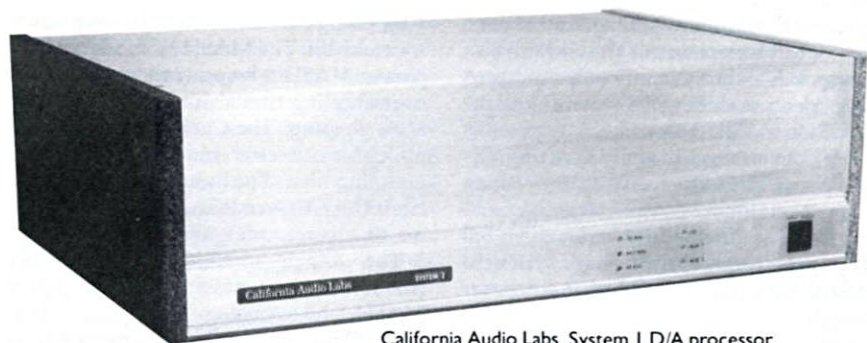


# CALIFORNIA AUDIO LABS SYSTEM I D/A PROCESSOR

Thomas J. Norton



California Audio Labs System I D/A processor

Digital to Analog converter with plug-in modules. Decoding system dependent upon module inserted. Dimensions: 5.9" H by 18.25" W by 12.5" D. Weight: 25 lbs. Price: \$1995 w/o modules. MASH IV module: \$200. Caelum module: \$350. Indus module: \$650. MASH V module: \$1500. Approximate number of dealers: 96. Manufacturer: California Audio Labs, 16812 Gothard Street, Huntington Beach, CA 92647. Tel: (714) 841-1140. Fax: (714) 841-2427.

There's no question that outboard digital processors have become a growth area in high-end audio. It's not difficult to understand why. The expertise of most US (and many European) high-end, non-loudspeaker manufacturers lies in circuit design, not mechanics. Digital converter design and manufacture, while it certainly requires new knowledge, also makes use of the same expertise and production facilities which turn out amplifiers and preamplifiers. Once the new digital skills are acquired or hired, the commitment to build a processor merely requires the right market conditions—the customer base must be seen as ready to accept that manufacturer's "going digital." Most US high-end electronics manufacturers have made this move.

Manufacturing a CD player, on the other hand, moves into uncharted waters of motors, gears, and other strange moving parts. This is beginning to happen, but, apart from the seemingly endless CD-player modifications more common in digital's early days than now, it has been a slow process.

California Audio Labs is a major exception. CAL has been marketing complete players since entering the marketplace back in 1986. Although their first model, the Tempest (reviewed by JA in Vol.9 No.7), was based on a Philips player, and some of their parts, par-

ticularly mechanical ones, have been and continue to be sourced overseas, the design and assembly of all their players since then has been done here. They have really had no need, up to this point, to manufacture outboard converters to make their mark in digital; digital is where they made their mark in the first place. When they finally felt the time was right to jump into the outboard processor game, they clearly decided to offer something other than just another converter. Something different was needed.

That something different is flexibility, both in the type of D/A conversion offered to the customer, and in regard to the whole question of rapid advances in digital technology obsoleting "this year's" products. With digital developments coming out almost daily, many buyers are understandably reluctant to buy an expensive processor which may well be old news in a year or less. While the situation today is not as fluid as it was two or three years ago, digital is still the most technically fluid product category in audio.

CAL's solution is unique: to my knowledge, their System 1 was the first converter on the market which could be easily updated without being returned to the factory.<sup>1</sup> The key digital parts—the D/A converter and digital oversampling filters—are encased in plug-in modules. The fixed circuitry consists of

power supplies, the final stages of post-processor filtration, analog circuitry, switching, and input and output circuits—those elements less subject to rapid obsolescence. CAL likens this arrangement to that of an analog playback system: The cartridge—in this case, the DAC/digital filter—is changed more often than the turntable and arm. The tonearm here corresponds to the System 1's unencapsulated components, including the chassis. With the CAL System 1 the customer can upgrade his or her converter more easily than upgrading a phono cartridge—no setup or tweaking required—as improved technology becomes available. The internal “motherboard” is full of jumpers which allow the basic system to be used with present and future converter modules.

There are two internal sockets for these modules. One is designed specifically for PCM or multi-bit processors, the other for PWM or so-called 1-bit processors.<sup>2</sup> Thus at any given time the user may have two modules on board, one of each type, and instantaneously select one or the other by means of a front-panel switch. Another switch permits selection of one of three inputs: two Toslink optical (EIAJ) and one coaxial. While the internal layout of the System 1 could accommodate an AT&T optical link, there are, at present, no plans to provide one as a standard or optional feature. Curious, since CAL's upcoming transport will have an optional AT&T outlet.

Switching to the appropriate sampling frequency (32kHz, 44.1kHz, or 48kHz) is performed automatically and the selected sampling rate is indicated by a front-panel LED. Both balanced and unbalanced outputs are provided. Most of the fixed circuitry in the System 1 is common to both module “stations.”

