1.267V RMS (pin 2 hot) with the internal attenuation jumper left unchanged. The headphone output at the maximum volume control setting is 2.87V RMS at 1kHz, with about 0.4dB imbalance between the two headphone jacks at the unity gain setting. The volume control does not operate on the balanced or unbalanced RCA outputs in calibrated mode.

MEASUREMENTS

The output impedance of the RCA jack analog outputs measured 29Ω at 20Hz and 1kHz, increasing slightly to 31Ω at 20kHz. The balanced XLR outputs measured 133Ω over the audio band (this will vary with the attenuator jumper settings). The front panel headphone output measured less than 1Ω with the volume control set for unity gain.

Hum and noise measured a low -110dB relative to 2V RMS, and -116dB A-weighted. The analog outputs had a negligible DC offset of 3.4mV. Separation between the stereo channels was about -105dB at 10kHz.

I recorded the frequency response shown in **Fig. 1** from the RCA analog outputs into 100k and 300Ω loads, using 16-bit/44.1kHz Red Book data as well as 24/48kHz and 24/96kHz data. The DAC1 USB response drops off by -0.23dB at 20kHz (44.1kHz data), and -0.81dB at 43kHz (96kHz data). When I decreased the line stage load to a difficult 300Ω, the frequency response fell by -0.84dB at 1kHz, with a slight droop at 10Hz with 16/44.1kHz data.

Figure 2 shows the deviation from flat response when I fed pre-emphasized Red Book 16/44.1kHz digital data to the digital input. The de-emphasis correction is accurate ±0.09dB, 20Hz to 20kHz.

The THD+N versus frequency for the DAC1 USB RCA analog outputs using 16/44.1kHz digital data is shown in **Fig. 3**. I used the steep distortion test set 22kHz low-pass filter to remove out-of-band noise. Note that the results shown here are just about at the low limit of my distortion measurement capability. Decreasing the load from 100k to 300Ω showed only a slight increase in THD+N. The headphone output with a 32Ω load is shown as a dashed line. This is all-around excellent performance.

Figure 4 shows THD+N versus output voltage for the RCA output into 100k at 1kHz. The THD+N level increases in a straight line as the output level decreases, up to the 0.5% vertical axis limit in my graph.

The DAC1 USB output spectrum of a 50Hz sine wave at 0dBfs into 100k is shown in **Fig. 5**, from zero to 1.3kHz. The THD+N measured 0.0027%, with no visible harmonics above the -105dB noise floor of my spectrum analyzer. Raising the frequency to 1kHz and expanding the spectrum range to 20.5kHz shows a similar benign result (not shown). The distortion residual waveform for a 0dBfs 1kHz sine wave, taken after the distortion test set notch filter, showed no discernible distortion harmonics or AC power line artifacts and just a low level of noise (also not shown).

Figure 6 shows the DAC1 USB output spectrum reproducing a combined 11kHz + 12kHz intermodulation distortion (IMD) signal at 0dBfs into 100kΩ. The 1kHz IMD product is -95dB (0.0018%). Repeating the test with a 19kHz + 20kHz CCIF IMD test signal (**Fig. 7**) resulted in a -102dBfs 1kHz product (0.0008%).

I applied a 1kHz square wave at 0dBfs, 16/44.1kHz digital data to the DAC1 USB and monitored the resulting scope trace from the DAC1 USB (**Fig. 8**). The Gibbs Phenomenon ringing is unremarkable except for the slight leading edge damped oscillation. Increasing the digital data to 24/96kHz (**Fig. 9**) showed a better representation of the square wave, with a bit higher peaking on the leading edges.

The reproduction of a 1kHz sine

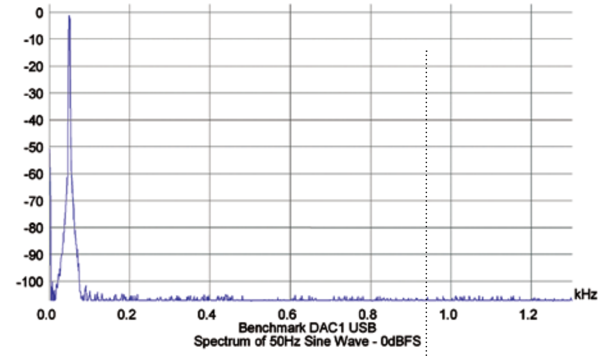

FIGURE 5: Spectrum of 50Hz sine wave.

