how it works

DAT GEAR IS RAPIDLY DISAPPEARING FROM MANUFACTURER WAREHOUSES AND STORE SHELVES. WHAT WILL REPLACE IT? CORE SOUND, ALONG WITH A SYMPHONY OF WORLDWIDE DEVELOPMENT PARTNERS, DELIVERS A HARMONIC PROPOSAL.

Sound savings: Portable audio recorder takes on tape, part 1

By Brian Dipert, Technical Editor

Since Sony introduced DAT (digital-audio tape) in 1987, it has been the preferred format option of many journalists, musicians, and live-concert and lecture-audience members, who want to capture a sonic snapshot of the events they attend. Record-label-piracy concerns and consequent copy-protection and royalty complications, though, have curtailed DAT's acceptance in the consumer-electronics world. With recording studios moving to hard-drive-based setups, DAT's popularity is even further on the wane, and recent reports indicating a near-future end to tape-drive-mechanism shipments will likely put the final nail in the DAT coffin (**Reference 1**).

Figure 1 The PDAudio-CF digital sound card is the centerpiece of the PDAudio system (courtesy Core Sound).

In retrospect, DAT's demise isn't devastating, because it was not an ideal audio format for a number of reasons. For example, if you accidentally damage a DAT, you disrupt the audio bit stream and have big and, likely, unrecoverable problems on your hands. Compare this situation with mutilating an analog-audio tape: A piece of adhesive tape and a pair of scissors gets you up and running again with only a brief sonic disruption to mark the impairment. Along similar lines, a slight head maladjustment, which would result only in attenuation of high-frequency details in the analog-audio-tape generation, would leave you listening to the "sounds of silence" with DAT.

Because DAT supported sample rates only as high as 48 kHz and per-channel samples as large as 16 bits, it was incompatible with emerging high-resolution-audio trends (**references 2** through **4**). And, to move the DAT-captured data to a computer, you had three choices: You could connect the digital output of the recorder to the S/PDIF (Sony/Philips-digital-interface) input of your PC's sound card and transfer the audio at a slow-as-molasses 1× rate. Alternatively, you could connect the analog output of the recorder to the PC-sound-card-line input, and suffer the additional misfortunes of quality-degrading interim digital-to-analog and analog-to-digital conversions. Or, you could install a DDS drive in your PC, along with software, such as DAT2WAV or Vdat (**Reference 5**).

Len Moskowitz, the owner of Core Sound, which has long catered to the audio-recording community, was well-aware of these DAT limitations when he set out to design a high-resolution-audio-capable DAT replacement (see **sidebar** "Other options"). He noticed that many former tapers were migrating to notebook PCs as their next-generation recording platforms. He also observed the exponentially increasing processing and storage capabilities of the latest handheld computers. Like many of us, he was also acutely aware of the talent and enthusiasm of open-source-operating-system and application developers (**Reference 6**).

Moskowitz, an electrical engineering alumnus with 20 years' experience at AlliedSignal (now Honeywell) and ITT Avionics, decided to tap into that worldwide talent to help develop his system, which at first glance had a number of seemingly contradictory requirements: It had to be low cost and have low shipping volumes. It also needed to have low power consumption for long recording times, even when diminutive PDA batteries powered it. Its interface had to be compatible with both PCs and handheld computers. It also had to support large samples and high sample rates if the target system hardware and software could process them, and it had to inject little noise to preserve the fidelity of captured audio. The resulting PDAudio system, which is now entering production, employs novel approaches to address these requirements.

PDAUDIO-CF

The heart of the PDAudio architecture, the $199 PDAudio-CF card, is the result of many hours of brainstorming Moskowitz spent on the proper form factor, the amount of hardware integration, and the appropriate hardware-versus-software partitioning for his target customers (**Figure 1**). Digigram's VxPocket PCMCIA card was one system whose approach he evaluated before coming up with his own. To maximize the SNR of the analog subsystem, he decided he'd need to move it outside the noisy PC environment. An all-in-one unit that combined microphone phantom power and preamp circuits, analog-to-digital conversion, and digital-processing functions would need to connect to the computer over USB or IEEE 1394 (FireWire).

However, USB Version 1.1 had unreliable latency times and inadequate bandwidth, and USB Version 2 and IEEE 1394 had insufficient penetration within the installed base of computers at which Moskowitz was aiming PDAudio. Further, none of these bus options were appropriate for PDAs. Examining the VxPocket, he also noted that the device's analog-audio-output circuits, although appropriate when Digigram designed the unit several years ago, were redundant in today's handheld and notebook computers, which have those functions built in. The VxPocket's digital output and time-code input weren't critical needs of the audio-recording community, either.