But the final low-pass filtering stage is located outboard of the modules, since PCM and PWM require different filtrations. Because of this, there are two separate analog

stages, one optimized for 1-bit processors, the other for multi-bit. The basic design of these two analog stages is, however, quite similar.

As of this writing, CAL Audio manufactures four of these plug-in modules. Two are 1-bit (using MASH<sup>3</sup> 1-bit technology), two are multi-bit. The MASH IV module incorporates MASH 1-bit processing with a 32x-oversampling digital filter and 4th-order noise shaping. The Caelum module has a multi-bit converter and 18-bit, 8x-oversampling filter. The Indus incorporates the latest Burr-Brown PCM63 DAC with 20-bit, 8x-oversampling filtration.

The fourth module, dubbed Super MASH, incorporates Matsushita's level V MASH 1-bit technology, which has, according to California Audio Labs, never before been made available commercially outside of Japan. Even in Japan it has only seen limited use. It is certainly too expensive to be used in the mid-level CD players which are Matsushita's audio bread and butter,<sup>4</sup> though it has apparently found an application in the video circuits of the Japanese HDTV system. CAL has an exclusive on the audio use of this processor for another year—their close relationship with Matsushita probably helped. The Super MASH module includes separate MASH V sigma-delta converters for each channel and 20-bit, 64x-oversampling filtration.

The Super MASH is apparently the only currently available converter which can accept a 20-bit input. There is, of course, a bit of a snag in this: the source signal from the CD is in a 16-bit format. To furnish the required 20-bit signal, CAL sends the digital input through a pre-processing board which actually performs another stage of D/A, A/D conversion. When I asked the obvious question—What's the advantage of the 20-bit input if you have to go through an extra conversion to analog and back again to use it?—CAL's Art Paymer answered that the overall resolution is improved with the 20-bit input even with the added signal processing required.

This extra stage of conversion also per-

3 MASH, or Multi stAge noise SHaping, is a Matsushita acronym for their version of a 1-bit PWM processor.

4 Art Paymer of California Audio Labs told me last year that Matsushita manufactures about 17,000 CD players per day. In contrast, he said the worldwide market for outboard D/A converters is about 400 per month.

1 Most high-end manufacturers provide upgrades of one sort or another. To use one well-known example, Theta's software-intensive designs are often upgraded with the change of a ROM chip. The same is true of Wadia. Also, as I write this, I note at least one other processor on the market, from Counterpoint, which offers a form of modular upgrading.

2 PWM, or Pulse Width Modulation, is the predominant type of 1-bit decoding used by manufacturers on the left side of the Pacific. Another common scheme, Philips's Bitstream, uses PDM, or Pulse Density Modulation. The System 1 is not currently compatible with the latter.



forms an anti-jitter function—not only with the Super MASH, but with the other modules as well. It is therefore in the circuit at all times. I still have some reservations about this from a technical standpoint; we have not yet discovered the perfectly transparent D/A and (especially) A/D converter. Adding additional ones to the chain seems like a touchy proposition. It can only be justified if the disease it is designed to cure is worse than the possible losses in the additional processing stages. Only the listening tests would answer that question, though not definitively—it is not possible to hear the System 1 *without* this pre-processing. This pre-processing board is, however, designed to be easily removable for possible future upgrades.

Installing (and changing) the System 1's plug-in modules is a relatively simple procedure. It does, however, involve removing the sides and top of the unit and making some internal adjustments by means of jumpers. To use the Super MASH module, a small, auxiliary circuit board must be properly inserted. None of these steps are at all challenging, but if you blush at the sight of anything resembling a naked circuit board, you should let your dealer do the honors.

The System 1's overall build quality is good, if not in the same league as the super-expensive processors. The only obvious cost-cutting measure is the chassis thickness; the top, especially, is rather flimsy. The front panel, available in black or brushed aluminum, is neat and well laid-out, but also lacks the extra-thick, massive look. None of this is likely reflected in any way in the System 1's performance, however, and the battleship construction used in pricier components adds a lot more to their cost than you might think. Inside, the impression is of a neatly laid-out, top consumer-grade product—nothing to generate either raves or criticism. The modules themselves are solidly encased in artificial marble of the Corian/Fountainhead family of fine *faux*—the same material dressing up the sides of the System 1's exterior, a number of upmarket loudspeaker enclosures, and mother's new kitchen countertops. The computer-board connectors which attach the modules to the motherboard make good contact, though the modules themselves will rock back and forth slightly after insertion. The System 1 should not be shipped with modules installed, as possible damage could result.

The first System 1 we received worked fine for several weeks. Then, during a hiatus in which I was away from Santa Fe for two weeks, it went wrong somewhere, for no apparent reason. It still *sounded* the same, except that it was now making odd intermittent noises, noises which resembled nothing so much as abrupt, widely spaced record ticks. These would vary in level from soft to very obvious, showed no particular preference for either channel, and would happen on an erratic time schedule, usually only every few minutes. It was consistent with all four modules. A return to CAL for servicing turned up no defect, nor could CAL repeat the problem in the factory. A second sample exhibited a similar problem. A third played a new game. The CAL uses muting relays in the circuit to blank the signal while the data is locking on (relays which, I should note, are mechanically quite audible from several feet away). The relays on this sample were hyperactive, muting the signal at random times, including the middle of the music.