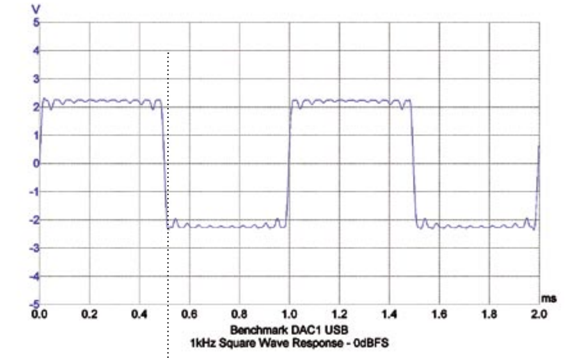

FIGURE 8: 1kHz square wave, 16/44.1 data.

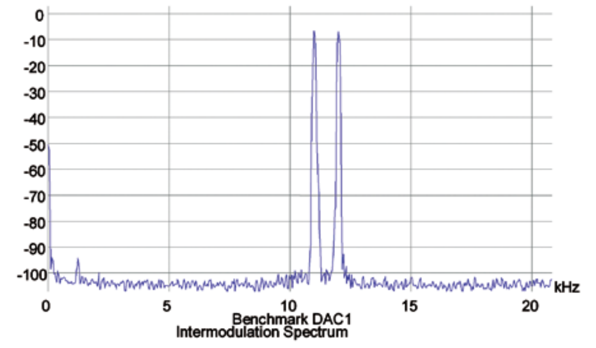

FIGURE 6: 11kHz + 12kHz intermodulation distortion.

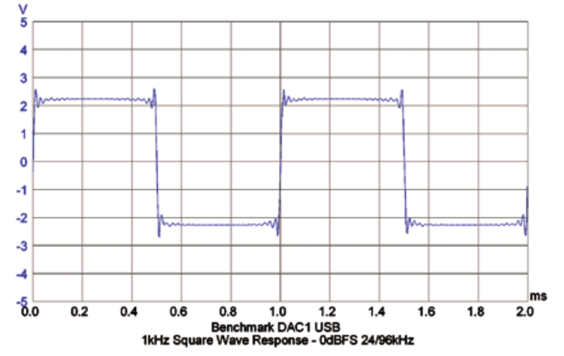

FIGURE 9: 1kHz square wave, 24/96 data.

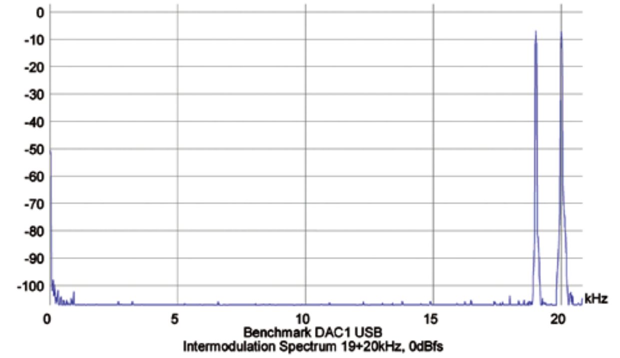

FIGURE 7: 19kHz + 20kHz intermodulation distortion.

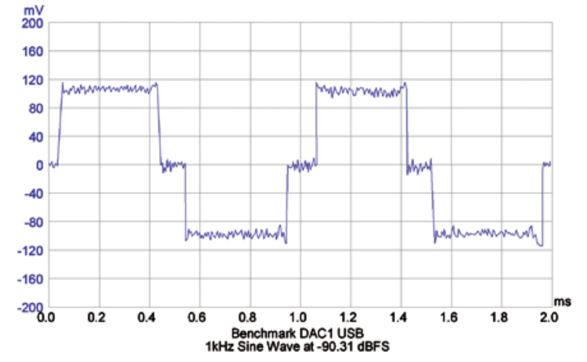

FIGURE 10: 1kHz sine wave at -90.3dBfs with 16/44.1 data.

wave at -90.3dBfs with 16/44.1kHz data is shown in **Fig. 10**. The sine wave at this ±1 bit signal level appears as three distinct levels, just as it should. Increasing the data resolution to 24/96kHz at -90.3dBfs produces the fine sinusoidal shape shown in **Fig. 11**.

