PRO AUDIO REVIEW
Gear & Software Reviews For The End-User
REPRINTED FROM DECEMBER 2005 WWW.PROAUDIOREVIEW.COM

Studio

Bench Test Page 16

Benchmark ADC1

Analog to Digital Converter

BY JOHN GATSKI

In the 10 years I have I known the Benchmark Media product line, I have found their digital converters, (designed by engineer John Siau) to be some of the best sounding that I have ever heard. From their 20-bit units from the late-1990s to the well-respected DAC-1 24-bit/96 kHz DAC, the company has pushed accuracy instead of marketing hype. The new ADC1 stereo A/D 24-bit/192 kHz sampling converter is no exception.

FEATURES

Priced at $1,775, the ADC1 matches the half-rack size of the DAC1 and is a full-featured A/D that offers not only 24/96 specs, but Benchmark's signature UltraLock jitter immune circuitry, single-wire 176 kHz and 192 kHz digital output, internal word clock, a host of I/Os and flexible controls. The unit was originally introduced in 2002, but has taken a while to get to market.

The rear panel includes two balanced XLR analog input connectors, four digital outputs — single-wire XLR digital output, optical output jack; independent or parallel-to-main output auxiliary digital output BNC, and a BNC sync input that accepts AES, SuperClock or word clock. There is also a BNC word clock output.

The front panel includes mode switch, meter display switch, first-stage left-gain switch, first-stage right-gain switch, left and right-gain trim pots, left and right-variable/fixed gain switches and a 41-step detented rotary gain control for each of the two channels. The first-gain switches enable either 0, +10 dB or +20 dB ranges. Gain can be set via the large variable channel knobs or the 10-turn input trimmer pots.

The left-side, nine-segment LED display indicates the selected sampling frequency. The word length is fixed at 24 bits on the main output, but is adjustable on the auxiliary output. The overall level is indicated by the nine-LED segment-per-channel meters. The meter switch allows the level to be indicated in -6 dB or -1 dB steps. The peak hold function duration is adjusted via the meter switch.

The ADC1 other features include SMUX output for either two channels of 24-bit/88.2 kHz or two channels of 24-bit/96 kHz audio on a normally 20-bit multichannel Alesis ADAT.

A word should be said about Benchmarks UltraLock jitter immunity circuit. The Benchmarks have always measured well — even with interface jitter interjected into the testing process. The result has always been clean sounding conversion without the smearing that jitter can impart (check out all the ADC-1's measurements on page 16).

IN USE

I used the ADC1 with two recording rigs: the TASCAM DV-RA1000 master recorder at 24-bit/96 kHz, and my Mac G5 using BIAS Peak at 24-bit/96 kHz. The interface for the ADC1/G5 connection was the Lynx 22 PCI-X card.

Since the Benchmark is one of the new breed of digital converters outputting 176 kHz and 192 kHz sample rate digital audio via single XLR cable, I could not record at those sampling frequencies into the TASCAM or the G5. The TASCAM requires two-wire output from external devices to accept 176 kHz or 192 kHz sampling rates and the Lynx 22 card sup-

Fast Facts

- **Applications:**
  Studio, post production
- **Key Features:**
  Two-channel; up to 24-bit/192 kHz; JitterLock circuitry; single-wire digital output for 176 kHz and 192 kHz; three-way gain adjustment; Main and Auxiliary outputs; word clock.
- **Price:**
  $1,749
- **Contact:**
  Benchmark Media at 315-437-6300; www.benchmarkmedia.com

Benchmark ADC 1 24-bit/192 kHz A/D Converter

INPUT SENSITIVITY

Fixed gain
20/10/0 1.22/3.84/12.2 V
4/14/24 dBu

Variable gain, controls full clockwise
20/10/0 0.153/0.467/1.55 V
-14.1/-4.4/6 dBu

INPUT IMPEDANCE

At 1 kHz, 186 kilohms

INPUT OVERLOAD

Unit reaches digital full scale before input overload occurs at N/A

OUPUT POLARITY

Digital output audio signal polarity relative to audio signal input non-inverting