The only possible explanation which we, or CAL, could come up with was the unusually dry and static-prone conditions in Santa Fe. Power or interference problems specific to my listening room were ruled out since GL, before he moved away from Santa Fe, briefly borrowed the System 1 and experienced the same muting problems in his listening room as I had in mine. Finally, to get around the problem, CAL provided us with a "Santa Fe" version of the System 1, identical in all respects to the normal version except that the relays had been partially disabled. I say "partially" only because I could still hear them working intermittently during operation, though not through the system. This appears to have cured the problem with no side-effects. CAL says that they have never before experienced this problem, so chances are that few buyers will require this work-around.

## OTHER EQUIPMENT

Equipment used with the System 1 included the Wadia WT-3200 transport, the CAL Genesis CD player, the Rowland Consummate preamplifier, the Threshold S/550e amplifier (and, briefly, the McCormack DNA-1). The loudspeakers were the Apogee Stages used on their matching stands. The



processor-to-preamp interconnect was the next-to-latest version of AudioQuest Lapis. Cardas Hexlink (not the latest version) was used from the preamp to the power amp.

The System 1 was not a simple processor to review. Not only are four different plug-in modules available for it, but it has both optical and coaxial inputs. Throw in balanced and unbalanced outputs, and you have a challenging number of possible combinations. I quickly decided to do my listening using the unbalanced outputs, since balanced-input preamps are still the exception and available to few readers. I also concentrated on the top-of-the-line modules—the MASH V or Super MASH 1-bit, and the Indus multi-bit. The less expensive Caelum and MASH IV were auditioned briefly near the end of the evaluation.

## SOUND

**The Indus:** Even with the early samples of the System 1, despite their functional problems here in Santa Fe, it was clear that something right was going on. I spent much of this early listening with the Indus multi-bit module, and was *very* favorably impressed. Voices were natural, and instruments were precisely detailed, with full-bodied yet not overwarm timbres. Leanness and artificiality were out, an almost analog-like three-dimensionality and richness were in. I definitely liked what I heard. Through the important midrange, there was a rightness to the sound which drew me into the music. The top end was delicate and unexaggerated, yet in no way lacking. The bottom leaned to the soft rather than to the tight and punchy, but never seemed short of definition and extension. The soundstage was tightly focused, with good, though not exceptional depth (the Apogee Stage loudspeakers also have this quality), and well-positioned and properly sized lateral images.

It is by now a cliché that it is difficult to hear the flaws in very good products until you compare them with something better. That is certainly true of the System 1 with the Indus. Kenny Rankin's *Because of You* (Chesky JD63) was airy at the top, slightly warm but not unnaturally so at the bottom, and very much *there* through the midrange. The Kenny Rankin definitely sounded like a record to die for through this system. As did, I might add, another new Chesky re-

cording, *Sara K.* (Chesky JD67). Sonically this is a knockout, superior to even the very fine Rankin recording. Both are models of what a well-recorded pop vocal should sound like, whether or not you care for the music and the performers. (I happen to think both are very fine, thank you.) The CAL delivered with both of them.

The System 1/Indus did just as well with such widely diverse program material as the Ken Peplowski Quartet's *Sonny Side* (Concord CCD-4376) and Bill Elgart's *A Life* (Cello Acoustic Recordings CAR003). In the former, an excellent recording, the CAL revealed a wealth of clean, sweet detail. Despite a slightly over-spotlighted soloist, the sound had a natural, pleasing presence. The Bill Elgart is part of a set of recordings made by Mark Levinson between 1972 and 1978, recently re-mastered on six CDs and available from Levinson's present company, Cello, as a complete set. A musically interesting attempt at an integrated work for solo drumset, *A Life* is stunningly well recorded and remastered. The System 1/Indus had no trouble with its sharp, punchy dynamics. The sound had snap and sock, with a convincing liveness. I had been particularly impressed with this recording in the Cello room at *Stereophile's* recent LA High End Hi-Fi Show, and while the sound through Cello loudspeakers certainly had more dynamic impact than what I heard over my own system, the latter definitely was not shamed and demonstrated the importance of a good source—disc and player. The System 1 with the Indus processor held up its own end of the bargain, and then some.

**Super MASH:** Switching from the multi-bit Indus module to the Super MASH did not result in a *dramatic* change in sound. That appealingly full-bodied quality and fully dimensioned soundstage were still present. The upper octaves were still extended and airy, the midrange was still richly detailed, and the bass still slightly softened but nevertheless more than adequately well-defined.

There were differences, however. On the plus side, the Super MASH module displayed a more layered soundstage from front to back, with a larger ambient "shell" surrounding the performers. We're not talking a huge difference here, or one noticeable with all program material. But it was nonetheless



audible, and clearly evident on a number of selections from *Auvidis* (an Astrée sampler, E 7699). The double bass on band 4 (from *Captaine Tobias Hume: Musicall Humors*, Astrée E 7723), the instruments and chorus on band 2 (from *Ensaladas*, Astrée E 7742), the harpsichord on band 7 (from *Louis Couperin: Les Pièces de Clavessin, Tome I*, Astrée E 7781), and the organ on band 8 (*Nicolas de Grigny: Le Livre D'Orgue, 1699*, Astrée E 7725), all had superior ambience, depth, or both with the Super MASH.

