Digital Audio Evangelists

By Erik Hawkins

Unless you've been in hibernation for the past year, you've undoubtedly heard the recent hubbub over D/A and A/D converters that claim better sound thanks to resolutions higher than sixteen bits. Having compared many of these new systems to older, 16-bit systems, I can definitely say that more bits yield better-sounding recordings. But exactly how many bits produce qualitatively better sound? Are all 16-bit systems about to be outmoded? These questions are difficult to answer, but a detailed look at several new, external, 20-bit converters can help sort through the issues.

External converters used to be the exclusive purview of major recording studios and big-time producers because of their price tags. For example, Benchmark's ADA2008 lists for $4,200, and Apogee's AD1000 costs $3,300. Both are 20-bit units. However, the prices of 20-bit converters have fallen dramatically—in many cases to less than $600—putting them within the reach of the personal studio owner. Assuming that these new under-$600 converters were not all created equal (a fair assumption), then which is the best?

Illustration by Dave Ember

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To find the answer to this question, I field-tested and compared Frontier Design Group's Zulu ($598); Lucid Technology's ADA1000 ($599); Midiman's Flying Cow ($400), Flying Calf A/D ($200), and Flying Calf D/A ($150); and Zefiro Acoustics' InBox ($295). (Note that I did not perform bench tests; only field tests.) These units differ in size, shape, and connections, but all perform similarly to their pricier counterparts to provide improved audio through digital I/Os. They can improve the performance of older 16-bit gear and open the doors to software programs that support 20-bit formats.

Doing Your Bit

Before getting down and dirty with these converters, let's start with some basic concepts. There are three stages in the digital recording and playback process where bit resolution comes into play: input, output, and internal storage. Until recently, the standard resolution for all three stages has been sixteen bits. There have been a few deviations from this standard, but for the most part, 16-bit architecture has reigned supreme for the past five years.

You can use a 20-bit analog-to-digital (A/D) converter as the input stage to a 16-bit recording device, which increases the input resolution but not the storage resolution. If the signal is stored with sixteen bits of resolution, it's still a 16-bit recording, even if the input is 20-bit. The question then becomes "If the signal is stored at 16-bit resolution, what makes a 20-bit converter sound better than a 16-bit converter?"

The answer lies in the converter's *dynamic range*, which is the difference in decibels (dB) between the noise floor of an audio device and the highest undistorted level that device can handle. A 20-bit converter has more dynamic range than a 16-bit converter because of its higher resolution.

The increased dynamic range of a 20-bit A/D converter can be preserved to some extent when the signal is stored with 16-bit resolution through a process called *dithering* (see "Square One: Dithering Heights" in the December 1996 **EM**). Even if a 20-bit signal is truncated to sixteen bits by simply ignoring the four least-significant bits, the quality of the signal is generally better than if the original audio had been converted to 16-bit resolution to begin with. In this case, the cut-off bits represent mostly noise, so the inherent noise floor of a 16-bit truncated signal is lower than the floor of one that had been converted to a 16-bit signal in the first place.

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The Zulu and ADA1000 are clean and transparent.

At the other end of the signal chain, a 20-bit digital-to-analog (D/A) converter might not improve the sound of audio stored at 16-bit resolution because it can't create information that isn't in the stored signal. However, not all converters are created equal; some are simply sweeter or more musical sounding. Without mentioning names, most people will agree that some 16-bit devices used today have some pretty brittle-sounding converters. These units can benefit from better-sounding, external D/A converters, which might perform better in terms of noise floor, linearity, or distortion.