FREQUENCY RESPONSE

44.1 kHz Fs +0.0, -3.0 dB 20 Hz – 21.1 kHz
96.0 kHz Fs +0.0, -3.0 dB 20 Hz – 46 kHz
192.0 kHz Fs +0.0, -3.0 dB 20 Hz – 91.4 kHz

TOTAL HARMONIC DISTORTION PLUS NOISE

At -1 dBFS, Measurement bandwidth = Fs/2,

44.1 kHz Fs <= 0.00071% 20 Hz – 20 kHz
96 kHz Fs <= 0.001% 20 Hz – 40 kHz
192 kHz Fs <= 0.0013% 20 Hz – 80 kHz

LINEARITY ERROR

44.1/96/192 kHz Fs
< +/- 1 dB 0 to –130 dBFS
< + 4 dB @ -140 dBFS

SIGNAL TO NOISE RATIO

Input termination 600 ohm, noise relative to 0 dBFS, 44.1/96/192 kHz Fs
Wide band (Fs/2) 118/114/109.4 dBFS
A weighted 120.5/120.2/119.8 dBFS

DYNAMIC RANGE

44.1/496/192 kHz Fs
A weighted,
<10 Hz - Fs/2 BW 118.2/118.1/118.3 dB

QUANTIZATION NOISE

44.1/496/192 kHz Fs
20 Hz @ 0 DBFS, THD+N
in 400 Hz – 20 lkHz BW -116.2/-116.2/-116.1 dBFS

CHANNEL SEPARATION

44.1/96/192.kHz Fs
Ch1 > Ch2 & Ch2 > Ch1
20 Hz - 20 kHz > 100 dB

Note: *Unless otherwise noted, all measurements are for the left channel, gain set for 20. Signal input was to the XLR balanced inputs.*

The long awaited Benchmark A/D converter companion to the DAC 1 is here in the form of the compact and versatile ADC 1. This two-channel unit supports sample rates up to 192 kHz via single wire AES/EBU XLR, S/PDIF BNC, and TOSlink optical connectors. Three fixed and three variable gain settings are settable on the front panel.

Measurements with a single-wire digital interface at the higher digital audio sample rates requires the latest Audio Precision test gear, namely the 2700 series instruments. My present Audio Precision System Two Cascade unit can only handle the high sample rates with the now obsolete two-wire interface. The West Coast Audio Precision representative, Jonathan Novick was kind enough to loan me his demo unit to enable me to measure the two higher sample rates of 176.4 and 192 kHz on the ADC 1. I am working on getting my own machine upgraded to handle the single-wire high sample rate interface for future digital audio products to measure for ***Pro Audio Review***.

To keep the number of measurement files and data presentation to something reasonable, most testing was done at 44.1, 96 and 192 kHz sample rates.

Figure 1 shows the high frequency response rolloffs for the main sampling frequencies of 44.1, 48, 88.2, 96, 176.4, and 192 kHz. The presentation is from 10 kHz upwards to best see the high frequency end of the response. The low frequency response of the unit (not shown) was essentially the same for all sample rates and was down about 0.05 dB at 10 Hz.

In measuring distortion of the unit, there was a tendency for rising high frequency distortion, more noticeable at the higher gain settings and for the right channel. This was true for all sampling frequencies. The distortion residual was dominant second harmonic for both channels. **Figure 2a** shows the distortion vs. frequency at fs = 192 kHz for the left channel as a function of gain setting of 20, 10, & 0. In all cases the output level was –1 dBFS to avoid possible clipping artifacts. **Figure 2b** is for the right channel. The measurement bandwidth was Fs/2 for these figures. **Figure 3** shows the lower noise floor (less bandwidth) of a similar plot for a 44.1 kHz sample frequency at –1 dBFS input level for left and right channels at the 20 gain setting. Distortion vs. level for a 1 kHz test frequency is shown plotted in **figure 4** for sampling frequencies of 44.1, 96, & 192 kHz. For clarity, the left channel only is shown. Also noticeable, is the 0 dBFS distortion is higher at the two higher sampling fre-