The Super MASH also had the more forward, immediate midrange, often sounding louder than the Indus. But care had to be taken here in making this comparison. All of the System 1's plug-in modules have slightly different output levels, and the output of the System 1 with the Super MASH was 1.3dB above that with the Indus.

Accurately comparing the two modules, then, was not just a simple matter of pushing the front-panel switch—which, it should be noted, switches silently between the onboard modules. The small gain change must also be accounted for, a simple matter with the Consummate preamplifier I used.

That forward quality of the Super MASH could be a mixed blessing, but in general it resulted in a positive sonic gain. It could work magic on vocal recordings, the above-mentioned Kenny Rankin and Sara K. being notable examples. The tactile feeling of a vocalist present in the room could be uncanny, and the forwardness was rarely an intrusion.

I did have reservations about the Super MASH's performance in two areas, however—transient performance and upper midrange, lower treble balance. First the latter. While I would not wish to overstate the case, I nevertheless found that, on a healthy proportion of good program material (though not all), the Super MASH's response in this region was a bit more "mechanical" than that of the Indus. The latter sounded sweeter. But, perhaps paradoxically, the Indus also seemed to have the better transient performance. It was more focused and detailed than the Super MASH, with a better sense of space between the notes and better-defined leading edges.

A couple of well-chosen examples will, I hope, tie all of these impressions together. On the previously referenced harpsichord piece from the Astrée sampler, the overall detail

was more clearly delineated on the Indus, with a better sense of attack and spacing between the notes. Earl Wild's playing on *Earl Wild Plays Rachmaninoff* (Chesky CD58) was rather softened with the Super MASH. There were ample helpings of warmth and timbral richness, but the dynamic impact was lessened in comparison with that with the Indus. On any objective scale, the difference was small. Without the direct comparison, it might pass unnoticed over the short haul. But subjectively, that all-important sense of dynamic shading and overall emotional force—factors which greatly influence my reaction to music—produced a solid vote here for the multi-bit Indus. I can't deny that the Super MASH produced the better sense of spatial ambience with both recordings, but overall the Indus took the honors.

The tables were turned with the above-mentioned Sara K. recording. I filled a page and a half with notes on this one. With the Super MASH, Sara K.'s voice was liquid and rounded, suspended in air between the loudspeakers and stunningly three-dimensional. That sense of forwardness in the upper midrange/lower treble was still there, but did not detract. With the Indus the reproduction was still very fine by any definition, but was cooler and leaner. Still, the Indus excelled in the finely focused rendition of transient details, which were less precisely defined with the 1-bit processor.

Putting it another way, the Indus had the superior image focus and definition while the Super MASH pumped up the overall picture, adding a natural and pleasing bloom to ambience and voice, but in the process losing a bit of definition by, in effect, closing-in the intertransient spaces. Both modules leaned more in the direction of warmth than of coolness, with the Super MASH going farther toward warmth. With either module, the System 1 continues the CAL tube-player tradition without using tubes. Both were detailed, yet extremely engaging and listenable, without the smear that those terms can imply.

Going back and forth with many recordings led me, eventually, to an overall preference for the Indus. It was detailed without being overly detailed. There was no sense of any analytical quality, yet no sense of anything being missing, either. Its sound was sweet yet vibrant with a fine sense of—



stay with me here—palpability. The Super MASH, because of its slight emphasis in the upper midrange/lower treble, initially sounded even more detailed, but that impression did not hold up over time. Still, it was also engaging in its own way, and did outpoint the Indus on a number of recordings. But not on the majority. The beauty of the System 1, however, is that you don't have to choose one or the other. You can have both, funds permitting. Many audiophiles have more than one cartridge available for analog playback. The System 1 provides that same option in the digital domain.

All of the above listening impressions were made with the Wadia WT-3200 transport and Kimber KCAG digital coaxial interconnect. CAL also sent along their Genesis CD player for transport use. The latter has only an optical output, of the Toslink (EIAJ) variety. They also sent one of their own fiber-optic cables.

Using the Genesis to drive the System 1—with the Super MASH processor and CAL's fiber-optic cable—resulted in a noticeable change. Unfortunately, not for the better. The overall definition was softened, there was a loss of three-dimensionality and focus, and everything seemed louder (though it measured the same). As always, such descriptions tend to overstate the case to make the point. The performance with the optical link was certainly a long way from unlistenable, and the System 1's essential performance remained intact. But the sound was less precise—the highs less defined, the midrange less transparent, the soundstage less layered. None of these losses individually could be called dramatic, but together they added up to a less involving experience. I also tried a different fiber-optic cable, from Audio-Technica, with no significant change in my observations.