Two of a Kind

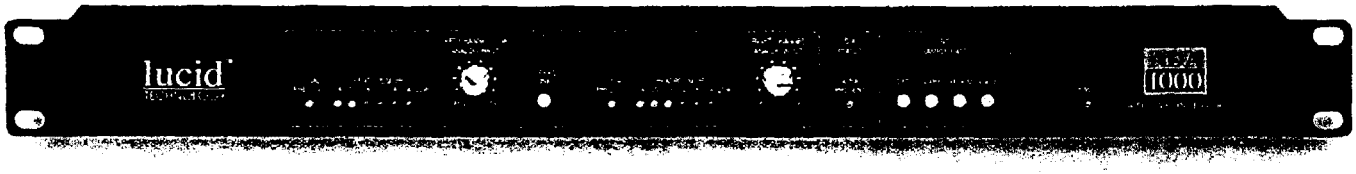
The Lucid ADA1000 is a 1U rackmount device that performs both A/D and D/A duties. It has two independent input channels that can be linked for stereo operation, which is a wonderful feature that lets you accommodate either mono or stereo sources. Each input channel has an associated level-control knob, an LED that indicates the presence of an analog input signal of -40 dB or greater, and a 7-segment LED meter (including a peak indicator). You can choose a sample rate of 48, 44.1, or 32 kHz, or you can lock the unit's sample rate to an incoming clock source. Another LED indicates a valid digital input signal. The ADA1000 has no power switch, but it does have a power-indicator light.

The ADA1000 accepts AES/EBU signals via XLR connectors or S/PDIF signals via RCA jacks. These connectors are on the rear panel, along with a button that selects the format. This button is inconveniently located if you have the unit rack-mounted and need to change formats regularly; I would have preferred it on the unit's front panel.

With a digital input, a signal is present at both output jacks simultaneously, letting the unit double as a digital audio splitter. Analog connections include balanced, XLR and unbalanced, ¼-inch inputs and outputs. Power is supplied by a proprietary, lump-in-the-line AC adapter.

Midiman's Flying Cow is radically different in appearance from the ADA1000, but it's identical in function. The Flying Cow is a ½-rack unit with a textured, gray finish, and it has a beautifully screened flying cow on its face and top. You might wonder what a flying cow has to do with a 20-bit converter. I prodded Midiman for an explanation, but they just mooed something about wanting to be different and kept on grazing.

The Flying Cow is a stereo unit with a single input-level knob on its front panel. The left and right input meters comprise six LEDs each, including a clip LED. A Mode Select button is used for toggling between AES/EBU and S/PDIF and selecting a sample rate: 48 kHz, 44.1 kHz, 32 kHz, or an external clock source. A series of LEDs indicates the Cow's current mode (e.g., AES/EBU at 48 kHz, S/PDIF at 44.1 kHz, etc.). But with only one button



Lucid Technology's ADA1000 provides two independent input channels that can be linked for stereo operation.

The Midiman Flying Cow's analog inputs and outputs use those nifty Neutrik connectors that accept both XLR and ¼-inch jacks.

for selecting formats and sample rates, you're forced to step through several combinations before reaching the one you want. The unit remembers the last mode it was in, but employing separate clock- and format-select buttons would have made moving between modes much quicker.

The rear panel is equipped with standard AES/EBU and S/PDIF connections. The analog ins and outs are those nifty Neutrik connectors that accept both XLR and ¼-inch jacks. All analog connections are balanced; the inputs also accept unbalanced signals. I love these connectors, but be forewarned: they're all female. This means the standard rule of "inputs are female and outputs are male" doesn't apply. The Cow is powered by a 9 VAC wall wart.

New Frontiers

Frontier Design Group's Zulu is based on Alesis's proprietary ADAT Optical digital audio interface (commonly called the Lightpipe), which carries up to eight channels of information simultaneously on a fiber-optic cable. Unlike the other converters discussed here, the Zulu's intended market is primarily Lightpipe-equipped multichannel digital audio cards. The Lightpipe is quickly becoming a de facto standard and can be found on all sorts of equipment, including MDMs, DAWs, effects processors, synths, and sound cards.