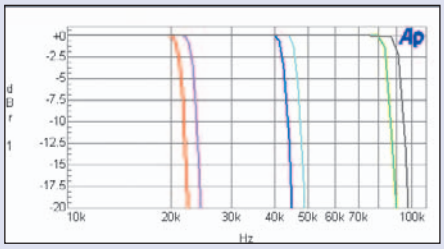

Figure 1: Frequency response of the ADC 1 as a function of sampling frequency. Red=44.1 kHz, Magenta = 48 kHz, Blue = 88.2 kHz, Cyan = 96 kHz, Green = 176.2 kHz, & Grey = 192 kHz

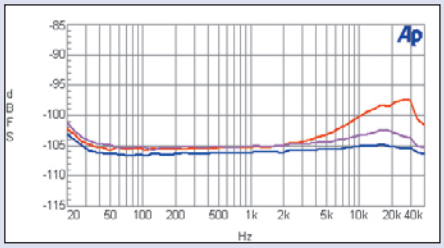

Figure 2a: Total harmonic distortion plus noise vs. frequency and gain setting for right channel. Fs = 192 kHz. Red = 20, Magenta = 10, Blue = 0 gain setting.

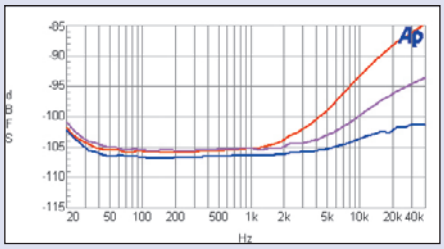

Figure 2b: Total harmonic distortion plus noise vs. frequency and gain setting for left channel. Fs = 192 kHz. Red = 20, Magenta = 10, Blue = 0 gain setting.

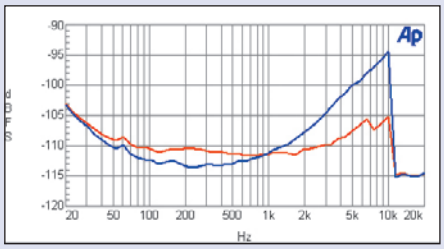

Figure 3: Total harmonic distortion plus noise vs. frequency for left and right channels at gain = 20. Fs = 44.1 kHz. Red = left channel, Magenta = right channel.

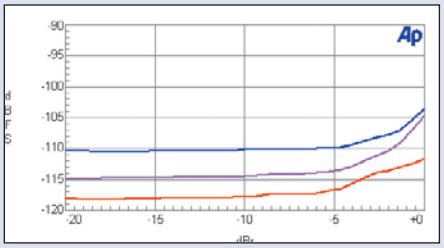

Figure 4: Total harmonic distortion plus noise vs. input level and sampling frequency. Red = 44.1 kHz, Magenta = 96 kHz, Blue = 192 kHz

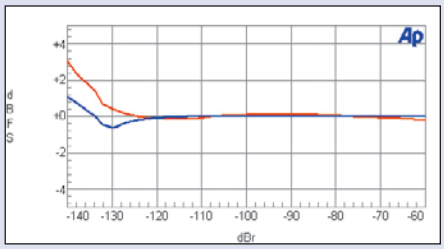

Figure 5: Typical deviation from linearity. Fs = 44.1 kHz. Red = left channel, Magenta = right channel.

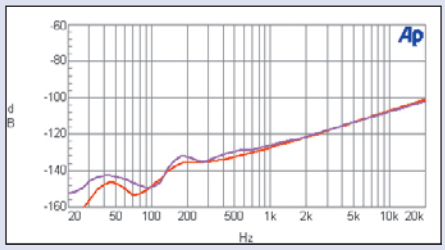

Figure 6: Typical channel separation vs. frequency. Fs = 44.1 kHz. Gain = 20. Red = L > R, Magenta = R > L direction.

quencies. The ultimate noise floor as distortion goes away with decreasing level is most a function of the sampling frequency and the resultant audio bandwidth, which in this case, was Fs/2, necessary for the measurements in the higher sampling frequencies.