But two variables were involved here: the link and the transport. To try to pin this down a bit more specifically, I experimented with using just the Wadia transport and comparing its own coax and fiber-optic (Toslink) outputs in driving the System 1. My observations read like a repeat of the above comments. The coax was more dynamic, defined, and articulate. The optical link was more laid-back, less precise. Again, the difference was not night-and-day—I would not bet the farm on an A/B comparison here—but, given the choice, there's no question in my mind that I would use the coax. Every time.

To try to place the System 1 in context with other competing processors, I compared it (using the multi-bit Indus module) with the Audio Research DAC1-20. I've been using the latter in my reference system and have found it to be a topflight unit. The ARC has definition to spare, with the superior sense of transient attack, but its overall balance is definitely leaner than that of the System 1. The CAL has a musical richness and rightness in its reproduction of the critical midrange. It also seems more finely grained at the very top end, more extended (though with some loss in tautness as a tradeoff) at the bottom. Sara K's voice was fuller, more three-dimensional, more arrestingly present through the System 1. Earl Wild's piano had more bloom and ambience with the CAL, though the ARC outscored it in conveying the instrument's percussive quality. And Bill Elgart's drumset was marginally more potent in its low-end wallop with the System 1.

Apples and oranges here, perhaps. Until we know *exactly* what a given CD is *supposed* to sound like, one could make arguments for the superior accuracy of either processor. I can only say that the System 1 drew me more deeply into the music.

This comparison was made using the AT&T fiber-optic link between the ARC and the Wadia, the Kimber KCAG coax with the System 1. I had originally intended to start by using the coax with both, changing the ARC to the AT&T link later in the listening. But the coaxial link to the DAC1-20 broke lock with the transport a few minutes into the listening. It was restored later, but too late to complete the first stage of the comparison. In general, however, the AT&T link has been preferred in these pages in those processors which have provision for it. Therefore, by comparing the ARC with AT&T to the System 1 with coax, each processor was performing at what I believe was its best.

**MASH IV & Caelum:** I spent some time with these less-expensive plug-in modules near the end of the evaluation period.

I'd done no listening for several days prior to trying out the less expensive MASH IV and Caelum modules. Beginning with the MASH IV, I immediately noted that something wasn't right. The superior qualities I'd noted with the Indus and Super MASH were



gone: instruments were brighter and leaner, and Earl Wild's piano lacked its former richness—a dry, somewhat grainy quality at the top replaced the pristine clarity I'd heard before. There was a crisp quality I hadn't noted before. Bill Elgart's drumset had a reasonable transient attack, but with a splashy, slightly fuzzy quality. The midrange—the vocal range in particular—was pallid and dimensionally flat in comparison to the naturally three-dimensional quality I'd noted earlier. Sara K.'s recording now sounded routine. I definitely felt less involved in the music with the MASH IV.

This admittedly brief audition wouldn't have been much longer even had time permitted. I simply did not like what I heard. It wasn't so much bad as ordinary—a sound no better than that available from any number of complete CD players selling for far less money. I wondered if something had gone wrong with the system in the days I hadn't listened to it, or if I'd been listening to the System 1 through rose-colored earplugs.

I hadn't. Switching to the multi-bit Caelum module resulted in an immediate sonic improvement. "Much better," I wrote in my notes on listening to the very first CD, Mary Black's *Babes in the Woods* (Curb D2-77538), a "smoother, less dry, less antiseptic sound." Much—though not all—of the delicacy and subtlety I'd noted earlier returned, along with a liquidity and richness which eluded the MASH IV. The Caelum had a good balance of warmth and detail, with a well-defined soundstage and a generous helping of depth. The time available for me to listen to the Caelum was no longer than what I'd spent with the MASH IV, but in this case I would not have objected to spending more time getting to know it better.

Returning to the Indus processor after listening to the Caelum, however, reaffirmed that there was nothing wrong with the system. All of the qualities I'd noted previously returned. The Caelum did a more than respectable job—good enough that it would take a longer evaluation period to point with confidence to specific shortcomings. But the Indus sounded just a little more "live," a little less "reproduced." It had the most solid low end, the most smooth, dimensional midrange, and the most finely detailed yet subtle and delicate highs.

I'm not certain how much these less ex-

pensive modules will appeal to System 1 buyers. With the latter selling for nearly two grand without modules, does it make sense to skimp on the processor itself? Perhaps. The buyer who wants to get into the System 1 because he or she likes the basic concept, but cannot afford the system *and* one of the pricier modules, might opt for this. Or the buyer who wants the option of single- or multi-bit playback but cannot afford the cost of the Indus or the even pricier Super MASH might go this route. And with CAL coming out with more modules next year, the inexpensive processors might just allay concerns that CAL is working on something which will supersede either the Super MASH or the Indus. I doubt that the Super MASH is about to be replaced, but a more upscale multi-bit processor is not unlikely. (I have no inside information on this other than the fact that, when I asked CAL's Art Paymer last year if they might come out with an UltraAnalog module, he did not deny the possibility.)

## MEASUREMENTS

Since four different plug-in modules are available for the System 1, there are also four different possible sets of measurements—not to forget its sets of balanced and unbalanced outputs. To retain a little control over the possible flood of data, I performed most of the measurements from the unbalanced outputs, those most likely to be used by the majority of listeners. I did run a complete set of measurements of the System 1 from the balanced outputs with the Super MASH processor. Those results are also given below when they differ significantly from those of the unbalanced outputs.