As a result of Frontier's marketing goals, the Zulu's only digital connection is Lightpipe: in fact, it's the only converter in this group with multichannel (i.e., greater than stereo) capabilities. If you want to use it with AES/EBU or S/PDIF equipment, you must use a product that has both Lightpipe and S/PDIF or AES/EBU ports. (Examples include Alesis's AI-1 converter, the new Yamaha and Panasonic digital mixers, and the Frontier WaveCenter, Sonorus StudI/O, and Korg SoundLink 1212 I/O computer audio cards.) In fact, Zulu derives both its input (A/D) and output (D/A) sampling clocks from the ADAT Lightpipe datastream, so you must send it a Lightpipe signal at all times. Even the analog I/O relies on the ADAT clock.

The Zulu is a ½-rack unit. As with many such devices, two Zulus fit side by side on a standard rack shelf (e.g., Middle Atlantic Products' U1). It has four analog inputs and eight analog outputs on the rear panel. All jacks are ¼-inch unbalanced; balanced connectors would have been more professional. (Frontier's Tango provides eight channels of balanced analog I/O in addition to Lightpipe for $898.) Power is supplied by a wall wart, and the unit does not have a power switch.

The Zulu's front panel includes no controls, only LEDs; input-level adjustments must be done at the source. There's an LED that glows green to indicate the presence of an optical input. For analog metering, there are four multihued LEDs, one for each input.

REALITY CHECK

Before deciding on whether these new boxes are worthy of purchase, let's take a hard look at a few facts. All consumer CDs use 16-bit resolution. No matter what resolution you use to record your material, it must be converted to sixteen bits if you want it on CD.

I wholeheartedly believe that tracks should be recorded using the best possible equipment regardless of where they will end up. And it's true that higher-resolution recordings reduced to sixteen bits do sound a tad better than straight 16-bit recordings. But does the incremental increase in sound quality justify the added expense of a 20-bit converter? In addition, will the average listeners be able to hear the difference on their boombox or car radio? Perhaps not.

Pairing 20-bit converters with 16-bit storage is not spectacular. On the other hand, using 20-bit converters with 20-bit storage starts to get the blood flowing, and using these converters with software that can handle 20-bit recording and playback is way cool.

But wait—since most of the programs slated to handle 20-bit recording are also expected to handle 24-bit recording (usually in the same version), why not just get 24-bit converters? Good question. In fact, most manufacturers I spoke with said 24-bit converters are just around the corner (Midiman expects to ship 24-bit products by the third quarter of this year), and one even said that those converters wouldn't cost too much more then the current 20-bit converters.

The best-sounding combination I've heard comes from pairing 24-bit converters with 24-bit storage. This is really mind-blowing sound. It won't fit on a compact disc, but it will fit on a DVD, the medium being touted to replace CDs (see "Tech Page: CD? No, DVD!" in the July 1998 EM). Many major studios are gearing up to handle 24-bit sound with an eye toward improving audio quality and being DVD-ready. This seems to provide a recipe for a new standard resolution that's greater than twenty bits.

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These LEDs change colors (green, orange, or red) to indicate the level of the associated input. This isn't a very accurate metering scheme, but I didn't find myself looking at them often. Usually, I was looking at the meters on my recorder. There is also a power-indicator LED.

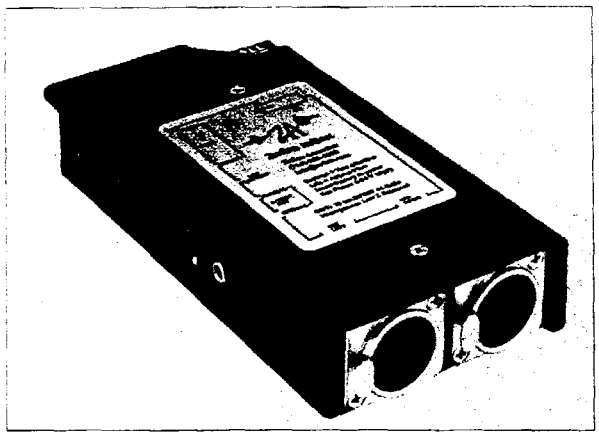
One-Way Wonders

Zefiro Acoustics and Midiman make some handy devices for those who only need a D/A or A/D converter and don't want to spend the money to have both in the same box. Zefiro's InBox is an A/D converter, and Midiman offers both A/D and D/A converters, which are called Flying Calves.