The DAC1 USB produced an excellent set of measurements. The instruction manual includes 15 pages of test graphs provided by an Audio Precision System 2 Cascade.

POWER SUPPLY CONCERN

I removed the cover to take a look at the PC board since the instructions to get internal access were in the instruction manual. I was a bit alarmed to see that the analog IC regulators are ±18V (7818A and 7918A). This is fine for the 5532 op amps (±20V maximum), but the LM4562 op amps and the BUF634s have an absolute maximum rating of ±18V. I didn't see any other local lower voltage PC board mounted regulator chips, nor a -5V regulator IC that might be teamed with the 7805A for a ±5V supply for the op amps and buffer ICs. This is not really possible, because the maximum headphone output is specified to be +21dBu (8.69V RMS) and the balanced outputs are specified to be +29dBu, or 21.8V RMS.

I did not attempt to measure the actual voltages at the op amp supply pins, but the ±18V regulators raise a red flag for me if those parts are actually used at ±18V (or even higher, since the tolerance on 78xxA and 79xxA regulators is 2% at 25° C, or 4% over the full temperature range). My absolute safe maximum for any analog IC is 90% of maximum rated, or ±16.2V in this case.

The reason I use 90% is because that's the maximum number that both MIL-HDBK-217 and the Telecordia (Bellcore) TR-332 "Reliability Prediction Procedure for Electronic Equipment" have in their MTBF calculations. I work pretty close with both documents and talk with the guys who have cognizance over the military handbook, and they say if you go above 90% for semiconductors, you are conducting experiments, not providing suitable power for long-term reliable operation of analog ICs and semiconductors. Calculated MTBF effectively becomes zero hours above 90% Vcc. Except for passive phono preamps that require lots of headroom to make up for the loss through the EQ stages, there is rarely any need for more than 2V RMS output to a power amp, so ±15V DC rails should be fine. **aX**

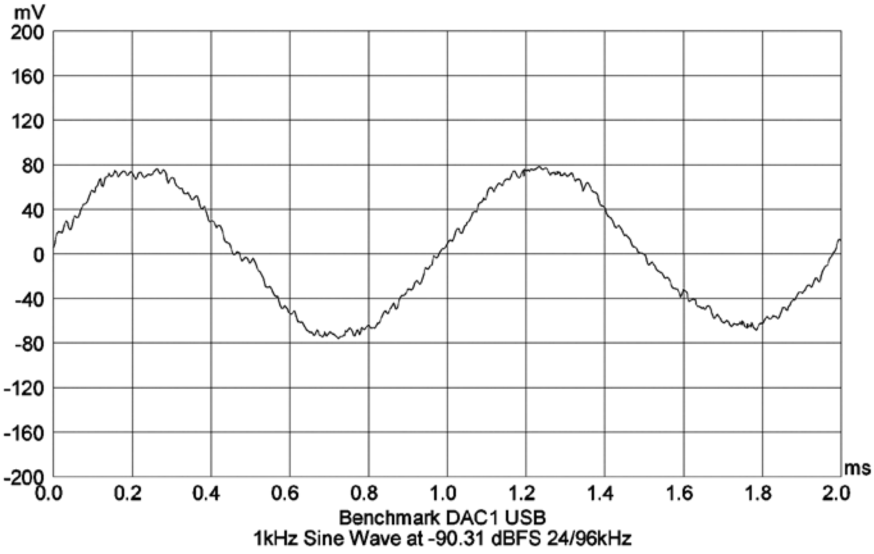

FIGURE 11: 1kHz sine wave at -90.3dBfs with 24/96 data.