The output level of the System 1 when decoding a full-scale sinewave at 1kHz differed with each module: Super MASH 3.44V, Indus 2.95V, MASH IV 3.0V, and Caelum 2.55V. The largest mismatch between channels was with the Caelum: 0.07dB. The balanced outputs gave the expected 6dB increase in output, 6.87V with the Super MASH module.

The output impedance of the CAL measured just under 47 ohms in the left channel (about 2 ohms less in the right) from below 20Hz to 1kHz, increasing to under 117 ohms (left channel, 110 ohms in the right) at 20kHz. The figures were about twice as high with the balanced outputs (under 117 ohms

left channel and 122 ohms right channel to 1kHz, 248 ohms left and 264 ohms right at 20kHz). The output of the System 1 is non-inverting from the unbalanced outputs. The balanced outputs conform to the AES/ANSI standard in having pin 2 as positive, pin 3 negative.

The System 1's frequency response (fig.1) shows a small rise peaking at just above 10kHz. This may result in a subtle brightening of the sound, but at a maximum of 0.25dB it would likely be almost subliminal in the best of circumstances and probably inaudible in any other. Note that only the results for the Indus module (top curves) and the Super MASH (bottom curves) are given

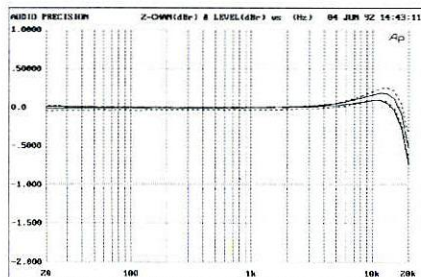


Fig.1 CAL System I, frequency response, Indus DAC (top), Super MASH DAC (bottom); unbalanced and balanced outputs matched within 0.1dB (right channel dashed, 0.5dB/vertical div.).

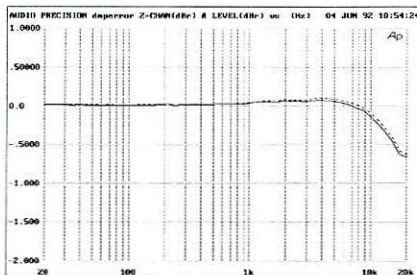


Fig.2 CAL System I, Super MASH DAC, de-emphasis error (right channel dashed, 0.5dB/vertical div.).

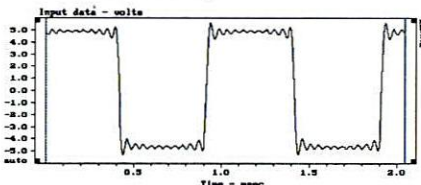


Fig.3 CAL System I, Super MASH DAC, 1kHz squarewave at 0dBFS.

here. The curves for the other two processors fall between the two shown.

The de-emphasis error is shown in fig.2. There is a slight softening in the top octave—again probably innocuous, and in any event of limited importance, since pre-emphasized discs make up only a small percentage of the total available. Fig.3, the output of a 1kHz squarewave, is a typical response to a circuit using a linear-phase filter, though there appears to be a little more leading-edge overshoot than usual. (In figs.2 and 3, the results for the Super MASH processor are shown; those for the other DACs were not significantly different.)

The stereo crosstalk (fig.4) is shown for all four processors. The lowest crosstalk was from the Super MASH (bottom curves), the highest from the Indus (top). While crosstalk in excess of 65dB at 20kHz—the worst case here—is unlikely to cause any audible degradation, it is still considerably worse than the best we've measured in a number of other processors. The high-frequency increase in-

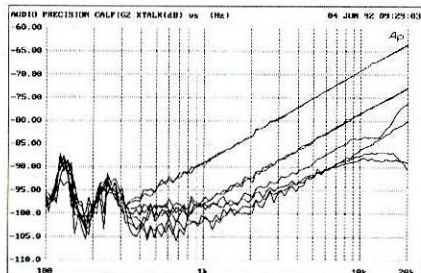


Fig.4 CAL System I, crosstalk, from top to bottom: Indus DAC, Caelum DAC, MASH IV DAC, Super MASH DAC (10dB/vertical div.).

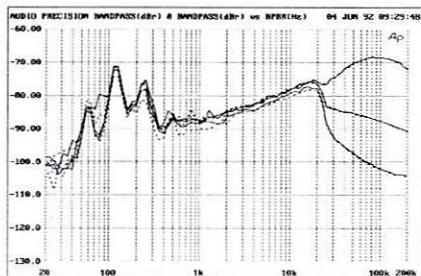


Fig.5 CAL System I, spectrum of silent track, 20Hz–200kHz with noise and spurs, from top to bottom above 10kHz: MASH IV DAC, Super MASH DAC, Indus DAC (Caelum DAC same as Indus) ( $\frac{1}{3}$ -octave analysis, right channel dashed).



icates capacitive coupling between channels.