All three units are about the same size, but Zefiro's InBox is the most portable because it can operate on a battery, has a mic preamp, and is equipped with a belt clip. It's constructed of blue, anodized aluminum and seems very rugged. The InBox can run for eight to ten hours on one 9V, alkaline battery, or you can power it with an external 9V, wall-wart adapter (which is sold separately for about $10). A patented, external battery clip lets you reverse the battery in lieu of a power switch (i.e., turning the battery around turns the unit off).

On the top is a diagram identifying the controls and connections. The unit doesn't come with a user's manual, so this diagram is important. It's a stereo device with left and right XLR mic inputs located on the bottom (the side facing down when it's clipped to your belt). In fact, this unit has no line-level inputs, but you can obtain a line-level adapter cable from Zefiro. The mic-preamp controls—one for each input—are found on the side. These mini pots are very small, making them difficult to set accurately. However, once they are set, you're not likely to bump into them, which is good for field recording.

Digital outputs include an optical S/PDIF (Toslink) connection and an electrical S/PDIF minijack connection. In order to turn the minijack into a standard S/PDIF connector, you'll need a minijack-to-RCA adapter. The folks at Zefiro opted for the minijack because they felt it provides a more secure connection; however, having dealt with minijacks in the field, I disagree with this view. Besides, an adapter is usually the least secure solution possible. Furthermore, there is a reason standards are adopted—to promote easy connectivity—and I think Zefiro should have used the standard RCA connector.



Zefiro Acoustics' InBox is designed for portable, field-recording applications.

STRAIGHT TALK

When asked why a 20-bit converter is useful, manufacturers tend to downplay the limitations of 16-bit internal storage. If you push the subject, and the person you're talking to is either uninformed or just sales happy, they will invoke the "software connection." Twenty-bit converters are an excellent (and inexpensive) way to access the new software programs that handle 20-bit file formats. These programs promise high-resolution recording without Digidesign hardware (or Digidesign price tags).

But don't be fooled by fast-talking sales staff that would have you believe it's as simple as updating your software and plugging into some digital I/Os on an audio card. (Of course, not all manufacturers are so flip.) Digital I/Os are not created equal. All common digital formats support incoming resolutions up to 24 bits and sampling rates up to 48 kHz, but some audio cards have dithering built into them. For example, the inputs on Lucid's PCI 24 (a digital-only card) stop at 20 bits (not 24), even though its outputs go up to 24 bits. Making matters worse, a digital card that accepts 20-bit input but uses the Mac OS Sound Manager will have its performance impeded by this system's 16-bit limitation. (Windows has no such limitation.)

Be especially wary of software that claims 24-bit internal processing. This is not the same as the ability to handle 20- or 24-bit files. Make sure the program can *record* in 20- or 24-bit word lengths as well as play such files back. In order to avoid the limitations of the Mac's Sound Manager, make sure that your audio card's driver works directly with the audio software, circumventing Sound Manager. If you can select your audio card directly from within the program instead of the desktop's sound control panel, you are probably fine. But before you invest in an external converter, contact the software manufacturer to be sure.

If you manage to jump through all these flaming hoops without getting too badly burned, you're well on your way to the "software connection." Manufacturers pitch 20-bit converters as inexpensive ways to take advantage of high-resolution software using an old sound card's digital I/O. They can also achieve better S/N ratios because the converter is not subjected to fans and EMF inside the CPU. These pitches are true.

Unfortunately, things aren't as easy as buying a new converter and plugging it in. The industry is in the midst of changing standards, and until resolutions and sample rates settle down, watch your ones and zeros.

Between the digital outs and the level controls is a single LED that glows red when the battery is dying. The InBox is factory-set to record at 44.1 kHz (a 48 kHz version is available upon request).