By developing a modular system that split the analog and digital portions of the recording chain, Moskowitz also enabled potential customers who owned microphone preamps and phantom power modules to upgrade their recording setups piecemeal. In its final definition, PDAudio-CF is a two-channel, digital-only device, supporting both coaxial and optical S/PDIF inputs at sampling rates as high as 192 kHz and per-channel sampling as large as 24 bits. He incurred the additional cost necessary to support both S/PDIF input types after his analysis of earlier Core Sounds customers' purchases suggested a roughly 50/50 usage split between the two formats in the recording community.

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OTHER OPTIONS

If your recording needs don't demand high-resolution audio, your list of available hardware options greatly expands. MiniDisc recorders from Sharp, Sony, and other companies capture sound in the lossy ATRAC (adaptive-transform-acoustic-coding) format; latest generation iterations of this algorithm deliver excellent quality and store as much as 320 minutes of data per disc (**Reference A**). Another all-in-one recording option with the choice of storing either to lossy MP3 or lossless WAV formats is Creative Labs' Nomad Jukebox 3 (**Reference B**). Whereas initial revisions of the unit's firmware couldn't make reliable glitch-free recordings, the latest iteration seems to have squashed the bugs. The Nomad Jukebox 3 captures incoming line- and microphone-level analog audio, for which it also provides gain controls and rudimentary level indicators, or digital audio through its S/PDIF (Sony/Philips-digital-interface) optical input.

If you prefer to employ your notebook-PC hard drive as the recording medium, consider the Digigram VxPocket PCMCIA sound card, which initially sold for around $1000 but that the company now promotes at $199. Although you need to either use self-powered microphones with it or purchase a separate phantom-power unit from Denecke or another company, the VxPocket's included microphone preamp and ADC circuits produce passable results for all but the most quality-critical situations. The VxPocket supports sampling rates only as high as 48 kHz, but it handles per-channel samples as large as 24 bits.

If you require something that's 1394- or USB-based, delivers full high-resolution audio, or can provide audiophile-worthy distortion and noise specifications, you might want to surf the Web sites and peruse the wares of retailers such as Core Sound, Oade Brothers, Sonic Sense, and Sound Professionals. Shop carefully, though, because many USB- and FireWire-based units resample incoming digital-audio data and, as such, are the bane of recording purists. And brace yourself for severe sticker shock when you examine the high-end gear. You'll soon see Core Sounds' $199 PDAudio-CF and companion less-than-$500 Mic2496, along with Digigram's $199 VxPocket, for the bargains they are!

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Inside PDAudio-CF you find few components, enabling Core Sound to squeeze the design into the CompactFlash form factor that many PDAs directly support and that, via a low-cost CF-to-PCMCIA adapter, notebook computers can also handle (see **sidebar** "A software smorgasbord"). Moskowitz included TTL-to-coaxial and TTL-to-optical S/PDIF transceivers, along with a small PROM to store the unit's CIS (card-information structure). One LED indicates a valid S/PDIF input signal; the other is available to application control and might find use in communicating the incoming sample rate or alerting the user to media-nearly-full or low-battery conditions.

An Actel antifuse FPGA houses most of the remaining logic circuits and translates the incoming serial bit streams into formatted data words for subsequent transfer over the CompactFlash bus. Why an FPGA? ASIC NRE (nonrecurring-engineering) charges would have been too extravagant, and minimum order volumes would have been too high for the customer demand that Moskowitz expects PDAudio-CF to achieve. He also valued the antifuse device's single-chip nature and its low power attributes over those of SRAM-based FGPAs. (PDAudio-CF draws an estimated 45 mA of current while operating at roughly 500 μA in standby.) His application also didn't require the hardware configuration flexibility that flash- SRAM-based FPGAs offer.

So far, we've talked about the digital-domain conversions that the PDAudio system tackles. But how do the analog sound waves hitting the microphones' diaphragms transform into a digital bit stream, in the first place? In the next issue of *EDN*, the second part of this article series will discuss the other half of the PDAudio hardware chain, Mic2496, along with the system software that completes the symphony.□

A SOFTWARE SMORGASBORD

The Pocket PC's audio capabilities extend beyond recording. Look, for example, at Phonature's PhonTuner and HandDee spectrum analyzer, which enable audio tuning and frequency analysis, respectively, via the PDA's built-in microphone. Bofinit's handheld audio spectrum analyzer is similar in features to the HanDee spectrum analyzer, and the company's freeware pocket oscillator generates single- and multiple-frequency tones and white noise, which other transformation effects supplement. Jan Bouwhuis' frequency tuner (www.frequencytuner.solcon.nl) is a freeware alternative to PhonTuner. Silicon Machines' PocketJam is, in the words of its developer, "a tiny rack of virtual analog synthesizers and effects for your Pocket PC."

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