The increase in crosstalk at the lower frequencies is due to power-supply noise skewing the measurements, this also evident in fig.5. The latter shows the System 1's output when decoding a test track of digital silence (all of the encoded data words set to zero). Note the considerable levels of noise at the power-supply frequency and its harmonics—no grounding scheme between the Audio Precision test set and the System 1 would reduce this. It never resulted in an audible problem during the listening, however.

Except for this problem, there are no converter artifacts visible. The divergence of the noise spectrum above 20kHz is worth noting. The MASH IV (top) and Super MASH (middle) show the highest noise levels. This is expected as a result of the noise shaping used in 1-bit decoding schemes, which moves the inherently high requantization noise of the process above the audible range. Note also, however, that of the two 1-bit modules, the noise is considerably less with the Super MASH. The curve for the Caelum module

is not shown here, as it precisely overlaid the curve for the Indus. Interestingly, allowing for the 6dB higher output level from the balanced output, the noise spectrum from the latter is still around 6dB higher across the band than from the unbalanced output. This is surprising. Note, however, that this does not necessarily mean that the noise from the balanced outputs *in a system* will be higher. The overall noise will depend on the relative contribution of any noise picked up by the interconnects, a characteristic in which balanced leads are generally acknowledged to be superior—for long lengths. For this measure-

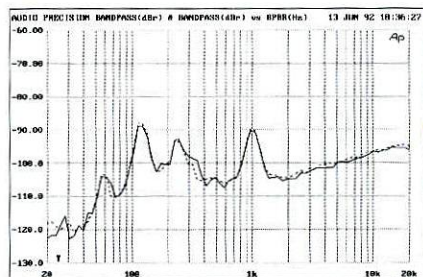


Fig.6 CAL System I, Super MASH DAC, spectrum of dithered 1kHz tone at -90.31dB with noise and spurs (1/3-octave analysis, right channel dashed).

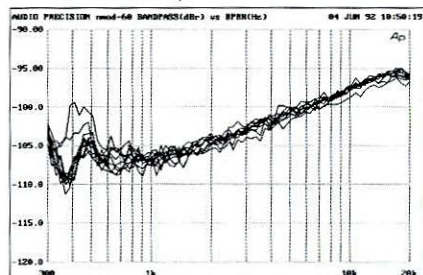


Fig.7 CAL System I, noise modulation, -60 to -100dBFS, Super MASH DAC and Indus DAC (peak at 400Hz is the Indus curve at -60dBFS, peak at 480Hz is the Super MASH -60dBFS curve) (5dB/vertical div.).

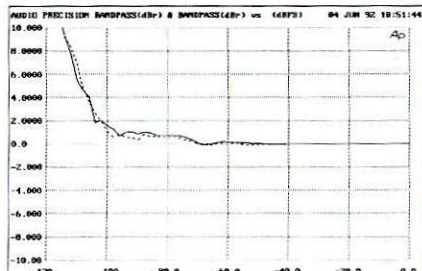


Fig.8 CAL System I, Super MASH DAC departure from linearity (right channel dashed, 2dB/vertical div.).

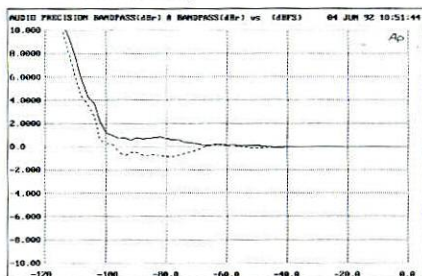


Fig.9 CAL System I, Indus DAC, departure from linearity (right channel dashed, 2dB/vertical div.).



Fig.10 CAL System I, MASH IV DAC departure from linearity (right channel dashed, 2dB/vertical div.).



ment, the interconnects were only 0.5m long, balanced or unbalanced.

Fig.6 indicates the output spectrum of the System 1 with the Super MASH module when replaying a digital representation of a dithered sinewave at -90.31dB. This curve, as expected, reveals the same power-supply noise as the earlier figures, negligible level error at the -90dB level, and no significant artifacts other than the low-frequency noise. The corresponding curves for the other modules (not shown) did not differ significantly, with similar noise levels and no more than 1dB variation in the 1kHz output.

In the February '92 issue (pp.143-45) RH described a new noise-modulation test for converters. I ran this test here with the converter driven with the code for a 41Hz sine-wave at five levels (-60dBFS, -70dBFS, -80dBFS, -90dBFS, and -100dBFS). I then performed a spectral analysis of the output. In an ideal converter, the resulting noise vs frequency plot would have a decreasing noise floor as frequency decreased and identical, overlapping traces. The traces for the System 1 are shown in fig.7. Here I have chosen to overlay the traces for the Super MASH and the Indus modules on the same graph. The

clustering is reasonably good above 1kHz, with no significant differences between the modules. There is some divergence below 1kHz (the peak at 400Hz is from the Indus's curve at -60dBFS, the peak at 480Hz is in the Super MASH's -60dBFS curve). The traces for the MASH IV and Caelum modules were not substantially better or worse than those shown, the sole notable deviation being a sharp peak (to -102dB) in the Caelum's -80dBFS curve. The significance of these results, barring the unlikely event of our finding a perfect processor, will become clearer as we run more processors through the test. RH's reviews of other processors in the next issue will give you further data points to which to relate the quality of the System 1's results.