The Golden Calf

In the words of Midiman, "The Flying Cow had babies." The Flying Calf D/A and A/D are housed in metal chassis with the same textured, gray finish as their mom. Both units have S/PDIF digital I/O, and the analog connections are ¼-inch unbalanced; again, balanced connectors would have been cooler. The Calves are powered by a wall wart.

The Flying Calf D/A has no front-panel controls, only an LED that lights to signify a digital lock. Midiman claims that all standard sample rates below 50 kHz are supported. The Flying Calf A/D has a button for selecting the sample rate: 44.1 or 48 kHz. As with the Flying Cow, the last setting is memorized on power-down. Incoming levels must be adjusted at the source. There are two 6-segment LEDs (including clipping) to help you tweak the input levels.

The Calves contain the same converters as the Flying Cow, but the specs are slightly better for the Calves (see the table, "Converter Specifications") due to their simpler design (i.e., fewer components in each Calf unit). In addition, the analog electronics are optimized for unbalanced operation. Given the time constraints for this face-off, I was only able to test the Flying Cow. Other than the simpler design, however, the Cow and Calves are identical pieces and should sound and perform pretty much the same.

Rules of the Game

In order to compare these converters, I needed to create a level playing field. This was difficult, because the variety of formats made things tricky. Eventually, I decided on a set of tasks using similar equipment, recording techniques, and monitoring, regardless of format.

To hear whether the converters could perk up gear with less than 20-bit resolution, I connected their digital outputs to a Panasonic SV-3700 DAT (16-bit), an original Alesis ADAT (16-bit), and an E-mu Darwin (18-bit A/D and D/A, 16-bit storage, like the Alesis ADAT XT). None of these outboard converters provide any sort of dithering to reduce the resolution, so the signal is simply truncated by the recording device.

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To evaluate their performance with higher-resolution gear, I also connected them with Digidesign's Pro Tools 24. Using various conversion boxes and hardware options, I was able to connect each converter to every piece of test equipment.

I first recorded material using the onboard A/D converters of the test equipment. Next, I recorded through the 20-bit A/D converters being evaluated. I then compared both recordings from the test equipment's onboard converters and the outboard 20-bit converters.

For the most part, the results were monitored on Hafler TRM8 powered monitors; a few things were played back on Meyer HD-1s and Genelec 1030s. I also double-checked everything through a pair of Sony MDR-V6 headphones.

Over the course of a few weeks, I recorded vocals, bass, drums, piano, and a Gibson semihollow-body guitar through each converter. I also tried some old 16-bit mixes to see if they sounded any better through the 20-bit converters.

Let the Games Begin

There was no question that 20-bit inputs sounded better than 16-bit inputs: this was true for every A/D converter. The recordings on the ADAT and SV-3700 seemed to have more space and body; vocals sounded breathier, drums sounded fuller, guitar and bass sounded beefier, and the piano had more depth.

On the other hand, there wasn't a noticeable difference between the Darwin's 18-bit A/D converters and the 20-bit A/D converters under evaluation. Comparing the external converters' inputs to Pro Tools 24's inputs was a tough call. All the frequencies and the dynamic range were present in both recordings, but the Pro Tools recordings had more air to them; they just seemed more alive and expansive.

Listening to the 20-bit D/A converters, I only heard a definitive sonic improvement with 20-bit audio files. When the audio was 16-bit (e.g., from the SV-3700 or ADAT), all I heard was differences in converter coloration (which I'll discuss shortly). The 20-bit outputs did not stack up to Pro Tools' 24-bit outputs for playback of 24-bit files. The Pro Tools outputs were significantly hotter and had more high-end definition. With 20-bit files, I really couldn't hear any difference between the 20-bit outputs and the 24-bit outputs.

As for coloration, the Zulu and the ADA1000 sounded identical to my ears;

Converter Specifications

These specs were provided by the manufacturers and might not be directly comparable due to differences in measurement techniques.