Input/output linearity was quite good for the ADC 1 and was more or less the same for all sampling frequencies. A typical result is plotted in **figure 5** for both channels and at a sample rate of 44.1 kHz.

Channel separation was essentially independent of sampling frequency but did vary a bit with the gain settings being a bit better at the lower gain settings. Still, better than 100 dB at 20 kHz is very good performance in this test. A plot of channel separation at the gain setting of 20 is shown in **figure 6**.

— Bascom H. King

ports only 96 kHz through its single-wire digital input.

The ADC1 is mostly straightforward and easy to use, and the manual is very detailed and chock full of specs and illustrations. The Benchmark, however, is one of those designs that requires manipulation of toggle switches and deciphering LEDs to select the sample rate. (Why can't we just get a display that says 24-bit/96 kHz, 16-bit/44.1 kHz, etc.?).

Anyway, once I learned that column 1's first two LEDs represent 48 kHz and 44.1 kHz respectively and column 2's first two LEDs represent 4X and 2X, I figured out how to toggle the mode switch to give me the sampling rates I wanted.

I first recorded the analog output of my Esoteric DV-50 DVD-A player into the ADC-1/DV-RA1000 combo at 24-bit/96 kHz. The material included prerecorded DVD-As and my own high-res acoustic guitar recording DVD-As using the Nightpro PreQ3 and a set of Audix SCX-25 microphones.

I played the material back via the Esoteric's excellent upsampling DAC as well as the Benchmark DAC1 24-bit/96 kHz converter. To play back the material on the Esoteric, I took the recorded 24-bit/96 kHz DVD+RW from the TASCAM transferred it to Minnetonka Bronze on the Mac and burned the audio onto a DVD-A, which was then played on the Esoteric.

After a few listening sessions, I was impressed. Using my high-end monitoring system with the Bryston amp, Legacy Focus ribbon speakers and a Pass Labs Class A preamp, I could not here the difference between the original DVD-As and the Benchmark one-generation copy of those recording. On the Benchmark converted copies of my best DVD-As, the nuance, space and realism of the recording was duplicated exactly from the original.

On original recordings of acoustic guitars, including a new Taylor concert-sized 712, the ADC1 transferred all the shimmer of the guitar and sound of the room space that could be heard during the performance, and there was no hint of harshness. The finger squeak decay from the guitar playing to the gradual fadeout of room reverb, this converter relayed all the information that was there. Stereo imaging at these high sampling rates is stunningly open. If you have the caliber of mics and preamps to make the best recordings, the ADC1 captures it in all its glory!

For those who are going to use multiple ADC1s for critical recording, I think they will be quite satisfied. For those who want it for archiving, mastering or other stereo tasks, the under $2,000 price per unit should make it attractive for those uses as well.

I wish it could have been a little closer in price to the DAC1, which is under $1,000, but the folks at Benchmark said it is not possible to US-manufacture this caliber of A/D converter at pro audio industry quantities at a lower price.

Besides the pristine audio of the ADC1, I liked the word clock I/O and the auxiliary output, which parallels the main 24-bit output or outputs a separate simultaneous digital signal at 16-bit/44.1 kHz or 48 kHz. You can record high res and CD quality at the same time.

My only quibble with the ADC1 is the same one as I had for the DAC1: the lack of a power switch. I know that it is built to withstand "all-the-time-on" status, but sometimes I like to turn off a component without pulling the plug, or turning off the entire power strip.

Summary

The ADC1 was a long time in coming since its original announcement in 2002, but it has been worth the wait. Though not the bargain the DAC1 is at $975, the ADC1 converter at the higher bit rates is about as accurate and artifact-free as I have ever heard. The Benchmark ADC1's sonic qualities are stunning; the converter has the ability to realistically reproduce all the fine inner detail and presence subtitles that only the best high-resolution converters can. Impressive. Put a set of these in your Pro Tools rig.

John Gatski is the publisher of ***Pro Audio Review.***