The System 1's linearity is shown in figs.8-11. The results with all four modules were quite good down to -100dB. What's interesting here is that the linearity with the multi-bit modules, though slightly different in detail, could be judged to be every bit as good as that from the 1-bit modules. Because this was the first processor we've tested which could be switched from 1-bit to multi-bit operation—with a change also

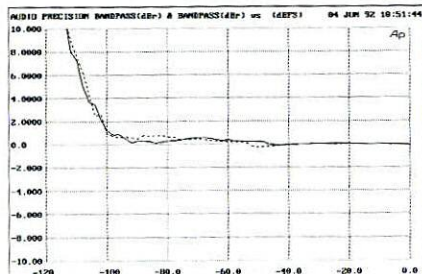


Fig.11 CAL System I, Caelum DAC, departure from linearity (right channel dashed, 2dB/vertical div.).

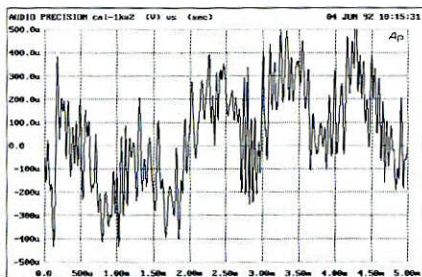


Fig.12 CAL System I, Super MASH DAC, undithered 1kHz sinewave at -90.31dB.

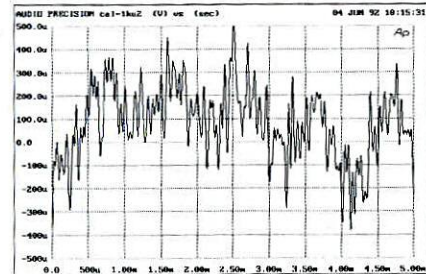


Fig.13 CAL System I, Indus DAC, undithered 1kHz sinewave at -90.31dB.

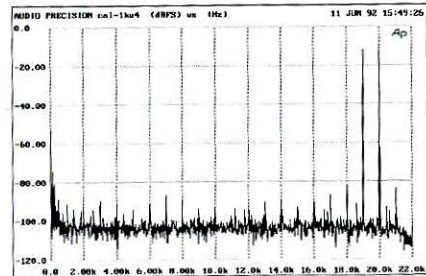


Fig.14 CAL System I, Indus DAC, HF intermodulation spectrum, DC-30kHz, 19+20kHz at 0dBFS (linear frequency scale).



in the digital filtration employed—while remaining essentially the same in other respects, the System 1 provided a unique test bed to compare the 1-bit and multi-bit formats. Recall that low-level linearity was, at the beginning of the 1-bit craze, the be-all and end-all of this new decoding technique.

Figs. 12 and 13 show the System 1's reproduction of a -90.31dB, 1kHz, undithered sine wave. Fig. 12 (Super MASH) is the best result obtained from all four modules, fig. 13 (Indus) the worst (the remaining two are not shown here). The ideal staircase response is barely visible from the Super MASH; even more imagination is required to see it with the Indus. In both cases the power-supply noise is clearly evident in the wave's slow up-and-down undulations.

Fig. 14 shows the output from the System 1 with a combined 19+20kHz input. The major IM artifacts are all below -68.7dB (about 0.04% distortion). The result shown is for the Indus module, which gave the best result. Even the worst, however (the Caelum, not shown), had no artifacts higher than -62.9dB (0.07% distortion).

Finally, the DC offset of the CAL System 1 measured 2.7mV (right) and 6.1mV (left).

## CONCLUSION

The true value of any audio component does not always lie in how well it reproduces favorite, good-quality recordings, although that is certainly a requirement. Rather, it lies in the component's ability to bring alive recordings which you had previously listened to briefly but then set aside as okay but nothing

to get excited about. No accurate component can do this for all recordings, of course—any component which does so should be suspect.<sup>5</sup>

The CAL System 1 passes this test decisively. A few months ago I bought the new Andreas Vollenweider recording, *Book of Roses* (Columbia CK 48601). It was okay, but I didn't listen to it again until recently—on the System 1 with the Indus module. The recording was not as edgy as I'd previously thought, though all of AV's recordings are on the hot side of neutral. Detailing was all there, but without any distracting edge or bite. Nor had I fully appreciated before this recording's musical qualities—it had never appealed to me enough to sit down and listen to it all the way through. This time I did, and found it involving both musically and (despite its obviously heavily overdubbed nature) sonically. I wrote in my notes that the highs here were "gorgeous," an adjective I would not often be inclined to attach to other recordings by this artist. There are also several rather striking examples of depth and sound-space in this recording, stunningly reproduced through the System 1.

While CAL's big-ticket multi-box CD players may have passed into history, there is no reason to mourn their disappearance. The System 1 is a winner, preserving the best qualities of those earlier players. Perhaps just as important, it gives the buyer a road to easy upgrading in a rapidly changing digital present leading toward an unpredictable digital future.

**\$**

5 Or purchased immediately.

—RL