	Frontier Zulu	Lucid ADA1000	Midiman Flying Cow	Midiman Flying Calf A/D	Midiman Flying Calf D/A	Zefiro InBox
Price	$598	$599	$400	$200	$150	$295
Number of Channels	8	2	2	2	2	2
Digital Connections	ADAT Optical	S/PDIF, AES/EBU	S/PDIF, AES/EBU	S/PDIF	S/PDIF	S/PDIF (minijack and Toslink)
Analog Connections	¼" unbalanced	XLR, ¼" balanced	XLR, ¼" Neutrik	¼" unbalanced	¼" unbalanced	XLR (mic only)
Mic Preamp	no	no	no	no	n/a	yes
Sample Rates A/D	external*	32 kHz, 44.1 kHz, 48 kHz; external*	32 kHz, 44.1 kHz, 48 kHz	44.1 kHz, 48 kHz	n/a	44.1 kHz
Sample Rates D/A	external*	external*; 20–50 kHz	external*; up to 50 kHz	n/a	external*; up to 50 kHz	n/a
A/D Frequency Response	20 Hz–20 kHz, ±0.05 dB	20 Hz–20 kHz, ±1 dB	20 Hz–20 kHz, +0/-0.5 dB	20 Hz–20 kHz, +0/-0.5 dB	n/a	10 Hz–21 kHz, ±0.25 dB
D/A Frequency Response	20 Hz–20 kHz, ±0.1 dB	20 Hz–20 kHz, ±1 dB	20 Hz–21.7 kHz, +0/-0.5 dB	n/a	20 Hz–21.7 kHz, +0/-0.5 dB	n/a
A/D S/N ratio	99 dB (A weighted)	95 dBFS (A weighted)	98 dB (A weighted)	99 dB (A weighted)	n/a	102 dB (A weighted); 98 dBFS
D/A S/N ratio	99 dB (A weighted)	90 dBFS (A weighted)	99 dB (A weighted)	n/a	102 dB (A weighted)	n/a
A/D THD	0.002% (A weighted)	<0.002% @ 0 dBFS	0.006% (A weighted)	0.003% (A weighted)	n/a	0.0029% @ -0.1 dBFS; 0.0023% (A weighted)
D/A THD	0.002% (A weighted)	<0.005% @ -6 dBFS	0.003% (A weighted)	n/a	0.0018% (A weighted)	n/a

*** locks to sample rate of incoming digital signal**

For manufacturer information, please see Contact Sheet, p 163.

they are both very clean and transparent. I'd describe their sound as similar to an ADAT XT but perhaps a hair closer to the Darwin.

The big surprise was the Flying Cow's sound, which was very pleasantly colored: fat, warm, and round. In listening tests, it was repeatedly selected as the best-sounding converter over its competition. In some ways, it is even more pleasing to the ears than Pro Tools' 24-bit converters. It isn't as harsh, especially in the high end, and it is less fatiguing, with an enhanced low/mid range.

The sound of Zefiro's InBox is affected by the D/A converters it's paired with. I could just call it a chameleon, but I'll step out on a limb and say its sound lies somewhere between the ADA1000 and the Flying Cow. It didn't seem as fat as the Flying Cow nor as transparent as the ADA1000. I'd describe it as having a TASCAM DA-38 sort of sound (i.e., flatter than the Flying Cow, without an enhanced low/mid range, and with some bite but not overly harsh).

Watch Out

Before moving on, I'd like to point out a couple of things that users should know. First of all, early versions of the Flying Cow had a reversed bit in the S/PDIF datastream. This causes certain DAT machines to incorrectly identify the incoming digital format, which results in lock problems. According to Midiman, the problem has been fixed for several months.

I mention this because it can be a bit bewildering; some DAT decks ignore the problem (e.g., TASCAM DA-30), while others are stumped by it (e.g., Panasonic SV-3700). It's one of those things that might lead you to suspect that something's wrong with your DAT deck when it's really the Cow. If you think you might have one of these afflicted bovines, call Midiman; a simple firmware swap will solve the problem.

Another point of some concern is that the Zulu will not work as an input device for the original ADATs without an external clock (e.g., a BRC). This is because the old ADAT must see a clock source when it uses the Lightpipe input. The Zulu does not generate its own clock and always looks for an external sync. Without an external clock, both units are hopelessly lost. If you have one old ADAT with no clock source, and you thought that buying a Zulu would be a quick sound improvement, think again.

The ADAT XT has a Clock Source setting that solves this problem by letting it lock to its internal clock despite being in digital-input mode. However, as I mentioned earlier, I heard no noticeable difference between 20-bit and 18-bit inputs.

To Frontier's credit, they discuss this problem thoroughly in the manual. In addition, this is not the primary application for which the Zulu is designed. Nevertheless, it is something you should be aware of.

Finally, the Zulu includes a function called Automute, which is turned on and off with a jumper on the main circuit board inside the unit. (The unit ships with this feature disabled.) When Automute is enabled, the analog output is muted whenever silence is encountered for 100 ms or more. In this case, silence is a stream of samples with zero amplitude. Think of it as a kind of gate with zero attack and zero release.

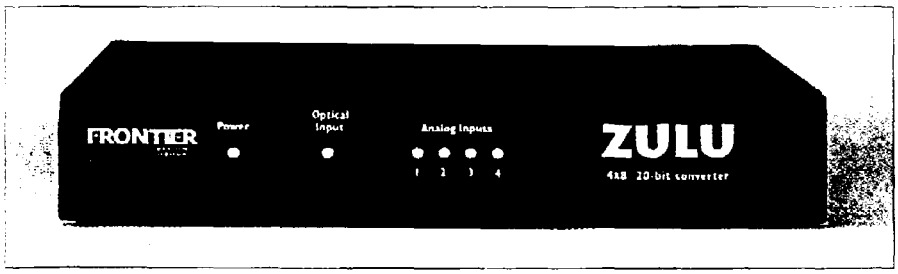
According to Frontier, Automute increases the Zulu's S/N ratio by about 10 dB. Unfortunately, there is a soft but audible pop that occurs whenever Automute turns on or off. Frontier doesn't try to hide this click; in fact, they mention it in their user's manual as an "effect" of the Automute function. I'm not sure what use this effect might have, but it isn't pretty. I hate listening to digital audio with clicks in it, no matter how subtle they are. The Zulu's S/N ratio is already great, so what's the point of Automute?

Final Call

Recording with 24-bit resolution isn't within everyone's reach, but it will be shortly. That's not hypothetical; it's reality. I never advise waiting for new gear, especially if it means putting off your music, but it seems more sensible to wait and make the jump to 24 bits instead of 20 bits. This would be wise not only for the sound quality but also because of the impending emergence of DVD (see the sidebar "Reality Check"). In the meantime, 16-bit gear still sounds okay, and most of us are still listening to 16-bit CDs. Certainly, these now-venerable discs are adequate for most of us to get our musical ramblings across.

If you just can't wait to get started recording at higher resolutions, I recommend the Zefiro InBox for professional, portable field recording. If you like a warm coloration to the sound, the Midiman Flying Cow or Flying Calf A/D fills the bill. However, if you believe that a converter should remain transparent and colorless, the Frontier Zulu and Lucid ADA1000 are excellent choices. Of course, if you're using a multichannel sound card or other gear with a Lightpipe interface, the Zulu is a great deal.

As for the D/A converters, they only make a major difference with material stored at 20-bit resolution. If your gear stores everything at 16-bit resolution, you might as well stick with your 16-bit outputs. However, if you can't stand the way your 16-bit outputs sound, I recommend the Midiman converters for a fat, warm sound and the Frontier and Lucid units for a clean, transparent sound.



The Frontier Design Group Zulu is the only converter in this face-off with multichannel (greater than stereo) capabilities using the Alesis Optical (Lightpipe) interface.

Erik Hawkins *hopes he's not attacked in the middle of the night by angry manufacturers who want to dither him down. But if they do, remember that, before they got him, he wasn't just another 2-bit punk.*